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CONTENTS / İÇİNDEKİLER

Research Papers / Araştırma Makaleleri

The Influence of Financial Stress on Dynamic Connectedness between Fossil Energy Commodities and Green Energy Markets / Finansal Stresin Fosil Enerji Emtiaları ile Yeşil Enerji Piyasaları Arasındaki Dinamik Bağlantılılığa Etkisi

Pınar Evrim Mandacı, Birce Tedik Kocakaya, Efe Çağlar Çağlı, Dilvin Taşkın 444-466

Household Consumption Expenditures in Türkiye: Socio-Economic Determinants, Spending Patterns, and Policy Perspectives / Türkiye'de Hanehalkı Tüketim Harcamaları: Sosyo-Ekonomik Belirleyiciler, Harcama Desenleri ve Politika Perspektifleri

Emre Yüksel, Dilek Başar 467-483

The Interaction Between Economic Uncertainties and Financial Cycles in Türkiye: Frequency Domain Symmetric and Asymmetric Causality Analysis / Türkiye'de Ekonomik Belirsizlikler ve Finansal Çevrimler Arasındaki Etkileşim: Frekans Alanında Simetrik ve Asimetrik Nedensellik Analizi

Ayşegül Şahin 484-501

The Role of Capital Flows in the International Transmission of US Monetary Policy: The Case of Turkey / ABD Para Politikasının Uluslararası Aktarımında Sermaye Akımlarının Rolü: Türkiye Örneği

Nuri Çağrı Akar, Cemil Varlık 502-528

Investigating the Relationship between ADR, Stock Prices and Macroeconomic Indicators: The Case of Türkiye / ADR ve Hisse Senetleri Fiyatlarının Makroekonomik Göstergeler ile Arasındaki İlişkinin Belirlenmesi: Türkiye Örneği

Çağrı Kaan Yalçın, Levent Sezal, Özge Korkmaz, Sedat Yenice 529-548

Short-term Price Prediction in Initial Public Offerings Using XGBoost: Bist Technology Sector Example / XGBoost ile İlk Halka Arzlarda Kısa Vadeli Fiyat Tahmini: BİST Teknoloji Sektörü Örneği

Gamze Şekeroğlu, Ayşe Merve Acılar 549-567

The Multidimensional Effect of Financial Development on Total Factor Productivity: Evidence from Cross-country Panel Data / Finansal Gelişmenin Toplam Faktör Verimliliği Üzerindeki Çok Boyutlu Etkisi: Ülkeler Arası Panel Verilerinden Elde Edilen Kanıtlar

Çağatay Vişne, Ramazan Ekinci 568-595

Analysis of Agricultural Performance of BRICS Countries and Türkiye with CRITIC-Based Grey Relational Analysis Method / BRICS Ülkeleri ve Türkiye'nin Tarımsal Performansının CRITIC Tabanlı Gri İlişkisel Analiz Yöntemi ile Analizi

Ahmet İnkaya, Mahmut Masca 596-618

The Mutual Relationship between Financial Inclusion and Effectiveness of Monetary Policy: Evidence from Upper-Middle-Income Countries / Finansal Kapsayıcılık ile Para Politikası Etkinliği Arasındaki Karşılıklı İlişki: Üst-Orta Gelirli Ülkelerden Kanıtlar

Hakan Yıldırım, Tuba Özkan, Anıl Lögün, Mesut Doğan 619-635

The Factors Influencing Banks' Risk-Taking Behavior: Evidence from The Turkish Banking Industry / Bankaların Risk Alma Davranışını Etkileyen Faktörler: Türk Bankacılık Sektöründen Kanıtlar

Erdal Demir, Yüksel Aydın 636-654

Exports and Tourism Demand: Evidence of a Strong Link Disrupted by Pandemic Restrictions / İhracat ve Turizm Talebi: Pandemi Döneminde Zayıflayan Güçlü Bir Bağ

Emre Kurnaz, Ümit Seyfettinoğlu 655-676

The Relationship between the Sectoral Structure of Female Employment and Economic Growth and Income Distribution in Türkiye: Empirical Evidence from Fourier-Based Cointegration and Causality Analyses / Türkiye’deki Kadın İstihdamının Sektörel Yapısı ile Ekonomik Büyüme ve Gelir Dağılımı Arasındaki İlişki: Fourier Tabanlı Eşbütünleşme ve Nedensellik Analizlerinden Ampirik Kanıtlar	
Aslı Özen Atabey, Mustafa Karakuş	677-708
Performance Anomalies and Determinants of Equity Funds: Evidence from Türkiye / Hisse Senedi Fonların Performans Anomalileri ve Belirleyicileri: Türkiye’den Kanıtlar	
Aykan Coşkun	709-727
Does GVC Participation Enhance Economic Performance? Evidence from the Turkish Manufacturing Sector / Küresel Değer Zincirine Katılım Ekonomik Performansı Artırır mı? Türkiye İmalat Sanayinden Bulgular	
Ali Benli, Özgür Tonus	728-757
Assessing Corporate Sustainability in Turkish Banks: WASPAS and ARAS Approaches in the Covid-19 and the Post-Covid-19 Era / COVID-19 ve Sonrası Dönemde Türk Bankalarında Kurumsal Sürdürülebilirliğin Değerlendirilmesi: WASPAS ve ARAS Yaklaşımları	
Özkan Çıtak, Ulaş Ünlü	758-780
Bir Makine Öğrenimi Uygulaması: G7 Ülkelerinde Finansal Kriz Tahminleme / A Machine Learning Approach: Financial Crisis Forecasting in G7 Countries	
Merve Mert Sarıtaş, Mert Ural	781-804
Spot ve Future Piyasalar Arasındaki Oynaklık Yayılımları ve Yayılımların Kalıcılığının Analizi / Volatility Spillovers between Spot and Futures Markets and the Analysis of Their Persistence	
Serap Kamışlı, Güven Sevil, Melik Kamışlı, Fatih Temizel, Tuba Sevil	805-826
Sermaye Yapısı ile Firma Performansı Arasındaki Nedenselliğin İncelenmesi / Examining Panel Causality Between Capital Structure and Firm Performance	
Metin Borak	827-853
Katılım Bankalarının Kredi Kalitesini Etkileyen Bankaya Özgü ve Makro Ekonomik Faktörler: Pandemi Dönemini İçeren Türkiye Örneği / Bank-Specific and Macroeconomic Factors Affecting the Credit Quality of Participation Banks: The Case of Türkiye During the Pandemic Period	
Ahmet Çakmak, Onur Sunal, Ünal Efe	854-875
İklim Değişikliği Risklerinin Bankacılık Sektörüne Etkileri: BRICS ve G7 Ülkeleri Örneği / The Effect of Climate Change Risks on the Banking Sector: A Case Study of the BRICS and G7 Countries	
Gizem Buse Sayıl, Müzeyyen Esra Atukalp	876-896

THE INFLUENCE OF FINANCIAL STRESS ON DYNAMIC CONNECTEDNESS BETWEEN FOSSIL ENERGY COMMODITIES AND GREEN ENERGY MARKETS¹

Finansal Stresin Fosil Enerji Emtiaları ile Yeřil Enerji Piyasaları Arasındaki Dinamik Baęlantılılıęa Etkisi

Pınar EVRİM MANDACI^{**} , Birce TEDİK KOCAKAYA^{***} ,
Efe Çaęlar ÇAęLI^{****}  & Dilvin TAŐKIN^{*****} 

Abstract

This paper aims to examine the impacts of selected stress variables, such as FSI (Financial Stress Index), VIX (Volatility Index), and EPU (Economic Policy Uncertainty), on dynamic connectedness between green markets (stocks and bonds) and fossil energy commodities. We employ the TVP-VAR model to measure connectedness and the Fourier Cumulative Granger Causality test to investigate the impacts of these stress variables on this connectedness from November 1, 2012, to November 15, 2022. The results indicate moderate return connectedness, mainly from short-term dynamics, suggesting that diversification may be more beneficial for long-term investments. We observe high connectedness during the COVID-19 pandemic. The connectedness is high among fossil energy commodities but low among green stock and bond markets, except for water company stocks. Water stocks have a significant impact on markets, followed by oil. Our causality test results indicate that the FSI and VIX impact the connectedness between them.

Öz

Bu makale, FSI (Finansal Stres Endeksi), VIX (Volatilite Endeksi) ve EPU (Ekonomik Politika Belirsizlięi) gibi seęili stres deęiřkenlerinin yeřil piyasalar (hisse senetleri ve tahviller) ile fosil enerji emtiaları arasındaki dinamik baęlantılılık üzerindeki etkilerini incelemeyi amaçlamaktadır. Baęlantılılıęı ölçmek için TVP-VAR modelini ve bu stres deęiřkenlerinin 1 Kasım 2012'den 15 Kasım 2022'ye kadar bu baęlantı üzerindeki etkilerini arařtırmak için Fourier Kümülatif Granger Nedensellik testini kullanıyoruz. Sonuçlar, esas olarak kısa vadeli dinamiklerden kaynaklanan orta düzeyde getiri baęlantılılıęı olduğunu gösteriyor ve bu da çeřitlendirmenin uzun vadeli yatırımlar için daha faydalı olabileceğini gösteriyor. COVID-19 salgını sırasında yüksek baęlantılılık gözlemliyoruz. Baęlantılılık, su řirketi hisseleri hariç, fosil enerji emtiaları arasında yüksek ancak yeřil hisse senedi ve tahvil piyasaları arasında düşüktür. Su hisselerinin piyasalar üzerinde önemli bir etkisi vardır, bunu petrol takip eder. Nedensellik test sonuçlarımız, FSI ve VIX'in bunların arasındaki baęlantılılıęı etkilediğini göstermektedir.

Keywords:

Financial Stress,
Green Markets,
Fossil Energy,
Connectedness

JEL Codes:

C32, G11, G15,
Q43

Anahtar

Kelimeler:

Finansal Stres
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1. Introduction

Stress in financial markets has increased due to greater volatility, deterioration in economic indicators, and uncertainty in future economic policies. This paper explores the impact of financial stress (FS) indicators on interactions between fossil energy and green markets. Our motivation for focusing on these markets is the increasing trend in investments in fossil energy commodities and green markets consisting of green stocks and bonds.

The financialization of energy commodities has increased interaction with other financial markets, especially stock markets. There are many studies investigating the influence of oil price shocks on equity markets (see, Sadorsky, 1999; Park and Ratti, 2008; Kilian and Park, 2009; Wang et al., 2013). The increasing interaction between energy and stock markets causes financial and economic indicators to affect stock markets and fossil energy prices. (Reboredo and Uddin, 2016). In addition, there is a transition from fossils to green energy. Besides the environmental and climatic concerns, volatility in fossil energy prices is driving this transition (Shinwari et al., 2022; Ari et al., 2022). Understanding the drivers of fossil energy commodities and green markets is essential for policymakers to ensure sustainable growth and stability in inflation and develop policies for energy security and climate change. It is also necessary for investors to assess the level of risks and determine the diversification potential associated with their investments in energy commodities and green markets.

The increase in fossil energy prices increases the costs and decreases the profitability of highly fossil energy-dependent companies. As a result, their market values are affected. In contrast, the market values of the companies using green energy are affected positively. Many studies examine the interactions between fossil and green markets, and a few discuss the effect of FS on these markets. Nonetheless, there remains a lack of studies analyzing the impact of FS on connectedness between them (see the literature review part). In parallel with many other studies, we expect an increasing connectedness, especially during stressful periods (Ang and Bekaert, 2002). This stress increases the relationship between these two markets, decreasing investors' diversification opportunities.

Within this scope, first, we assess the interrelationship and spillover among the green energy (solar, wind, geothermal, bio/clean fuels, and water), green bonds, and fossil energy (oil, natural gas, heating oil, and gasoline) assets, employing a time-varying parameter-based vector autoregressive model (TVP-VAR) over November 1, 2012, to November 15, 2022. Second, we use the Fourier Cumulative Granger Causality Test to examine whether some selected stress variables increase this connectedness. In addition to the Financial Stress Index (FSI) developed by the Federal Reserve Bank of St. Louis, we consider the CBOE Volatility Index (VIX) and the Economic Policy Index (EPU) developed by Baker et al. (2016).

This paper contributes to the literature in many aspects. First, as well as much studied crude oil prices, we additionally consider natural gas, gasoline, and heating oil prices, which are rarely discussed. Second, many papers consider green markets on an aggregate/global level. Here, we extend the scope of data by considering the sectoral level and examining a large scale of green energy markets such as wind, solar, water, geothermal, and bio-clean markets. Third, we included green bonds as an essential part of the green market. Fourth, this paper differs from the related literature regarding methodology; unlike the studies investigating the correlation between these two markets, we employ a TVP-VAR model. This econometric framework does not follow the sliding windows procedure according to standard models. Therefore, there is no observation loss,

making robust parameter estimation even in the presence of outliers. Fifth and finally, to the best of our knowledge, this is the first paper focusing on the role of FS on time-varying (TV) connectedness between fossil energy commodities and green markets. In this context, the paper makes a potential contribution to literature.

After the introduction, the paper continues with documentation of the relevant literature, a description of the data and econometric framework, a report and discussion of the findings, and a summary of the main findings.

2. Literature Review

We categorize the related literature into two groups: studies investigating the connection between fossil and clean energy markets and studies examining the influence of FS on these markets.

Most of the first papers focus on oil and consider green markets at the aggregate level. These studies argue that changes in oil prices influence clean energy stocks (see Bondia et al., 2016; Dawar et al., 2021; Attarzadeh and Balcilar, 2022; Hanif et al., 2023, Ren et al., 2024; Tang et al., 2023). Hanif et al. (2023) discussed the green stock market was not sufficiently developed to diverge from the traditional energy market. On the other hand, Lucey and Ren (2023) found that green stocks were persisting volatility transmitters, while green bonds and energy commodities were tail volatility receivers. However, there are a few papers at the sectoral level. Reboredo (2015) analyzed the link between oil and renewable energies (wind and solar) stock prices and found a strong interdependence. However, Pham (2019) found that the price of oil affected wind, geothermal, and fuel cells slightly. Foglia and Angelini (2020) argued that the connection between renewable energy and oil rose during the COVID-19 pandemic.

Among the papers, which included other fossil fuels, Song et al. (2019) found static and dynamic connections among renewable energy index, oil, gas, and coal. Similarly, Jiang et al. (2021) found that renewable energy indices positively influenced oil and coal but not gas. However, Umar et al. (2022) found a slight volatility connectedness between clean and dirty energy. Corbet et al. (2020) found risk transmission from oil to clean energy and coal when the oil prices became negative. Zhou et al. (2022) found that extreme volatility spillover highly impacted the clean energy market, especially in the bullish market. Among the papers focused on green bonds, Reboredo (2018) and Reboredo et al. (2020) revealed a weak link between energy commodities and green bonds, while Hammoudeh et al. (2020) reported bounded causality from renewable energy to green bonds. Using time and frequency-domain analyses, Naeem et al. (2021a) showed a vital link between green bonds and oil. Naeem et al. (2021b) documented green bonds had a remarkable negative connection with all energy commodities other than natural gas. Nguyen et al. (2021) found that green bonds had a negative or limited correlation with commodities and stocks, making these assets suitable for diversification. Saeed et al. (2021) investigated the connectedness among indices of green energy, green bonds oil, and energy ETFs and revealed that return shocks were transmitted principally from clean energy to oil. Among all variables, green bonds were the most diminutive receiver and contributor in the return connectedness system. Lee et al. (2021) documented a dualistic link between oil and green bonds in lower quantiles. Naeem et al. (2021c) reported that bearish market conditions in energy commodities result in a fall in return on green bonds. Mensi et al. (2022) showed that oil and

green bonds are the net recipients of all the G7 stock markets, except for Japan's. Tiwari et al. (2022) revealed that green energy is the most significant sender of information to green bonds. Umar et al. (2024) investigated the influence of oil price shocks on green bonds and found a low degree of connection, implying potential diversification benefits.

The second stream of papers explores the influences of risks and uncertainties on energy markets, including the FS factor. Nazlioglu et al. (2015) considered the Cleveland FS index. They found a volatility transmission from crude oil prices to this index before the crises and in the opposite direction after them. On the other hand, after the crisis, there was a causal direction from oil prices to FS, and during the crises, from FS to oil prices. In a similar paper, unlike the previous paper, Das et al. (2022) considered the categorical stress components in addition to a composite FS index. They used oil price uncertainty (OVX) instead of oil prices, showing the presence of co-movement between these during economic turmoil. The relationship was mainly positive, with OVX generally leading to FS.

In a more comprehensive paper, in addition to the FS index (STLFSI), Reboredo and Uddin (2016) examined the effects of VIX and EPU on dirty energy commodities, precious metals, and copper futures using a quantile regression model. They observed that STLFSI affected all return quantiles other than lower quantiles for all commodities. He et al. (2021) found a meaningful negative impact of FS on green energy stocks when the markets were bullish. In a similar paper, Fu et al. (2022) suggested that an increased FS index depressed the renewable energy stocks' performances in all periods.

Elsayed et al. (2022) focused on green bonds. They examined the linkage between green bonds and other traditional and green markets using multiple correlations and dynamic connectedness techniques. Their analysis also considered the economic activity index, the VIX, the world FSI, and the Twitter Economic Uncertainty Index. Their results indicated low interdependence in the short run but high integration in the long run. The static connectedness results revealed that the green bond market received more volatility than it transmitted. On the other hand, dynamic connectedness results showed that the traditional stock and energy, green energy, and VIX were contributors to shocks. In contrast, both the conventional and green bonds, business conditions, FSI, and TEU were the recipients of shocks.

Tiwari et al. (2024) analyzed the dependence between oil, the stock market, and FSI and found that oil prices influenced stock prices positively during extreme market conditions. Additionally, the link became stronger after they considered policy uncertainty and FS, indicating that uncertainties also led the stock price returns. Elsayed et al. (2024a) investigated the connection between the FS indexes of the GCC economies and oil prices. They found vital interconnectedness and risk transmission patterns in time and frequency areas. Elsayed et al. (2024b) examined the relationship between FS and shocks, including oil supply and demand and financial risk shocks in MENA countries. They found FS particularly strong during exceptional oil demand and supply shocks for exporter countries and extended periods.

3. Methodology

We first employ the frequency connectedness approach of Chatziantoniou et al. (2023), based on the TVP-VAR. This approach integrates research by Baruník and Křehlík (2018) and Antonakakis et al. (2020), considering the frequency and TVP-VAR connectivity, respectively.

We analyze the connectivity in the short (1 day – 5 days) and long (5 days - Infinity) terms. The advantages of the TVP-VAR model are (i) no loss of observations, (ii) no arbitrarily selected rolling window sizes, and (iii) resistance to outliers. Second, we conduct the Fourier cumulative Granger causality framework to assess the potential effect of FS on interconnectivity.

3.1. TVP-VAR-Based Connectedness in the Time and Frequency Domain

The TVP-VAR(p) model can be written as:

$$x_t = \Phi_{1t}x_{t-1} + \Phi_{2t}x_{t-2} + \dots + \Phi_{pt}x_{t-p} + \epsilon_t \quad \epsilon_t \sim N(0, \Sigma_t) \quad (1)$$

here, Φ_{it} and Σ_t denote the TV coefficients and the TV variance-covariance matrix, respectively, and x_t and ϵ_t are the $N \times 1$ dimensional vectors. The generalized forecast error variance decomposition (GFEVD), as described by Koop et al. (1996) and Pesaran and Shin (1998), is formulated as follows:

$$\theta_{ijt}(H) = \frac{(\Sigma_t)_{jj}^{-1} \sum_{h=0}^H ((\Psi_h \Sigma_t)_{ijt})^2}{\sum_{h=0}^H (\Psi_h \Sigma_t \Psi_h')_{ii}} \quad (2)$$

$$\tilde{\theta}_{ijt}(H) = \theta_{ijt}(H) / \sum_{k=1}^N \theta_{ikt}(H) \quad (3)$$

where $\tilde{\theta}_{ijt}(H)$ represent the impact of variable j to the “forecast error variance” of variable i at horizon H . Based on the above, the following measures can be computed:

$$TO_{it}(H) = \sum_{j=1, j \neq i}^N \tilde{\theta}_{jit}(H) \quad (4)$$

$$FROM_{it}(H) = \sum_{j=1, j \neq i}^N \tilde{\theta}_{ijt}(H) \quad (5)$$

$$NPDC_{ijt}(H) = \tilde{\theta}_{ijt}(H) - \tilde{\theta}_{jit}(H) \quad (6)$$

TO and FROM represent the extent to which variable i transmits shocks to or receives shocks from all other variables, respectively. NPDC stands for net pairwise directional connectedness, which measures whether variable j exerts more influence on variable i or vice versa. Using the TO and FROM, we compute the following connectedness measures:

$$TCI_t(H) = N^{-1} \sum_{i=1}^N TO_{it}(H) = N^{-1} \sum_{i=1}^N FROM_{it}(H) \quad (7)$$

$$NET_{it}(H) = TO_{it}(H) - FROM_{it}(H) \quad (8)$$

Here, TCI represents the level of connectedness among variables within the VAR system; NET stands for the net directional connectedness, indicating whether a variable exerts more influence on all other variables than it receives from them.

The above measures can be decomposed into frequencies exploiting the Stiasny's (1996) spectral decomposition. The density of x_t at a given frequency ω can be expressed as the Fourier transform of the TVP-VMA (∞) model:

$$S_x(\omega) = \sum_{h=-\infty}^{\infty} E(x_t x_{t-h}') e^{-i\omega h} = \Psi(e^{-i\omega h}) \Sigma_t \Psi'(e^{+i\omega h}) \quad (9)$$

where the frequency response function is expressed as $\Psi(e^{-i\omega}) = \sum_{h=0}^{\infty} e^{-i\omega h} \Psi_h$ with $i = \sqrt{-1}$. The GFEVD in frequency domain is derived by aggregating the spectral density and GFEVD, and is expressed through normalization as follows:

$$\theta_{ijt}(\omega) = \frac{(\Sigma_t)_{jj}^{-1} \left| \sum_{h=0}^{\infty} (\Psi(e^{-i\omega h}) \Sigma_t)_{ijt} \right|^2}{\sum_{h=0}^{\infty} (\Psi(e^{-i\omega h}) \Sigma_t \Psi(e^{i\omega h}))_{ii}} \quad (10)$$

$$\tilde{\theta}_{ijt}(\omega) = \theta_{ijt}(\omega) / \sum_{k=1}^N \theta_{ijt}(\omega) \quad (11)$$

We compute the high and low frequency interconnectedness by aggregating frequencies over defined ranges.

$$N\tilde{\theta}_{ijt}(d) = \int_a^b \tilde{\theta}_{ijt}(\omega) d\omega \quad (12)$$

where $d = (a, b)$: $a, b \in (-\pi, \pi)$, $a < b$.

3.2. Fourier Cumulative Granger Causality Test

Nazlioglu et al. (2016, 2019) enhance the Granger causality framework of Enders and Jones (2016) with Fourier approximation, incorporating the Toda and Yamamoto (1995) procedure (TY) to consider the structural breaks:

$$y_t = a(t) + \beta_1 y_{t-1} + \dots + \beta_{p+d} y_{t-(p+d)} + \varepsilon_t \quad (13)$$

where y_t is endogenous variables vector in the VAR($p+d$) model, β is the matrix of parameters, d represents the highest integration level, and ε_t is error terms vector. $a(t)$ denotes the Fourier approximation, designed to capture structural shifts of unknown timing, quantity, and form, expressed as a function of time, relaxing the constant intercept assumption:

$$a(t) \cong a_0 + \sum_{k=1}^n \gamma_{1k} \sin\left(\frac{2\pi kt}{T}\right) + \sum_{k=1}^n \gamma_{2k} \cos\left(\frac{2\pi kt}{T}\right) \quad (14)$$

where n and T are the quantity of frequency and observations, respectively, k is a specific frequency, γ_{1k} and γ_{2k} represent frequency magnitude and shift, respectively (see Enders and Lee, 2012: 197; Nazlioglu et al., 2019). The final model, gathered by substituting equation (13) into equation (14), can be estimated by setting n greater than unity, indicating cumulative frequencies:

$$y_t = a_0 + \sum_{k=1}^n \gamma_{1k} \sin\left(\frac{2\pi kt}{T}\right) + \sum_{k=1}^n \gamma_{2k} \cos\left(\frac{2\pi kt}{T}\right) + \beta_1 y_{t-1} + \dots + \beta_{p+d} y_{t-(p+d)} + \varepsilon_t \quad (15)$$

4. Data and Descriptive Analysis

In the first phase, to analyze the dynamic connectedness between fossil energy commodities and green energy markets, we obtained daily data on the indices of various green energy (sub) sectors, the green bond index, and the prices of different fossil energy commodities.

The green energy (sub)sectoral indices include solar (SOL), wind (WND), geothermal (GEO), bio/clean fuels (BIO), and water (WAT), as well as the green bonds index (BND). Fossil energy commodities include oil (OIL), natural gas (NGS), heating oil (HOI), and gasoline (GAS). All data, except for the S&P Green Bond Index (BND), was extracted from Thomson Reuters DataStream. The BND was obtained from the S&P Global Website. The study period spans from November 1, 2012, to November 15, 2022, dictated by the data availability and regularity on Thomson Reuters DataStream. All data used in this study was denominated in USD. The data was transformed into a natural logarithm return series. Figure 1 depicts the movements of the time series. The variables exhibited similar behavior during the 2020 pandemic period. In the second phase, to analyze the impact of FS on the connectedness above (LONG), (SHORT), and (TOTAL), we collected weekly data on the FS index (FSI), the Chicago Board of Exchange (CBOE) volatility index, and the economic policy uncertainty index for the US (EPU) from the FRED website.

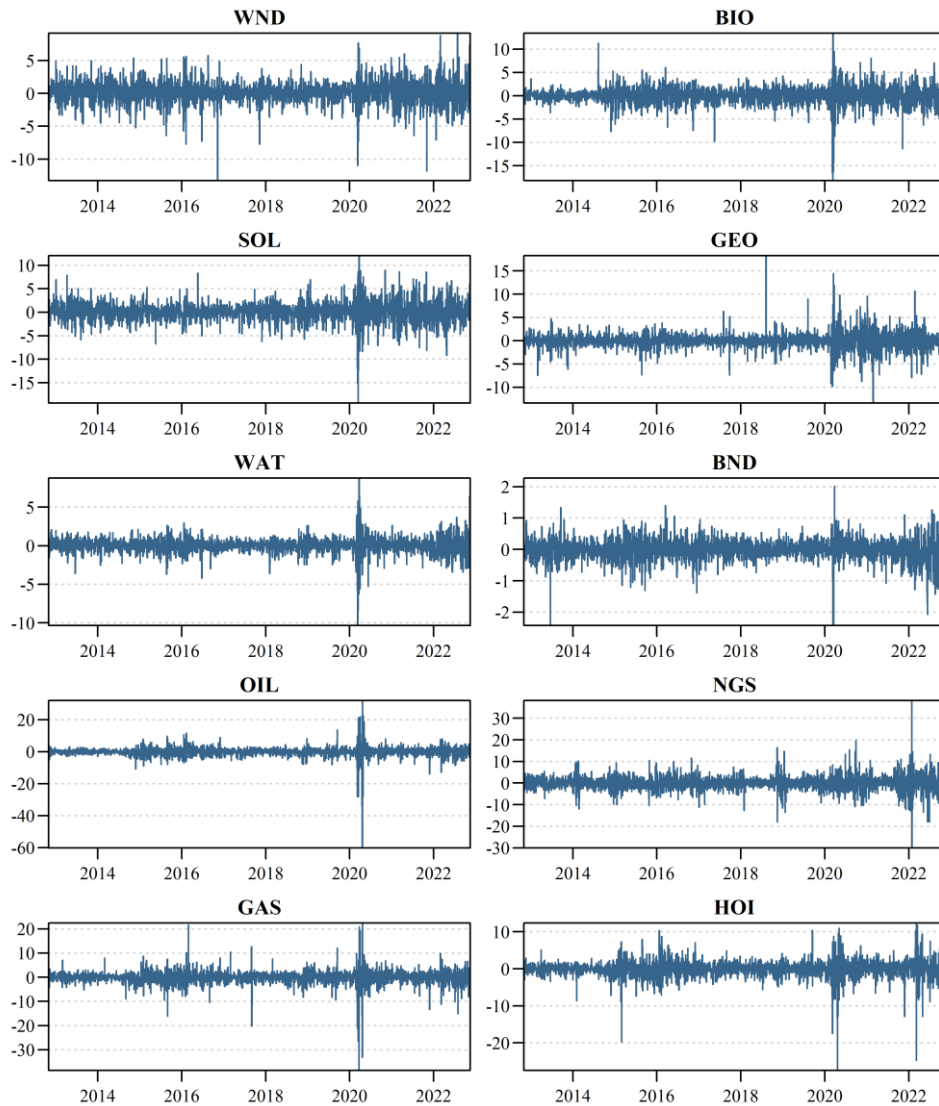


Figure 1. The Return Series Plots of Green Energy Indices, Green Bonds, and Fossil Energy Commodities

Hata! Başvuru kaynağı bulunamadı. shows the descriptive statistics of the log return series. According to Jarque and Bera (1980), from now on referred to as JB, the test results indicate that the null hypothesis is rejected at a 1% significance level for all series. Therefore, data is not normally distributed. The unit root test proposed by Elliott et al. (1996), referred to as ERS, was used to assess the stationarity of the data. The result shows that the entire data set is stationary at the 1% significance level. Fisher and Gallagher (2012) developed the tests for the serial correlation, from now on referred to as Q and Q^2 . At a 1% significance level, the time series is autocorrelated up to 20 lags.

Table 1. Summary Statistics of Return Series

	Mean	Variance	Skewness	Ex. Kurtosis	JB	ERS	Q(20)	Q ² (20)
WND	0.066*	2.913***	-0.331***	5.069***	2753.51***	-19.996***	25.164***	196.98***
BIO	-0.001	3.847***	-0.877***	10.801***	12616.50***	-15.792***	66.714***	2179.16***
SOL	0.103**	4.506***	-0.498***	6.392***	4409.82***	-13.606***	58.391***	1368.22***
GEO	0.015	3.123***	0.369***	12.231***	15821.41***	-12.479***	27.031***	339.16***
WAT	0.035*	1.019***	-0.587***	12.812***	17441.36***	-8.310***	138.967***	2681.71***
BND	-0.005	0.124***	-0.505***	5.228***	2987.196***	-15.726***	51.968***	607.93***
OIL	0.000	9.472***	-2.857***	74.911***	594768.24***	-16.182***	108.499***	538.81***
NGS	0.019	11.916***	0.234***	10.841***	12406.65***	-23.562***	41.718***	506.89***
GAS	-0.004	8.219***	-1.884***	31.322***	104877.57***	-5.041***	25.140***	571.26***
HOI	0.007	5.628***	-1.458***	17.928***	34763.79***	-14.576***	22.300***	302.54***

Notes: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$ imply significance levels at 1%, 5%, and 10%. JB (Jarque Bera (1980)) is the normality test. ERS stands for the Elliot et al. (1996) unit root test. $Q(20)$ and $Q^2(20)$ are for the Fisher and Gallagher (2012) portmanteau statistics.

5. Empirical Results

5.1. TVP-VAR-based Frequency Connectedness

We estimate the TVP-VAR model with one lag—as determined by the Schwarz Information Criterion—and employ a 10-day forecast horizon. To test the robustness of these results, we extend the forecast horizon to 20 and 30 days. The outcomes across these alternative horizons remain qualitatively similar, confirming the reliability of the original model's outputs. Consequently, we present the findings based on the original model. Table 2 presents the static return connectedness results in both time and frequency domains. Panel A shows time connectedness, while other panels illustrate frequency connectedness with short (1-5 days) and long (5-Inf) terms. The first panel's average total connectedness index (TCI) is 43.68%, indicating that 43.68% of the variation in the variables is attributable to network connectedness. In the other panels, analysis reveals that total connectedness is driven by short-term connectedness (39.06%), while the effect of long-term connectedness is less pronounced (4.61%). The rest of TCI (56.32%) is derived from its own variable (idiosyncratic) shocks. NGS exhibits the highest autocorrelation within the network and, thus, the lowest cross-correlation effects. For instance, 88.57% of future return shocks in natural gas can be attributable to own previous shocks. On the other hand, other energy commodities, including OIL, GAS, and HOI, show the lowest autocorrelation and the highest cross-correlation effects. Thus, future return shocks for these commodities are less influenced by the shocks in others in the network.

The diagonal values in Table 2 indicate idiosyncratic shocks, while off-diagonal values represent pairwise spillover. According to Panel A, the most considerable average pairwise

spillovers are found between the fossil energy futures from OIL to HOI, HOI to OIL, OIL to GAS, and HOI to GAS (25.36%, 21.18%, 20.93%, and 19.88%, respectively). However, the lowest average pairwise spillover is found from NGS to WAT (0.44%). One of the highest pairwise spillovers other than fossils and BND is seen from WAT to other green markets (from WAT to SOL with 15.39%). Similar to the findings of Umar et al. (2022) like oil, other fossil energy commodities also have low connectedness with green markets, indicating diversification opportunities. Our findings on green bonds support the conclusions of Reboredo (2018), Reboredo et al. (2020), and Nguyen et al. (2021), indicating a low relationship between green bonds and fossil energy markets and parallel to the findings of Tiwari et al. (2022), the return transmissions from green stocks to green bonds are greater compared to others.

Net directional connectedness is displayed at the bottom of each panel. A positive (negative) value represents the net shock transmitter (receiver), which means the transmitters (receivers) influence (influenced by) other variables. Amongst the greens, WAT, BIO, and SOL are the net shock transmitters, and the most dominant net transmitter is WAT (13.53%), followed by BIO (2.92%). In contrast, the primary net receiver among these is BND (-9.15%), followed by WND (-8.13%). Furthermore, except NGS and GAS, fossil energy commodities act as net shock transmitters. The leading net transmitter is OIL (7.27%), followed by HOI (4.32%). In contrast to Reboredo (2015) and consistent with Pham (2019), we find that oil has low effects on wind and geothermal stocks. In contrast to Saeed et al. (2021), the return shock spillover from oil to green markets is more significant in parallel to our expectations. However, NGS (5.14%) is the primary net receiver among fossil energy commodities. Panels B and C illustrate the average short-term and long-term connectedness, respectively. We observe that short-term drives the overall return connectedness. When we look at the pairwise contribution, we observe that most of it is short-term, other than BIO. In addition, while HOI is a transmitter in the short term, it turns into a receiver in the long term.

Table 2. The Average Time and Frequency Connectedness

Panel A: Total	WND	BIO	SOL	GEO	WAT	BND	OIL	NGS	GAS	HOI	FROM
WND	58.36	5.96	8.91	4.26	13.20	3.74	1.85	0.58	1.61	1.54	41.64
BIO	4.58	51.95	8.57	5.34	12.20	2.03	5.75	0.92	3.80	4.86	48.05
SOL	6.75	9.19	52.81	6.20	15.39	1.09	3.06	0.77	2.46	2.28	47.19
GEO	4.40	6.63	7.34	62.44	10.96	1.11	2.59	0.77	1.76	2.00	37.56
WAT	9.20	11.13	13.33	7.63	45.74	3.51	3.47	0.44	3.01	2.53	54.26
BND	4.98	3.76	2.03	1.62	6.09	76.28	1.99	0.52	1.43	1.32	23.72
OIL	0.95	4.68	2.74	1.75	3.20	1.06	40.58	0.72	19.39	24.92	59.42
NGS	0.72	1.75	1.16	1.13	1.02	0.58	1.69	88.57	1.65	1.72	11.43
GAS	1.10	3.68	2.66	1.33	3.21	0.64	20.93	0.75	44.53	21.18	55.47
HOI	0.82	4.21	2.21	1.41	2.52	0.81	25.36	0.81	19.88	41.97	58.03
TO	33.50	50.98	48.95	30.66	67.78	14.58	66.69	6.28	54.99	62.35	436.76
Inc.Own	91.87	102.92	101.75	93.10	113.5	90.85	107.27	94.86	99.53	104.32	cTCI/TCI
Net	-8.13	2.92	1.75	-6.90	13.53	-9.15	7.27	-5.1	-0.4	4.32	48.53/43.68
NPDC	3	5	5	2	7	1	9	0	5	8	
Panel B: Short Term	WND	BIO	SOL	GEO	WAT	BND	OIL	NGS	GAS	HOI	FROM
WND	52.62	5.00	7.56	3.62	11.36	3.38	1.65	0.49	1.49	1.41	35.97
BIO	4.05	46.76	7.69	4.70	10.89	1.84	5.21	0.81	3.47	4.45	43.10
SOL	5.93	8.02	47.24	5.55	13.68	0.98	2.73	0.66	2.25	2.04	41.86
GEO	3.83	5.82	6.41	56.37	9.64	0.98	2.27	0.69	1.65	1.78	33.06
WAT	8.22	9.74	11.80	6.82	40.88	3.13	3.10	0.40	2.79	2.28	48.29
BND	4.34	3.09	1.66	1.40	5.07	68.75	1.75	0.46	1.21	1.15	20.14
OIL	0.88	4.22	2.53	1.57	2.93	1.01	37.33	0.65	17.86	22.93	54.60
NGS	0.66	1.57	1.05	1.02	0.93	0.53	1.57	81.07	1.51	1.58	10.42
GAS	0.96	3.26	2.40	1.19	2.84	0.59	19.25	0.66	40.58	19.42	50.55
HOI	0.73	3.75	2.00	1.26	2.26	0.76	23.11	0.71	18.07	38.19	52.65
TO	29.61	44.48	43.09	27.14	59.59	13.19	60.64	5.54	50.32	57.04	390.64
Inc.Own	82.22	91.25	90.32	83.51	100.48	81.94	97.97	86.61	90.89	95.23	cTCI/TCI
Net	-6.36	1.39	1.23	-5.92	11.31	-6.96	6.04	-4.88	-0.24	4.39	43.40/39.06
NPDC	3	5	5	2	7	1	9	0	5	8	

Table 2. Continue

Panel C: Long

Term

WND	5.75	0.95	1.34	0.63	1.85	0.37	0.20	0.08	0.11	0.13	5.67
BIO	0.53	5.18	0.88	0.63	1.31	0.19	0.55	0.11	0.33	0.42	4.96
SOL	0.81	1.16	5.57	0.65	1.71	0.12	0.33	0.10	0.21	0.24	5.33
GEO	0.57	0.81	0.93	6.07	1.32	0.13	0.32	0.08	0.12	0.22	4.50
WAT	0.99	1.39	1.53	0.81	4.86	0.38	0.37	0.04	0.22	0.24	5.97
BND	0.63	0.67	0.37	0.21	1.02	7.53	0.23	0.06	0.22	0.17	3.58
OIL	0.07	0.45	0.21	0.18	0.26	0.05	3.25	0.07	1.53	1.99	4.82
NGS	0.06	0.18	0.11	0.11	0.09	0.05	0.12	7.51	0.14	0.14	1.00
GAS	0.15	0.42	0.27	0.14	0.37	0.05	1.68	0.09	3.96	1.76	4.91
HOI	0.09	0.46	0.21	0.15	0.26	0.05	2.24	0.11	1.81	3.77	5.38
TO	3.90	6.49	5.86	3.52	8.19	1.39	6.05	0.74	4.68	5.31	46.13
Inc.Own	9.64	11.68	11.43	9.59	13.05	8.92	9.30	8.25	8.63	9.08	cTCI/TCI
Net	-1.77	1.54	0.52	-0.98	2.22	-2.19	1.23	-0.26	-0.24	-0.07	5.13/4.61
NPDC	2	8	5	4	7	0	9	2	3	5	

Notes: The outcomes are derived from the TVP-VAR (1), where the forgetting factors are set to 0.99, and a Bayesian prior is applied, as in Chatziantoniou et al. (2023). TO denotes the transmission from one variable to others. FROM shows the level of return spillover one variable receives from others. Net implies the subtraction of TO from FROM, reflecting the net transmission. TCI denotes the total connectedness index. cTCI denotes corrected TCI. NPDC represents the net pairwise directional connectedness, quantifying the number of bilateral relationships in which a variable exerts greater influence over other variables.

The visual representation of the static relations can be seen in Figure 2. From left to right, networks depict the total, high (1 day - 5 days) and low (5 days - Infinity) frequencies, respectively. The larger the nodes, the more pronounced the degree of transmission and vice versa. Thicker arrows represent the more substantial effect from the primary variable to the target variable, and the blue (yellow) color shows that the assets are net information sources (net recipients).

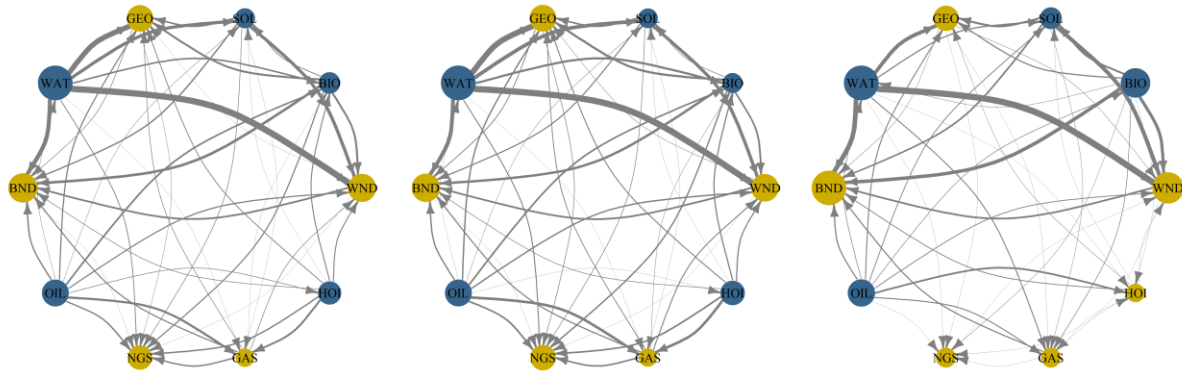


Figure 2. Time and Frequency Connectedness Network

Notes: The outcomes are derived from the TVP-VAR (1).

Figure 3 depicts the time and frequency connectedness indices. The black, red, and green-shaded areas show the time, short (1 day - 5 days), and long-term (5 days - Infinity) connectivity indices, respectively. The sharp rise in short-term and long-term frequency connectedness indices, and hence the total, may be related to the COVID-19 outbreak at the beginning of 2020. Consistent with the findings of Foglia and Angelini (2020), we observe high connectedness during the COVID-19 pandemic, indicating that connectedness increased during uncertainty periods. Figure 4 illustrates the net directional time and frequency connectedness and reveals that certain variables, including WAT, OIL, and HOI, act as net transmitters. Over time, changes in direction and magnitude are observed. For instance, BIO and SOL shifted from net receivers to net transmitters after 2020. In contrast, OIL previously acted as a net transmitter but temporarily switched to a net receiver after 2020. Additionally, certain variables, such as WAT and BND, experienced an increase in magnitude. Next, we investigate the bilateral dynamics among the assets by drawing on two complementary measures: net pairwise directional connectedness indices in Figure 5 and pairwise connectedness indices in Figure 6. The former captures which asset dominates (transmits shocks to) the other, while the latter reflects the degree of interdependence between the two assets. From Figure 5 WAT, OIL, and HOI emerge as persistent transmitters, although OIL and HOI briefly shift to net receivers in the post-2020 environment. Likewise, BIO and SOL have begun transmitting shocks to other green energy and fossil-based assets, aside from WAT, following the COVID-19 outbreak. By contrast, WND and NGS consistently receive shocks from nearly all other assets (except BND) throughout the sample period, suggesting that they generally act as receivers of shocks. Turning to Figure 6, the pairwise connectedness indices underscore stronger bilateral linkages within the same asset classes compared to those across different categories (e.g., green vs. fossil), which further intensified during the COVID-19 outbreak. Notable exceptions include the WAT-fossil and BIO-fossil pairs (excluding NGS), which exhibit higher interconnectedness and thus challenge the notion of clear market segmentation. Overall, this relatively low interconnectivity across green and fossil energy assets may imply potential diversification opportunities since shocks do not fully propagate between these two market segments.

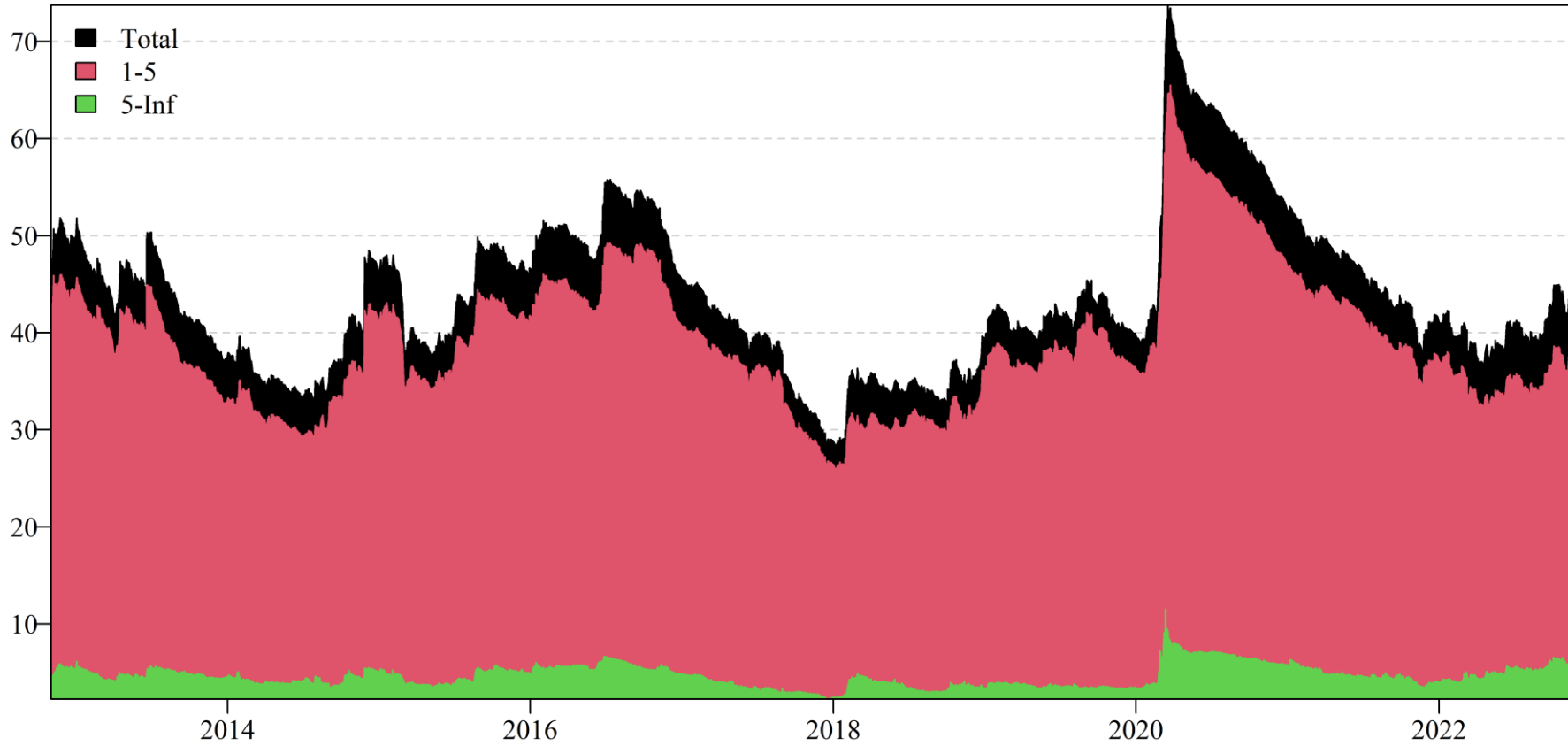


Figure 3. Dynamic Time and Frequency Connectedness Indices

Notes: The outcomes are derived from the TVP-VAR (1). The black, red, and green regions show total (Diebold and Yilmaz, 2012), high (1 day - 5 days), and low (5 days - Infinity) frequency (Baruník and Křehlík, 2018) TCI, respectively.

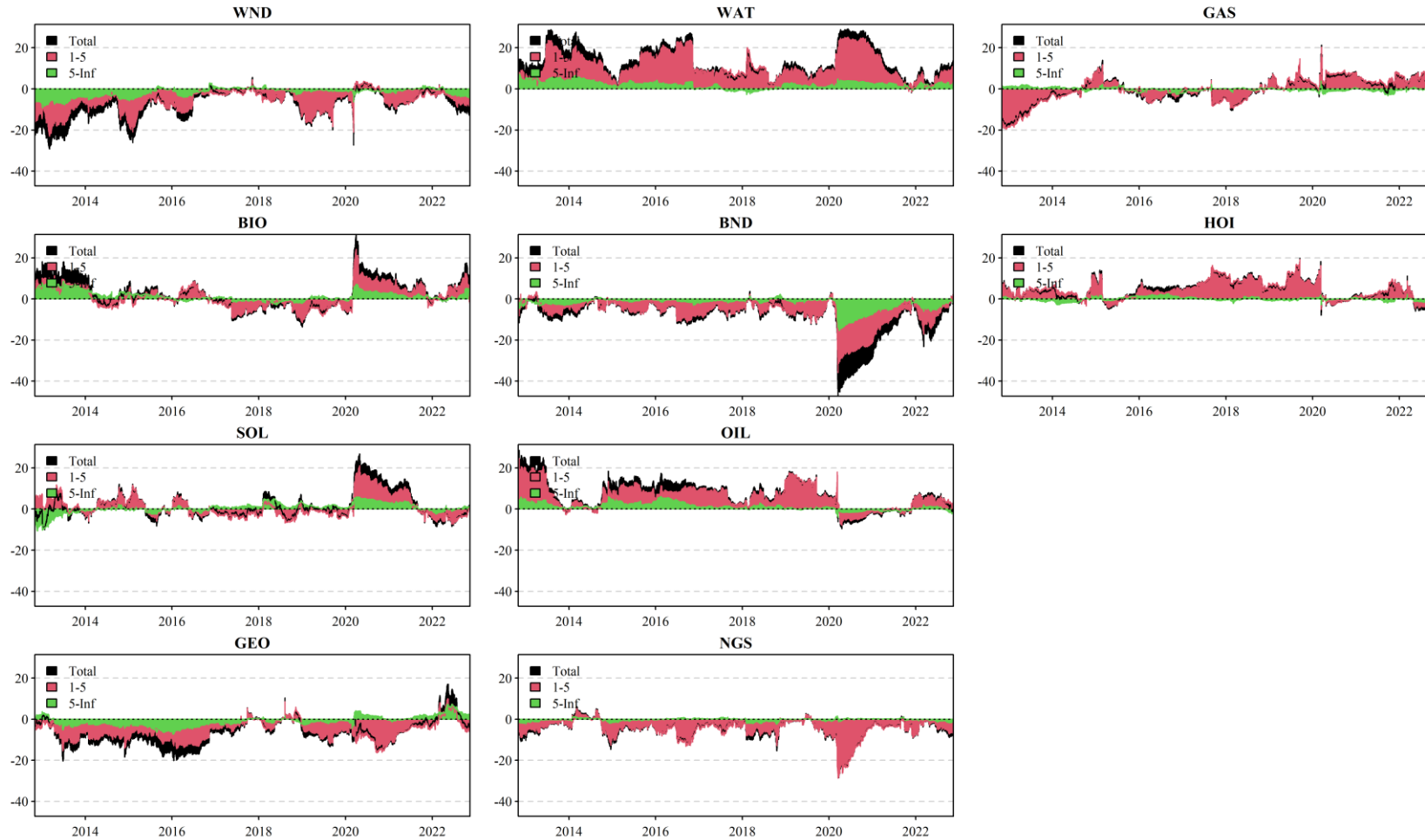


Figure 4. Net Directional Time and Frequency Connectedness

Notes: The outcomes are derived from the TVP-VAR (1). The black, red, and green regions show the total, high (1 day - 5 days) and low (5 days - Infinity) frequency net directional connectedness, respectively.

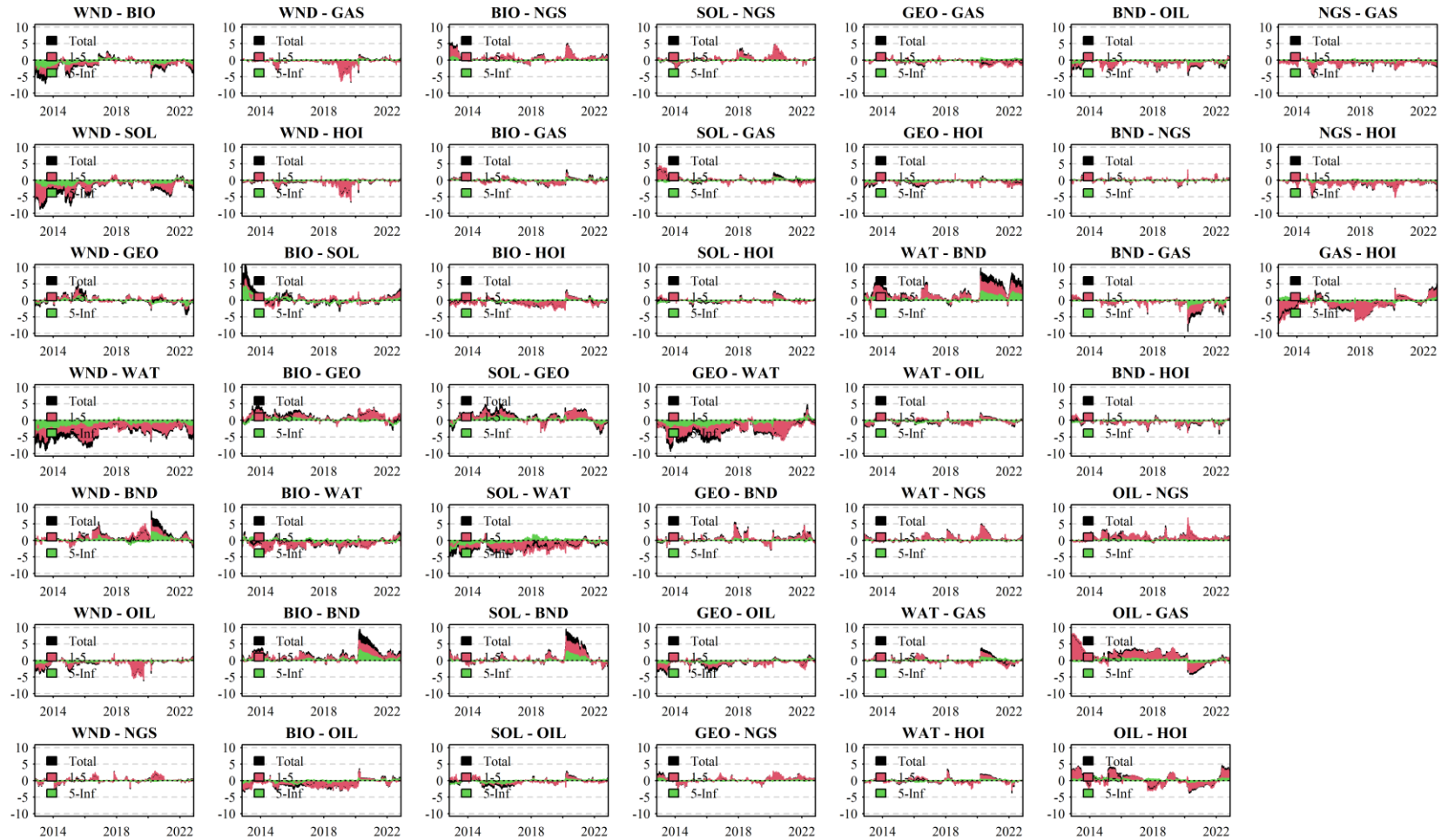


Figure 5. Net Pairwise Directional Time and Frequency Connectedness

Notes: The shaded area above (below) zero means that the first asset spreads (receives) the spillover to (from) the second asset.

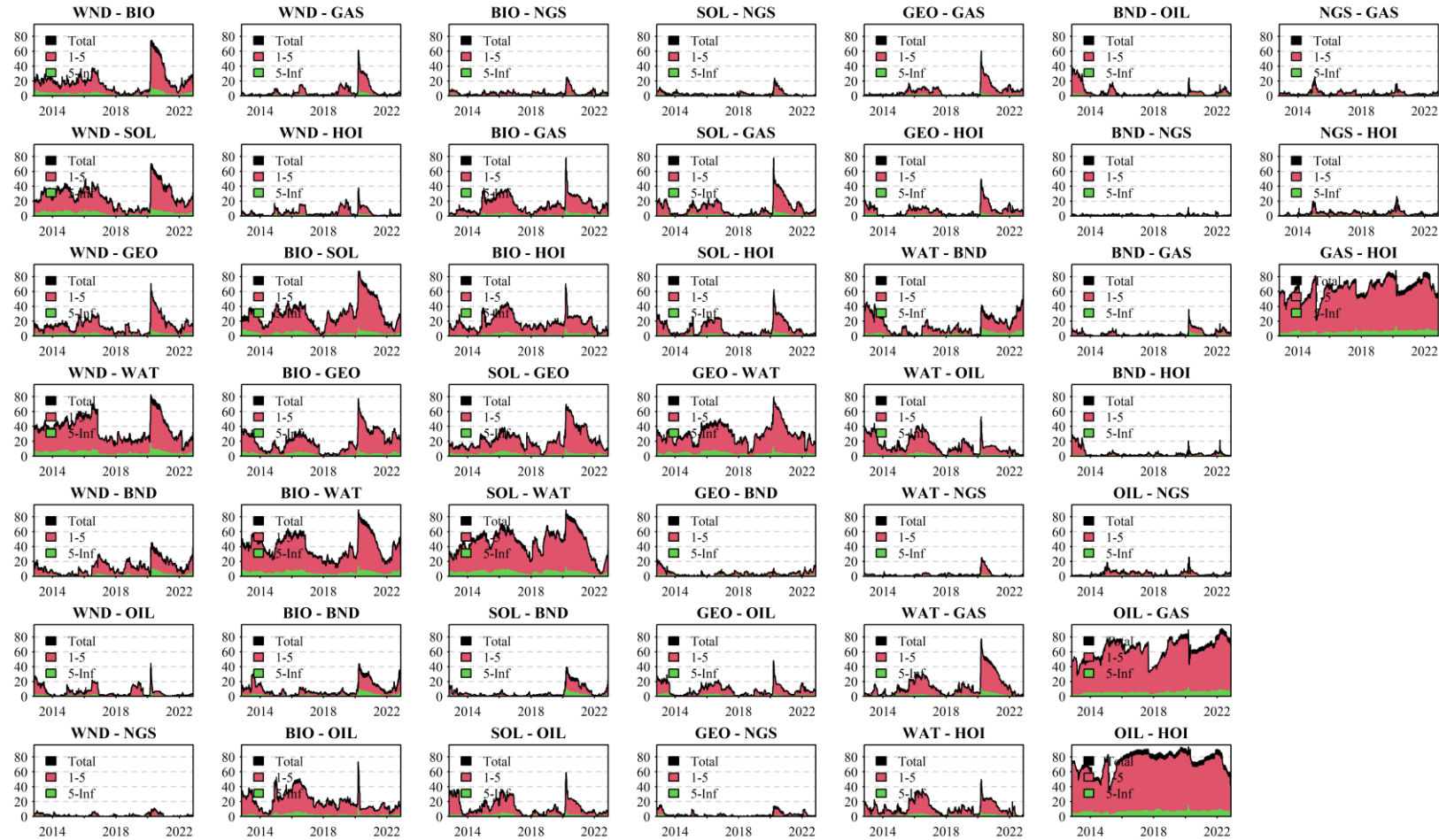


Figure 6. Pairwise Connectedness Indices

Notes: The black, red, and green regions show the total, high (1 day - 5 days) and low (5 days - Infinity) frequency pairwise connectedness indices, respectively.

5.2. The Fourier Cumulative Granger Causality Test Results

The results of the Fourier ADF (FADF) unit root test proposed by Enders and Lee (2012) are reported in Table 3. It shows that the optimal frequency for TOTAL, SHORT, and LONG is 2. For VIX and EPU, the optimal frequency is set as 1, while for FSI, it is set as 3. According to the results, all series are stationary at the 5% significance level or, even better, at the 1% significance level. This implies the rejection of the null hypothesis of a unit root.

Table 3. Fourier ADF Unit Root Test

	ADF	Lag	Freq
TOTAL	-3.284**	1	2
SHORT	-3.419**	1	2
LONG	-3.495**	2	2
VIX	-6.418***	0	1
EPU	-5.386***	2	1
FSI	-6.712***	1	3

Notes: *** and ** denote the 1% and 5% significance, respectively. The highest number of Fourier frequencies (k_{max}) is three; the lag length (p_{max}) is 12.

Table 4 shows the test results of the Fourier (cumulative) Granger causality. Based on these findings, we reject the null of “no causality” for 14 among 18 pairs, thereby indicating the presence of causal linkages between these variables. The causality test provides evidence of bi-directional Granger causality between TOTAL/SHORT/LONG and VIX. In addition, the test results reveal bi-directional Granger causality between TOTAL/SHORT and FSI. On the other hand, a unidirectional causality is observed from TOTAL/SHORT/LONG to EPU, as well as from LONG to FSI.

Table 4. Fourier Cumulative Granger Causality

Direction	Wald	Bootstrap p-value	Lag	Freq.
VIX $\nrightarrow$ TOTAL	26.234	0.000*	2	3
TOTAL $\nrightarrow$ VIX	12.889	0.000*	2	3
EPU $\nrightarrow$ TOTAL	1.546	0.457	2	3
TOTAL $\nrightarrow$ EPU	65.028	0.000*	2	3
FSI $\nrightarrow$ TOTAL	10.179	0.020*	2	3
TOTAL $\nrightarrow$ FSI	57.822	0.000*	2	3
VIX $\nrightarrow$ SHORT	28.056	0.000*	2	3
SHORT $\nrightarrow$ VIX	15.912	0.000*	2	3
EPU $\nrightarrow$ SHORT	2.019	0.367	2	3
SHORT $\nrightarrow$ EPU	65.736	0.000*	2	3
FSI $\nrightarrow$ SHORT	11.467	0.004*	2	3
SHORT $\nrightarrow$ FSI	58.242	0.000*	2	3
VIX $\nrightarrow$ LONG	14.106	0.002*	1	3
LONG $\nrightarrow$ VIX	4.243	0.042*	1	3
EPU $\nrightarrow$ LONG	1.224	0.724	3	3
LONG $\nrightarrow$ EPU	38.924	0.000*	3	3
FSI $\nrightarrow$ LONG	1.818	0.537	3	3
LONG $\nrightarrow$ FSI	64.752	0.000*	3	3

Notes: $\nrightarrow$ represents the null hypothesis of “no Granger causality”. The bootstrap-p values were obtained from 1000 repetitions. * represents that values are significant at conventional levels, indicating the presence of causality for the corresponding direction. The highest number of Fourier frequencies (k_{max}) is three; the lag length (p_{max}) is 12. The optimal frequencies (k) and length of lag (p) are suggested by the BIC.

For robustness purposes, we also check the causality between the variables using the framework by Nazlioglu et al. (2019), which follows the TY procedure, accounting for the variables with different integration levels. Based on the results, we obtained results that were very similar to those reported in Table 4.

6. Conclusion and Recommendations

In this paper, first, we investigate return connectedness between the green energy markets (solar, wind, geothermal, bio/clean fuels, and water), green bonds, and fossil energy markets (oil, natural gas, gasoline, and heating oil) and then we measured the impacts of selected stress variables (FSI, VIX, and EPU) on this connectedness to investigate whether they were the drivers of it. The paper contributes to the literature by depicting a broader perspective on the relationship between green and fossil energy markets by considering the effect of FS. As far as we know, this is the first study considering the impact of FS on connectedness between these markets. The findings unveil the dynamics between these markets, with significant implications for decision-making by investors and policymakers.

Our results on time and frequency connectedness indicate a moderate level, which mainly originated from short-term dynamics. This result provides an important implication for investors: diversification opportunities may be more important in long-term investments. Fossil energy commodities, except natural gas, are more connected, whereas green energy markets, except water, are less connected. This finding suggests that there are still benefits from diversification within green stocks and bonds markets, but the diversification benefit within the fossil energy commodities is limited to natural gas.

Since the return spillover from oil to green markets is more significant than vice versa, this might result from the considerable role of oil in financial markets. Our findings indicate a low return connectedness between fossil energy markets and green bonds, and the transmissions from green stocks to green bonds are more pronounced than those from fossil energy commodities. Fossil energy commodities have low connectedness with green markets, indicating diversification opportunities for the portfolios of both green and fossil energy markets. In addition, we find that while water and oil impact the market, the others influence green bonds and wind. This may indicate that investors concerned with optimal portfolio management should consider investing in net transmitters, such as water and oil, and avoid net receivers, such as green bonds and wind, since many risk sources may affect net shock receivers. While short-term main drives return connectedness, the increase in TCI is time and event-dependent.

The causality test results reveal the presence of significant causal relationships between connectedness measures and stress variables. Our findings highlight the presence of bi-directional Granger causality among the connectedness of all frequencies with VIX, indicating that changes in VIX may trigger changes in connectedness measures and vice versa. Similarly, the bi-directional Granger causality between total and short connectedness and FSI implies that changes in the stress index may influence the total and short-term connectedness between fossil and green energy markets and vice versa. Besides, EPU does not impact connectedness measures, while all connectedness measures influence EPU. As a result, FS variables, namely FSI and VIX, lead to the connectedness measures between fossil and green markets. In contrast, the economic

variable, namely the EPU, is led by connectedness measures. Therefore, investors holding green and fossil assets should consider FS factors rather than economic ones.

Several policy implications can be suggested from empirical results. First, given the positive connectedness between green energy markets, it is recommended that policymakers encourage investments in green energy sectors. Providing incentives and creating a favorable investment environment will initiate more investment flows to green energy projects. Given that wind, solar, and bio-clean sectors act as net shock transmitters, diversification of the energy sources by emphasizing renewable energy sources could enhance the stability and resilience of the overall energy system. Moreover, policymakers should concentrate on integrating renewable energy sources into the current energy infrastructure to reduce fossil dependence. Both diversifying energy sources and implementing energy efficiency strategies can help reduce the economic and business risks related to volatility in fossil energy prices. The analysis reveals that the network relationship is driven by short-term rather than long-term connectedness. Therefore, policymakers and investors should consider short-term and long-term dynamics when formulating strategies and making investment decisions. Short-term fluctuations may be influenced by market sentiment and immediate shocks, while long-term dynamics indicate structural changes and trends in the energy markets.

The analysis of stress indicators also provides policymakers with various insights. They should consider the impact of VIX as an indicator of stock market risk and volatility on connectedness between green and fossil energy markets to develop risk management strategies and policies to ensure financial stability and sustainability. Similarly, they should consider the influence of the FS index on total and short-term connectedness between green and fossil markets. Policymakers can use this insight to assess systemic risks in the economic system and implement appropriate measures to mitigate the inherent risks in the relationship between green and fossil markets. Additionally, they should consider the influence of connectedness on changes in these stress indicators. This can help detect irregularities and ensure necessary actions are taken to protect investors and maintain market integrity. Policymakers should consider monitoring these measures more closely to understand the impact of market interconnectedness on economic conditions and formulate more appropriate policy responses. These insights can inform the design and implementation of policies and regulations to promote financial stability, mitigate systemic risks, and safeguard the interests of market participants and the broader economy.

Further research is needed to validate and expand upon these findings by including other economic, financial, and political risks and uncertainties, given the evolving nature of the energy markets and the changing nature of green finance instruments.

Declaration of Research and Publication Ethics

This study, which does not require ethics committee approval and/or legal/specific permission, complies with the research and publication ethics.

Researcher's Contribution Rate Statement

The authors declare that they have contributed equally to the article.

Declaration of Researcher's Conflict of Interest

There are no potential conflicts of interest in this study

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HOUSEHOLD CONSUMPTION EXPENDITURES IN TÜRKİYE: SOCIO-ECONOMIC DETERMINANTS, SPENDING PATTERNS, AND POLICY PERSPECTIVES*

Türkiye’de Hanehalkı Tüketim Harcamaları: Sosyo-Ekonomik Belirleyiciler,
Harcama Desenleri ve Politika Perspektifleri

Emre YÜKSEL** & Dilek BAŞAR***

Abstract

This study investigates the socio-economic determinants of household consumption in Türkiye from 2005 to 2019, using the Marshallian demand function and a negative binomial regression model to address data overdispersion. Based on a uniquely constructed dataset combining Household Budget Surveys and regional Consumer Price Index, the analysis examines how income, education, household size, and demographic structure influence spending across expenditure categories. Results show that higher-income households allocate more to discretionary goods, while lower-income groups focus on necessities. Education is a key driver of spending on housing and human capital, with a nonlinear effect. Consumption rises with age and size but later declines, reflecting life-cycle and scale effects. In-kind transfers reduce direct spending, mortgage debt limits consumption, and single-parent households face greater financial pressure, unlike extended families who benefit from economies of scale. These findings underscore the complex relationship between socio-economic factors and consumption, offering policy insights into household welfare and inequality.

Keywords:

Household
Consumption
Expenditures,
Socio-economic
Determinants,
Demand Function,
Negative Binominal
Regression,
Consumer Behavior

JEL Codes:

C25, D11, D12,
I31, O52

Öz

Bu çalışma, 2005–2019 yılları arasında Türkiye’de hanehalkı tüketimini belirleyen sosyo-ekonomik faktörleri incelemekte; veri aşırı yayılımını dikkate alarak Marshallgil talep fonksiyonu ve negatif binominal regresyon modeli kullanmaktadır. Hanehalkı Bütçe Anketleri ile bölgesel Tüketici Fiyat Endeksi verilerinin birleştirilmesiyle oluşturulan özgün veri seti, gelir, eğitim, hanehalkı büyüklüğü ve demografik yapının çeşitli harcama kategorileri üzerindeki etkilerini analiz etmektedir. Bulgular, yüksek gelirli hanelerin ihtiyari harcamalara daha fazla pay ayırırken, düşük gelirli grupların zorunlu harcamalara odaklandığını göstermektedir. Eğitim, konut ve beşeri sermaye harcamalarının belirleyicisi olarak doğrusal olmayan bir etki göstermektedir. Tüketim, yaş ve hane büyüklüğüyle birlikte artmakta ancak zamanla azalma eğilimi göstermektedir; bu durum yaşam döngüsü ve ölçek ekonomilerine işaret etmektedir. Aynı transferler doğrudan harcamaları azaltmakta, ipotek kredileri tüketimi sınırlamakta ve tek ebeveynli haneler daha fazla mali baskı yaşarken, geniş aileler maliyet paylaşımından fayda sağlamaktadır. Bulgular, sosyo-ekonomik faktörlerle tüketim davranışı arasındaki karmaşık ilişkiyi ortaya koyarak hane refahı ve eşitsizlik politikaları açısından önemli çıkarımlar sunmaktadır.

Anahtar Kelimeler:

Hanehalkı Tüketim
Harcaması,
Sosyo-ekonomik
Belirleyiciler,
Talep Fonksiyonu,
Negatif Binominal
Regresyon,
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1. Introduction

Household consumption expenditures (HCE) play a crucial role in shaping both short-term economic stability and long-term development by influencing key determinants of total factor productivity, such as education, health, and cultural investments. Beyond their direct impact on individual well-being, these expenditures serve as a fundamental driver of economic growth, reflecting broader socio-economic dynamics. Understanding the determinants of household spending is therefore essential for designing effective policies that promote sustainable and inclusive economic development. Türkiye presents a particularly compelling case for studying household consumption due to its dynamic economic transformation over the past few decades. Structural reforms, rapid urbanization, demographic shifts, and increasing integration into the global economy have significantly altered consumption patterns. Changes in labor market structures, income distribution, and policy interventions—such as social assistance programs and universal health coverage—have further shaped household spending behaviors. These transformations underscore the need for a comprehensive analysis that accounts for both micro-level household characteristics and macroeconomic influences.

The existing literature on HCE in Türkiye has evolved considerably over the years, reflecting both changes in data availability and methodological advancements. Early studies, such as those by Bulmuş (1980) and Tansel (1986), focused on expenditure elasticity and Engel curves, laying the foundation for later analyses. Subsequent research, including that by Şenesen and Selim (1995), and Selim (2001), and Nişancı (2002) expanded the scope by incorporating multi-year comparisons and regional variations. The introduction of the Almost Ideal Demand System (AIDS) model by Nişancı (1998), and Alpay and Koç (2002) marked a methodological shift, providing a more detailed understanding of demand elasticities. More recently, researchers have leveraged standardized and detailed Household Budget Survey (HBS) data, published annually since 2003, to examine specific consumption categories such as food Şahinli (2013), health (Yardım et al., 2010), alcohol and tobacco (San and Chaloupka, 2016; Aksoy et al., 2019), and education (Acar et al., 2016), and recreation and culture (Şengül et al., 2018; Gül, 2019). These studies highlight key socio-economic determinants of consumption, including income, education, regional disparities, and demographic composition.

Despite these contributions, gaps remain in understanding the interplay between various socio-economic factors and household expenditure decisions over an extended period. Many existing studies rely on short time spans, limiting their ability to capture structural shifts in consumption behavior. Moreover, while prior research has explored individual expenditure categories, there is a need for a holistic approach that integrates multiple determinants across different spending groups. This study aims to address these gaps by analyzing the socio-economic determinants of HCE in Türkiye between 2005 and 2019 using the Marshallian demand function. By merging data from HBS and regional consumer price indices (RCPI), this research constructs a comprehensive dataset to examine factors such as income, education, household size, and demographic composition shape spending behaviors. Another notable contribution of this research is the development of a robust demand function that systematically captures the drivers of HCE. This function establishes a solid foundation for future studies exploring causal relationships and evaluating policy interventions.

The findings reveal that income plays a crucial role in shaping household consumption, with higher earnings leading to increased spending, while in-kind assistance reduces direct

expenditure on necessities, thereby lowering overall consumption. Mortgage obligations are found to limit spending due to repayment burdens, whereas larger living spaces and advanced heating systems are linked to greater expenditures, likely driven by higher utility costs and improved financial capacity. Additionally, consumption patterns exhibit non-linear relationships with education, age, and household size. While higher education eventually leads to increased spending due to enhanced earning potential, the inverse U-shaped pattern observed with age and household size suggests that consumption growth slows and eventually declines as these factors increase. Household structure also influences expenditure, with single-parent households displaying lower spending due to financial constraints, while extended families benefit from shared resources, resulting in higher consumption. Moreover, compared to underutilized individuals¹, households with more babies and children spend less due to simpler needs, whereas a larger proportion of older adults corresponds to slightly higher expenditures, likely reflecting stable incomes and increased healthcare and leisure costs. The heterogeneity of the effects of socio-economic determinants on expenditure was found via the marginal effects varying among consumption categories. In other words, changing priorities, lifestyle adjustments, and preferences shifts spending patterns.

The remainder of this paper is structured as follows: Section 2 presents the data and methodology, detailing the HBS and the econometric techniques employed in the analysis. Section 3 provides a comprehensive discussion of the empirical findings, examining the determinants of household consumption across different expenditure categories. Section 4 concludes the study by summarizing the key results, discussing policy implications, the shortcomings of the analysis and offering directions for future research.

2. Data and Methods

2.1. Data

For the analysis, the following Marshallian demand function is constructed.

$$D = f(P_x, P_y, B, H, D, I, L, C) \quad (1)$$

The Equation (1) uses P_x and P_y to represent the prices of the relevant goods and other goods, respectively, while B denotes the household's total expenditure, reflecting its budget constraint. These variables form the foundation for the demand function, enabling the calculation of income and price elasticities. The function also includes socio-economic determinants affecting household consumption, such as household characteristics (H), demographics (D), income conditions (I), labor market relations (L), and consumption preferences (C).

HBS is the primary data source with these key features. According to TURKSTAT (2024), HBSs are crucial sources of information on the socio-economic status, living conditions, and consumption behavior of households. This study aims to compile data on consumption habits, socio-economic characteristics, labor market relations, and income conditions of

¹ Underutilized individuals are referred as working-age household members who are not part of the labor force and do not fall into categories such as students, retirees, or housewives.

individuals and their households. The information gathered can be used to assess the impact of micro and socio-economic policies.

HCE are likely to be explained by variables constructed from the Individual, Household, and Consumption sub-datasets of the HBS, which are merged at the household level. RCPI published by Turkish Statistical Institute (TURKSTAT) were used to adjust nominal consumption expenditures for price effects. Due to the lack of RCPI data before 2005, HBS data from 2003 and 2004 were excluded. Additionally, HBS data for 2020 and 2021 were not included in the analysis because they could not be compiled at a comparable level due to pandemic-related restrictions.

The primary manipulation involves merging the Household, Individual, and Consumption datasets from the HBS with the RCPI data. The month the survey was conducted and the region where the responding household resides were determined by using responses to various survey questions. With this detailed information, all datasets were successfully matched, representing one of the key contributions of the analysis. This comprehensive approach effectively reveals the socio-demographic determinants of household consumption behavior, while keeping prices and budget constraints constant.

2.2. Marshallian Demand Function

As shown in Equation (2), the dependent variable, D_{rimyc} , is the consumption expenditure in 2003 TL prices of household i in region r in month m in year y in Classification of Individual Consumption by Purpose (COICOP) group c .

$$D_{rimyc} = HCE_{rimyc}/CPI_{rimyc} \quad (2)$$

where P_{myrc}^x is the natural logarithm of the CPI index for COICOP group c in region r in month m in year y . Food is defined as a *numeraire* product and its price is assumed to be one. All other prices are calculated as relative prices in terms of food prices by proportioning them to food prices, as specified in Equation (3).

$$RP_{myrc}^x = P_{myrc}^x/P_{food_{myrc}} \quad (3)$$

where RP_{rimyc}^y is the weighted average price of COICOP group c in month m in year y for household i in region r , calculated for all other groups except the related consumption group, based on the formulation in Equation (4). In other words, for each group, this variable transforms the analysis into a two-product structure and derives a price index for all products except the product chosen by the household when determining its consumption basket.

$$RP_{rimyc}^y = \left[\sum_{c=11 \& c \neq n}^{c=127} \left(\frac{HCE_{ic}}{THCE_i - HCE_{in}} \right) * P_c \right] / P_{food_{rimyc}} \quad (4)$$

In studies on socio-economic factors affecting households, variables are often based on the household head's characteristics. However, this study takes a broader approach by creating variables for the entire household. Socio-economic indicators are measured as ratios comparing individuals with a given characteristic to total household members.

Table 1. Descriptive Statistics for Socio-Economic Determinants of Household Consumption

Variable	Definition	Obs.	Mean	Std. Dev.	Min.	Max.
Household Size	Total number of individuals in the household	153411	3.70	1.89	1	30
Household Size Square	Square of the total number of individuals in the household	153411	17.24	21.52	1	900
Area of Dwelling	Area of dwelling in terms of m ²	153411	104.83	33.47	10	870
Heating System	Heating system of the dwelling (base category is stove)	153411	0.41	0.49	0	1
Mortgage	Active housing loan payment (base category is no payment)	153411	0.07	0.26	0	1
Household Type 1	Couples	153411	0.70	0.46	0	1
Household Type 2	Extended Family	153411	0.16	0.37	0	1
Household Type 3	Single Parent Family	153411	0.12	0.33	0	1
Household Type 4	Other types of families	153411	0.02	0.12	0	1
Early Childhood Dummy	At least one person in the household at age between 0 and 5	153411	0.26	0.44	0	1
Early Childhood Ratio	For households with at least one individual aged between 0 and 5 years, the ratio of the number of those to household size	40380	0.28	0.11	0.05	0.75
School-Age Dummy	At least one person in the household at age between 6 and 14	153411	0.39	0.49	0	1
School-Age Ratio	For households with at least one individual aged between 6 and 15 years, the ratio of the number of those to household size	59153	0.33	0.13	0.05	0.83
Over 65 Dummy	At least one person in the household at age over sixty-five	153411	0.23	0.42	0	1
Over 65 Ratio	For households with at least one individual aged over 65 years, the ratio of the number of those to household size	34908	0.56	0.34	0.03	1
Working Age Dummy	At least one person in the household aged between 16 and 65	153411	0.92	0.27	0	1
Household Age	Average age of working-aged people in the household	141605	38.21	9.74	17	62
Household Age Square	Square of the average age of working-age people in the household	141605	1554.62	830.31	289	3844
Male Dummy	At least one person in household is male	153411	0.93	0.26	0	1
Male Ratio	For households with at least one individual is male, the ratio of the number of those to household size	142520	0.52	0.17	0.06	1
Health Dummy	At least one person in the household has health insurance	153411	0.95	0.21	0	1
Health Coverage	For households with at least one individual has health insurance, the ratio of the number of those to household size	146131	0.96	0.13	.06	1

Two types of variables are used: dummy variables, which indicate if a household has at least one member with the characteristic, and ratio variables, representing the proportion of members with that characteristic. Both are included to capture presence (dummy) and marginal effects (ratio) of the characteristic.

Table 2. Descriptive Statistics for Socio-Economic Determinants of Household Consumption (Continued)

Variable	Definition	Obs.	Mean	Std. Dev.	Min.	Max.
Employed Dummy	At least one person in family has job in survey month	153411	0.771	0.42	0	1
Employed Ratio	For households with at least one person who has a job, the ratio of the number of those to household size	118309	0.444	0.241	0.053	1
Unemployment Dummy	At least one person in the family seeks a job in survey month	153411	0.098	0.297	0	1
Unemployed Ratio	For households with at least one person who seeks a job, the ratio of the number of those to household size	14978	0.3	0.155	0.033	1
Student Dummy	At least one person in the family is in education in survey month	153411	0.181	0.385	0	1
Student Ratio	For households with at least one person who is in education, the ratio of the number of those to household size	27819	0.279	0.132	0.038	1
Housewife Dummy	At least one person in family who is at age between 15 and 65 and is housewife in survey month	153411	0.541	0.498	0	1
Housewife Ratio	For household with at least one person who is housewife, the ratio of the number of those to household size	83058	0.312	0.143	0.045	1
Retired Dummy	At least one person in the family who is at age between 15 and 65 and is retired in survey month	153411	0.12	0.324	0	1
Retired Ratio	For households with at least one person who is retired, the ratio of the number of those to household size	18342	0.409	0.219	0.038	1
Underutilized Dummy	At least one person in family who is at age between 15 and 65 and is in neither education nor employment in survey month	153411	0.108	0.311	0	1
Underutilized Ratio	For households with at least one person who is neither education nor employment, the ratio of the number of those to household size	16592	0.299	0.167	0.038	1
Workforce Dummy	At least one person in the household participate in workforce	153411	0.804	0.397	0	1
Workforce Education	Average education level of people in the household that participate in workforce	123306	2.668	1.097	1	6
Workforce Education Square	Square of the average education level of people in the household that participate in workforce	123306	8.321	7.344	1	36
Income Quintile 1	Average Real Consumption Expenditure for income quantile 1 (lowest)	30635	552.8	497.9	2	12235.6
Income Quintile 2	Average Real Consumption Expenditure for income quantile 2	30681	730.8	596.6	10.2	20158.4
Income Quintile 3	Average Real Consumption Expenditure for income quantile 3	30695	899.4	736.2	21.5	15237.2
Income Quintile 4	Average Real Consumption Expenditure for income quantile 4	30702	1130.8	909.5	7	20877.9
Income Quintile 5	Average Real Consumption Expenditure for income quantile 5	30698	1825.3	1639.7	4.9	37161.1
In-kind Assistance	Whether the household receives in-kind assistance such as food, kindergarten, and transportation (base category is no assistance)	153411	0.568	0.495	0	1

Detailed definitions and descriptive statistics for all variables that best represent the above demand function are provided in Tables 1–2.

3. Empirical Strategy

To investigate the factors influencing household consumption behavior, a demand function is estimated as follows.

$$D_{rimy} = \beta_0 + \beta_1 * RP_{myr}^x + \beta_2 * RP_{myr}^y + \beta_3 * BC_{rimy} + \Phi * X_{rimy} + \gamma * C_{irmy} + \alpha + \pi + \Omega \quad (5)$$

The dependent variable in the Equation (5) is the consumption expenditure in 2003 prices made by household i in region r in month m in year y . BC_{rimy} is the consumption expenditure of household i in the region of 2003 TL prices in month m in year y . The coefficients β_1 , β_2 and β_3 are own price, cross price, and income elasticities, respectively. Independent variables of interest, X_{irmy} , a set of socio-economic determinants such as demographics, and income status. These variables capture spending patterns on consumption and the coefficient matrix (Φ) quantifies these relationships. C_{irmy} , added the Equation (5) to control for the effects of households' labor market situation and consumer preferences on expenditures². Equation (5) is repeated for whole consumption expenditure and COICOP two-level breakdowns. In all these specifications, year (α), region (π), and month (Ω) fixed effects are applied.

HCE are compiled monthly, making it unlikely that households consume all types of goods and services within a single month. As a result, the dataset contains a large number of zero values, reflecting non-consumption of certain items during the observed period. Additionally, due to the non-negativity of consumption data, econometric techniques specifically suited to handle such characteristics were adopted. After assessing the data distribution, overdispersion, where the variance exceeds the mean, was identified as a significant feature. To address this, a negative binomial regression model was employed, which is well-suited for count data with overdispersion. This approach enables a more accurate modeling of consumption behavior while accommodating the specific nature of the dataset.

4. Results and Discussion

Table 3 presents the results for the relationship between socio-economic variables and overall household total consumption expenditures. In this model, prices and budget constraints are excluded due to collinearity.

The main findings indicate that households receiving in-kind assistance exhibit lower consumption levels than those not receiving such support. This is likely because in-kind assistance serves as a substitute for direct expenditure, thereby reducing the overall spending of recipients compared to non-recipients, assuming all other factors remain constant.

² Labor market status (employed, unemployed, homemaker, retired, student) is controlled for to account for its potential effect on consumption. Consumption preferences are captured through dummy variables indicating spending in specific COICOP groups, controlling for their influence on demand for other categories. Results for those are available upon request.

When income quantiles are compared to the lowest income group, it is observed that higher income levels generally lead to greater consumption due to increased purchasing power. The positive coefficients of income quantiles indicate that transitioning from the lowest to the highest income quantile increases HCE by the corresponding coefficient units on the log scale. The results further indicate that households with a mortgage loan tend to spend less on consumption, likely due to the financial burden of loan repayments reducing disposable income. In contrast, households with more advanced heating systems and larger dwellings exhibit higher consumption levels. This may be attributed to increased utility costs or higher income levels that facilitate improved living conditions, thereby allowing for greater discretionary spending.

Table 3. Socio-Economic Determinants of Overall Consumption Expenditures

In-kind Assistance	-0.0470*** (0.00356)	Early Childhood Ratio	-0.130*** (0.0413)
Income Quintile 2	0.178*** (0.00521)	School-Age Ratio	-0.200*** (0.0365)
Income Quintile 3	0.285*** (0.00581)	Over 65 Ratio	0.175*** (0.0407)
Income Quintile 4	0.397*** (0.00659)	Extended-Family	0.0139** (0.00559)
Income Quintile 5	0.632*** (0.00792)	Single Parents	-0.0488*** (0.00707)
Workforce Educ.	-0.0345*** (0.00910)	Others	0.0321** (-0.0163)
Workforce Educ. Sq.	0.0106*** (0.00136)	Mortgage Loan	-0.0636*** (0.00590)
Household Age	0.00755*** (0.00136)	Heating System	0.0632*** (0.00378)
Household Age Sq.	-0.0000782*** (1.65e-05)	Area of Dwelling	0.189*** (0.00596)
Household Size	0.126*** (0.00362)	Health Coverage	-0.0108 (0.0111)
Household Size Sq.	-0.00322*** (0.000230)	Constant	3.794*** (-0.0465)

Note: Data are used from HBS conducted by TURKSTAT. Respondent’s self-reported consumption expenditures in terms of 2003 price are used as a dependent variable. Negative binominal regression models are used. Year, region, month fixed effect, labor market controls, and consumption preference controls are used. Robust standard errors are in parenthesis. Sample weights are used. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

In addition, quadratic relationships between education, age, and size with HCE are particularly notable in the results. A non-linear, positive relationship suggests that beyond a certain threshold, higher education leads to increased spending, likely due to the higher incomes associated with higher levels of education. Meanwhile, the inverse U-shaped relationship between age, household size, and expenditure indicates a diminishing marginal effect on household consumption. To be specific, as the average household age increases or household size expands, the rate of consumption growth gradually slows, eventually reaching a plateau or even declining.

When underutilized individuals are used as the reference category, the coefficients for the early childhood ratio and school-age ratio are negative. While this might seem surprising, it can be explained as follows: since underutilized individuals are at least 16 years old, their consumption bundle is more complex, including transportation, communication, and higher calorie needs compared to babies and children. In contrast, a higher ratio of older adults compared to underutilized individuals are associated with a slight increase in consumption. This suggests that older individuals may have more stable incomes, which could lead to higher expenditures on healthcare or leisure activities.

The findings regarding the effect of household types on consumption demonstrate that while extended families and other household types exhibit slightly higher consumption than couples, single-parent households have significantly lower consumption expenditure in comparison. The lower spending of single-parent households likely reflects the financial strain of managing dependent care on a single income. In contrast, the higher consumption levels of extended families may be attributed to shared resources and economies of scale, while other household types may benefit from diverse financial structures that enhance spending capacity.

In Tables 4-6, the heterogeneity of the effects of each socio-economic variable on consumption is analyzed. The impact of each determinant on overall expenditures and on sub-groups of consumption were calculated separately. The first row presents the results for total consumption expenditure, while the subsequent rows repeat similar equations for each COICOP 2-level consumption category. In the equations for sub-groups, prices and budget constraints are included to control price and income elasticities.

In Table 4, one of the most striking findings is that the negative relationship between in-kind assistance and total HCE are primarily driven by significant reductions in spending on food and non-alcoholic beverages, clothing and footwear, and communication. These subcategories suggest that in-kind assistance often substitutes for essential goods. In contrast, the positive effect on expenditures for hotels, cafes, and restaurants reflects the potential for reallocating savings from essential goods to discretionary spending. When examining the relationship between income quintiles and household consumption subcategories, the findings indicate that all subcategories, except for food and housing-related expenditures, are normal goods. Further, the only exception is alcohol³ consumption, which, with an elasticity greater than one, falls into the category of luxury goods. The insignificant health expenditure coefficients suggest no strong link between income quantiles and health spending, likely due to high public health coverage. However, positive coefficients for the highest income groups indicate greater allocation to private medical expenses.

The impact of education on consumption varies across categories according to Table 4. Alcohol, tobacco, furniture and white goods spending is higher at lower education levels but declines with increasing education. Housing, utilities, and transportation expenses rise with education but stabilize at advanced levels. Clothing and footwear spending grow but plateau at higher education levels, while health expenditure follows a U-shape. Communication, recreation, and cultural spending increase but decline at advanced levels, whereas hotel and

³ While the results are reported at the COICOP 2-digit level, additional estimations at the COICOP 3-digit level for alcohol, and tobacco products consumption have also been conducted and are available upon request.

restaurant expenses peak at moderate education. Overall, higher education shifts spending patterns, reflecting changing priorities and lifestyle adjustments.

Table 4. Effect of Socio-Economic Determinants on Consumption Expenditures (COICOP 2 Level)

COICOP 2	In-kind Assist.	Income Quintile 2	Income Quintile 3	Income Quintile 4	Income Quintile 5	Workforce Educ.	Workforce Educ. Sq.
Household Consumption Expenditure	-0.047***	0.178***	0.285***	0.397***	0.632***	-0.035***	0.0106***
Food and Non-alcoholic Beverages	-0.055***	-0.026***	-0.038***	-0.056***	-0.152***	-0.022***	-0.0012
Alcoholic Beverages and Tobacco Products	-0.0050	0.062***	0.113***	0.186***	0.224***	0.152***	-0.0525***
Clothing and Footwear	-0.060***	0.082***	0.164***	0.210***	0.299***	0.068***	-0.0063**
Housing, Water, Electricity, Gas and Other Fuels	0.010**	-0.021***	-0.098***	-0.183***	-0.281***	0.134***	-0.0128***
Furnishings, Household Equipment, Routine Maintenance of the House	-0.025***	0.128***	0.206***	0.259***	0.346***	-0.065***	0.0072**
Health	-0.025*	-0.022	-0.015	0.032	0.180***	-0.134***	0.0182***
Transport	0.014*	0.186***	0.293***	0.396***	0.581***	0.176***	-0.0195***
Communications	-0.059***	0.135***	0.190***	0.229***	0.222***	0.231***	-0.0311***
Recreation and Culture	-0.037**	0.189***	0.283***	0.417***	0.589***	0.188***	-0.0117**
Education	-0.131***	0.313***	0.476***	0.578***	0.745***	1.364***	-0.163***
Hotels, Cafes, and Restaurants	0.541***	0.235***	0.276***	0.343***	0.511***	0.083***	-0.0106***
Miscellaneous Goods and Services	-0.0102	0.0790***	0.128***	0.227***	0.404***	0.102***	-0.0107**

Note: Data are used from HBS conducted by TURKSTAT. Respondent’s self-reported consumption expenditures in terms of 2003 price are used as a dependent variable. Negative binominal regression models are used. Year, region, month fixed effect, labor market controls, and consumption preference controls are used. Robust standard errors are in parenthesis. Sample weights are used. *** p<0.01, ** p<0.05, * p<0.1.

Table 5 presents the results that relate to household age and size. Household spending patterns are influenced by the age composition of its members. A higher proportion of babies leads to increased expenditures on clothing, utilities, recreation, culture, and miscellaneous goods, reflecting their specific needs, while spending on alcohol, tobacco, communication, transportation, and furniture declines. Similarly, a greater presence of children results in higher spending on education, recreation, culture, and clothing, while expenditure on alcohol, tobacco, and transport decrease as these categories become less relevant. In households with more elderly individuals, spending on education, transportation, alcohol, and tobacco is reduced, whereas food and dining expenditures rise, reflecting the lifestyle and preferences of older adults.

Household consumption patterns are also shaped by the average age of its members. Spending on alcohol, tobacco, communication, and education follows a reverse U-shaped pattern, with higher expenditures in younger and middle-aged households, then declining as health concerns and reduced dependency on technology emerge. In contrast, expenditures on housing, utilities, furnishings, and household equipment follow a U-shaped pattern, increasing in older households as discretionary spending shifts toward home maintenance and comfort. Similarly, spending on hotels, cafes, and restaurants rises in later life, reflecting a greater emphasis on leisure and social experiences.

Table 5. Effect of Socio-Economic Determinants on Consumption Expenditures (COICOP 2 Level) (Continued)

COICOP 2	Early Childhood Ratio	School-Age Ratio	Over 65 Ratio	Household Age	Household Age Sq.	Household Size	Household Size Sq.
Household Consumption Expenditure	-0.130***	-0.200***	0.175***	0.008***	-0.000***	0.126***	-0.003***
Food and Non-Alcoholic Beverages	-0.014	-0.110***	0.100***	0.010***	-0.000	0.091***	-0.004***
Alcoholic Beverages and Tobacco Products	-0.594***	-0.701***	-0.364***	0.059***	-0.001***	0.071***	-0.003***
Clothing and Footwear	0.222**	0.660***	-0.216**	-0.017***	0.000	0.040***	-0.001***
Housing, Water, Electricity, Gas and Other Fuels	0.250***	0.413***	-0.023	-0.022***	0.000***	-0.141***	0.003***
Furnishings, Household Equipment, Routine Maintenance of the House	-0.218**	0.000	0.112	-0.026***	0.000***	0.024***	-0.002***
Health	0.204	-0.496***	0.203	-0.002	0.000	-0.071***	0.003***
Transport	-0.219**	-0.180*	-0.434***	0.004	-0.000***	0.020**	-0.001**
Communications	-0.485***	-0.435***	-0.217***	0.022***	-0.000***	0.015**	-0.001
Recreation and Culture	0.303*	0.979***	0.177	-0.004	-0.000	-0.077***	0.004*
Education	-0.060	1.302**	-2.555***	0.191***	-0.002***	0.073**	-0.010***
Hotels, Cafes, and Restaurants	-0.162	-0.119	0.228*	-0.023***	0.000***	-0.028***	0.002**
Miscellaneous Goods and Services	0.953***	0.050	-0.215	-0.003	-0.000	0.028**	-0.002***

Note: Data are used from HBS conducted by TURKSTAT. Respondent's self-reported consumption expenditures in terms of 2003 price are used as a dependent variable. Negative binominal regression models are used. Year, region, month fixed effect, labor market controls, and consumption preference controls are used. Robust standard errors are in parenthesis. Sample weights are used. *** p<0.01, ** p<0.05, * p<0.1.

The inverted U-shaped relationship between household size and total consumption expenditure aligns with economic theories emphasizing economies of scale in household

consumption, where larger households can share resources and lower the marginal cost per member. However, subgroup analysis reveals varying patterns, with certain categories, such as housing, water, electricity, gas, and other fuels; furniture; healthcare; entertainment and culture; and hotels, cafes, and restaurants, exhibiting a U-shaped relationship.

Table 6 presents the results for household characteristics. The negative relationship between mortgage loans and total consumption expenditures can be attributed to the reduced likelihood of spending on rent, alongside significant cutbacks in discretionary spending (e.g., clothing, recreation, culture). It is also posited that the negative correlation with food expenditure and the positive correlation with restaurant spending are not directly linked to mortgage loans but rather indicate that mortgage payers tend to have higher income levels than non-payers.

Table 6. Effect of Socio-Economic Determinants on Consumption Expenditures (COICOP 2 Level) (Continued)

COICOP 2	Health Coverage	Mortgage Loan	Heating System	Area of Dwelling	Extended Family	Single Parents	Others
Household Consumption Expenditure	-0.011	-0.064***	0.063***	0.189***	0.014**	-0.049***	0.032**
Food and Non-alcoholic Beverages	0.000	-0.027***	-0.089***	-0.074***	-0.048***	-0.079***	-0.075***
Alcoholic Beverages and Tobacco Products	-0.401***	0.027	-0.118***	-0.197***	0.101***	0.058***	0.320***
Clothing and Footwear	0.101***	-0.064***	-0.019*	-0.015	-0.038***	0.034*	0.053*
Housing, Water, Electricity, Gas and Other Fuels	-0.025	-0.306***	0.110***	0.153***	0.072***	-0.005	0.092***
Furnishings, Household Equipment, Routine Maintenance of the House	0.028	0.079***	0.088***	0.179***	-0.004	-0.084***	-0.207***
Health	-0.200***	-0.009	-0.003	0.070***	0.132***	-0.269***	-0.163***
Transport	0.111***	-0.021*	0.009	0.043***	0.003	-0.262***	-0.183***
Communications	0.034	-0.016*	0.057***	0.033***	-0.013	-0.024**	0.013
Recreation and Culture	0.005	-0.115***	0.094***	0.086***	0.003	0.091***	0.098**
Education	0.255**	-0.055	0.283***	0.476***	-0.069	0.164**	0.042
Hotels, Cafes, and Restaurants	0.108***	0.067***	-0.024**	-0.071***	0.018	0.195***	0.152***
Miscellaneous Goods and Services	-0.095**	-0.044**	0.019	-0.045**	0.038*	0.031	-0.035

Note: Data are used from HBS conducted by TURKSTAT. Respondent’s self-reported consumption expenditures in terms of 2003 price are used as a dependent variable. Negative binominal regression models are used. Year, region, month fixed effect, labor market controls, and consumption preference controls are used. Robust standard errors are in parenthesis. Sample weights are used. *** p<0.01, ** p<0.05, * p<0.1.

The positive correlation between more advanced heating systems, larger dwelling areas, and total consumption expenditure can be attributed to higher utility costs as well as discretionary spending on furnishings, household equipment, and maintenance. The modest positive coefficients associated with communication, culture, and education suggest higher income levels. Conversely, the negative coefficients for food, restaurants, alcohol, and tobacco in relation to mortgage loans and total consumption expenditure indicate that households with such housing tend to have smaller household sizes and older average household ages.

Extended families tend to spend more on utilities, healthcare, alcohol, and tobacco, reflecting the broader and more diverse needs of multigenerational households compared to couples. Economies of scale allow them to reduce their per capita food and clothing expenditure through shared meals and clothing, while their overall expenditure remains higher. In contrast, single parents, faced with financial hardship and smaller household sizes, spend significantly less in most discretionary categories. However, they allocate more money to social activities such as dining out and cultural events, and to stress-related consumption such as alcohol and tobacco. Despite financial constraints, they also prioritize spending on education for dependents. Other household types exhibit higher consumption compared to couples due to shared rent arrangements, budget-friendly but necessary discretionary spending, and lifestyle that emphasizes individual consumption such as dining out and socializing. Couples, on the other hand, tend to save more and are more likely to own homes, contributing to lower consumption expenditures.

The findings of this study align with the existing literature, confirming established relationships between socio-economic determinants and household consumption. Consistent with prior research, the results indicate that in-kind assistance is associated with a decline in spending on essential goods (see, for example, Hoynes et al., 2007; Redmond et al., 2014). Moreover, evidence suggests that households often reallocate the savings from essential expenditures toward discretionary spending, which is also consistent with the existing literature (see, for example, Tirivayi and Groot, 2010; Hasanah et al., 2023).

The relationship between income status and consumption expenditures is also in line with existing studies. The transition from the lowest to the highest income quintiles has been widely documented as leading to increased consumption. While most consumption categories are classified as normal goods, food and housing remain essential expenditures, whereas alcohol consumption is considered a luxury good (Bertrand and Morse, 2016; Kneebone and Wilkins, 2018; Dahan and Sayag, 2024). Healthcare expenditures, however, do not exhibit a strong correlation with income quintiles, although higher-income households may allocate more resources to private medical expenses (Malinowski, 2024).

Regarding housing-related expenditures, prior studies highlight a negative correlation between mortgage payments and both discretionary and essential spending, particularly on food, suggesting that financial constraints limit household budget flexibility (Caspi et al., 2024). While higher-income mortgage holders may continue spending on dining out, this suggests that income level, rather than mortgage status alone, is a key determinant of expenditure patterns. However, in Turkey, these effects appear less pronounced. The results indicate that mortgage repayments are generally lower than rental payments, which explains the negative coefficient observed in the analysis.

The link between advanced heating systems, larger dwellings, and HCE also supports previous research. Studies have shown that homes equipped with advanced heating systems typically incur higher utility costs, whereas larger dwellings are associated with increased discretionary spending on furnishings and maintenance (Fisher and Williams, 2011; Sevinç, 2023). Additionally, larger dwellings are often occupied by smaller households with an older average age, which tends to result in lower expenditures on food and other essential items (Cheshire and Forrest, 2021).

The influence of household composition on expenditure patterns has also been extensively documented in the existing literature, further supporting the findings of this research. The age composition of household members plays a crucial role in shaping consumption behavior, as evidenced by varying expenditure patterns across demographic groups (Song and Zhang, 2018; Travassos et al., 2021). Single-parent households often face financial constraints due to the burden of covering dependent care expenses with a single income, resulting in lower overall consumption (Öztürk and Boylu, 2015). In contrast, extended families benefit from shared resources, enabling higher levels of consumption (Klocker et al., 2012; Calvi et al., 2023).

5. Conclusion

This study has explored the determinants of HCE in Türkiye, offering a comprehensive analysis of how socio-economic and demographic factors influence spending behaviors. By utilizing the extensive dataset from the HBS and employing robust econometric techniques, the research has provided valuable insights into household expenditure dynamics across various categories.

The results indicate that income significantly shapes consumption patterns, with higher-income households allocating a larger share of their budgets to discretionary categories such as cultural activities and recreation. Conversely, lower-income households focus predominantly on essential items like food and housing. Household size and average age of household's members emerged as another critical factor, displaying a reverse U-shaped relationship with total consumption expenditure. This pattern highlights the balance between economies of scale in smaller households and rising costs in larger households due to increased demands on resources.

Education level was also found to play a pivotal role in household spending behavior. Households with more educated members tend to allocate more resources to housing, education, and cultural activities, reflecting their preferences for quality and long-term investments. In contrast, lower education levels were associated with higher expenditures on necessities and less engagement with discretionary spending categories. Additionally, household type and the presence of children and elderly members within a household influenced spending priorities, with families allocating more to education and health services, respectively.

A significant contribution of this study is the derivation of a robust demand function that captures the key drivers of HCE. This function provides a solid foundation for future research, enabling the analysis of causal relationships and the evaluation of potential interventions. Researchers can leverage this framework to conduct impact analyses, further refining our understanding of how socio-economic factors shape household behavior and laying the groundwork for evidence-based policy development.

In-kind assistance is effective in supporting low-income households without generating excessive additional demand. Expanding such assistance programs could provide targeted relief to vulnerable groups without significantly distorting overall consumption patterns. Given that essential goods such as food, rent, and utilities are identified as inferior goods, direct support in these areas for low-income households may allow them to allocate more resources toward other necessary expenditures, improving overall well-being. Households with infants and children exhibit distinct consumption patterns, with specific expenditure categories becoming more

prominent. To address long-term demographic challenges, sustained subsidies for child-related goods and services could encourage higher fertility rates by reducing the financial burden of child-rearing. Additionally, single parents face notable financial constraints in meeting certain essential needs. Providing targeted support for this group, particularly in key expenditure areas, could enhance their economic stability and contribute to broader social well-being.

Declaration of Research and Publication Ethics

This study which does not require ethics committee approval and/or legal/specific permission complies with the research and publication ethics.

Researcher's Contribution Rate Statement

The authors declare that they have contributed equally to the article.

Declaration of Researcher's Conflict of Interest

There are no potential conflicts of interest in this study.

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THE INTERACTION BETWEEN ECONOMIC UNCERTAINTIES AND FINANCIAL CYCLES IN TÜRKİYE: FREQUENCY DOMAIN SYMMETRIC AND ASYMMETRIC CAUSALITY ANALYSIS

**Türkiye'de Ekonomik Belirsizlikler ve Finansal Çevrimler Arasındaki Etkileşim:
Frekans Alanında Simetrik ve Asimetrik Nedensellik Analizi**

Ayşegül ŞAHİN* 

Abstract

This study analyzes the impact of the Turkish Economic Uncertainty Index on financial cycles with monthly data for the period 2010:01–2024:12. Financial cycles are represented by a composite index formed by indicators such as banking spread, real housing prices, and the BIST100 index. In order to examine the relationship at the short-, medium-, and long-term levels, Breitung and Candelon (2006) applied a frequency domain symmetric and asymmetric causality test. The findings show that decreases in economic uncertainty significantly affect the positive component of financial cycles in both the short and long term. On the other hand, it was found that the economic uncertainty index tended to decrease in the short term during financial contraction periods. The results indicate that reducing uncertainties not only provides market confidence but also supports persistent financial expansion processes. The study makes an original contribution to the literature by revealing for the first time the impact of policy uncertainty on financial cycles on a frequency-based basis through the asymmetric effect channel.

Keywords:

Economic Policy
Uncertainty,
Financial Cycles,
Symmetric and
Asymmetric Causality

JEL Codes:

E30, E44, D80

Öz

Bu çalışma, Türkiye ekonomik belirsizlik endeksinin finansal çevrimler üzerindeki etkisini 2010:01–2024:12 dönemi için aylık verilerle analiz etmektedir. Finansal çevrimler, bankacılık spreadi, reel konut fiyatları ve BIST100 endeksi gibi göstergeler üzerinden oluşturulan bileşik bir endeks ile temsil edilmiştir. İlişkiyi kısa, orta ve uzun dönem düzeyinde inceleyebilmek amacıyla Breitung ve Candelon (2006) frekans alanı simetrik ve asimetrik nedensellik testi uygulanmıştır. Bulgular, ekonomik belirsizlikteki azalışların finansal çevrimlerin pozitif bileşenini hem kısa hem de uzun vadede anlamlı şekilde etkilediğini göstermektedir. Buna karşılık, finansal daralma dönemlerinde ekonomik belirsizlik endeksinin kısa vadede azalma eğilimi gösterdiği tespit edilmiştir. Elde edilen sonuçlar, belirsizliklerin azaltılmasının sadece piyasa güveni sağlamakla kalmayıp, aynı zamanda kalıcı finansal genişleme süreçlerini desteklediğine işaret etmektedir. Çalışma, asimetrik etki kanalıyla politika belirsizliğinin finansal döngüler üzerindeki etkisini frekans-temelli olarak ilk kez ortaya koyarak literatüre özgün bir katkı sağlamaktadır.

Anahtar Kelimeler:

Ekonomik Politika
Belirsizliği,
Finansal Çevrimler,
Simetrik ve Asimetrik
Nedensellik

JEL Kodları:

E30, E44, D80

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1. Introduction

Economic policy uncertainty (EPU) affects many aspects of countries, from their level of development to their business activities and even their real and financial markets. The most prominent example of global uncertainty is the 2008 Global Financial Crisis, which started with the bursting of the housing bubble in the US and later resulted in the negative impact of many macroeconomic indicators and financial markets. Then, with the COVID-19 pandemic in 2020, essential activities such as production and foreign trade came to a standstill, creating a widespread environment of uncertainty. Financial markets, especially stock markets, were also affected by this uncertainty, with the S&P500 and NASDAQ losing approximately 5% of their value (Dai et al., 2021). In the same period, BIST100 also fell by approximately 15%. The COVID-19 pandemic has imposed a similar or even more significant uncertainty on financial markets than the Global Financial Crisis (Narayan et al., 2021; Vidya et al., 2022).

This study investigates a critical issue regarding EPU, which is an important risk factor on financial markets and negatively affects returns. Policy-related uncertainties have significant effects on consumers and investors. In an economic environment where uncertainty is high, new investors may hesitate to enter the market, which may cause consumers to reduce their current spending (Fasanya et al., 2020). In addition, policy uncertainty slows down economic activity by delaying investment, production, and consumption decisions; at the same time, it can affect credit expansion and asset prices by increasing uncertainty premiums on financial markets (Pastor and Veronesi, 2012; Baker et al., 2016). For this reason, it would not be wrong to say that EPU directly affects financial markets. Although it has different effects on stock markets from different industries, economic uncertainties can increase long-term volatility in stock markets (Yu et al., 2018). Uncertainty shocks negatively affect financial markets, especially by causing increases in credit spreads and significant decreases in stock returns (Popp and Zhang, 2016). In addition, uncertainty is generally accepted as an important factor that harms investment decisions; if it increases, it will create an economic expectation that threatens future earnings and negatively affects stock prices (Chen and Chiang, 2020).

It is also thought that the causal relationship between EPU and financial markets may be bidirectional. On the one hand, policy uncertainty can affect the decision-making processes of businesses and households, leading to significant consequences on both the real economy and financial markets. On the other hand, when economic activity weakens, credit conditions tighten, and volatility increases in financial markets, the likelihood of government intervention increases, which may lead to increased policy uncertainty (Ludvigson et al., 2021). This interaction between EPU and financial cycles is critical for financial stability and macroeconomic management. Financial cycles carry a dynamism that can create severe crises and long-term economic expansion processes. Especially during periods of financial expansion, the increase in risk appetite can make the responses to uncertainty shocks asymmetric (Pastor and Veronesi, 2012; Ludvigson et al., 2021).

As discussed above, there are multiple channels through which EPU can affect financial cycles. First, increased uncertainty can increase risk perception in credit markets, limiting credit supply and negatively affecting credit expansion (Bernanke, 1983; Bloom, 2009). Banks and financial institutions follow a more cautious credit policy by tightening credit conditions during periods of uncertainty. This can trigger a contraction in financial cycles. Second, increased uncertainty can also affect international capital flows and disrupt liquidity conditions in

financial markets. In heightened uncertainty, investors turn to safe-haven assets; capital outflows may occur from emerging economies. This process can deepen financial contraction (Pastor and Veronesi, 2012). Third, uncertainty shocks can have a direct effect on asset prices. Increased uncertainty can lead to higher risk premiums and lower asset prices, such as stocks and housing markets. Downturns in these asset markets, which are important components of financial cycles, can trigger the contraction phase of the cycle (Borio, 2014).

This study examines the impact of EPU on financial cycles in both the short and long-term using a frequency-based approach and evaluates whether this relationship is asymmetric. The impact of EPU on financial cycles can be asymmetric depending on the direction of the shock. While increasing uncertainty (positive EPU shock) accelerates the contraction trend of the financial cycle, decreasing uncertainty (negative EPU shock) supports financial expansion; this effect is often more limited and delayed. The fundamental theoretical framework of the study is based on the literature explaining the effects of uncertainty shocks on financial market variables. It emphasizes the effects of financial cycles on macroeconomic stability. Thus, the study addresses the role of uncertainty in economic activities and its interaction with financial vulnerabilities from a holistic perspective.

The research proceeds as follows: The next section reviews the relevant literature. Section 3 explains the dataset and methodology. Section 4 presents the analysis results, and Section 5 presents the general evaluation of the results and policy recommendations.

2. Literature Review

Financial cycles represent not only short-term financial volatility movements but also longer-term and structural change processes. Financial cycles, which are formed by factors such as borrowing trends, credit size, asset prices, and risk appetite, are fundamental dynamics that determine the expansion and contraction phases of the economic system (Borio, 2014). The literature defines financial cycles as dynamic processes that can create longer and more profound effects than economic cycles. While risk appetite increases in periods of financial expansion, financial stability may weaken in periods of contraction (Claessens et al., 2012). In this context, financial cycles affect not only the formation of financial crises but also the speed and strength of the recovery process after the crisis. Therefore, understanding the impact of EMU on financial cycles is of critical importance in terms of both financial stability policies and macroeconomic governance.

Financial cycles can be affected by uncertainties at different frequencies and timings. Aizenman and Pinto (2005) emphasized that there is a positive relationship between policy uncertainty and financial fragility. Increases in uncertainty can affect lending behaviour by changing the risk perception of investors and banks. This can determine the direction and severity of financial cycles. Liu et al. (2023) examined the relationship between EPU and financial cycle variables (total credit, housing, and stock prices) in the Chinese economy using wavelet analysis in the time-frequency domain. The study revealed that this relationship varies in frequency and time and is significantly strengthened, especially in crisis periods (e.g., the 2008 crisis, COVID-19, trade wars). In addition, it was determined that EPU acts as a leading indicator that drives financial cycles in some periods and as a responsive variable in others.

The effects of macroeconomic uncertainty shocks on financial cycles may vary in level and depending on the current cycle. In this context, Popp and Zhang (2016) analyzed the effects of uncertainty shocks depending on the regime. They showed that these shocks have more substantial and permanent effects, especially during recession periods. Alessandri and Mumtaz (2019) analyzed the macroeconomic effects of economic uncertainty shocks, mainly how they differ depending on financial regimes. The regime-dependent nonlinear Threshold VAR model they estimated using monthly data for the US economy shows that the effect of uncertainty shocks on outputs is approximately six times larger during financial crisis periods compared to standard times. The study also emphasizes that the uncertainty-financial cycle interaction is not linear and constant over time but varies significantly depending on regimes. The findings support the key role played by the financial channel in transmitting uncertainty shocks.

Fasanya et al. (2021) analyzed the impact of global economic policy uncertainty (GEPU) on volatility spillovers in financial markets for the Asia-Pacific manufacturing sector. The findings reveal a strong volatility interaction across markets, and GEPU significantly affects this interaction, especially at medium quantile levels. This suggests that the impact of uncertainty shocks on the financial system has a nonlinear structure.

In summary, studies in the literature focus on the structure of financial cycles and the impact of EPU on these cycles. Previous studies show that financial cycles contribute to economic fluctuations through credit expansion, risk appetite, and asset prices, while increases in uncertainty weaken these cycles by creating credit crunches and market volatility (Bloom, 2009; Claessens et al., 2012; Borio, 2014). The literature also revealed that the uncertainty-financial cycle relationship becomes more pronounced during crises and differentiates over time (Popp and Zhang, 2016; Alessandri and Mumtaz, 2019; Liu et al., 2023).

In studies explicitly conducted for Türkiye, the effects of EPU on the stock market (Korkmaz and Güngör, 2018; Koncak and Nazlıoğlu, 2024), inflation (Tümtürk and Kırca, 2024), exchange rates, and CDS (Aydın et al., 2024) have been analyzed. However, there is no study that directly addresses the relationship between EPU and financial cycles at both time and frequency levels and in an asymmetric structure.

Although the relationship between EPU and macroeconomic indicators has been extensively examined in the existing literature, its impact on financial cycles has been addressed to a limited extent, especially with frequency-based and asymmetric approaches. In particular, empirical analyses that reveal the relationship between EPU and financial cycles changes at different time scales and according to shock directions are not found in the literature, especially in the Turkish economy. The aim of this study is to contribute to the literature by analyzing the impact of EPU on financial cycles in the frequency domain and from a symmetric/asymmetric perspective in the case of Türkiye. This method was chosen based on the assumption that the relationship between EPU and financial cycles may vary depending on the frequency and direction of the shock. Considering the dynamic structure of the Turkish economy, this method provides more explanatory results by allowing the separation of relationships according to time and shock type. Thus, short-term market reactions and long-term structural effects will be separated, and a more comprehensive analysis will be presented for decision makers. In this respect, the study aims to contribute significantly to the existing literature methodologically and empirically. In addition, while previous studies used GEPU, this study used the Türkiye

economic uncertainty index, which has just begun to be calculated by Kilic and Balli (2024). In this sense, the study is quite different from the existing studies in the literature.

3. Data and Methodology

3.1. Data Set and Index Estimation

This study aims to investigate the impact of EPU on financial cycles in Türkiye using monthly data for the period 2010:01-2024:12. For this purpose, the Türkiye economic uncertainty index (TEUI) calculated by Kilic and Balli (2024) was used as the EPU indicator. This index was calculated depending on the frequency of occurrence of the words “economy” and “uncertainty” in 6 leading newspapers published in Türkiye, utilizing the methodology of Baker et al. (2016). Unlike other uncertainty indices, TEUI focuses on the Turkish economy. The monthly time series of the index is obtained from Policy Uncertainty (2024). EPU measures the level of uncertainty arising from decisions and practices regarding economic policies. An increase is observed in the index, especially in periods when uncertainty increases regarding the decision-making processes of policymakers, legal regulations, and the direction of future economic policies. This index is an important indicator for investors and businesses because an increase in EPU may lead to the postponement or reconsideration of investment and consumption decisions (Baker et al., 2016).

The second indicator, financial cycles, is a dynamic process in which the interactions between asset valuations, risk perceptions, risk taking, and financial constraints reinforce each other (Borio, 2014). Many indicators have been used in the literature in terms of financial variables. Many variables, from real exchange rates to housing prices, from stock prices to banking spreads, can be used to represent financial cycles (Goodhart and Hofmann, 2005; Hatzius et al., 2010; Liu, 2016; Ma and Zhang, 2016; Karagöl, 2021). Based on this, banking spread (BS), which shows the difference between loan interest and deposit interest, was used as a credit market indicator, the realized housing price index (RHPI) was used to represent housing markets, and the realized BIST100 Return Index (RBIST) was used to represent stock markets. RBIST and housing price index data were converted to real series by eliminating the effect of inflation. CPI (Consumer Price Index, 2005=100) was used for real values. All variables were obtained from the CBRT Electronic Data Distribution System. In addition, seasonal adjustment was made in the series using the TRAMO/SEATS method. Time series graphs of the variables are shown in Figure 1.

The upper panel of the Figure 1 shows the Türkiye economic uncertainty index (TEUI). As can be seen in the figure, fluctuations are directly caused by uncertainties. The most significant increases in uncertainty are due to inflation, interest rates, exchange rates, and general elections in 2011 (Kilic and Balli, 2024). The sudden increase in the dollar exchange rate and the crises with the US in 2018, the COVID-19 pandemic and global lockdowns in 2020, the sudden jumps in the exchange rate, rising inflation, and foreign trade deficit in 2022, and the new economic management after the general elections in 2023 have caused an increase in uncertainty. Slight upward movements begin in 2024; this may reflect the uncertainty of expectations regarding the effects of tight monetary policies on the economy. The lower panel of the figure shows the time series graphs of the components of the FC. The BS has been relatively flat and has had limited fluctuations until 2018. This indicates that the intermediation

cost of the banking sector is relatively stable. Significant increases have occurred in 2018 and beyond, especially in the 2018 currency crisis, the 2020 pandemic, and the tightening process after 2023. The sharp increase in the spread in 2022–2023 may be due to the increase in loan interest rates rising faster than deposit interest rates. This indicates that financial conditions are tightening and the banking sector demands a higher risk premium. A slightly upward and fluctuating structure exists in the real BIST100 index (RBIST) between 2010 and 2017. During this period, inflation-adjusted returns are relatively stable. A rapid recovery in real terms is striking as of mid-2022. This increase is associated with nominal BIST increases and stock returns that do not remain below high inflation. The RHPI is relatively stable until 2021. A rapid and striking increase in real housing prices is observed as of 2021. The main reasons for this increase are the motivation to protect against inflation and the negative real interest rate environment.

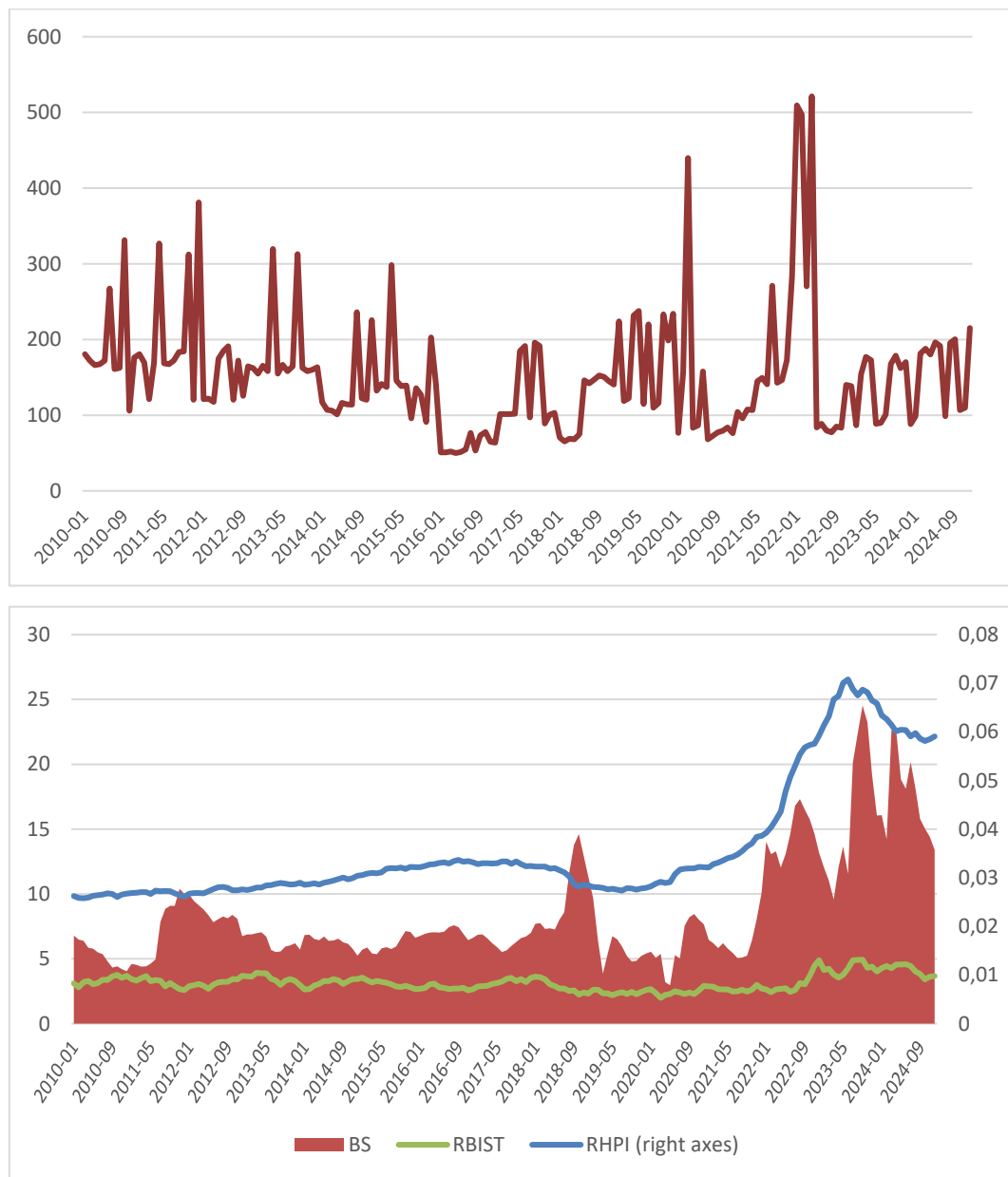


Figure 1. The Trend of the Series

Instead of separately considering the indicators selected from the credit market, housing market, and stock market to represent the characteristics of financial cycles, the study aimed to calculate an FC, as in the study of Ma and Zhang (2016). It is thought that calculating the index with variables selected from different financial markets will better represent financial cycles. Since the data used in creating financial cycle indices are expressed in different units, bringing them together in the index calculation is only possible by expressing them on the same scale. This method allows each series to be compared on the same scale, prevents negative values in the dataset, and provides easy interpretation in the index's composition. An alternative method, z-score standardization, can normalize the series around the mean. However, it is found to be incompatible because it can change the structure of the FC due to its potential to produce negative values. This preference is also a common practice in studies on the creation of financial cycles and is supported in the literature (Schüler et al., 2015). Based on this, the empirical normalization method, which allows the series to be scaled between 0-1, was used (Karagöl and Doğan, 2021). In the empirical normalization method, the values of the series are calculated with the following equation:

$$A_i^n = \frac{A_i - A_{min}}{A_{max} - A_{min}} \quad (1)$$

In Equation 2, A^n represents the normalized observation, A_i represents the relevant observation, A_{min} represents the minimum observation of the relevant variable, and A_{max} represents the maximum observation. After the series are normalized, the variables must be weighted to create the index. In the literature, methods include equal weighting (1/3), correlation coefficient with output gap, or weighting with inverse variance. However, the inverse variance weighting method proposed in the study of Ma and Zhang (2016) was used in this study. Here, each variable is weighted inversely proportional to its volatility. This means that the weight assigned to each variable reflects its relative stability throughout the sample period, i.e., a higher weight is assigned to a relatively more stable variable and is calculated with the following formula:

$$w_i = \frac{1}{\sigma_i^2} / \sum_i \frac{1}{\sigma_i^2} \quad (2)$$

where w_i is the weight of the variable, σ_i is the variable's standard deviation. Based on this, the calculated weights of each indicator are given in Table 1.

Table 1. Calculated Weights for Financial Cycle

Variable	Normalized Value	Weight
VNBS	23.88491	0,40
VNHPI	12.99895	0,22
VNBIST	22.45751	0,38
Total	59.34137	1,00

When the model is estimated with OLS, it is seen that the housing price index coefficient has a negative sign, and when calculating the cycle index, it will be assumed that the variable affects the cycle negatively. Similarly, the literature shows that real declines in housing prices lead to credit contraction in the banking sector, deterioration in balance sheets, and financial

tightening, thus deepening the contraction phases of financial cycles (Claessens et al., 2012; Borio, 2014). Based on this, the weight vector calculated will be as follows:

$$w_i = [0.40, -0.22, 0.38] \quad (3)$$

After the FC was created, the HP filter was used to analyze better the periods of contraction and expansion in the series. The HP filter identifies excessive variability in margins (Bloechl, 2014). Hodrick and Prescott (1997) stated that the optimization problem should also be solved when separating the trend and cycle components in a time series:

$$\min_{(g_t)_{t=-1}} \left\{ \sum_{t=1}^T c_t^2 + \beta \sum_{t=1}^T [(g_t - g_{t-1}) - (g_{t-1} - g_{t-2})]^2 \right\} \quad (4)$$

where g_t represents the trend component, c_t represents the cycle component, and β represents the smoothing parameter. The graph of the financial cycle series, which is detrended with the help of the HP filter, is given in Figure 2.

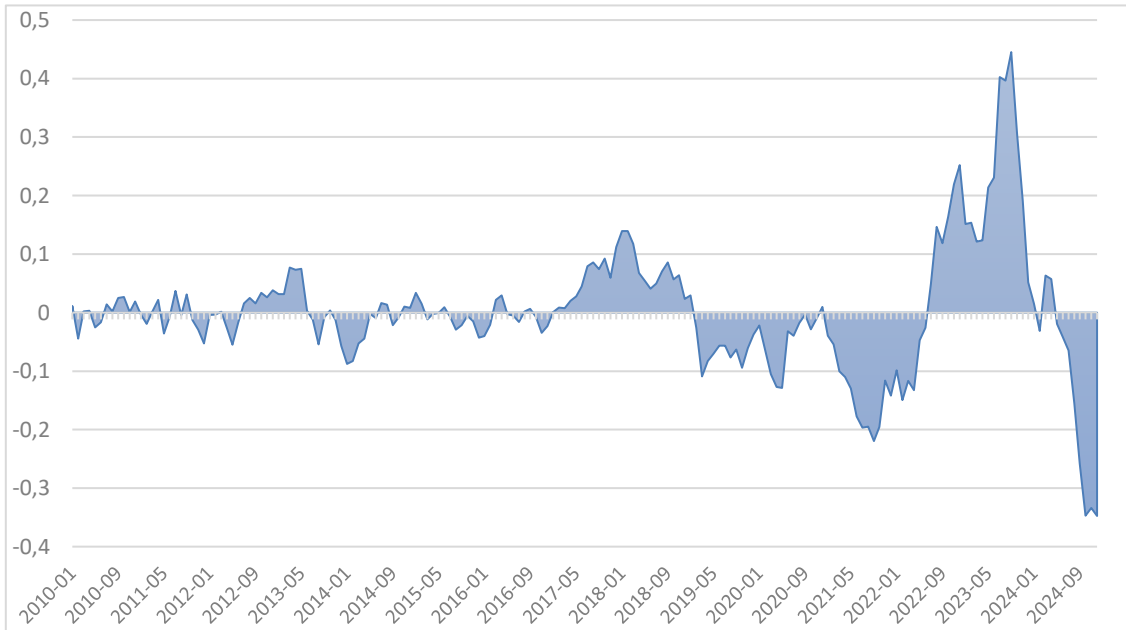


Figure 2. Financial Cycle Index

The financial cycle index (FC), shown in Figure 2, provides important information about the course of credit volume, asset prices, and general financial conditions in the Turkish economy. The time series graph of the index reveals remarkable dynamics regarding the direction and strength of the financial cycle from the beginning of 2010 to the end of 2024. A value above zero in the index represents periods of financial expansion, while a value below zero represents periods of financial contraction. Financial cycles experienced more limited fluctuations until 2016 due to the recovery effects after the global financial crisis. In 2017, the financial cycle entered the positive zone and gave expansion signals. This period is consistent with the credit growth supported by the Credit Guarantee Fund implemented in 2017. However, this expansion was short-lived, and by the middle of 2018, the FC had rapidly turned negative. The exchange rate shock experienced in the summer of 2018 (especially the sharp increase in

USD/TRY) and the subsequent financial fragilities, interest rate hikes, and credit crunch caused the financial cycle to sharply contract. The economic uncertainty created by the COVID-19 pandemic in 2020 and the foreign exchange reserve losses and exchange rate pass-through in 2021 contributed to the continuation of this contraction. The index has moved into strong positive territory since mid-2022. This expansion, which peaked in early 2023, was shaped by the impact of various fiscal and monetary expansion tools, primarily subsidized loans provided through public banks. At the same time, keeping the policy rate low, facilitating access to credit, and pre-election fiscal expansion supported this process. Tight monetary policy practices that began in the second half of 2023, successive increases in policy rates, and the slowdown in credit expansion caused the index to contract again. At the same time, increasing borrowing costs reduced the credit demand of households and firms and increased the perception of risk in the financial system. This period is an important indicator that financial cycles in Türkiye have become quite sensitive and fragile.

3.2. Methodology

The main reason for choosing the frequency domain asymmetric causality method in this study is the assumption that the effect of EPU on financial cycles may vary depending on the time scale (short, medium, long term) and the shock direction (positive/negative shocks). Traditional time series methods can only measure the average effects of such relationships (Geweke, 1982; Hosoya, 1991). Although the Toda–Yamamoto (1995) causality test can detect a general causality relationship without being sensitive to the integration degrees of the variables, it cannot distinguish which dynamics the effects occur over in the short, medium, or long term. Unlike traditional Granger causality tests, this method provides diverse information about the timing and severity of the effects for policymakers. The primary method used in this study, which investigates the relationship between the financial cycle and the Turkish economic uncertainty index, is the frequency domain causality test of Breitung and Candelon (2006). This causality test, unlike standard time series causality tests, can separate short-, medium- and long-term causality between variables, and has been used recently both when examining the relationship between cycles and in many other macroeconomic models (Bozoklu and Yilanci, 2013; Gomez-Gonzalez et al., 2015; Strohsal et al., 2019; Kırca and Canbay, 2021). The frequency domain causality test of Breitung and Candelon (2006) allows us to determine whether the relationship between two variables is permanent or temporary.

Breitung and Candelon (2006) extended the Wald test procedure of Geweke (1982), which imposes correct restrictions on the coefficients to test Granger causality in a specific frequency range, to a two-variable VAR model. Since this test is based on VAR models, it is used when the variables are stationary. If the variables are $I(0)$, the VAR(p) model determines the appropriate lag. However, if the variables are not stationary, the maximum degree of cointegration of the variables (d_{max}) is determined here, and the appropriate lag is VAR(p+ d_{max}). A restricted VAR model for the frequency domain causality test can be defined as follows:

$$\begin{aligned} Y_t &= \phi_{21,1}Y_{t-1} + \phi_{21,2}Y_{t-2}, \dots, + \phi_{21,p}Y_{t-p} + \phi_{22,1}X_{t-1} + \phi_{22,2}X_{t-2}, \dots, + \phi_{22,p}X_{t-p} \\ X_t &= \phi_{11,1}Y_{t-1} + \phi_{11,2}Y_{t-2}, \dots, + \phi_{11,p}Y_{t-p} + \phi_{12,1}X_{t-1} + \phi_{12,2}X_{t-2}, \dots, + \phi_{12,p}X_{t-p} \end{aligned} \quad (5)$$

If we want to express this model in matrix form with the lag operator (L):

$$\phi(L) = \begin{pmatrix} Y_t \\ X_t \end{pmatrix} = \begin{pmatrix} \phi_{11}(L) & \phi_{12}(L) \\ \phi_{21}(L) & \phi_{22}(L) \end{pmatrix} \begin{pmatrix} X_t \\ Y_t \end{pmatrix} = \begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{pmatrix} \quad (6)$$

where, $\phi(L) = I - \phi_1 L - \phi_2 L^2 - \dots - \phi_p L^p$ is the 2x2 delay polynomial and ε_{1t} and ε_{2t} are the error terms including white noise.

$$\begin{pmatrix} Y_t \\ X_t \end{pmatrix} = \Psi(L)\eta_t = \begin{pmatrix} \Psi_{11}(L) & \Psi_{12}(L) \\ \Psi_{21}(L) & \Psi_{22}(L) \end{pmatrix} \begin{pmatrix} \eta_{1t} \\ \eta_{2t} \end{pmatrix} \quad (7)$$

In Equation 7, $\Psi(L) = \phi(L)^{-1}G^{-1}$ is expressed as $\eta_t = G\varepsilon_t$. G represents the lower triangular matrix. Y_t is the sum of two components: real and prediction. The predictive power of X_t is calculated by comparing the spectrum of the real component with the prediction component at each frequency (Bozoklu and Yılandı, 2013). The measurement of causality proposed by Geweke (1982) is defined as follows:

$$M_{X \rightarrow Y}(\omega) = \log \left[1 + \frac{|\Psi_{12}(e^{-i\omega})|^2}{|\Psi_{11}(e^{-i\omega})|^2} \right] \quad (8)$$

Under the condition $\Psi_{12}(e^{-i\omega}) = 0$, Equation 8 equals zero. It is stated that Y_t does not Granger cause X_t at frequency ω . Breitung and Candelon (2006) are based on the following linear constraints:

$$\sum_{j=1}^p \phi_{12j} \cos(j\omega) = 0 \quad (9)$$

$$\sum_{j=1}^p \phi_{12j} \sin(j\omega) = 0 \quad (10)$$

As a result of the test, test statistics are calculated using the Wald-F test at each ω frequency value. The hypotheses for each frequency are as follows:

$$H_0: R(\omega)\beta = 0 \text{ and } R(\omega) = \begin{pmatrix} \cos(\omega) & \cos(2\omega) & \dots & \cos(p\omega) \\ \sin(\omega) & \sin(2\omega) & \dots & \sin(p\omega) \end{pmatrix} \quad (11)$$

When testing the H_0 hypothesis, if the probability values of the test statistics are less than 10%, 5%, and 1%, the null hypothesis is rejected. Three different test statistics are used to determine whether the causal relationships between variables are significant in the long, medium, and short term. A significant probability value of ω at a frequency of 0.5 indicates long-term causality, a significant probability value of 1.5 indicates medium-term causality, and a significant probability value at a frequency of 2.5 indicates short-term causality (Ciner, 2011). Long-term causality generally indicates a permanent relationship, whereas short-term causality reflects a temporary association. Furthermore, based on the statistically significant frequency values, the duration over which the relationship between the variables persists can be calculated using the formula $2\pi/\omega$ (Tastan, 2015).

The methodology described above represents a symmetric frequency domain causality relationship. However, the relationship between variables may not always be symmetric. Traditional causality tests grounded in the assumption of symmetry do not differentiate between the impacts of positive and negative shocks (Bahmani-Oskooee et al., 2019). However, as Hatemi-J (2019) highlights, participants in financial markets tend to respond more strongly to

negative news than to positive developments. Ranjbar et al. (2017) developed the asymmetric frequency domain causality test, which considers the relationships at different frequencies of positive and negative shocks of variables. Based on this, the study has also tested whether variables have an asymmetric causality relationship. A causality test used the variables' positive and negative components (cumulative shocks).

Positive and negative shocks in the variables are defined as in Equation 12 (Hatemi-J, 2012):

$$\begin{aligned}\epsilon_{1t}^+ &= \max(\epsilon_{1t}, 0), \epsilon_{2t}^+ = \max(\epsilon_{2t}, 0) \rightarrow \text{positive shocks of both variables} \\ \epsilon_{1t}^- &= \min(\epsilon_{1t}, 0), \epsilon_{2t}^- = \min(\epsilon_{2t}, 0) \rightarrow \text{negative shocks of both variables}\end{aligned}\quad (12)$$

Hatemi-J (2012) assumes the causal relationship between positive and negative shocks operates similarly at all frequencies. However, Granger (1969) pointed out that the causality between two variables may exhibit different characteristics at different frequency components of the time series. Based on this approach, Bahmani-Oskooee et al. (2019) adapted Hatemi-J's asymmetric causality test in the time domain to the frequency domain. Based on this, if we rearrange Equation 6 to include positive and negative components:

$$\phi(L) = \begin{pmatrix} Y_t \\ X_t \end{pmatrix} = \begin{pmatrix} \phi_{11}(L) & \phi_{12}(L) \\ \phi_{21}(L) & \phi_{22}(L) \end{pmatrix} \begin{pmatrix} X_t^{+,-} \\ Y_t^{+,-} \end{pmatrix} = \begin{pmatrix} \epsilon_{1t} \\ \epsilon_{2t} \end{pmatrix}\quad (13)$$

There are four different combinations of positive and negative shocks, and all of them will be discussed in the study (X_t^+, Y_t^+ ; X_t^+, Y_t^- ; X_t^-, Y_t^+ ; X_t^-, Y_t^-).

4. Results

First, Breitung and Candelon (2006) applied symmetric and asymmetric causality tests to the Türkiye economic uncertainty index and financial cycle series. However, to perform the causality test in the frequency domain, firstly, the stationarity levels of the variables should be examined and the maximum lag length (d_{max}) should be determined. For this purpose, traditional unit root tests such as the Augmented Dickey-Fuller (ADF) developed by Said and Dickey (1984) and the structural break unit root test developed by Perron (1989) and Perron and Vogelsang (1992) are used in the study. Although classical unit root tests were developed under the assumption of linearity, they are generally robust to minor nonlinear deviations, especially in macroeconomic time series (Enders, 2015; Hamilton, 2020). In addition, studies such as Caner and Kilian (2001) and Glynn et al. (2007) indicate that unit root tests can produce meaningful results in practical applications even when the linearity assumption is violated. For this reason, unit root tests were performed directly on the series without performing a linearity analysis (Table 2).

Table 2. Unit Root Test Results

Variable	ADF Test	Breakpoint Test
TEUI	-6.0480*** (0.0000)	-10.0602*** (<0.01)- Break Date: 2022M04
FC	-3.2597** (0.0183)	-4.3043* (0.0739)- Break Date: 2024M01
TEUI ⁺	-0.2638 (0.9264)	-2.3840 (0.9289)- Break Date: 2019M03
ΔTEUI ⁺	-14.7264*** (0.0000)	-16.1705*** (<0.01) Break Date: 2020M03
TEUI ⁻	-0.5054 (0.8861)	-2.6666 (0.8434)- Break Date: 2019M05
ΔTEUI ⁻	-15.5530*** (0.0000)	-17.5639*** (<0.01)- Break Date: 2022M05
FC ⁺	1.8730 (0.9998)	-2.0325 (0.9808)- Break Date: 2021M10
ΔFC ⁺	-7.2418*** (0.0000)	-15.2750*** (<0.01)- Break Date: 2023M07
FC ⁻	3.1536 (1.0000)	-0.1468 (>0.99)- Break Date: 2023M08
ΔFC ⁻	-9.6097*** (0.0000)	-11.7335*** (<0.01)- Break Date: 2023M07

Note: ***, **, and * indicates stationarity with a 1%, 5%, and 10% level of statistical significance, respectively. The values in parentheses indicate probability values. Δ is the difference operator.

The financial cycle series becomes stationary because it is detrended with the HP filter (Gomez-Gonzalez et al., 2015). In addition, the Türkiye economic uncertainty index, which is not separated into its components, is also stationary at the level value. In order to perform asymmetric tests, the series were separated into positive and negative components. As a result of the unit root tests, it was seen that all variables separated into their components became stationary at the first difference. Then, the appropriate VAR(p) model with the variables was determined using the Akaike Information Criterion (AIC), as indicated by Breitung and Candelon (2006). The symmetric and asymmetric causality test results in the frequency domain obtained based on the stationarity and VAR(p) values determined for each model are given in Table 3 and Table 4.

Table 3. Symmetric Causality Test Findings in the Frequency Domain

H ₀ Hypothesis	Long Term ($\omega=0.5$)	Mid- Term ($\omega=1.5$)	Short Term ($\omega=2.5$)	Var (p+d _{max})
	T-stat. (Prob.)	T-stat. (Prob.)	T-stat. (Prob.)	
TEUI $\rightarrow$ FC	2.9422 (0.2296)	4.4898 (0.1059)	5.0135 (0.0815)	4
FC $\rightarrow$ TEUI	0.5111 (0.7744)	2.7394 (0.2541)	5.4068 (0.0669)	4

Table 3 summarizes the findings of the symmetric causality test in the frequency domain. According to the findings of this test, there is a significant causality at the 10% level, both from EPU to the financial cycle and from the financial cycle to EPU in the short term. Although there seems to be a two-way causality relationship in the short term, this causality is relatively weak at the 10% level. This shows that the relationship between uncertainty and the financial cycle is limited to short-term market reactions. For example, policy uncertainty increases during election periods or sudden political developments in Türkiye, leading to temporary fluctuations in stock and credit markets. However, such effects do not create a permanent financial cycle change, and market conditions can quickly normalize when the shocks are overcome. Similarly, short-term fluctuations in financial markets (such as sudden exchange rate shocks or stock market volatility) can also lead to temporary increases in uncertainty in policymakers' decision-making processes. However, such effects are generally weak and short-lived because they do not

permanently change macroeconomic fundamentals. In this context, the weak causality found to be significant at the 10% level reflects the short-term, fragile, and temporary interactions between financial cycles and EPU.

Table 4. Asymmetric Causality Test Findings in the Frequency Domain

H₀ Hypothesis	Long Term ($\omega=0.5$)	Mid- Term ($\omega=1.5$)	Short Term ($\omega=2.5$)	Var ($p+d_{\max}$)
	T-stat. (Prob.)	T-stat. (Prob.)	T-stat. (Prob.)	
TEUI ⁺ $\rightarrow$ FC ⁺	2.2378 (0.3266)	0.7359 (0.6921)	1.1841 (0.5531)	3
TEUI ⁺ $\rightarrow$ FC ⁻	0.4655 (0.7923)	1.6680 (0.4343)	0.9570 (0.6196)	5
TEUI ⁻ $\rightarrow$ FC ⁻	2.1967 (0.3334)	2.1669 (0.3384)	2.1965 (0.3334)	3
TEUI ⁻ $\rightarrow$ FC ⁺	17.3254 (0.0001)***	24.9998 (0.0000)***	9.9019 (0.0007)***	4
FC ⁺ $\rightarrow$ TEUI ⁺	0.2500 (0.8824)	0.3137 (0.8548)	0.3146 (0.8544)	3
FC ⁺ $\rightarrow$ TEUI ⁻	2.2106 (0.3310)	1.9647 (0.3744)	3.4531 (0.1778)	5
FC ⁻ $\rightarrow$ TEUI ⁻	0.3748 (0.8290)	0.6053 (0.7388)	0.7856 (0.6751)	3
FC ⁻ $\rightarrow$ TEUI ⁺	0.3095 (0.8566)	2.9193 (0.2323)	6.0354 (0.0488)**	4

Notes: ***, **, and * indicates significance level at 1%, 5%, and 10%, respectively.

Table 4 shows the findings of the asymmetric causality test in the frequency domain. Although there are many findings between the different components of the variables, two important findings stand out. The first is the short-, medium-, and long-term causal relationship from the negative component of the Turkish economic uncertainty index to the positive component of the financial cycle. The negative component of TEUI represents the decreases in EPU, while the positive component of the financial cycle represents the expansion (revival) periods of the financial cycle. As EPU decreases, i.e., as markets become more predictable and stable, it is seen that the financial cycle accelerates in the direction of expansion. It can be said that the market responds quickly to the decrease in short-term uncertainty (e.g., the stock market rises, credit conditions loosen). In the medium term, the recovery in the financial system continues. Investments increase, and the credit market expands. In the long term, there is a more permanent financial expansion; capital markets are deepening, and asset prices may increase permanently. All these results show that the decrease in uncertainty in the Turkish economy triggers financial recovery and that this effect is temporary in the short term and may be permanent in the long term. It not only creates temporary optimism in financial markets but also initiates a cyclical expansion trend. The second important finding is the existence of short-term causality from the negative component of the financial cycle to the positive component of TEUI. Periods of financial contraction led to increased EPU in the short term. When there is a deterioration in the financial system, market pressure occurs, exchange rates fluctuate, stock markets fall, and CDS premiums increase. This leads to increased economic uncertainty.

The reduction of EPU in Türkiye not only creates positive expectations in the market but is also a determining factor in medium- and long-term financial expansion. The findings

obtained in this study show that the expansionary tendency in financial cycles strengthens in periods when EPU decreases, and this effect is not limited to the short term but spreads to the medium and long term. This result is consistent with the findings of Liu et al. (2023) in their study on the Chinese economy, which indicated that the relationship between uncertainty and financial cycles becomes especially evident during crisis periods. Similarly, the findings of Popp and Zhang (2016) and Alessandri and Mumtaz (2019) in their regime-based analyses that uncertainty shocks create stronger effects, especially during financial recession periods, have also been observed in the case of Türkiye through asymmetric causality. In this context, the reduction of uncertainty not only creates a temporary market morale but also initiates a more permanent financial expansion process by activating investment and credit mechanisms. Therefore, how EPU affects financial cycles in Türkiye overlaps with the nonlinear, regime-dependent, and frequency-based approaches suggested in the literature.

When the study's findings and their comparison with the studies in the literature are evaluated, Türkiye's financial system has a more limited financial depth compared to large-scale emerging markets such as China. Türkiye has a more fragile structure in terms of the share of the banking sector in GDP, the depth of capital markets, and the diversity of alternative financing instruments. This situation causes financial cycles to respond more sensitively and immediately to policy uncertainty shocks. In addition, since the predictability level of monetary and fiscal policies in Türkiye is relatively low, market actors can give shorter-term and volatile responses to policy changes. In contrast, in economies such as China, the power of central authorities to intervene in financial markets is higher, and the effects of uncertainty shocks are felt in a more controlled and time-spread manner. These differences necessitate that the findings obtained in the study be evaluated initially in the context of Türkiye. The two-way but weak effect of EPU on financial cycles in Türkiye in the short-term points to the sensitivity of markets to shocks and the relative fragility of the financial system. On the other hand, the finding that the decrease in uncertainty supports financial expansion in the medium and long term shows that financial cycles gain stability when the uncertainty environment is permanently improved. In this respect, the findings in Türkiye support the non-linear and frequency-based relationship suggested in the literature and provide important clues about how country-specific conditions shape financial cycle dynamics.

In addition, when the significant frequencies are examined, it is seen that $\omega \in (0-2.5)$. Here, using the $2\pi/\omega$ formula, it is calculated that a shock occurring in the economic uncertainty of Türkiye affects financial cycles over 2.51 months ($2\pi/2.5$).

5. Conclusion

In this study, the effect of the Turkish economic policy uncertainty index (TEUI) on financial cycles was analyzed with both symmetric and asymmetric frequency domain causality tests for the period 2010:01-2024:12. The findings revealed that there is a significant but asymmetric relationship between TEUI and financial cycles in time and frequency dimensions. It was determined that decreases in economic uncertainty positively affect financial cycles, and that this effect is not limited to the short term but spreads to the medium and long term. On the other hand, it was observed that periods of financial contraction cause economic uncertainty to increase in the short term. This bidirectional and asymmetric relationship shows a dynamic and complex interaction between policy uncertainty and financial cycles.

Based on this, it is observed that reducing economic uncertainties not only creates short-term market confidence but also brings about a permanent improvement in financial cycles. Therefore, implementing economic policies within a transparent, predictable, and consistent framework is critical for the sustainability of financial stability. The findings show policymakers' uncertainty-reducing discourses can be effective during financial contraction periods. In this context, the clear messages that the economic management gives to the market in times of crisis will prevent possible panic and speculative movements. While excessive risk appetite and asset bubbles may occur during expansion periods of financial cycles, credit tightening and liquidity problems emerge during contraction periods. Therefore, macroprudential tools such as credit growth, capital buffers, and liquidity ratios should be used proactively in order to limit fluctuations caused by uncertainty. The Central Bank should plan liquidity management simultaneously with early warning systems based on the uncertainty index. In addition, the TEUI used in the study offers a significant advantage in capturing country-specific dynamics. The more effective use of this index by economic management, financial analysts, and investors in decision-making processes will contribute to better management of uncertainty-related risks.

Although this study has important contributions, the analysis is focused only on the Turkish economy; therefore, the generalizability of the findings is limited. Conducting similar analyses in countries with different institutional structures and financial depths can contribute to the comparative evaluation of the results. Additionally, future studies would benefit from a more component-based analysis, examining the separate effects of different components of financial cycles, such as the housing market, stock market, and credit market.

Declaration of Research and Publication Ethics

This study which does not require ethics committee approval and/or legal/specific permission complies with the research and publication ethics.

Researcher's Contribution Rate Statement

I am a single author of this paper. My contribution is 100%.

Declaration of Researcher's Conflict of Interest

There is no potential conflicts of interest in this study.

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THE ROLE OF CAPITAL FLOWS IN THE INTERNATIONAL TRANSMISSION OF US MONETARY POLICY: THE CASE OF TURKEY*

ABD Para Politikasının Uluslararası Aktarımında Sermaye Akımlarının Rolü: Türkiye Örneđi

Nuri Çađrı AKAR** & Cemil VARLIK***

Abstract

This article aims to examine the impacts of US monetary policy (MP) changes on the Turkish economy. A Structural Vector Autoregressive (SVAR) model is estimated for the period 2002:01–2017:12, during which a flexible exchange rate regime was adopted in the Turkish economy. According to the impulse-response analysis, the Turkish interest rate responds positively and significantly to the US Effective Federal Funds Rate (EFFR). This result shows that the Central Bank of the Republic of Turkey's (CBRT) MP follows the FED's MP, consistent with the dilemma hypothesis of Rey (2015). The analysis also demonstrates that both the EFFR and the VIX have a negative impact on net total capital inflows to the Turkish economy. The impulse-responses for the three components of net capital inflows indicate important conclusions. Firstly, neither EFFR nor VIX has a significant impact on Net Foreign Direct Investment (NFDI) inflows. Secondly, Net Portfolio Investments (NPI) respond significantly to the VIX but not to the EFFR. Thirdly, Net Other Investments (NOI) respond significantly to the EFFR but not to the VIX. These findings indicate that the NOI component plays a direct and major role in the emergence of the US MP's spillover effects on the Turkish MP.

Öz

Bu makale, ABD para politikasındaki deđişikliklerin Türkiye ekonomisi üzerindeki etkilerini incelemeyi amaçlamaktadır. Türkiye ekonomisinde esnek döviz kuru rejiminin benimsendiđi 2002:01–2017:12 dönemi için bir Yapısal Vektör Otoregresif (SVAR) model tahmin edilmektedir. Etki-tepki analizine göre, Türkiye faiz oranı, ABD Efektif Federal Fon Oranı'na (EFFR) pozitif ve anlamlı şekilde tepki vermektedir. Bu sonuç, Rey'in (2015) ikili açmaz hipoteziyle tutarlı biçimde, Türkiye Cumhuriyet Merkez Bankası'nın (TCMB) para politikasının FED'in para politikasını takip ettiđini göstermektedir. Analiz aynı zamanda hem EFFR'nin hem de VIX'in Türkiye ekonomisine yönelik net toplam sermaye girişleri üzerinde negatif etkiye sahip olduđunu kanıtlamaktadır. Net sermaye girişlerinin üç bileşeni için elde edilen etki-tepkiler, önemli sonuçlara işaret etmektedir. İlk olarak ne EFFR'nin ne de VIX'in Net Yabancı Doğrudan Yatırım (NFDI) girişleri üzerinde anlamlı bir etkisi bulunmamaktadır. İkinci olarak, Net Portföy Yatırımlarının (NPI) VIX'e tepkisi anlamlı iken, EFFR'ye tepkisi anlamlı değildir. Üçüncüsü, Net Diğer Yatırımların (NOI) EFFR'ye tepkisi anlamlı iken, VIX'e tepkisi anlamlı değildir. Bu bulgular, ABD para politikasının Türkiye para politikası üzerindeki yayılma etkilerinin ortaya çıkmasında, NOI bileşeninin doğrudan ve önemli bir rol oynadıđını göstermektedir.

Keywords:

US Monetary Policy Spillovers, Capital Flows, Global Risk, International Risk-taking

JEL Codes:

E52, E58, F32, F42.

Anahtar

Kelimeler:

ABD Para Politikası Yayılımları, Sermaye Akımları, Küresel Risk, Uluslararası Risk-alma

JEL Kodları:

E52, E58, F32, F42.

* This study is derived from the PhD thesis titled “Can Capital Control Be a Solution in the Light of the Discussions on the Modern Version of the Trilemma?: The Case of Türkiye” and presented at Gazi University, Ankara.

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1. Introduction

After the 2008 Global Financial Crisis, discussions on the effects of center countries' MP practices on the economic variables and MPs of peripheral countries have gained momentum. In this context, Rey (2015) argued that in an environment where international capital moves freely, MP in Emerging Market Economies (EMEs) is dependent on US MP even under a flexible exchange rate regime and claimed that the traditional open economy policy trilemma has turned into a dilemma. Accordingly, a change in US MP leads to a change in international risk perception, shaping a Global Financial Cycle (GFCy) in asset prices, credits, and capital flows. According to Rey (2015), the VIX index, which is an indicator of global risk and uncertainty, exhibits a high correlation with the GFCy. Therefore, US MP is accepted as one of the determinants of the GFCy (Kalemli-Özcan, 2019; Miranda-Agrippino and Rey, 2020). An expansionary MP that leads to a decrease in the Federal Funds Rate (FFR) in the US economy causes a decrease in global risk perception (i.e., a decrease in the VIX). As a result, there is a rise in capital inflows to EMEs. These capital inflows cause credit expansion and local currency appreciation in EMEs (Gourinchas and Obstfeld, 2012), while they feed domestic asset price bubbles and create risks that threaten financial stability (Ferrero et al., 2022). In order to avoid the negative impact of excessive real appreciation of the local currency on the export sector, foreign exchange market interventions are seen in EMEs. In addition, the potential for increased capital inflows to lead to excessive debt and overheating in the economy is also among the reasons for foreign exchange market interventions (Kalemli-Özcan, 2019). Therefore, monetary expansion (and a decrease in interest rates) occurs as a result of foreign exchange interventions made for the reasons mentioned above in EMEs. A contractionary MP that leads to a rise in the FFR in the US economy causes capital outflows from EMEs and pressures for local currency depreciation. In EMEs where domestic liability dollarization is high, monetary authorities may intervene in the foreign exchange market (with fear of floating) to avoid the potential damage that local currency depreciation would inflict on the balance sheets of indebted economic units (Calvo and Reinhart, 2002). As a result, the domestic economy experiences monetary contraction (and an increase in interest rates). The processes described above reveal that MP in EMEs tends to follow US MP.

This study addresses the hypothesis that the international risk-taking channel plays an important role in the transmission of the effects of US MP on the MP of the Turkish economy. Borio and Zhu (2012) state that risk perception has a role in the transmission of MP in a closed economy. Accordingly, local MP affects financial conditions and the real economy by changing investors' willingness to take risks. This mechanism is defined by the authors as the risk-taking channel of MP. On the other hand, the transmission of US MP between countries by affecting the risk appetite of international investors is called the international risk-taking channel (Yıldırım, 2022). Bruno and Shin (2015a) explain the international risk-taking channel with a model in which regional banks, that borrow in USD from global banks, lend to local borrowers. The spread between the local loan rate and the USD financing rate rises in this context as the US interest rate declines. As a result, recipient economies experience a loosening of credit standards and an acceleration of bank capital flows. This lowers the dollar funding cost. According to this model, a loosening of US MP will lead to increased cross-border liabilities and, via the bank leverage channel, will have a spillover effect on global financial conditions. Bruno and Shin (2015b) provide evidence supporting the international risk-taking channel by demonstrating that an increase in FFR causes a decrease in banking flows and international bank leverage. Jordà et

al. (2019) show that the co-movement in global stock markets has increased sharply over the last three decades and that fluctuations in risk premiums explain a large part of this synchronization in stocks. They state that this situation can be explained by the prominent role played by leveraged financial intermediaries and international banks in the global economy. The authors also prove that the US MP has been a significant source of risk perception fluctuations in global stock markets in recent years. They argue that these fluctuations are transmitted to economies regardless of exchange rate regimes and that this finding is suggestive proof that MP in the center economy triggers fluctuations in risk appetite that appear independent of local monetary conditions. Kalemli-Özcan (2019) argues that the international risk spillover channel of MP is generally effective in EMEs where local banks intermediate capital flows. Accordingly, when US interest rates and global risks are low, domestic banks in EMEs borrow more cheaply from global markets, and then provide loans to domestic firms and households more cheaply. In this environment where capital inflows to the country increase, banks' low funding costs transform into low borrowing costs for domestic economic units. When US interest rates and global risk perception increase, banks are forced to provide less credit due to capital outflows from the country, which means an increase in the borrowing costs of domestic economic units. This process results in policy spillovers between the US and EMEs. Miranda-Agrippino and Rey (2020) prove how US monetary contractions cause global credit flows to sharply reduce, international financial intermediaries' leverage to decrease, domestic credit levels globally to shrink, and external financial conditions to tighten. The authors note that countries with flexible exchange rates are also disposed to the same spillovers. Morais et al. (2019) demonstrate that lower interest rates and quantitative easing in high-income countries (US, UK, and Eurozone) lead international banks to enhance the supply of credit in EMEs to get more returns.

This study aims to investigate the effects of US MP changes on Turkey's MP practices and the transmission channels of these effects. For this purpose, a Structural Vector Autoregressive (SVAR) model is estimated for the period 2002:01-2017:12, in which the flexible exchange rate regime was implemented in the Turkish economy. The data set after 2017 was not included in order to avoid deviations in the analysis due to the foreign exchange rate shock experienced in the country in 2018 and, accordingly, the resulting changing monetary policies. The following topics will be examined using the model. First, it is investigated whether changes in the FFR, which is an indicator of FED MP, have an effect on the MP of the Turkish economy. According to the estimation results in this article, the Turkish interest rate responds positively to an increase in the FFR. This result indicates a finding supporting the dilemma hypothesis and shows that there is a transmission mechanism that allows changes in US MP to spread to the Turkish economy. Second, it is questioned whether capital flows play a role in the transmission of changes in US MP and VIX to the Turkish economy. Eller et al. (2020) demonstrate how changes in the GFCy have a significant impact on changes in capital flows that are country-specific. In contrast, Cerutti et al. (2019a) state that although the common movement in capital flows focuses on bank, portfolio debt, and portfolio equity flows, global conditions do not affect all EMEs in a similar way. Cerutti et al. (2019b) find that changes in the GFCy have little explanatory power on the changes in capital flows. The estimation results of the model in this article prove that both the FFR and the VIX significantly affect total capital inflows to the Turkish economy. Therefore, it is understood that capital inflows play a role in the spillover mechanism created by the US MP on the Turkish economy. Third, it investigates

which components of capital inflows play an important role in the transmission of the effects of the FED MP on the Turkish economy. Avdjiev et al. (2018) emphasize that when investigating the relationship between international capital flows and global factors, it is necessary to distinguish between the different components of these flows. Habib and Venditti (2019) examine the transmission of changes in global risk to different components of capital flows. They prove that the effects of global risk on the domestic economy are mainly transmitted through the other investment component. There are few studies in the literature on the relative importance of the components of capital flows in the international transmission of US MP. It is expected that this article will contribute to this relatively less studied aspect of the literature. The empirical findings reached in this article highlight the role of the other investments component in the transmission of the spillover effects created by changes in the FFR on the Turkish economy.

The structure of the article is as follows. Section 2 presents a literature review, which includes Pull/Push Drives of Capital Flows, Discussions on Dilemma/Trilemma, and Spillover Effects of US Monetary Policy. Section 3 describes the empirical model of the analysis, which is SVAR, explanations of the data, and ordering of the variables. Section 4 has interpretations of Impulse-Response and Variance Decomposition Analyses’ findings. Finally, the last section concludes the article.

2. Literature Review

This study is related to three branches of literature: pull/push drivers of capital flows, discussions on dilemma versus trilemma, and spillovers of center countries’ monetary policies.

2.1. Pull/Push Drivers of Capital Flows

The first strand of literature related to this article investigates the push and pull factors that lead capital flows, pioneered by Calvo et al. (1993, 1996) and Fernandez-Arias (1996). While push factors reflect global conditions, pull factors refer to recipient country-specific conditions. Push factors in the literature include risk perception indicators such as VIX, indicators reflecting monetary conditions in core countries such as policy interest rate and global liquidity, and real activity indicators such as growth rate in center economies and commodity prices. Pull factors include domestic growth rate, asset return indicators, sovereign risk indicators, financial market depth, and institutional quality measures. The literature provides clear empirical proof on the role of push factors on international capital flows. Koepke (2019) conducted a qualitative meta-analysis with 34 empirical studies on the subject. As a result of the analysis, it is determined that the two push (global) factors that have the strongest effect on portfolio flows and banking flows are global risk perception and center country interest rates. Milesi-Ferretti and Tille (2011), Fratzscher (2012), Broner et al. (2013), Rey (2015), Ahmed and Zlate (2014), Ananchotikul and Zhang (2014) and Koepke (2018) discover a negative and significant effect of global risk perception on portfolio flows; while Fernandez-Arias (1996), Taylor and Sarno (1997), World Bank (1997), Chuhan et al. (1998), Montiel and Reinhart (1999), Baek (2006), Dahlhaus and Vasishtha (2014), Feroli et al. (2014), Koepke (2018) and Fratzscher et al. (2016) reach strong findings about a negative and significant effect of the center countries’ interest rates on portfolio flows. Studies that identify

strong evidence of a negative impact of global risk perception on banking flows include Jeanneau and Micu (2002), Ferrucci et al. (2004), Takats (2010), Milesi-Ferretti and Tille (2011), Rey (2015), Bruno and Shin (2015b), Herrmann and Mihaljek (2013) and Bruno and Shin (2015a). A few studies identify relatively weak evidence of a negative impact of center country interest rates on banking flows (Cerutti et al., 2014; Ghosh et al., 2014; Bruno and Shin, 2015b). Forbes and Warnock (2012) identify extreme movements in gross capital inflows and outflows and find that sudden stops (sharp decreases in gross capital inflows) and retrenchments (sharp decreases in gross capital outflows) accompany global factors, especially global risk changes. Scheubel et al. (2019) find that the GFCy has a significant effect on the probability of surges (sharp increases in gross capital inflows), sudden stops, and capital flight (sharp increases in gross capital outflows). CGFS (2021) states that the composition of capital flows shifted from banking flows to portfolio flows after the Global Crisis, and argues that this situation weakens the role of VIX in determining aggregate capital flows. In contrast, Buono et al. (2020) found that the VIX became more important for portfolio debt flows after the expectation of a decrease in quantitative easing in 2013. This article investigates the impact of two push factors (the US FFR and the VIX) on net capital inflows to the Turkish economy for the period under consideration.

2.2. Discussions on Dilemma/Trilemma

The second strand of literature related to this article addresses the debates on open economy policy impasses. The Mundellian trilemma hypothesis argues that it is impossible to have a fixed exchange rate, perfect capital mobility, and MP independence simultaneously; just two of these three can coexist (Obstfeld and Taylor, 1998). In contrast, Rey (2015) argues that in an environment where international capital moves freely, the Mundellian trilemma turns into a dilemma. Accordingly, in a globalized financial world with different capital flows and financial market imperfections, the MPs of the center countries can affect the monetary conditions and financial stability of other countries. A flexible exchange rate regime might not be enough in such a world to protect the local economy from outside influences and to provide the independence of MP (Rey, 2016). If the domestic policy rate does not closely follow it, it is often regarded as evidence of MP autonomy with respect to the center country. Additionally, the fact that the effect of the center country interest rate on domestic interest rates, especially in EMEs, depends on the applied exchange rate regime, is interpreted as the validity of the trilemma. When a fixed exchange rate regime is applied by an open economy, the country's MP is expected to be more affected by the US interest policies, while it is expected to be less affected in a flexible exchange rate regime. Accordingly, the autonomy of MP is higher in a flexible exchange rate. In a fixed exchange rate, MP becomes more dependent on the center country's MPs. On the other hand, the fact that center country interest policies, independent of the exchange rate regime, lead to effects that weaken the MP autonomy of EMEs is interpreted as the validity of the dilemma.

Obstfeld et al. (2019) show that global financial shocks are transmitted more to economies with fixed exchange rates than to those with relatively flexible rates, using panel data from 40 EMEs. Similarly, Habib and Venditti (2019) find that countries adopting a tight fixed exchange rate regime in an environment of financial openness are more sensitive to global risk with panel data from 50 countries. Georgiadis and Mehl (2015) find that under unrestricted

capital mobility, the preference of exchange rate regime is a determinant of monetary autonomy with a GVAR model using data from 61 developed and developing countries. Aizenman et al. (2016) prove that the implemented exchange rate regime affects the susceptibility degree to changes in financial circumstances or policies in core economies by using panel data from 100 countries. Herwartz and Roestel (2017) show that monetary autonomy decreases as exchange rate flexibility decreases in an environment of open capital accounts with panel data from 20 countries; Conversely, as exchange rate stability increases, the need to follow world interest rates and hence monetary dependence increases. Ligonniere (2018) shows that MP autonomy is lost in economies that are financially open and have a fixed exchange rate regime with a panel data set of 161 countries. Bekaert and Mehl (2019) find that the pass-through from the center country interest rate to local interest rates depends on the extent of global financial integration and the exchange rate regime applied, and that in a financially integrated environment, countries with flexible exchange rate regimes are exposed to much less pass-through than countries with fixed exchange rate regimes. Obstfeld et al. (2005), Goldberg (2013), Klein and Shambaugh (2015), and Obstfeld (2015) find that short-term interest rates are less correlated with the center country interest rate for countries with flexible exchange rates than for countries with fixed exchange rates. This situation is interpreted as the validity of the trilemma view.

On the other hand, Rey (2016) argues that the fact that policy rates or short-term interest rates are less correlated under flexible exchange rates is not sufficient to show that economies can have an independent MP by implementing flexible exchange rates. Rey (2015) uses VAR analysis to show that the MP of the center country affects the leverage ratios of global institutions in the international financial system, capital flows and credit growth, leading to GFCy; and that the GFCy affects the national MPs of the peripheral countries under capital mobility, independently of the exchange rate regime. Therefore, national MP remains dependent on global monetary conditions even under flexible exchange rates. Hofmann and Takats (2015) use panel data analysis to show that there is a spillover effect from the FFR to interest rates in EMEs and small developed economies under both fixed and flexible exchange rate regimes. Similarly, Edwards (2015) finds that in countries with flexible exchange rates and open capital accounts, FED policies affect domestic interest rates, and therefore these countries tend to import FED policies. Anaya et al. (2017) state that US monetary changes after the Global Crisis affected the MP stances of 19 EMEs, and that this finding is independent of the characteristics of the countries such as financial openness, institutional quality and exchange rate regime. Gülşen and Özmen (2020) show that local interest rates in both EMEs and advanced economies respond importantly to the center country interest rate and global financial conditions; however, the effect of foreign interest rates is greater in EMEs than in advanced economies. The findings of the study prove that exchange rate flexibility is ineffective in isolating countries' central bank policy actions against US MP, consistent with the dilemma view. Moreover, the findings prove that under flexible exchange rate regimes, the impact of FED interest rates has increased significantly in both EMEs and advanced economies after the Global Financial Crisis. Using a dynamic factor model and a global Bayesian VAR, Miranda-Agrippino and Rey (2020) demonstrate the significance of FED MP as one of the drivers of the GFCy. The results demonstrate that significant global financial intermediary deleveraging, a rise in overall risk aversion, a contraction of the global component of asset values and a decline in international credit, an expansion of corporate bond spreads, and a decline in gross capital flows occurred after the US experienced monetary contractions. They emphasized that these results also hold

for the economies with floating exchange rates. Estimating dynamic panel regressions for 26 small open economies with floating exchange rate regimes, Georgiadis and Zhu (2021) discover that even after adjusting for macroeconomic fundamentals, MP in these economies reacts to MP in base country. The authors discover that tighter base-country MP and foreign currency exposures resulting from debt instruments exacerbate the evidence for ‘fear of floating’ caused by concerns about financial stability. In short, the findings in all these studies may be interpreted as the validity of the dilemma.

There are also studies in the literature that conclude that the dilemma is partially valid. Han and Wei (2018) show with panel data of 28 countries that when the center country tightens its MP, flexible exchange rates provide monetary autonomy in peripheral countries, but when the center country loosens its MP, loose MPs are also implemented in peripheral countries due to fear of exchange rate appreciation. A similar result is found by Eterovic et al. (2022) using panel data of 21 countries implementing flexible exchange rate regimes. The authors prove that the spillover effects of the FED MP on other countries are larger in periods of FED interest rate cuts than in periods of interest rate increases. These results mean that the partial dilemma is valid. Another study that concludes that the dilemma is partially valid is Cheng and Rajan (2020), who conducted panel data analysis with data from 88 countries. However, unlike the previous two studies, this study shows that flexible exchange rates provide a degree of monetary autonomy for peripheral countries that do not implement capital controls when the center economy loosens its MP. It is also proven that when the center country implements a tight MP, peripheral countries also follow a tight MP due to fear of capital outflow or reserve loss. This study examines the effects of changes in the FFR on Turkey's monetary policy by focusing on the period during which a flexible exchange rate regime was implemented. The study reaches conclusions in favor of the dilemma that Turkey's MP was affected by the US MP under the floating exchange rate regime.

2.3. Spillover Effects of US Monetary Policy

The third strand of literature related to this article is related to the spillover effects of US MP on EMEs. There is a large body of literature on international MP shock transmission to EMEs. The literature shows that center country monetary shocks have spillovers on emerging countries' variables such as interest rates, equity prices, exchange rates, domestic credits, and capital flows. Akıncı and Queralto's (2018) two-country quantitative macroeconomic model shows how US MP shocks can have a significant effect on a number of variables in EMEs.

According to Dağlaroğlu et al. (2018), after 2010, the US MP and other global financial factor(s) have become remarkable influences on Turkey's MP. Their findings demonstrate how important global financial indicators like the VIX and EMBI have become when determining the short-term policy rate. Using SVAR methodology, Epstein et al. (2019) demonstrate that even though EME interest rates showed a strong on-impact rise in response to increased global financial risk, they followed the same trajectory as US interest rates as the increase in global financial risk subsided, persistently declining and remaining below the mean over the medium term. Degasperi et al. (2023) contend that following a US tightening, fragile five countries (Turkey, Brazil, South Africa, Chile, and Mexico) experience steep devaluations of the domestic currency, while interest rates spike up due to the response of the interest rate and the rise in risk premia.

Gilchrist et al. (2019) show that the US MP shock has a spillover effect on foreign bond yields. Hofmann et al. (2020) conclude that one key factor influencing investor risk-taking and, hence, EME domestic currency bond spreads is exchange rates. Their results show that when EME currencies appreciate relative to the dollar, the global investors' optimum portfolio choice under standard mean-variance preferences results in higher portfolio flows into EME local currency bond markets. Using the SVAR model, Bernoth and Herwartz (2021) find that sovereign risk rises when the local currency depreciates in relation to the US dollar and that the non-public sector's currency mismatch has an important role in the transmission of exchange rate shocks to country risk. Estimating the SVAR model with 4 inflation targeting EMEs (Turkey, Indonesia, Brazil and South Africa) data, Yıldırım (2022) finds that EME central banks tend to react in a procyclical manner to global financial risk shocks at first, as changes in sovereign risk and exchange rates pose a threat to financial stability by encouraging risk-taking behavior. The initial procyclical policy response can also be justified by examining the inflation patterns and the extent of liability dollarization. Gilchrist et al. (2022) discovered that there is a consistent and noteworthy influence of global financial risk on sovereign bond spreads through panel regressions and local projection analysis for 50 countries.

Gajewski et al. (2019) find that MP shocks in center countries are transmitted to the financial markets of small and open emerging countries (Chile, Korea, and Poland) through international banks. According to Schmidt et al. (2018), shifts in MP in center countries (US and UK) cause changes in the interest rate differential and credit availability in peripheral nations like France and Italy, which in turn cause changes in financial conditions and credit rationing in these peripheral countries. Using bank-level data from twelve Asian countries, Lee and Bowdler (2022) show that banks cut loan growth rates, and the interest rates charged on bank loans increase in response to an increase in the FFR. Di Giovanni et al. (2022) demonstrate that increased exposure of domestic banks to international capital markets allows them to transmit the GFCy locally. They also demonstrate that an improvement in international financial circumstances results in lower borrowing costs and a rise in domestic lending in Turkey.

Estimating a GVAR model, Tumala et al. (2021) demonstrate that the MP decisions of the US and China have a significant effect on the interest rates and exchange rates in Nigeria and South Africa. Dedola et al. (2017), using Bayesian VAR with 36 developed and EMEs, find that the majority of the sample countries experienced a depreciation against the dollar and a recession as a result of an unexpected tightening of US MP. According to Jordà et al. (2019), the US MP has been a significant factor in the fluctuations in risk appetite that have been observed in international equity markets. Dées and Galesi (2021), using the GVAR model for 33 countries' data, show that the US monetary easing triggers increases in international equity prices and surges of gross capital inflows in other countries.

Fratzscher et al. (2018) argued that the pro-cyclicality of capital flows to EMEs has been greatly aggravated by Fed policy measures, which magnify portfolio inflows during times when capital is already large and raise outflows even further during times when capital flees EMEs. According to Tian et al. (2022), a rise in the US interest rate results in a decrease in capital inflow to China, which has a negative spillover effect on the country's economy and lowers real output. Regarding the components of capital flows, Georgiadis and Jarociński (2023) find that US MP spillovers mostly affect global investors' risk perception and decrease portfolio inflows to EMEs through financial channels. Converse et al. (2020) find that in countries where exchange-traded funds hold a larger share of the equity market relative to mutual funds, global

financial conditions are more significantly sensitive to the total cross-border equity flows and returns. Their results mean that the rising role of exchange-traded funds as a channel for international capital flows has amplified the GFCy in EMEs.

In summary, the literature finds that capital movements have an important role in the transmission of US MP to other economies. However, the issue of which components of capital flows play a more important role in the transmission mechanism has been addressed less. This article investigates the role of different components of capital flows in the transmission of US monetary changes to the Turkish economy. Thus, it is expected that the article will contribute to a relatively less studied aspect of the literature.

3. Data and Methodology

3.1. Structural VAR Model

A reduced form VAR process is presented as:

$$y_t = A_1 y_{t-1} + \dots + A_p y_{t-p} + u_t \quad (1)$$

where, y_t is a $(K \times 1)$ vector of endogenous variables, the A_i 's ($i=1, \dots, p$) are $(K \times K)$ coefficient matrices and u_t is K -dimensional white noise with $u_t \sim (0, \Sigma u)$ (Lütkepohl, 2005). Errors (u_t) are assumed to be serially uncorrelated. The basic VAR model explains the endogenous variables solely by their history. In order to model possible contemporaneous relations between the variables, a structural form of the VAR is needed:

$$A y_t = A_1^* y_{t-1} + \dots + A_p^* y_{t-p} + B e_t \quad (2)$$

The structural errors, e_t , are assumed to be serially and cross-sectionally uncorrelated. The A_i^* ($i=1, \dots, p$) are $K \times K$ coefficient matrices. The relationship between error terms in the reduced and structural forms is the following:

$$u_t = A^{-1} B e_t \quad (3)$$

Also, the relationship between the variance-covariance matrix of u_t (observed) and the variance-covariance matrix of e_t (unobserved) will be:

$$\Sigma_u = A^{-1} B B' (A^{-1})' \quad (4)$$

The model for shocks is can be written as:

$$A u_t = B e_t \quad (5)$$

The main purpose is to decompose the structural errors (e_t) into components caused by the unexplained contemporary reduced-form shocks (u_t). In order to highlight contemporaneous relations, it is necessary to impose $2K^2 - K(K+1)/2$ restrictions on the A and B matrices to be able to exactly identify the system. In this article, structural shocks are determined by imposing a zero restriction on the contemporaneous structural parameters in matrix A .

3.2. Data

The dataset includes five variables, with two US variables and three local variables. The US interbank market overnight interest rate (effective FFR) is used as a proxy for US MP.

EFFR is the weighted average of the interest rate subject to overnight swap transactions of US depository institutions' funds held at the FED. Although the effective FFR is primarily determined by the market, it is affected by the open market operations carried out by the FED to achieve the FFR target.

The second variable considered regarding the US economy is the VIX index, which is widely used as an indicator of global risk and uncertainty. VIX measures the market expectation regarding the short-term volatility exhibited by stock index option prices on the Chicago Stock Exchange.

To determine the role of international capital movements in the transmission of changes in US interest rate and global risk perception to the Turkish economy, NTCI was used in the model. To determine which component of net capital inflows played a more important role in this transmission, NFDI, NPI, and NOI components were included in the model separately. Net capital inflows were found by subtracting the net asset acquisition item from the net liability formation item in the balance of payments presentation. Therefore, net capital inflows for each component were calculated as the difference between gross capital inflows and gross capital outflows.

Another variable in the model regarding the Turkish economy is related to the exchange rate. Considering that exchange rate changes may have an important role in the emergence of the possible effects of the US MP transmitted through net capital inflows, the Dollar/TL exchange rate was included.

Finally, the Turkish interbank market overnight interest rate was added to the model to represent the Central Bank of the Republic of Turkey's (CBRT's) MP. EFFR and VIX data regarding the US economy were obtained from the St. Louis FED database. Net capital inflows, exchange rate, and interest rate data for the Turkish economy were obtained from the Electronic Data Distribution System of CBRT. EFFR, VIX, exchange rate, and Turkish overnight interest rate data were used in the estimations by taking the logarithmic difference, and the series regarding net capital inflows were used by taking the first differences. A dummy representing the Global Financial Crisis is also included as an exogenous variable. This takes the value 1 for the period October 2008-December 2008, and takes 0 otherwise. Explanations regarding the data in the model are provided in Table 1. Figure 1 shows the time series of the variables in the model for the analysis period.

Table 1. Explanations of Data

Variable	Explanation
DLEFFR	Change in the logarithm of the effective federal funds rate compared to the previous period
DLVIX	Change in the logarithm of the VIX compared to the previous period
DNTCI	Change in net total capital inflows compared to the previous period (billion USD)
DNFDI	Change in net foreign direct investment inflows compared to the previous period (billion USD)
DNPI	Change in net portfolio inflows compared to the previous period (billion USD)
DNOI	Change in net other investment inflows compared to the previous period (billion USD)
DLEXRATE	Change in the logarithm of the nominal Dollar/TL exchange rate compared to the previous period
DLTRINT	Change in the logarithm of the interbank market overnight interest rate compared to the previous period

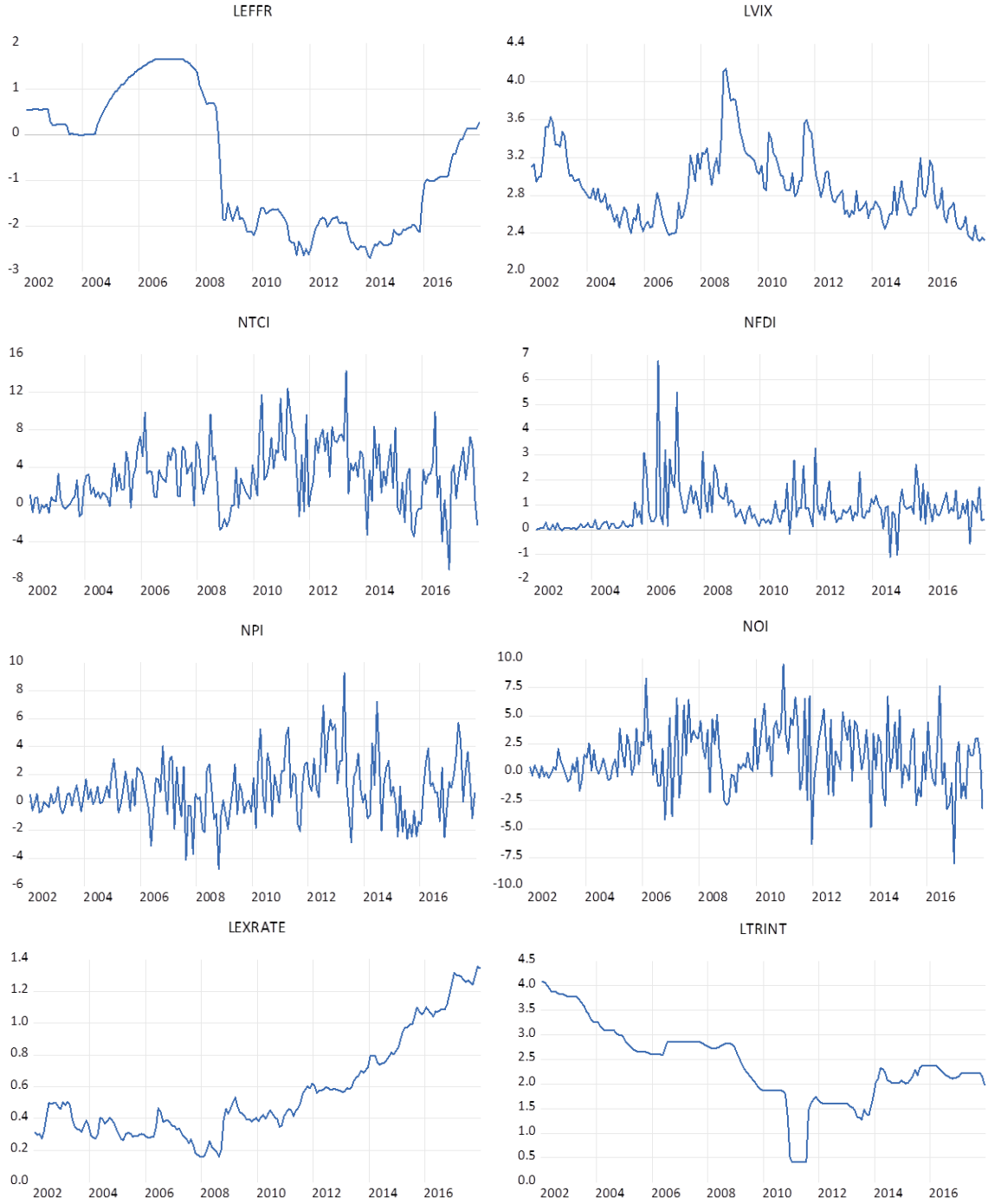


Figure 1. Time Series Plots of the Variables in Levels

Notes: The figure plots the levels of the logarithm of the effective federal funds rate (LEFFR), the logarithm of the VIX (LVIX), net total capital inflows (NTCI), net foreign direct investment inflows (NFDI), net portfolio inflows (NPI), net other investment inflows (NOI), the logarithm of the nominal Dollar/TL exchange rate (LEXRATE) and the logarithm of the Turkish interbank market overnight interest rate for the period 2002:01-2017:12.

3.3. Ordering of the Variables

It is important to correctly order the variables when constructing the SVAR model matrix. The ordering of the variables is made from the most exogenous variable to the most endogenous one. The ordering of the variables included in the SVAR model of the Turkish economy was made by taking into account theoretical predictions. Since the Turkish economy is a small and open economy, it should be assumed that it cannot affect global variables (Obsfeld and Rogoff, 1996). Therefore, global variables are included before domestic variables in the model. After making a distinction between global and domestic variables, a classification is also made between real variables and financial variables. The basic condition behind dynamic adjustment in small open economy models is that financial markets are cleared faster than real markets (Obsfeld and Rogoff, 1996). Therefore, financial variables are listed after real variables in the model. Thus, the ordering is made as follows; {EFFR, VIX, NTCI, EXRATE, TRINT}. The most exogenous variable of the model is the EFFR. It is assumed that this variable is affected by only its own shocks and affects all variables following it, contemporaneously. And it is assumed that VIX is affected by EFFR shocks and its own shocks, and affects all other variables, contemporaneously. The assumption that VIX is contemporaneously affected by EFFR is based on the risk-taking channel of MP (Bekaert et al., 2013). According to this channel, an increase in the EFFR is followed by a rise in the VIX index. Rising EFFR also leads to decreasing leverage ratios of international institutions as a result of the increase in risk perception in international markets. This results in decreasing international capital flows (Bruno and Shin, 2015b; Rey, 2015). Thus, immediately after the global variables, the sequence continues with domestic variables. It is assumed that NTCI is affected by global variables and that it affects the nominal exchange rate (EXRATE) and the Interbank Market Overnight Interest Rate of Turkey (TRINT), contemporaneously. It is also assumed that the EXRATE affects the TRINT, contemporaneously. The TRINT, which is assumed to be contemporaneously affected by all the variables in the model, is ordered last. This setup creates a lower triangular matrix A , where the first variable is not contemporaneously affected by the other variables in the system. The next variable is affected by the first variable and is not affected by the variables below it, contemporaneously. The process continues until the last variable is affected by all the variables, contemporaneously. Therefore, the following restrictions are imposed on the contemporaneous structural parameters in matrices A and B :

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 \\ a_{31} & a_{32} & 1 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & 1 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 \end{bmatrix} \begin{bmatrix} u^{dleffr} \\ u^{dlvix} \\ u^{dntci} \\ u^{dlexrate} \\ u^{dltrint} \end{bmatrix} = \begin{bmatrix} b_{11} & 0 & 0 & 0 & 0 \\ 0 & b_{22} & 0 & 0 & 0 \\ 0 & 0 & b_{33} & 0 & 0 \\ 0 & 0 & 0 & b_{44} & 0 \\ 0 & 0 & 0 & 0 & b_{55} \end{bmatrix} \begin{bmatrix} e^{dleffr} \\ e^{dlvix} \\ e^{dntci} \\ e^{dlexrate} \\ e^{dltrint} \end{bmatrix} \quad (6)$$

In Equation 6, e^{dleffr} is the US FFR shock, e^{dlvix} is the global risk shock, e^{dntci} is the capital inflow shock, $e^{dlexrate}$ is the exchange rate shock and $e^{dltrint}$ is the Turkish interest rate shock. Additionally, u^{dleffr} , u^{dlvix} , u^{dntci} , $u^{dlexrate}$ and $u^{dltrint}$ are the equation residuals of the reduced form VAR model.

4. Findings

The model constructed above is estimated for the period 2002:01-2017:12. To obtain reliable findings from an SVAR model, the series considered must be stationary. Augmented

Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root test results show that all series used are stationary for the relevant period (Table 2). The optimal lag of 4 was chosen based on the LR, FPE, and AIC criteria (Table 3).

Table 2. Unit Root Tests

Variable	ADF Test Stat. (Prob.)	PP Test Stat. (Prob.)	Variable	ADF Test Stat. (Prob.)	PP Test Stat. (Prob.)
DLEFFR	-8.523** (0.000)	-8.639** (0.000)	DNPI	-10.822** (0.000)	-63.350** (0.000)
DLVIX	-13.632** (0.000)	-14.724** (0.000)	DNOI	-10.375** (0.000)	-83.439** (0.000)
DNTCI	-14.427** (0.000)	-43.888** (0.000)	DLEXRATE	-9.882** (0.000)	-9.365** (0.000)
DNFDI	-15.120** (0.000)	-61.547** (0.000)	DLTRINT	-9.603** (0.000)	-9.581** (0.000)

Note: In unit root tests, a constant term is added to the estimates. ** indicates significance at the 1% level.

Table 3. Lag Length Selection

Lag	LogL	LR	FPE	AIC	SC	HQ
0	240.7843	NA	6.22e-08	-2.404003	-2.234342	-2.335289
1	329.7614	171.4662	3.19e-08	-3.070431	-2.476617*	-2.829932*
2	367.6956	71.12674	2.79e-08	-3.205163	-2.187196	-2.792879
3	394.3574	48.60215	2.75e-08	-3.222473	-1.780353	-2.638404
4	425.5752	55.28152*	2.58e-08*	-3.287242*	-1.420968	-2.531387
5	441.1166	26.71176	2.86e-08	-3.188714	-0.898288	-2.261075
6	451.1665	16.74990	3.37e-08	-3.032985	-0.318405	-1.933560

The unit circle test shows that all the inverse roots of the autoregressive polynomial are within the unit circle, and the model satisfies the stability condition (Figure A1 in the Appendix). According to the Lagrange Multiplier (LM) test results, the null hypothesis that there is no autocorrelation between the error terms of the reduced form of the model could not be rejected (Table A1 in the Appendix). According to the White heteroscedasticity test results, the null hypothesis that there is no heteroscedasticity problem between the residuals of the model could not be rejected (Table A2 in the Appendix). In short, it is understood from the diagnostic tests on the error terms that there is no structural problem in the model.

4.1. Impulse-Response and Variance Decomposition Analyses

In order to evaluate the responses of the variables in the model to structural shocks, impulse-response functions were obtained. Figure 2 shows the responses of other variables to a one-standard-deviation shock on the variables included in the model. In the impulse response graphs in Figure 1, the dotted lines are 95% confidence bounds. If the confidence interval does not contain zero, it means that the p-value is less than 0,05, indicating a statistically significant response. The impulse-response results are as follows;

The findings of the impulse-response analysis show that the increment in the EFFR has a positive and significant effect on the VIX index, which is considered to be an indicator of global risk. The graph (a) in Figure 2 shows that a positive shock to the VIX creates a positive impact

on the EFR in the first period, and then the effect of the shock dies out in the second period, where the lower bound confidence interval reaches zero. This result confirms the view that the FED MP is the main determinant of global financial conditions (Rey, 2015; Miranda-Agrippino and Rey, 2020). Accordingly, the increase in the US EFR leads to a contraction in the GFCy as a result of the decreasing global risk appetite.

According to the findings of the analysis, NTCI to the Turkish economy respond negatively and significantly to the increase in the US interest rate. The graph (b) in Figure 2 indicates that a positive EFR shock leads to a decrease in the NTCI in the third period after increasing it in the second period. In the literature on the pull and push determinants of capital flows (Calvo, 1996; Koepke, 2019), it is predicted that international capital moves from developing countries such as Turkey to center countries with the expectation of higher returns in the face of the increase in the US interest rate. The result reached here shows that the US interest rate is a significant external factor that affects net capital flows in the Turkish economy. This result also proves that net capital inflows play a role in transmitting US MP shocks to the Turkish economy.

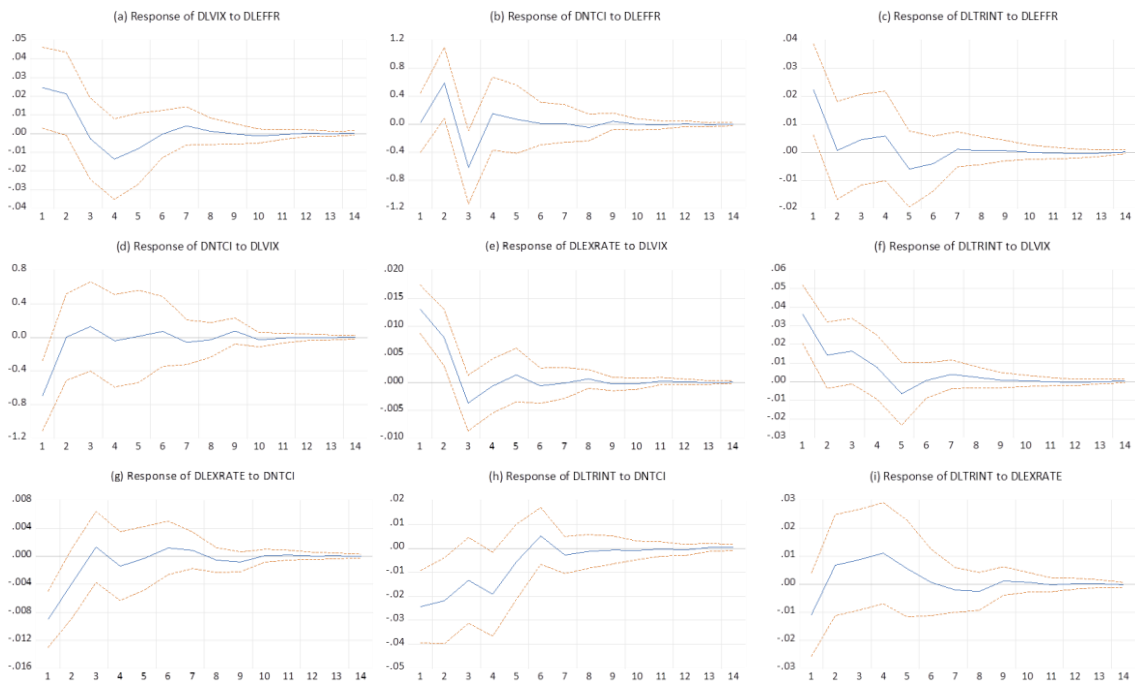


Figure 2. Impulse-Response Functions

The domestic interest rate in the Turkish economy responds positively and significantly to the increase in the FFR in the first period (Figure 2c). This finding seems to be parallel to the view that EMEs' central banks will tend to imitate the MPs of center countries due to reasons such as excessive borrowing, overheating and fear of floating in the face of center country MP shocks (Georgidas and Zhu, 2021).

The analysis findings also prove that net capital inflows respond negatively and significantly to the increase in the VIX index in the first period (Figure 2d). This finding shows

that the increment in the VIX index leads to a decline in net total capital flows in the Turkish economy. This result confirms the view that global uncertainty is another global variable affecting international capital flows (Koepke, 2019). Accordingly, in the face of increasing global risk and uncertainty, international capital flows to center countries are seen as safe havens. Therefore, it can be said that the mechanism that emerges through capital flows in the transmission of US monetary shocks works not only via the search for yield but also through the risk-taking channel.

According to the impulse-response analysis, the increase in the VIX index has a positive and significant effect on the Dollar/TL exchange rate in the Turkish economy in the first and the second periods (Figure 2e). It should be noted that the rise in the exchange rate indicates a depreciation of the TL. Therefore, it is understood that the increase in global risk, which leads to a strengthening of the currencies of the center countries, which are seen as safe havens, causes a depreciation of the Turkish Lira.

Similarly, the increment in the VIX index also has a positive and significant effect on the domestic interest rate in the Turkish economy in the first period (Figure 2f). Accordingly, when the currencies of the center countries appreciate as a result of the increase in global risk, an upward movement is observed in the domestic interest rate.

The impulse-response analysis proves that the exchange rate responds negatively and significantly to a shock in capital flows in Turkey in the first period (Figure 2g). Therefore, an increase in net capital inflows causes the Turkish Lira to appreciate. Therefore, the effect that occurs on the exchange rate in the Turkish economy through the VIX as a result of the FED MP shock is also strengthened through the capital flows channel.

In addition, the results of the impulse-response analysis prove that a shock on net capital flows in the Turkish economy creates an opposite and significant effect on the domestic interest rate in the first and the second periods (Figure 2h). Accordingly, an increase in net capital inflows causes a decrease in the interest rate.

Finally, the local interest rate responds positively to a shock in the exchange rate, although its statistical significance is low (Figure 2i). This result shows that the depreciation of the Turkish Lira creates increasing pressure on the domestic interest rate.

The impulse-response analysis shows that capital inflows, exchange rates, and interest rates in the Turkish economy respond quickly to US monetary policy and VIX shocks. These results are in line with the findings in the previous empirical literature that US monetary policy shocks have immediate effects on financial variables in small open economies (Bowman et al., 2015; Rey, 2016; Ganelli and Tawk, 2019). These results are also in line with the theoretical prediction that financial markets adjust quickly in the face of economic shocks (Obstfeld and Rogoff, 1996).

In order to see to what extent the changes in the variables in the model are explained by other variables, variance decomposition analysis was used. Table 4 shows that the forecast error variance of each variable is explained by other variables. The findings of the variance decomposition analysis provide support for the results obtained from the impulse response analysis. Accordingly, the variable that affects the changes in the global risk variable the most, other than its own shocks, is the FFR. While the proportion of DLVIX's variability explained by DLEFFR is 2.63 percent in the first period, it is 4.43 percent and 5.04 percent in the second and

fifteenth periods, respectively. The variables that affect the changes in total capital inflows the most, other than their own shocks, are the domestic interest rate, the FFR, and global risk, respectively. The part of DNTCI's variability explained by DLEFFR is 2.79 percent in the second period, 5.58 percent in the third period, and remains at 5.26 percent in the fifteenth period. The part of DNTCI's variability explained by DLVIX is 5.67 percent in the first period, and decreases in the following periods, reaching 3.59 percent in the fifteenth period. The changes in the USD/TL exchange rate, other than its own shocks, are explained mostly by global risk and total capital inflows, respectively. The part of DLEXRATE's variability explained by DLVIX is 17.35 percent and 19.94 percent in the first and second periods, respectively, and remains high in the following periods, reaching 20.17 percent in the fifteenth period. In addition, while DTCI's rate of explaining DLEXRATE's variability is 8.23 percent in the first period, it does not show any significant change in the following periods, reaching 8.24 percent in the fifteenth period. The changes in the domestic interest rate, other than its own shocks, are explained mostly by global risk, total capital inflows, and the US FFR, respectively. DNTCI's explanation ratio of DLTRINT's variability is 4.56 percent in the first period, 7.34 percent in the second period, and 10.48 percent in the fifteenth period. DLVIX's explanation ratio of DLTRINT's variability is 10.21 percent in the first period and reaches 11.98 percent in the fifteenth period. DLEFFR explains 3.88 percent of DLTRINT's variability in the first period, while this ratio remains largely unchanged in the following periods and reaches 3.82 percent in the fifteenth period.

As a robustness check, generalized impulse responses were also obtained to assess whether the findings of the SVAR model are robust to the order of the variables. Orthogonalized impulse responses may differ based on the order of the variables in the VAR, whereas generalized impulse responses proposed by Koop et al. (1996) and Pesaran and Shin (1998) are invariant to the variable order. In other words, with generalized impulses, the ordering of the variables does not matter. Therefore, the recourse to generalized impulses helps avoid uncertainties associated with the ordering of the variables. Figure A2 in the Appendix shows the generalized impulse response functions obtained for net capital inflows. The generalized impulse response functions give very similar results to the orthogonalized Cholesky impulse response functions in Figure 1. These findings confirm the reliability of the results based on the ordering of the variables according to theoretical predictions.

The impulse-response and variance decomposition analyses show that the effects of changes in the US FFR are transmitted to the interest rate in the Turkish economy through total capital inflows. The results also show that the effects on capital inflows emerge through changes in both the FFR and the VIX.

In order to see which components of capital inflows have a greater effect on the transmission of US monetary shocks, the model is re-estimated using the variables DNFDI, DNPI, and DNOI, respectively, instead of DNTCI. The impulse-response functions obtained for foreign direct investment flows show that neither the FFR nor the VIX has a significant effect on DNFDI (Figure 3). In the empirical literature, the impact of global factors such as foreign interest rates and global risk on FDI flows is often found to be ambiguous and inconclusive. Most studies in the literature conclude that FDI flows are affected not by global push factors but by factors such as domestic tax regime, trade protection, and the strength of bilateral trade

relations (Koepke, 2019). Therefore, as expected, it is understood that FDI flows do not have a notable role in the emergence of the spillover effects of FED MP on the Turkish economy.

Table 4. Variance Decompositions

Variance Decomposition of DLVIX:						
Period	S.E.	DLEFFR	DLVIX	DNTCI	DLEXRATE	DLTRINT
1	0.151395	2.631391	97.36861	0.000000	0.000000	0.000000
2	0.154515	4.430409	94.16261	0.053120	0.208057	1.145799
3	0.159320	4.195789	93.09670	0.264645	1.048797	1.394073
5	0.161821	5.032130	90.34059	0.636037	2.040898	1.950345
15	0.162907	5.045106	89.31984	1.215537	2.228200	2.191319
Variance Decomposition of DNTCI:						
Period	S.E.	DLEFFR	DLVIX	DNTCI	DLEXRATE	DLTRINT
1	2.922954	0.005039	5.667166	94.32779	0.000000	0.000000
2	3.538268	2.795697	3.867655	92.94569	0.345122	0.045839
3	3.611827	5.584232	3.845137	89.24902	0.375500	0.946111
5	3.778840	5.296646	3.525412	81.61296	1.618631	7.946351
15	3.801569	5.264457	3.595102	81.23099	1.705521	8.203929
Variance Decomposition of DLEXRATE:						
Period	S.E.	DLEFFR	DLVIX	DNTCI	DLEXRATE	DLTRINT
1	0.031413	0.351107	17.35739	8.233608	74.05789	0.000000
2	0.034341	1.211468	19.94806	8.146959	69.78594	0.907573
3	0.034705	1.377509	20.67231	8.124175	68.86661	0.959395
5	0.035083	1.979724	20.40904	8.119167	68.16338	1.328693
15	0.035353	2.012984	20.17768	8.248475	67.76244	1.798420
Variance Decomposition of DLTRINT:						
Period	S.E.	DLEFFR	DLVIX	DNTCI	DLEXRATE	DLTRINT
1	0.114026	3.879843	10.21701	4.566997	0.913545	80.42260
2	0.120689	3.466452	10.51193	7.346116	1.134604	77.54089
3	0.123206	3.461017	11.85302	8.224337	1.595094	74.86654
5	0.126149	3.738949	11.95747	10.33984	2.490988	71.47275
15	0.126731	3.821479	11.98703	10.48235	2.550335	71.15881

Note: Cholesky Ordering: DLEFFR DLVIX DNTCI DLEXRATE DLTRINT

The impulse response functions obtained for net portfolio investments indicate similar findings to the functions obtained for total capital inflows (Figure 4). As in the DNTCI estimates, the negative effect of DLVIX on DNPI and the negative response of DLEXRATE to DNPI are statistically significant. However, the response of DNPI to DLEFFR and the effect of DNPI on DLTRINT are not significant. Accordingly, it can be said that portfolio investments have an indirect role, operating through VIX, in the emergence of the spillover effects of FED MP on the Turkish MP.

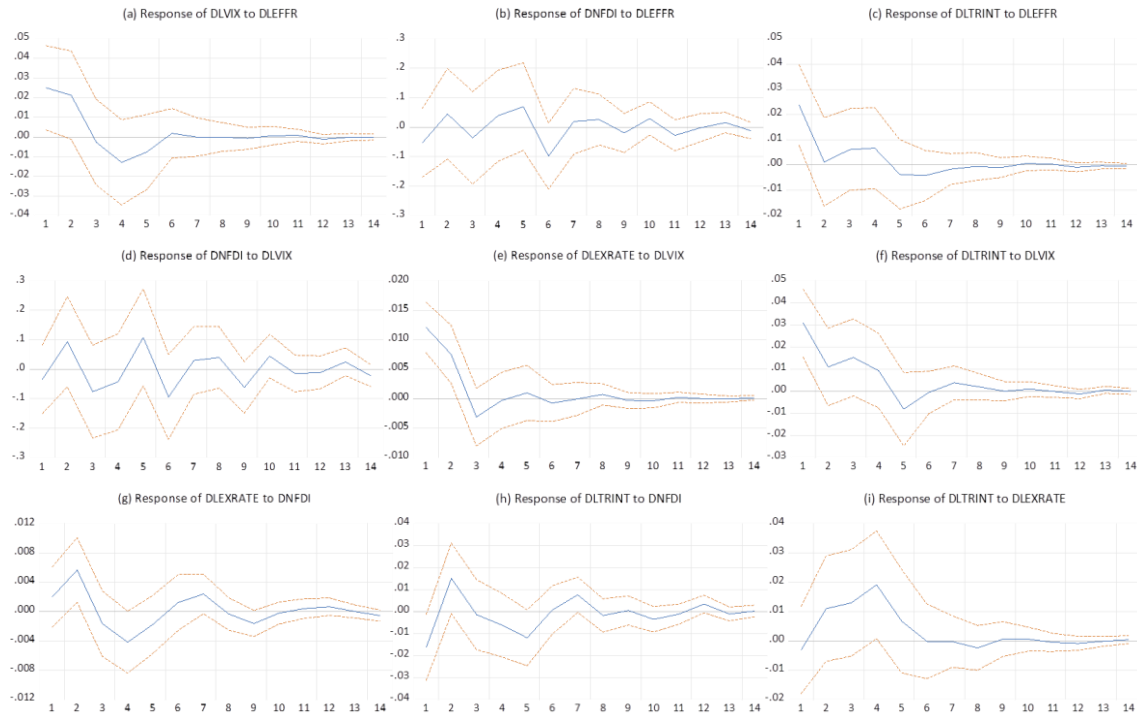


Figure 3. Impulse-Response Functions Containing Net Foreign Direct Investments

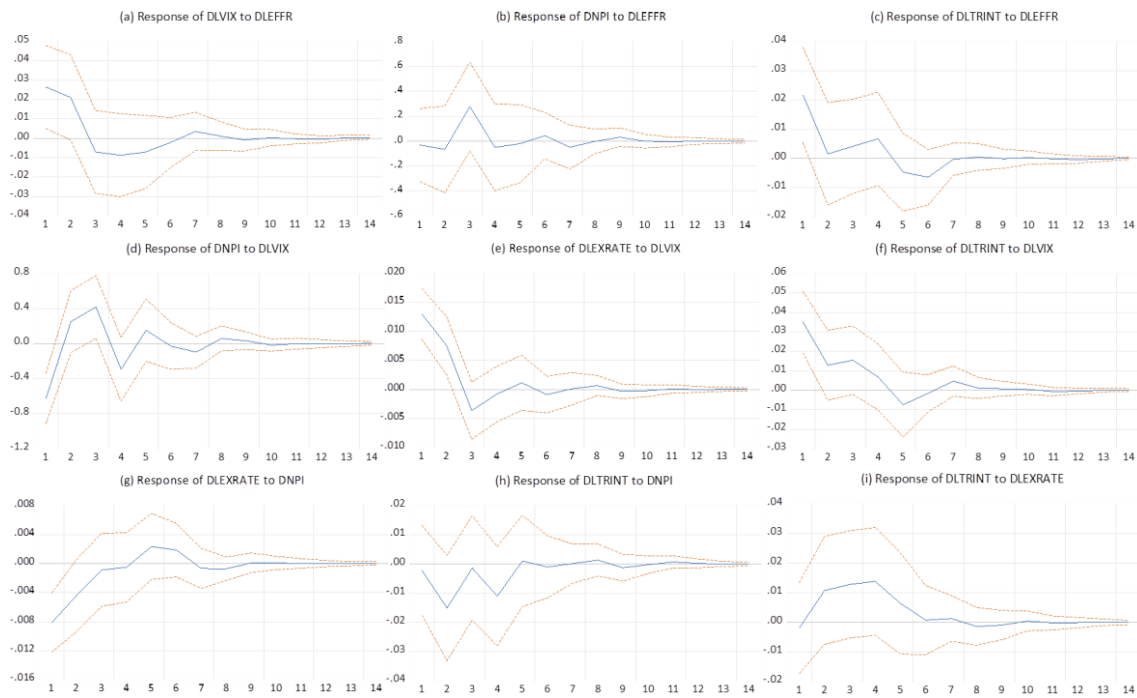


Figure 4. Impulse-Response Functions Containing Net Portfolio Investments

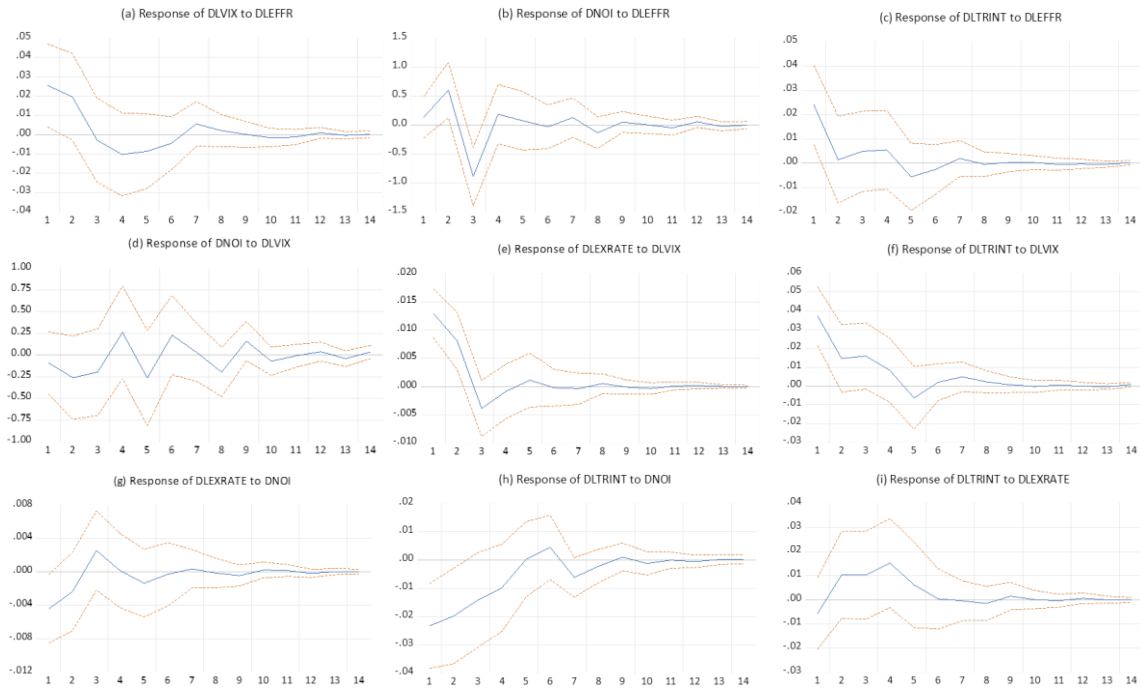


Figure 5. Impulse-Response Functions Containing Net Other Investments

The impulse response functions obtained for net other investments also give very similar results to the functions obtained for total capital inflows (Figure 5). As in the DNTCI estimates, the negative effect of DLEFFR on DNOI and the negative responses of DLTRINT and DLEXRATE to DNOI are statistically significant. However, the response of DNOI to DLVIX is not significant. Accordingly, it can be said that the role of other investments in the emergence of the spillover effects of US MP on the Turkish economy works directly through the FFR channel. When the impulse-responses related to different components of capital flows are evaluated together, it is seen that the spillover effects of the FED's FFR policy on the MP of the Turkish economy are mainly transmitted through the other investments component of capital flows.

5. Conclusion

This study addresses the hypothesis that the international risk-taking channel plays an important role in the transmission of the effects of US MP on the MP of the Turkish economy. According to the international risk-taking channel, monetary contractions in the US lead to an increase in global risk perception, and a decline in the leverage of the global financial intermediaries. This causes a strong decrease in international credit flows and domestic credits, and an increase in the borrowing costs of domestic economic units in EMEs. In addition, in EMEs where domestic liability dollarization is high, pressures for domestic currency depreciation may force central banks to intervene in the foreign exchange market with financial stability concerns. This process results in policy spillovers between the US and EMEs.

In this study, the effects of US MP changes on Turkey's MP practices and the transmission channels of these effects are empirically investigated. For these purposes, a structural VAR model is estimated for Turkey, a small open country with a flexible exchange

rate regime, using the data covering the period 2002:01-2017:12. In this section, the impulse-response and variance decomposition analyses results obtained from the structural VAR estimation will be summarized. Firstly, it is determined that an increase in the FFR increases the Turkish interest rate. Therefore, it can be said that the CBRT's monetary (interest rate) policy follows the FED's MP. This result is consistent with the findings of Rey (2015), Hofmann and Takats (2015), Edwards (2015), Anaya et al. (2017), Akıncı and Queralto (2018), Dağlaroğlu et al. (2018), Gülşen and Özmen (2020), Miranda-Agrippino and Rey (2020), Georgiadis and Zhu (2021), proving the dilemma hypothesis is valid. This result also shows that there is a transmission mechanism that allows changes in the FED's MP to spread to the Turkish economy. Secondly, it is empirically proven that two global (push) factors, the FFR and the VIX, negatively affect capital inflows to Turkey. This result is consistent with the findings of many studies in the literature, e.g. Calvo (1993, 1996) and Koepke (2019), among others. Additionally, it is shown that global risk also affects exchange rate and Turkish interest rates, positively and significantly. These findings mean that the mechanism arising from capital flows in transmitting US MP shocks to the Turkish economy works not only through yield search but also through the risk-taking channel.

The impulse-responses for the three components of NTCI (FDI, NPI, and NOI) indicate important conclusions. Firstly, net foreign direct investment (NFDI) inflows are not affected by either FFR or VIX. Therefore, it can be said that FDI inflows do not have a notable role in the emergence of the spillover effects of US MP on the Turkish economy. Secondly, net portfolio investments (NPI) respond significantly to the VIX but not to the EFFR. Therefore, it can be concluded that portfolio investments indirectly (through VIX) transmit the spillover effect of the FED MP on the Turkish MP. The result regarding the relationship between VIX and portfolio investments is consistent with the findings of Milesi-Ferretti and Tille (2011), Fratzscher (2012), Broner et al. (2013), Rey (2015), Ahmed and Zlate (2014), Ananchotikul and Zhang (2014) and Koepke (2018), among others. Finally, net other investments (NOI) respond significantly to the EFFR but not to the VIX. The result regarding the relationship between the center country's interest rate and other investments is parallel to the findings of Ghosh et al. (2014), Cerutti et al. (2014), and Bruno and Shin (2015b), among others. Therefore, it can be said that the spillover effect of the US MP on the Turkish economy is directly and mainly transmitted through NOI. In summary, while the US MP affects capital inflows through both the FFR and the VIX, the spillover effects of the US MP are strengthened and transmitted to the exchange rate and domestic interest rate through the capital inflows channel.

All these results show the dependence of the CBRT's MP on the US MP. The results reveal that the mechanism works as follows. An increase in US interest rates increases the global risk indicator VIX. Both reduce capital inflows to Turkey. This results in upward pressure on the exchange rate and depreciates the domestic currency. In the face of a depreciating Turkish Lira, the CBRT applies a monetary contraction, possibly with financial stability concerns. This policy causes a rise in the domestic interest rate. The mechanism explained above means that the CBRT loses monetary autonomy. The loss of monetary autonomy prevents the use of MP for domestic macroeconomic purposes, such as avoiding economic contraction. To regain monetary autonomy, it can be recommended the countercyclical use of macroprudential policies and/or capital controls to cope with financial fragilities arising from US MP spillovers. It may be proper policy to tighten macroprudential policies or capital controls when US interest rates and global risk perception are low, and gross

capital inflows are high; conversely, to loosen these policies when US interest rates and global risk perception are high, and gross capital inflows are low.

This article has contributed to the relevant global literature as an empirical study specific to Turkey. Since there are not many studies in this field specific to Turkey, it aims to fill this gap. It provides empirical findings to researchers in new studies to be conducted on this subject. However, the structural VAR model used in the current study has some limitations. Although this study finds that the effects of economic shocks are robust to the ordering, the recursive framework has a risk of misidentifying some economic shocks due to Cholesky ordering. Future studies may estimate non-recursive models that include different structural restrictions within the predictions of economic theory. Although the recursive VAR model assumes that domestic variables do not have simultaneous effects on foreign variables, their lagged effects are estimated. Future studies can use the block exogeneity assumption, which does not allow domestic variables to affect foreign variables simultaneously or with a lag. The standard structural VAR model neglects the effect of temporary structural breaks on the model. Actually, macroeconomic time series may be structurally unstable over time, and the parameters of the underlying time series may not be time-invariant. Future studies may take this issue into account using models such as time-varying parameter VAR. The linear structural VAR model ignores the fact that domestic economic variables may respond differently to foreign shocks under different financial conditions. For example, the effects of foreign shocks may be more pronounced in periods of financial stress than in normal periods. Future studies can use a nonlinear threshold VAR model that divides the sample period into various regimes based on a selected threshold variable.

Declaration of Research and Publication Ethics

This study which does not require ethics committee approval and/or legal/specific permission complies with the research and publication ethics.

Researcher's Contribution Rate Statement

The authors declare they have contributed equally to the article.

Declaration of Researcher's Contribution of Interest

There is no potential conflicts of interest in this study.

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APPENDIX

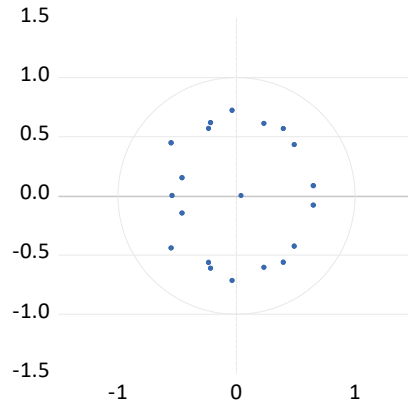


Figure A1. Inverse Roots of AR Characteristic Polynomial.

Table A1. LM test

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	29.29882	25	0.2516	1.177910	(25, 599.6)	0.2518
2	18.34403	25	0.8274	0.730868	(25, 599.6)	0.8275
3	28.81609	25	0.2717	1.158041	(25, 599.6)	0.2719
4	30.48656	25	0.2066	1.226862	(25, 599.6)	0.2067
5	22.50062	25	0.6067	0.899547	(25, 599.6)	0.6069
6	26.63274	25	0.3745	1.068374	(25, 599.6)	0.3747

Table A2. White Test

Chi-sq	df	Prob.
616.6761	615	0.4734

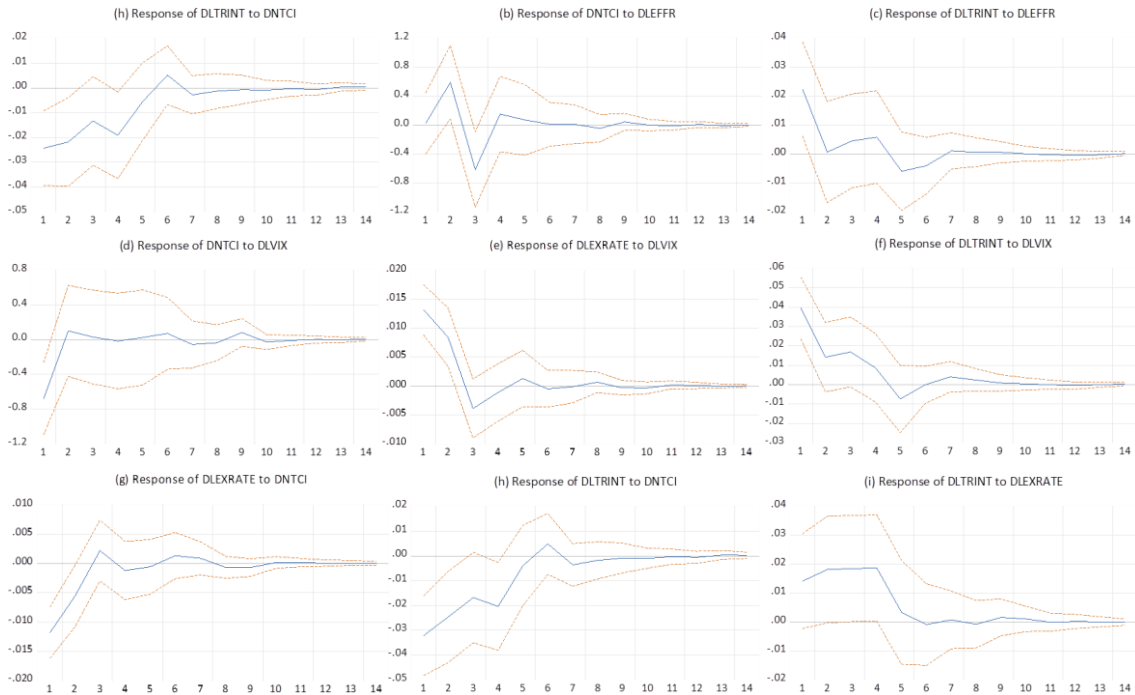


Figure A2. Generalized Impulse-Response Functions

INVESTIGATING THE RELATIONSHIP BETWEEN ADR, STOCK PRICES AND MACROECONOMIC INDICATORS: THE CASE OF TÜRKİYE

ADR ve Hisse Senetleri Fiyatlarının Makroekonomik Göstergeler ile Arasındaki İliřkinin Belirlenmesi: Türkiye Örneęi

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Abstract

Keywords:
ADR,
Macroeconomic
Indicators,
Arbitrage

JEL Codes:
D53, E44, G14

American Depositary Receipts (ADRs), which are traded through depositary receipt management by accepting the stock as an underlying asset, have become a frequently used investment instrument today. Since ADRs are linked to the underlying stock, there are multiple variables in determining their price. The effects of these variables on the ADR price may lead to an arbitrage gain between the underlying stock and the ADR return. The aim of the study is to identify the indicators affecting the Turkish ADR prices and to reveal the existence of arbitrage opportunities in ADRs. In the study, economic indicators affecting the price of Turkish ADRs were identified. Exchange rate, CDS premium, and various stock market indices were selected as economic indicators to be used in the analysis. Regression analysis was used in the study, where daily data were used between 2014 and 2024. As a result of the study on eight different ADRs, it is determined that the return differences between ADRs and stocks are affected by various economic indicators. Moreover, the fact that this difference does not follow a random walk, i.e., it is predictable, provides evidence that the ADR market is inefficient within the framework of the efficient market hypothesis.

Öz

**Anahtar
Kelimeler:**
ADR,
Makroekonomik
Göstergeler,
Arbitraj

JEL Kodu:
D53, E44, G14

Hisse senedini dayanak varlık olarak kabul edip depo sertifikası yönetimiyle işlem gören American Depositary Receipts (ADR) günümüzde sık kullanılan bir yatırım aracı haline gelmiştir. ADR'lerin dayanak hisse senedine baęlı olması nedeniyle fiyatının belirlenmesinde birden çok deęişken mevcuttur. Bu deęişkenlerin ADR fiyatına etkileri temel hisse senedi ile ADR getirisi arasında bir arbitraj kazancına yol açabilme olasılığı taşımaktadır. Çalışmanın amacı, Türkiye ADR fiyatlarına etki eden göstergelerin tespit edilerek ADR'lerin arbitraj fırsatlarının mevcudiyetini ortaya koymaktır. Arařtırmada Türkiye ADR'lerinin fiyatını etkileyen ekonomik göstergeler tespit edilmiştir. Analizde kullanılmak üzere ekonomik gösterge olarak; döviz kuru, CDS primi, çeşitli borsa endeksleri seçilmiştir. 2014-2024 yılları arasında günlük verilerin kullanıldığı çalışmada Regresyon yöntemi kullanılmıştır. Sekiz farklı ADR üzerine yapılan çalışma sonucunda ADR ile hisse senedinin getiri farklılıklarının çeşitli ekonomik göstergelerden etkilendięi tespit edilmiştir. Ayrıca bu farklılığın rastgele bir yürüyüş izlememesi yani tahmin edilebilir olması, etkin piyasa hipotezi çerçevesinde ADR piyasasının etkin olmadıęına yönelik kanıtlar sunmaktadır.

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1. Introduction

With the increase in globalisation and the advancement of technology, financial markets, like all other areas, have become global. The effect of physical borders on financial markets has decreased, and the parties have the opportunity to trade in the capital markets of their choice within the market opportunities by using technological facilities. In this context, new investment instruments have emerged with the global development of financial markets. In fact, in recent years, new investment instruments derived from existing investment instruments have been frequently used. American Depositary Receipts (ADR) are one of these investment instruments.

From a general perspective, ADRs are investment instruments that represent stocks traded in the United States of America (USA) markets with underlying assets in another country. ADRs, which have similar characteristics to any stock, are transferable certificates issued by US banks and represent the ownership of shares in non-US companies (Fang and Loo, 2002). An ADR is a security that represents the shares of a non-US company but has the added convenience of being traded as a typical US share (Mitra et al., 2019). The main purpose of ADRs is to facilitate the trading of companies, especially international firms, in the US capital markets. In other words, ADRs are an easy way for a foreign firm to trade its shares in the US or to raise international capital. Being traded in a foreign stock exchange reduces the capital costs of firms due to the resources raised from abroad (Peterson and O'Shaughnessy, 2016).

In the ADR system, in order to be traded in the US markets, firms enter into an agreement with a bank in the US, which can be used as a depository bank, and issue their shares to the US markets under the name of ADR through this bank. In other words, firms entrust their shares to the depository bank, and the depository bank issues the shares in the relevant markets in dollars using a certificate logic. ADRs are used by investors as a practical tool to avoid the stock costs of companies located in foreign countries and to diversify their portfolios (Bandopadhyaya et al., 2008). In addition, firms with ADRs are not subjected to the reporting and accounting policies of the US, with all the conditions compared to the initial public offering. Investing in ADRs, like other equities, provides two types of income: dividend income and capital gains (Callaghan and Barry, 2003).

ADRs are affected by different indicators, just like ordinary stocks. These indicators may consist of firm-specific issues as well as external micro or macroeconomic parameters. In other words, while the price of a stock is affected by the financial structure of the firm, it may also be affected by market and economic conditions. In other words, the price of a stock includes variables such as the assets, capital structure, investment opportunities, profitability, dividend policy, sectoral structure, and cyclical fluctuations (Ercan and Ban, 2016). Since ADRs reflect the concept of an existing stock being issued and traded by the depository bank in the US capital market, every factor affecting the existing stock plays a role in ADR price and return. The same is also true for the variables affecting the ADR market. This is also the case for Turkish ADRs traded in Türkiye and traded in the US capital market. In fact, the prices of Turkish ADRs may also be affected by factors affecting the underlying stock and variables specific to the ADR market. In this context, an ADR linked to a stock traded in Borsa Istanbul is likely to be affected both by the current stock and the factors affecting it and by the conditions of its own market. In other words, it is important whether a price prediction can be made for the ADR by looking at the underlying stock and the underlying stock market, and whether a return can be achieved. The fact that the ADR price is affected by the local stock and its specific variables creates arbitrage

opportunities for investors. In this context, investors can predict the ADR price according to the movements of the underlying stock and local economic indicators and generate returns by making a purchase or sale decision. At the same time, it is thought that a comprehensive analysis using the existing ADR market variables can increase the arbitrage opportunity. This may also be the case for Turkish ADRs, and it is thought that Borsa Istanbul and local stock variables may have an impact on ADR prices. This study attempts to answer the question of whether the existing Turkish ADRs have an arbitrage opportunity. In other words, it aims to determine the existence of an arbitrage formation by revealing how much the price and, accordingly, the return of Turkish ADRs are affected by the local stock price and the main economic indicators of the local country and the ADR market indicators.

This study analyses the relationship between the performance of Turkish ADRs and various economic indicators between 2014 and 2024. The main objective of the study is to determine the impact of the economic effects in the home countries of ADRs on the value of the ADR. In other words, it tries to determine the reflection of various economic effects in the country where the underlying asset is located on the price of the ADR. Thus, it is made to understand whether an arbitrage opportunity exists or not. The study aims to contribute to the literature by determining the probability of Turkish ADRs to provide returns by being affected by local market conditions and underlying stock price. In other words, it is thought that determining whether Turkish ADRs contain arbitrage opportunities by being affected by the variables used in the study will contribute to the studies on Turkish ADRs in the literature.

The increasing number of ADRs issued by Turkish firms and the limited number of studies on Turkish ADRs in both domestic and foreign literature make it important to investigate this issue. The extent to which local economic changes affect ADR price discovery is important in determining whether bilaterally traded stocks have arbitrage opportunities. At the same time, the correct flow of information in the price discovery process is also important in terms of investor protection and market efficiency. The globalisation and accessibility of financial markets with technological developments and the desire of international firms to trade in different markets by turning to ADRs emphasise the timeliness of the study.

In the second part of the study, ADRs, price discovery processes, arbitrage opportunities, and their evaluation in terms of efficient market hypothesis are discussed conceptually. In the third section, existing literature studies on ADRs are mentioned. Data and the methodology used in the study are explained in the fourth section. In the fifth section, research findings are presented. In the last part of the study, research results, opinions, and suggestions are given.

2. Conceptual Framework

There are multiple factors that constitute security prices. In publicly traded enterprises, the share price is calculated by dividing the market capitalisation of the firm by the number of shares. In other words, the market value of the firm is the price at which the stock is traded in the market (Ercan and Ban, 2016). The market value of the firm is determined by external factors as well as internal factors. In this context, macroeconomic evaluations are also taken into consideration in stock valuation. Factors such as country economic analysis, political analysis, and market analysis can be examples of these indicators. In fact, the value of a stock, with its high beta value, may be directly dependent on the movement of the market in which it is located, or it may be vulnerable

to fluctuations in the country's basic exchange rate. These issues may vary depending on the company structure and/or sector.

The concept of security price discovery, especially for equities, is important for investors, brokerage houses, and market makers. Market parties want to predict security prices in the earliest and most accurate way in order to minimise their risks and increase their earnings. In this context, they can use emerging analysis techniques and technological instruments. Price discovery involves the incorporation of all new information into the security price (Hasbrouck, 1995). The security price is determined as a result of the flow of information in financial markets and how market participants use this information (Howe and Ragan, 2002).

The requirement that stock prices should move within market boundaries in an efficient market is explained in the finance literature within the efficient market hypothesis. According to the efficient market hypothesis, market participants have access to all information in the market under the same conditions. Therefore, asset prices reflect all the information occurring in the market in an uninterrupted manner. Therefore, Fama emphasises that in the efficient market hypothesis, security prices already reach their fundamental value within the market. The efficiency of a market depends on how fast the asset price can react to new information coming to the market (Karan, 2004). The efficient markets hypothesis argues that changes in asset prices follow a random walk (Malkiel and Fama, 1970). In other words, efficient market hypothesis accepts the random walk hypothesis and states that asset prices in the markets move randomly and new information reaching the market affects prices instantaneously. In other words, the resulting price changes continue in an unpredictable series. For this reason, in efficient markets, future price forecasts cannot be made by using past information.

Like all securities, the price of ADRs depends on a number of factors. However, unlike others, since ADRs are dual-registered investment instruments, they are likely to be affected by the markets and economic conditions of their home countries in addition to their current markets. In addition, factors such as information flow and time difference between the US market and the local market are among the issues that may affect the ADR price. In this context, it is important to investigate whether both markets are efficient in the price discovery process from the perspective of the efficient market hypothesis. In addition, determining the extent to which ADRs specific to emerging financial markets are affected by local economic changes allows us to understand the market efficiency of these markets within the framework of the efficient market hypothesis. There are conflicting views on whether markets for cross-listed stocks are indeed fully efficient (Suarez, 2005). In the case of ADRs traded in an efficient market, market efficiency may be distorted by market conditions in the home country. Accordingly, arbitrage opportunities may arise. In other words, the ADR price may be predictable, and market parties may take positions accordingly. The persistence of such arbitrage opportunities for long periods is one of the indicators of low market efficiency (Gorbatikov and Dobrynskaya, 2019).

In general terms, arbitrage is the profit obtained by selling a product at different prices in different markets without assuming any risk. According to the arbitrage pricing theory, arbitrage opportunities arise from the violation of the law of one price. In other words, arbitrage opportunities arise when the law of one price, which states that the price of two securities should be the same even if they are in different markets, is violated (Ross, 1976). Arbitrage Pricing Theory argues that arbitrage opportunities that may arise in the markets for a short period of time will be used by market players in a short time, and the market will rebalance (Cihangir and

Kandemir, 2010). Arbitrage pricing theory is based on the idea that investors will always want to utilise arbitrage opportunities. According to the theory, there may be more than one factor affecting the expected returns of an asset. Factors such as interest rate, inflation, market index, gross domestic product growth, exchange rate, etc. can be examples of these factors. Arbitrage pricing theory assumes that the return of an asset is generated by a multi-factor model. Each factor can be seen as a specific beta coefficient for a given risk premium (Nguyen et al., 2017).

Under standard conditions, there should be no significant differences between the return distribution of locally traded equities and the return distribution of ADRs traded in the US. In other words, it should not harbour arbitrage opportunities. However, arbitrage opportunities may arise when the returns between ADRs and underlying stocks are significantly different (Koum kwa and Susmel, 2008). Since ADRs are issued linked to an underlying stock, there is a possibility that their correlation to the local market and the stock may be high. For example, sudden changes in the dollar exchange rate in the home country may create a buying or selling opportunity for the ADR traded in dollars. Or, an increase in the risk premium of the home country and unfavourable economic conditions in the country may decrease the value of stocks with high export volume, and therefore, fluctuations in the ADR price may occur. Especially in times of crisis, there may be large return differences between stocks and ADRs due to economic conditions that vary greatly. These yield spreads can be converted into arbitrage gains through time differences between markets, cheap transaction costs, and technological opportunities. This situation is contrary to the efficient market hypothesis and arbitrage pricing theory for efficient markets.

When investors have the possibility to predict the ADR price depending on the movements in the home country or the underlying stock, they may have the opportunity to make arbitrage gains through bilateral trading. Therefore, determining whether ADRs are more affected by current market conditions or local market conditions may be an indicator of whether there is an arbitrage opportunity for the ADR market. It may also provide a measure of the correlation between the local market and the ADR market. Indeed, the cross-listing of stocks by foreign firms in the US and elsewhere contributes to increased correlation between financial markets (Poshakwale and Aquino, 2008).

In this study, the relationship between various economic indicators and ADR price is investigated in order to determine whether Turkish ADRs have an existing arbitrage opportunity. It is important for all market parties to determine to what extent the changes in the market of the underlying asset subject to ADRs and the economic changes in the home country are reflected in the ADR price and whether they create arbitrage opportunities.

3. Literature

Although the research on ADRs is multifaceted, more studies have focused on the pricing of ADRs, dividend policy, and the relationship with corporate governance. From a general perspective, the ADR market can be considered as an extension of the basic stocks. Therefore, the ADR market should reflect the relationship between the underlying stock market and economic variables (Gupta et al., 2016).

There are many studies in the literature on the economic indicators of stocks and the markets in which they are located. However, the number of studies focusing on ADRs in this respect is limited. It is inevitable that economic changes in the base country will be effective in

ADR pricing and price forecasting, taking into account time zone differences. Therefore, the relationship between the ADR price and the economic indicators of the home country is important. In the majority of previous studies on this subject, the view that ADRs are affected by the economic indicators in the local country and the underlying stock price is dominant. Similarly, studies on Turkish ADRs have also reached similar conclusions.

Gupta et al. (2016) investigated the long-run and short-run relationship between ADR prices of 4 BRIC countries and the economic fundamentals of their underlying stocks. The main objective of the study is to understand the macroeconomic transmission mechanism of emerging market ADRs. The study is based on the 2000-2013 period, and the main economic indicators such as production index, inflation, money supply, crude oil prices, and stock market indices of the relevant countries are used. Johansen cointegration test and Vector Autoregressive (VAR) analysis were applied in the study. As a result of the study, it is concluded that in the long run, economic growth positively affects ADR returns for Brazil and China, while it negatively affects ADR returns for Russia and India. In a study on Turkish ADRs, Kaygın and Barut (2020) investigated the endogenous factors affecting the prices of 7 stocks in the period 2013-2018. They used Panel data analysis in their study. As a result of the research, a significant (positive) relationship was found between foreign and domestic prices of stocks. Similarly, the relationship between ADR price and relative financial ratios was investigated. Şencan (2021) investigated the volatility link between the underlying assets of 5 Turkish ADRs and themselves. Between 2015 and 2021, weekly data were used, and the GARCH model was applied. It was observed that the volatility of the stock market, which is accepted as the underlying, affects the ADR market. It is concluded that the shocks of the underlying stock and the linked ADRs in the past period are effective on the volatility of the current period.

Bae et al. (2008) aimed to investigate the volatility of the local and existing ADR market over ADRs based on exchange rate changes. Using weekly data of 54 ADRs from 4 different countries, the study utilized exchange rates, risk-free interest rates, and local stock market indices. The Seemingly Unrelated Regression (SUR) model was used as the method in the study. In the study, it is observed that exchange rate changes have a negative relationship with the returns of ADR underlying stocks and a positive relationship with the returns of ADRs in the US markets. In addition, according to the study, ADR returns are more closely related to local market returns than US market returns, suggesting that the local market environment plays a greater role in determining ADR returns. In addition, investors in the US or trading in the local market demand different risk premiums for the exchange rate risk in ADR investments. Esqueda and Jackson (2012) aimed to analyze the behaviour of ADR returns during the currency crisis period. In the study where 74 ADRs originating from Argentina, Brazil, Chile, and Mexico between 1994-2009 were used, the Seemingly Unrelated Regression (SUR) model and Multiple Regression (MVRM) model were applied. The study reveals that ADRs generated significant negative abnormal returns during the currency crisis. It is also concluded that ADR prices are affected by variables such as the underlying stock price, exchange rates, and host country index. Bin et al. (2003) investigated the effect of various risks, particularly exchange rate risk and interest rate risk, on the price of ADRs by considering three different periods between 1990 and 2000. Seemingly Unrelated Regression (SUR) model and GARCH model were used in the study. They found that ADR returns are sensitive to local market movements, foreign exchange fluctuations, and the US stock market. In addition, when the effect of international crises on the changes in ADR prices is

analyzed, they found that the exchange rate risk premium of the ADR of the country where a financial crisis occurred was significantly positive.

Figueiredo and Parhizgari (2017) investigated the conditions affecting ADR pricing using high-frequency data. The EGARCH model was used as the methodology in the study, in which a total of 73 ADRs were analyzed with minute data. The study attempts to identify the factors affecting ADR returns and their relative effects for each ADR and for subsamples based on currency, industry, and emerging or developed market classifications. Consistent with previous studies, the study finds that the main determinants of ADR returns are the returns of the relevant underlying stocks and the relevant exchange rate changes. Taking these two factors into account, we conclude that exchange rate returns represent approximately 30% of ADR total returns. Moreover, in addition to the underlying stock returns and exchange rate fluctuations affecting ADR returns, the contemporaneous returns of the US market and the returns of the relevant local stock markets were also found to have a statistically significant effect. Chen et al. (2009) used daily data for the period 2002-2005 in their study on the market sentiment of ADRs. Variance decomposition analysis and the EGARCH model were applied in the study. As a result of the study, it is stated that there is not a perfect integration between UK markets and UK ADRs and that trading location may have an impact on ADR prices. We also find that UK ADRs exhibit a U-shaped volatility curve on a daily basis.

Pan et al. (2012) investigated the impact of corporate governance and external governance on firm value based on ADRs in China, Hong Kong, and Taiwan. In line with the literature, the study examines cross-listing performance and finds that environments that provide stronger governance and investor protection lead to higher firm value. Although firm characteristics and internal governance mechanisms are important for firm value, external governance decisions outweigh these effects. Chen et al. (2020) examined ADRs within the framework of investor protection. In their study on 430 ADRs from 34 different countries between 2000-2017, they investigated the relationship between earnings management and investor protection, market surveillance, and liquidity. As a result of the research, it was found that firms with low share liquidity are more prone to earnings management than those with high liquidity.

Ejara and Ghosh (2004) comparatively analyzed ADRs and stocks in terms of initial public offerings (IPOs). In their study, the pricing and post-trade performance differences of IPOs with ADR IPOs in the period between 1990-2001 were analyzed. As a result of the study, it was found that ADR and US IPOs generally outperformed the market in less than one year, but their performance weakened in the longer term. Muscarella et al. (1996) investigated stock splits in the context of ADRs. Specifically, the study analyzed 143 cases of ADR splits between 1962 and 1993, where ADRs were split but the underlying country stocks were not. As a result of the study, it was observed that ADR prices increased after the news of a stock split. Investors generally perceive the increase in liquidity as a positive factor and therefore increase ADR prices by increasing demand.

Jun and Partington (2014) investigated the relationship between the dividend yields of ADRs traded on Australian equities and their underlying stocks. Using data on 41 Australian stocks traded in the US markets between 1992 and 2009, the study finds that dividend yields are higher in the market where the underlying stock is located due to various tax advantages. Tong et al. (2022) examined the dividend policies of ADRs and compared these policies with the dividend policies of US stocks. Based on the 2009-2018 period and using regression analysis, the study

found that ADR firms have higher dividend yields than US firms, but US firms have higher share repurchase rates than ADR firms.

Grossman and Ngo (2020) examined the impact of economic policy uncertainty on the pricing of ADRs. In their study, they investigated the hypothesis that the difference between policy uncertainty in the US and policy uncertainty in the country of the underlying asset creates an additional source of mispricing in ADR pricing. Using multiple regression analyses, 605 ADRs from 13 countries and the period 2010-2018, the study found evidence that US policy uncertainty has a different impact on the mispricing of ADRs than economic policy uncertainty in the underlying country of the asset. That is, economic policy uncertainty in the US and the source country may affect ADRs and their underlying assets differently, leading to widening price differences between the two assets and providing different arbitrage opportunities.

Chung (2006) investigated the impact of country-level investor protection mechanisms on the liquidity of cross-listed securities in the US. In the study, 204 ADRs operating in 29 different countries were analyzed in the time period coinciding with the Asian crisis, i.e., the second half of 1997. As a result of the study, it was observed that ADRs operating in countries with better investor protection mechanisms and higher levels of legal enforcement have lower asymmetric information costs and higher liquidity during crisis periods.

4. Data and Methods

In the study, various variables are utilized to measure the vulnerability of the ADR price. In order to reveal the price difference between the underlying stocks and the depositary receipts of the same stock, the data of eight firms from five different sectors operating in Borsa Istanbul, and also issued as ADRs and traded in the US, are used as dependent variables. The ADRs used in the study are selected among the ADRs that are actively traded in the ADR market today and have not been closed due to insufficient trading volume. A total of fifteen Turkish ADRs are traded. The other seven ADRs were not included in the analysis since they were traded at the same prices for a long time due to insufficient trading volume. The fact that the majority of ADRs are bank stocks explains the fact that eight stocks have five different sectors.

In addition, macroeconomic indicators, which are frequently used in the literature, are selected as independent variables to explain the price difference. Bae et al. (2008) applied a regression model using exchange rates, bilateral stock market indices, and risk-free interest rates in their study on the vulnerability of ADR prices. Similarly, Esqueda and Jackson (2012) used variables such as exchange rate, local stock price, and the stock market index of the home country in their study to analyse the ADR price. Similar to the literature, Gupta et al. (2016) expanded the variables in their study and used exchange rates, production indices, inflation rates, stock market indices, and similar variables. In this study, in line with the literature, as independent variables, stock market indices, which are the main indicators of both markets, stock prices of the main country, exchange rates, and additionally, Türkiye's CDS premium have been selected, as it contains international risk. These indicators consist of the BIST 100 index, Türkiye's CDS premium, USD/TL exchange rate, NASDAQ Composite Index, and S&P ADR Composite Index.

For the analysis, firstly, the changes in the daily stock returns of eight companies traded in Borsa Istanbul and the daily changes in the ADR prices of the same stocks were determined. The difference between these two datasets was taken and used as the dependent variable in the study.

The purpose of this arrangement is to ensure the harmonization between stocks traded in TL in Türkiye and ADRs traded in USD in the US. In addition, since there is a difference in other variables used in the study, daily changes are calculated and included in the analysis in a similar way. The variables used in the study are shown in the table below.

Table 1. Variables Used in the Analysis

Variable	Explanations of Variables
Dependent Variable	
AKBANK	Difference of Daily Changes between Ak Bank Stock and ADR
TURKCELL	Difference in Daily Changes between Turkcell Stock and ADR
KOCHOL	Difference of Daily Changes between Koç Holding Stock and ADR
THY	Difference of Daily Changes between Turkish Airlines Stock and ADR
TTKOM	Difference of Daily Changes between Turk Telekom Stock and ADR
AEFES	Difference of Daily Changes between Anadolu Efes Stock and ADR
GARANTI	Difference of Daily Changes between Garanti Bank Stock and ADR
TAV	Difference of Daily Changes between TAV Hava Limanları Stock and ADR
Independent Variable	
BİST100	Borsa İstanbul 100 index Daily Change
CDS	Daily Change in CDS Premiums for Türkiye 5-year USD Bonds
EXCHANGE	Daily Change in Dollar / TL
NASDAQ	Daily Change in NASDAQ Composite Index
S&P ADR	Daily Change in S&P ADR Composite Index

A total of 2419 observations between 25.09.2014 and 18.09.2024 were used in the study, and daily data for all variables were identified and used. Within the scope of the relevant dates, necessary arrangements have been made by taking into account the official business days between Türkiye and the USA. Data on the variables used in the analysis were obtained from Bloomberg (2024) and Investing (2024) financial information platforms.

In the case of a high correlation between independent variables in the models, it is decided that there is a multicollinearity problem. In such a case, the findings obtained from the model will not be reliable. For this reason, the Spearman correlation matrix was used to create the models in the study. The Spearman correlation matrix gives more reliable results than the Pearson correlation matrix in cases where the variables do not have a normal distribution. For this reason, first, the descriptive statistics of the variables were investigated in the study, and the obtained findings are given in Table 2; then, the correlation matrix is presented in Table 3.

Table 2. Descriptive Statistics

	AKBANK	BIST100	CDS	EXCHANGE	GARANTI	KOCHOL	AEFES
Mean	0.0001	0.0005	0.0011	0.0006	0.0011	0.0007	0.007
Median	0.0002	0.0011	0.0014	7.41e-05	0.0005	0.0003	0.009
Maximum	0.3480	0.2649	0.0988	0.4910	0.1864	0.1706	0.1832
Minimum	0.3982	0.3025	0.0979	0.2209	0.2429	0.2639	0.2308
Std.Dev.	0.0515	0.0540	0.0159	0.0328	0.0124	0.0389	0.0322
Skewness	0.4359	0.0952	0.4178	2.2356	0.0119	0.0932	0.1004
Kurtosis	12.2296	5.8696	7.5208	32.7297	105.999	5.1042	5.9256
Jarque-Bera statistics	8666.266***	833.993***	2130.335***	91100.33***	1069278***	450.000***	867.1305***
Observations	2419	2419	2419	2419	2419	2419	2419
	NASDAQ	S&P ADR	TAV	THY	TTKOM	TURKCELL	
Mean	0.0006	0.0001	0.007	0.0007	0.0007	0.0010	
Median	0.0010	0.0004	0.001	0.0000	0.0005	0.0009	
Maximum	0.0934	0.0864	0.2269	0.4562	0.2584	0.1477	
Minimum	0.1232	0.1070	0.3370	0.2919	0.7284	0.1709	
Std.Dev.	0.0136	0.0116	0.0368	0.0374	0.0430	0.0306	
Skewness	0.3907	0.7284	0.5641	0.6957	2.4685	0.0456	
Kurtosis	10.1362	12.4269	10.5995	19.8267	44.9560	6.0218	
Jarque-Bera statistics	5194.478***	9171.034***	5946.281***	28745.1***	179956.2***	921.6***	
Observations	2419	2419	2419	2419	2419	2419	

While the TTKOM variable has the highest maximum value, the S&P ADR variable has the lowest minimum value. It is seen from Table 2 that the AEFES variable has the highest standard deviation value, and the S&P ADR variable has the lowest standard deviation value.

Table 3. Spearman Correlation Matrix

	AEFES	AKBANK	BIST100	CDS	EXCHANGE	GARANTI	KOCHOL	NASDAQ	SPADR	THY	TAV	TTKOM	TURKCELL
AEFES	1.0000												
AKBANK	-0.0210	1.0000											
	0.3012	-											
BIST100	0.0380*	0.0028	1.0000										
	0.0614	0.8916	-										
CDS	-0.0383*	-0.1226*	-0.3833*	1.0000									
	0.0598	0.0000	0.0000	-									
EXCHANGE	-0.004	-0.0342*	0.0161	0.0094	1.0000								
	0.8357	0.0929	0.4278	0.6442	-								
GARANTI	0.1732*	-0.0342*	-0.0046	0.0939*	0.0331	1.0000							
	0.0000	0.0000	0.8230	0.0000	0.1038	-							
KOCHOL	0.1462*	-0.3697*	-0.0077	0.0989*	0.0183	0.4421*	1.0000						
	0.0000	0.0000	0.7052	0.0000	0.3689	0.0000	-						
NASDAQ	0.0460*	0.0000	0.1744*	-0.2876*	0.0346*	-0.0058	0.0325	1.0000					
	0.0236	0.9996	0.0000	0.0000	0.0890	0.7771	0.1102	-					
SPADR	0.0323	0.1330	0.2732*	-0.3591*	0.0484*	-0.0309	0.0143	0.7532*	1.0000				
	0.1128	0.5136	0.0000	0.0000	0.1730	0.1289	0.4808	0.0000	-				
THY	0.1819*	-0.0831*	0.0197	0.0121	0.0220	0.2444*	0.2399*	-0.0031	-0.0041	1.0000			
	0.0000	0.0000	0.3321	0.5518	0.2788	0.0000	0.0000	0.8774	0.8419	-			
TAV	0.1232*	-0.1382*	0.0041	0.0231	-0.0470	0.2034*	0.2847*	0.0217	-0.0078	0.2267*	1.0000		
	0.0000	0.0000	0.8397	0.2564	0.8172	0.0000	0.0000	0.2862	0.7017	0.0000	-		
TTKOM	0.1238*	-0.1791*	-0.0136	0.0393*	0.0185	0.2927*	0.3499*	0.0071	-0.0075	0.2193*	0.2191*	1.0000	
	0.0000	0.0000	0.5052	0.0533	0.3619	0.0000	0.0000	0.7274	0.7017	0.0000	0.0000	-	
TURKCELL	0.1725*	-0.30631*	0.0015	0.0698*	0.0107	0.3905*	0.4396*	0.0273	0.0287	0.2379*	0.2305*	0.3862*	1.0000
	0.0000	0.0000	0.9429	0.0006	0.5994	0.0000	0.0000	0.1788	0.1580	0.0000	0.0000	0.0000	-

Note: * shows the correlation coefficient is statistically significant at a 10% significance level.

According to Table 3, there is a negative relationship between CDS and AEFES. This relationship is also valid for CDS and AKBANK. AKBANK and EXCHANGE are negatively related. There is a positive relationship between SPADR and BIST100, and a negative relationship between SPADR and CDS. There are positive relationships between SPADR and EXCHANGE and between SPADR and NASDAQ. These relationships are also valid between BIST100 and NASDAQ, AEFES and NASDAQ, and EXCHANGE and NASDAQ. There is a negative relationship between NASDAQ and CDS. When the results for AKBANK are examined, it is noteworthy that the positive relationships are specific to GARANTI, THY, TAV, TTKOM, TURKCELL, and KOCHOL. When the results for GARANTI are examined, it is noted that the positive relationships are specific to THY, TAV, TTKOM and TURKCELL. These variables are also valid for KOCHOL. The existence of positive relationships between THY, TAV, TTKOM and TURKCELL variables is seen in Table 3. Positive relationships were found between the AEFES variable and BIST100, GARANTI, KOCHOL, THY, TAV, TTKOM and TURKCELL variables, respectively. The highest positive significant relationship between the variables is between SPADR and NASDAQ (0.7532). In other words, there is a strong relationship in the same direction between the two variables. The negative significant relationship between the variables is between KOCHOL and AKBANK (-0.36972). Accordingly, it is seen that there is an inverse relationship between the two variables.

Models according to the correlation matrix are given below:

$$\textbf{Model 1: } AEFES = f (BIST100_{t-i}, EXCHANGE_{t-i}, CDS_{t-i}, S\&PADR_{t-i}, NASDAQ_{t-i}) \quad (1)$$

$$\textbf{Model 2: } AKBANK = f (BIST100_{t-i}, EXCHANGE_{t-i}, CDS_{t-i}, S\&PADR_{t-i}, NASDAQ_{t-i}) \quad (2)$$

$$\textbf{Model 3: } GARANTI = f (BIST100_{t-i}, EXCHANGE_{t-i}, CDS_{t-i}, S\&PADR_{t-i}, NASDAQ_{t-i}) \quad (3)$$

$$\textbf{Model 4: } KOCHOL = f (BIST100_{t-i}, EXCHANGE_{t-i}, CDS_{t-i}, S\&PADR_{t-i}, NASDAQ_{t-i}) \quad (4)$$

$$\textbf{Model 5: } TAV = f (BIST100_{t-i}, EXCHANGE_{t-i}, CDS_{t-i}, S\&PADR_{t-i}, NASDAQ_{t-i}) \quad (5)$$

$$\textbf{Model 6: } THY = f (BIST100_{t-i}, EXCHANGE_{t-i}, CDS_{t-i}, S\&PADR_{t-i}, NASDAQ_{t-i}) \quad (6)$$

$$\textbf{Model 7: } TTKOM = f (BIST100_{t-i}, EXCHANGE_{t-i}, CDS_{t-i}, S\&PADR_{t-i}, NASDAQ_{t-i}) \quad (7)$$

$$\textbf{Model 8: } TURKCELL = f (BIST100_{t-i}, EXCHANGE_{t-i}, CDS_{t-i}, S\&PADR_{t-i}, NASDAQ_{t-i}) \quad (8)$$

The t index represents the current period of the variables in the models. The Schwarz information criterion was used to determine the appropriate lag number. The maximum lag number is 8 and $0 \leq i \leq 8$. The graphs of the data used in the analysis are shown in Figure 1.

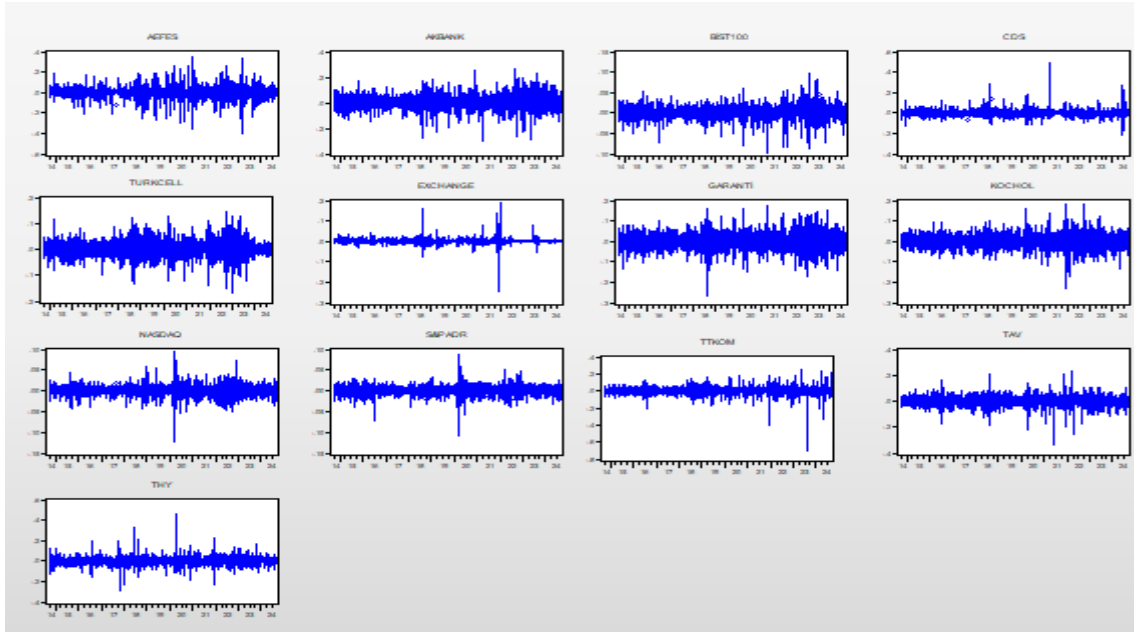


Figure 1. Graphs of the Variables Used in the Analysis

As can be seen from the correlation matrix, a high correlation between independent variables was not detected. Accordingly, the above models were created. Another essential issue in regression analysis is determining the levels and differences where the variables are stationary to avoid the spurious regression problem when working with time series. The most preferred unit root test in the finance literature is the Dickey-Fuller (1979-1981) unit root test. Dickey-Fuller (DF) test, which is based on the distribution of the least squares estimator of the parameters. In the DF test, the error term is assumed to be non-autocorrelated. However, the autocorrelation of the error term renders the use of the distribution in the DF test ineffective. Therefore, Dickey and Fuller developed the extended DF test (ADF) by adding the lagged values of the dependent variable to the model for the case where the error term is autocorrelated (Gujarati and Porter, 2012). The three equations for the ADF unit root test are as follows (Dickey and Fuller, 1981):

$$\Delta y_t = \delta y_{t-1} + \sum_{i=1}^p \beta_i \Delta y_{t-i} + \varepsilon_i \quad (9)$$

$$\Delta y_t = \mu + \delta y_{t-1} + \sum_{i=1}^p \beta_i \Delta y_{t-i} + \varepsilon_i \quad (10)$$

$$\Delta y_t = \mu + \beta t + \delta y_{t-1} + \sum_{i=1}^p \beta_i \Delta y_{t-i} + \varepsilon_i \quad (11)$$

Dickey-Fuller tests assume that error terms are statistically independent and have constant variance. When using this methodology, it is necessary to ensure that there is no correlation between the error terms and that they have constant variance. Phillips and Perron (1988) extended Dickey-Fuller's assumption for error terms. For this purpose, they developed a nonparametric unit root test. The Phillips-Perron (PP) test uses the same regression equations as in the Dickey-Fuller test but solves the autocorrelation problem by making a nonparametric correction to the τ statistic of the parameter (δ) of the previous term in the equation. The thresholds for the tests remain the same. As in the ADF test, the PP test is also applied in three different ways: without constant, with constant, with constant, and with trend, and its equation is as shown below:

$$\Delta y_t = a y_{t-1} + x_t^l \delta + \varepsilon_t \quad (12)$$

For the information obtained from the models to be reliable, whether the Least Squares assumptions are provided should be investigated. One of these assumptions, the standard normal distribution assumption, is that the error terms show a standard normal distribution feature. The Jarque-Bera test is used to determine whether this assumption is met. This test procedure is as follows:

$$JB = n \left[\frac{S^2}{6} + \frac{(K - 3)^2}{24} \right] \sim \chi^2(2) \quad (13)$$

The test's null hypothesis states that the error terms have a normal distribution, while the alternative hypothesis states that they do not conform to a normal distribution. This test statistic conforms to the chi-square distribution with a degree of freedom of 2. If the test statistic is greater than the critical value, it is decided that the error terms are not normally distributed. The autocorrelation problem occurs when there is a relationship between the lagged values of the error term. The Breusch-Godfrey LM test was used in the study to determine the existence of this problem. In addition, the existence of heteroscedasticity in the model should be investigated. For this purpose, the Breusch-Pagan test was used in the study. When utilizing time series datasets, it is common to encounter serial correlation and heteroskedasticity within the data. These instances elevate the likelihood of acquiring serially associated mistakes with non-constant variance. If our primary focus is on statistical conclusions, we should opt for HAC robust standard errors within the context of time series analysis (Wooldridge, 2013).

5. Findings

To avoid the spurious regression problem in the study, the stationarity level and differences of the variables should be determined before model estimation. Here, traditional unit root tests, Augmented Dickey-Fuller (ADF), and Phillips-Perron (PP) unit root tests were used, and the test results are shown in Table 4.

Table 4. Unit Root Tests

	AEFES	AKBANK	BIST100	CDS	EXCHANGE	GARANTI	KOCHOL
ADF test t-Statistic	-25.8100***	-47.6641***	-49.4805***	-46.2109***	-25.8628***	-28.1361***	-29.0335***
PP test t-Statistic	-75.8456***	-47.6840***	-49.5074***	-46.1282***	-43.6413***	-100.3899***	-106.2278***
	NASDAQ	S&P ADR	TAV	THY	TTKOM	TURKCELL	
ADF test t-Statistic	-18.4721***	-33.4761***	-37.2188***	-34.1008***	-30.8092***	-26.7811***	
PP test t-Statistic	-54.9202***	-52.3859***	-92.089***	-72.5669***	-77.4665***	-97.7247***	

Note: *** shows that the variable is stationary at 1% significance level.

When the ADF and PP test results from traditional unit root tests are considered together, it can be said that all variables are stationary at level $I(0)$. After investigating the stationarity, before reporting the model results, the Least Squares Assumptions of the estimated models should be analyzed to determine whether they are valid. For this purpose, the study used the Breusch-

Pagan-Godfrey test, the Breusch-Godfrey-LM test, the Jarque-Bera test, and the Ramsey RESET test. The Breusch-Pagan-Godfrey test is used to investigate the existence of heteroscedasticity. The Breusch-Godfrey-LM test is used to examine the existence of an autocorrelation problem, and the Jarque-Bera test is used to analyze the normality assumption. The Ramsey Reset test was used to investigate the specification of that regression. The results obtained are reported in Table 5.

Table 5. Diagnostics Tests

	Jarque-Bera	Breusch-Pagan-Godfrey	Breusch-Godfrey LM	Ramsey Reset
Model 1	10445.91***	2.6762	106.1654***	0.0852
Model 2	2210.591***	95.6717*	11.78299***	0.5165
Model 3	570.7802***	20.1741	414.7586***	1.0911
Model 4	735.5785***	28.4195**	439.4909***	1.5378
Model 5	6060.514***	44.2334***	233.9133***	0.3047
Model 6	31897.85***	30.1800**	109.9672***	0.0053
Model 7	285023.4***	67.0712***	63.9320***	2.1569
Model 8	578.3546***	40.2297***	435.2554***	0.1036

Note: ***, **, and * show the model assumptions are not valid at 1%, 5%, and 10% significance levels, respectively.

We determined the heteroscedasticity problem in all models (except Model 1 and Model 3), that the error terms were not normally distributed in all models, and that there was an autocorrelation problem. Also, according to the Ramsey Reset test results, we determined that appropriate specifications were in all models. In cases where the models' assumptions cannot be provided, the models should be estimated with robust estimators in the regression analysis. Therefore, HAC robust standard errors were considered when evaluating all models in the study. Accordingly, the obtained model results are given in Table 6.

The change in BIST100 value two periods ago increases AEFES return in the current period by 0.4912 points and the change in EXCHANGE one period ago increases AEFES return by 0.1741 points.

While the change in BIST100 value one period ago affects AKBANK's return positively in the current period, the change in exchange rate and CDS premium in the current period, one period ago, and two periods ago affect AKBANK's return negatively. Similarly, the change in NASDAQ two periods ago decreases AKBANK's return by 0.2191 points.

While the change in the BIST100 value one period ago decreases the return of GARANTI, the change in the BIST100 value 2 and 3 periods ago increases the same return. Similarly, changes in one-period ago EXCHANGE, current and one-period ago CDS premiums, and two-period ago S&P ADR values increase the return on GARANTI. However, changes in the two-period CDS premium, current and one-period ago S&P ADR values decrease the return on GARANTI.

Changes in the BIST100 value one period ago affect KOCHOL return negatively, while changes in the BIST100 value two and four periods ago affect KOCHOL return positively. Changes in the CDS premium in the current and previous periods, S&P ADR two periods ago, NASDAQ value in the current period, and NASDAQ value in the previous period affect KOCHOL return positively. Changes in one-period prior S&P ADR and two-period prior NASDAQ values decrease KOCHOL return.

Table 6. Results of the Models

Dependent Variable	AEFES	AKBANK	GARANTI	KOCHOL	TAV	THY	TTKOM	TURKCELL
	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
BIST100 _t	0.1027 (0.0947)	-0.0701 (0.0559)	0.0598 (0.0553)	0.0503 (0.0542)	0.1003 (0.0631)	0.0800 (0.0510)	0.0270 (0.0736)	0.0359 (0.0464)
BIST100 _{t-1}	0.0053 (0.0755)	2.1843*** (0.0911)	-0.7057*** (0.0755)	-0.7303*** (0.0562)	-0.4206*** (0.0723)	-0.1413** (0.0673)	-0.3656*** (0.0803)	-0.5611*** (0.0056)
BIST100 _{t-2}	0.4912*** (0.0802)	0.1060 (0.0966)	0.7938*** (0.0683)	0.7167*** (0.0760)	-	0.7298*** (0.0834)	0.6775*** (0.0925)	0.7343*** (0.0595)
BIST100 _{t-3}	-	-	0.0993** (0.0524)	0.0204 (0.0412)	-	-0.0991* (0.0615)	-	-0.0625 (0.0420)
BIST100 _{t-4}	-	-	-	0.1062*** (0.0400)	-	-	-	0.0405 (0.0367)
EXCHANGE _t	-0.1192 (0.0739)	-0.2319** (0.1104)	0.0854 (0.0581)	0.0293 (0.0458)	0.1004 (0.1180)	0.0711 (0.1101)	0.0978 (0.0920)	0.0935** (0.0485)
EXCHANGE _{t-1}	0.1741** (0.0844)	-0.2827*** (0.1008)	0.1349** (0.0600)	-	0.0051 (0.1806)	0.0607 (0.0753)	0.0085 (0.0619)	0.0526 (0.0634)
EXCHANGE _{t-2}	-	-0.3254*** (0.1175)	0.0563 (0.0782)	-	0.1389 (0.1377)	0.2651** (0.1232)	0.1657*** (0.0589)	0.1664*** (0.0523)
EXCHANGE _{t-3}	-	-0.0855 (0.0762)	-	-	0.0051 (0.1806)	-	0.1122 (0.1267)	0.0962 (0.0626)
EXCHANGE _{t-4}	-	-0.1002 (0.0780)	-	-	-	-	0.2757 (0.1882)	0.0703* (0.0438)
CDS _t	-0.0332 (0.0391)	-0.1291** (0.0346)	0.0924*** (0.0307)	0.0976*** (0.0280)	0.0747*** (0.0320)	0.0380 (0.0356)	0.0786** (0.0408)	0.0481** (0.0223)
CDS _{t-1}	0.1073*** (0.0469)	-0.1707*** (0.0529)	0.1779*** (0.0345)	0.0701*** (0.0274)	0.0195 (0.0438)	0.1172*** (0.0389)	0.0950* (0.0591)	0.0834*** (0.0283)
CDS _{t-2}	-	-0.0538** (0.0267)	-0.0758*** (0.0302)	-	-0.0076 (0.0342)	-0.0240 (0.0324)	-0.0561* (0.0344)	-
CDS _{t-3}	-	-	-	-	-	0.0485*** (0.0234)	0.0721*** (0.0307)	-
S&P ADR _t	-0.1007 (0.1598)	-0.1506 (0.1300)	-0.1273 (0.1014)	-0.0500 (0.0856)	-0.2337** (0.1012)	0.0158 (0.1102)	0.0464 (0.1619)	0.0594 (0.0942)
S&P ADR _{t-1}	-	0.1644 (0.1151)	-0.2378*** (0.0733)	-0.3386*** (0.0980)	-0.0047 (0.1115)	-0.0117 (0.0636)	-0.3188*** (0.1078)	-0.1740** (0.0854)
S&P ADR _{t-2}	-	0.1222 (0.1384)	0.2312*** (0.0811)	0.3448*** (0.0929)	0.2809*** (0.1183)	0.1421 (0.0995)	-	-0.0482 (0.0880)
S&P ADR _{t-3}	-	-0.0166 (0.1327)	-	-	-	-	-	-
NASDAQ _t	0.1735 (0.1259)	0.0696 (0.1125)	0.1163 (0.0957)	0.1242* (0.0774)	0.2401*** (0.0895)	-0.0428 (0.0825)	-0.0160 (0.1432)	0.0204 (0.0820)
NASDAQ _{t-1}	-	-0.0273 (0.1089)	-	0.0284 (0.0762)	-0.0291 (0.0976)	-	-	-0.0120 (0.0771)
NASDAQ _{t-2}	-	-0.2191* (0.1184)	-	-0.1390* (0.0802)	-0.1304 (0.0988)	-	-	0.2044*** (0.0823)
NASDAQ _{t-3}	-	-0.1652 (0.1149)	-	-	0.0979* (0.0559)	-	-	-
Constant	-0.0008 (0.0006)	-0.0003 (0.0008)	-4.99E-08 (0.00003)	0.0004* (0.0002)	0.0005 (0.0004)	-0.0004 (0.0005)	-0.0005 (0.0006)	0.0001 (0.0003)
R ²	0.3164	0.5128	0.2984	0.3461	0.1552	0.2425	0.2426	0.3311
χ ²	70.7625***	1330.226***	406.6079***	494.3404***	89.4654***	157.9395***	187.3845***	329.0479***

Notes: ***, **, and * show the coefficient is statistical significance at 1%, 5%, and 10% significance levels, respectively. Maximum lags are selected 8 and Schwarz information criteria is used for optimal lag selection.

Changes in BIST100 value one period ago and S&P ADR value in the current period decrease TAV return, while changes in CDS premium and NASDAQ values in the current period, S&P ADR two periods ago, and NASDAQ three periods ago increase TAV return.

It is observed from Table 6 that one-period and three-period prior BIST100 decrease the return of THY, while two-period prior BIST100 and EXCHANGE increase the return of THY. Similarly, changes in the CDS premium one and three periods ago increase the return on THY.

Changes in one-period-ahead BIST100, one-period-ahead S&P ADR, and two-period-ahead CDS premium decrease TTKOM return. However, two-period-ahead BIST100, two-period-ahead EXCHANGE, current period CDS premium, one and three-period-ahead CDS premiums have a positive and significant effect on TTKOM return.

Changes in one-period ago BIST100 and one-period ago S&P ADR have a negative effect on TURKCELL return. BIST100 two periods ago, EXCHANGE in the current period, and EXCHANGE two and four periods ago have a positive effect on the same return. Similarly, changes in the CDS premium in the current period, the CDS premium one period ago, and NASDAQ two periods ago increase the return of THY.

6. Conclusion

ADRs are investment instruments issued by certificate method in the US capital markets in relation to equities. They are frequently used by international firms due to their cost advantages and sourcing benefits. As with all investment instruments, market participants make price forecasts for ADRs. However, unlike others, since the underlying stocks of ADRs are traded in different countries, many parameters need to be taken into account in price forecasts. These parameters range from the economic indicators of the home country to the market conditions in which the ADR is located.

Depending on the parameters, the main objective of the study is to investigate whether market participants realize arbitrage gains from bilaterally traded stocks as a result of price discovery. In fact, given the time differences between the two markets, there is a possibility that predicting the impact of economic changes in the home country on the ADR price may lead to arbitrage gains. The continuity of arbitrage opportunities indicates that the ADR has moved away from a random walk; that is, its price does not follow a random direction but is predictable. In a similar situation, it can also be interpreted that market efficiency has decreased within the framework of the efficient market hypothesis. In other words, identifying the main country factors affecting the price of ADRs is important to provide insight into the efficiency of the ADR market. Moreover, the persistence of arbitrage opportunities may lead to long-term arbitrage opportunities, contrary to the Arbitrage Pricing Theory, which states that the market will reach equilibrium after short-term arbitrage. In this context, it is important to determine the vulnerability of ADR prices.

Although there are many studies on ADRs in the literature, the number of studies on Turkish ADRs is limited. In this study, it is made to determine whether the prices of Turkish ADRs are affected by various economic indicators. A 10-year time period between 2014 and 2024 is taken as the basis for the analysis. As a result of the analysis, it is determined that each ADR is affected by different indicators at different rates. As a result of the study, it is thought that investors are sensitive to the reflections in the markets. Similarly, it is not concluded that these reflections have a uniform effect on the eight returns considered. According to the findings, the return differences between ADRs and underlying stocks are affected by the macroeconomic indicators selected as independent variables at different levels and in different directions. In other

words, it is determined that the return differences between ADRs and stocks can be converted into arbitrage opportunities by utilizing various indicators. The results are in line with the studies of Gupta et al. (2016), Figueiredo and Parhizgari (2017), Esqueda and Jackson (2012), and Bae et al (2008).

The increasing use of technology in financial markets and the proliferation of ADR-like investment instruments in developed markets indicate that the number of ADRs of stocks traded in emerging markets, such as Turkish markets, will increase over time. Therefore, it is important for market participants to investigate the factors affecting the price of ADRs. Since ADR price discovery provides arbitrage opportunities, it is recommended to investigate the issues affecting the price of ADRs in future studies, as it will directly contribute to mutual funds and portfolio management. In addition, it would be beneficial for brokerage houses and investors to address the effects of ADRs on transaction costs, market liquidity, and security selection decisions of market users. In addition, it is thought that a broader analysis by specifically evaluating the price difference between each ADR and stock will provide more precise results.

Declaration of Research and Publication Ethics

This study which does not require ethics committee approval and/or legal/specific permission complies with the research and publication ethics.

Researcher's Contribution Rate Statement

The authors declare that they have contributed equally to the article.

Declaration of Researcher's Conflict of Interest

There is no potential conflicts of interest in this study.

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SHORT-TERM PRICE PREDICTION IN INITIAL PUBLIC OFFERINGS USING XGBOOST: BİST TECHNOLOGY SECTOR EXAMPLE*

XGBoost ile İlk Halka Arzlarda Kısa Vadeli Fiyat Tahmini: BİST Teknoloji Sektörü Örneđi

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Abstract

The aim of the study is to predict the closing price of the next trading day's stocks, of the initial public offering firms in the short term (between 5 and 10 days). For this purpose, firstly, the companies that went public in BIST in 2022, 2023, and 2024 are listed. Among these sectors, the decision was made to conduct the research in the technology sector, which experienced the highest number of initial public offerings in 2024. Using the model created with the XGBoost algorithm, price prediction for the Borsa Istanbul technology sector was made. The data to be used in the analyses consist of the daily closing stock prices of FORTE, which was the first IPO in 2023 and operates in the technology sector, from 15.06.2023 to 28.06.2024. It also includes the daily closing values of the BIST TECHNOLOGY and BIST IPO indices, and the first four-day closing stock prices of the technology sector companies (ODINE, PATEK, and ALTNY) that were the first IPOs in 2024. As a result of the coding steps performed using Python, it was found that the difference between the predicted prices and the actual prices gradually decreased from the fifth to the tenth day after the IPO.

Keywords:

Initial Public Offering,
Stock Price Prediction,
XGboost Algorithm

JEL Codes:

E27, E44, O16

Öz

Çalışmanın amacı, ilk halka arz edilen firmaların hisse senetlerinin kısa vadeli olarak (5 ile 10 gün arasındaki) bir sonraki işlem gününün kapanış fiyatının tahmin edilmesidir. Bu amaçla öncelikle 2022, 2023 ve 2024 yıllarında BİST'te halka arz edilen şirketler listelenmiştir. Bu sektörler arasında 2024 yılında en fazla ilk halka arzın gerçekleştiđi teknoloji sektöründe araştırmanın yapılması tercih edilmiştir. Bu sebeple Borsa İstanbul teknoloji sektörü özelinde, XGBoost algoritmasıyla oluşturulan model yardımıyla fiyat tahmini yapılmıştır. Analizlerde kullanılacak veriler, 2023 yılında ilk halka arz olan ve teknoloji sektöründe faaliyet gösteren FORTE firmasının 15.06.2023 ile 28.06.2024 tarihleri arasındaki günlük hisse senedi kapanış fiyatlarından, BİST TEKNOLOJİ ve BİST HALKA ARZ endekslerinin günlük kapanış değerlerinden ve 2024 yılında ilk halka arz olan teknoloji sektörü firmalarının (ODINE, PATEK ve ALTNY) ilk dört günlük hisse senedi kapanış fiyatlarından oluşmaktadır. Python programlama dili kullanılarak gerçekleştirilen kodlama adımlarının sonucunda, halka arzdan sonraki beşinci günden onuncu güne kadar hesaplanan tahmini fiyatlar ile gerçek fiyatlar arasındaki farkın giderek azaldığı belirlenmiştir.

Anahtar Kelimeler:

İlk Halka Arz,
Hisse Senedi Fiyat
Tahmini,
XGBoost Algoritması

JEL Kodları:

E27, E44, O16

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1. Introduction

Going public is one of the most important financial decisions made in the history of the firm. There may be many reasons that lead firms to this initial public offering. Firms sometimes decide to go public in order to finance their growth, to increase their credibility with financial institutions to increase their recognition to compete with firms that are financially stronger than themselves. The initial public offering process is made possible by the fulfillment of certain prerequisites. For firms that fulfill these conditions, there are many advantages, disadvantages, and some obligations that come with becoming a publicly traded company.

There are many studies on initial public offerings (IPOs), one of the most interesting topics in finance literature related to the stock market. The first study on the subject in the Scopus database is by Dawson (1987). Dawson (1987) analyzed the performance of IPOs in the secondary market for the years 1978-1984 in Hong Kong, Singapore, and Malaysia. Subsequent studies on the subject are generally related to post-IPO performance, abnormal returns, underpricing, and anomalies. The studies of Jindal et al. (2024), Bakırhan and Sayılğan (2023), Gupta et al. (2023), Haque et al. (2023), Mangala and Dhanda (2022), Jamaani and Abdullahi (2021), Yıldırım and Dursun (2016), Kıymaz (1997) are related to the performance of stocks after IPOs. In addition, the studies of Cai and Lee (2013), Tong and Ahmad (2015), Usanmaz and Söylemez (2021) deal with abnormal returns, while the studies of Yıldırım and Dursun (2016), Yılmaz and Abdioğlu (2023) deal anomalies.

In recent years, in the post-Covid-19 period, participation in IPOs has gradually increased, indicating a rising trend on the investor front. According to the reports published by the Central Registry Agency (CRA), the total number of investors participating in IPOs was recorded as approximately 9 million (8,713,686) in 2022. This number increased 13.5-fold, reaching approximately 124 million (123,881,239) in 2023. In 2024, the total number of investors participating in IPOs was 23,382,697 at the end of the first quarter and 52,609,000 at the end of the second quarter, and is predicted to be around 150 million by the end of the year.

Although the number of long-term investors in IPOs is very low, there are a large number of investors who want to make high gains in the short term, recently. Scientific studies also indicate that IPOs exhibit high performance in the short term due to low pricing (Savaşkan, 2005; Bakırhan and Sayılğan, 2023; Haque et al., 2023). Therefore, the most important issue investors who want to make high gains in the short term should know is the short-term price course of IPOs. It is extremely important for investors participating in IPOs to know on which day they can make the highest profit by disposing of their stocks, thanks to accurate price forecasts to be made in the short term. There are many studies in the literature that generally examine the short term in five, ten, and fifteen-day periods (Chi and Padgett, 2005; Orhan, 2006; Tunçay, 2019; Yetim and Koy, 2022)

This study aims to predict the closing stock prices of IPOs on the next trading day in the short term. For this purpose, the companies that went public in 2022, 2023, and 2024 were listed, and the sectors in which these companies operate were determined (Table 2). The technology sector, which is one of the sectors with the highest number of IPOs in these three years, was chosen as the focus of this research. For price prediction, a model was created using the XGBoost algorithm, a popular machine learning algorithm. The BIST IPO index, BIST Technology index, and the data of a technology firm that went public in 2023 were used as model variables to predict the market prices of three firms with IPOs in the technology sector on their fifth trading day in

2024. The reason for the fifth day price estimation within the scope of the study is both because the five-day period is mostly preferred as a short-term period in the literature, and the finding of Yetim and Koy (2022) that the index volatility is affected in the five and ten-day periods after the IPO date.

2. Methodology

2.1. Method

The aim of the study is to predict in the short run the closing stock prices of the firms that are offered to the public for the first time on the next trading day. For this purpose, the XGBoost (Extreme Gradient Boosting) algorithm is used to create a model. The XGBoost algorithm, which is effectively used in classification and regression problems, was developed in the paper "XGBoost: A Scalable Tree Boosting System" by Chen and Guestrin (2016). XGBoost is an ensemble learning algorithm based on decision trees and uses the Boosting technique, where weak learners come together to form a strong predictor. In this study, a data set of approximately one year is used. In the literature, studies by authors such as İmece (2019) and Ülker (2023) also used the XGBoost algorithm in short-term forecasts and stated that the model is appropriate.

Ensemble learning refers to a process where decision trees from multiple machine learning models are combined to reduce errors and improve prediction, compared to a single machine learning model (Malik et al., 2020: 7). In the XGBoost algorithm, normalization is used in the objective function to reduce model complexity, prevent overfitting, and make the learning process faster (Jabeur et al., 2024: 688). Since normalization usually helps the model to generalize better, a normal distribution of the training data or compression to a certain range, can make the model more consistent and accurate on the test data. Therefore, it is a widely preferred method in machine learning and optimization problems.

In XGBoost, various parameters need to be adjusted to optimize model performance and avoid overloading issues. This process, called hyperparameterization, can significantly improve the performance of the model when done correctly. Therefore, hyperparameter tuning is an essential step in the design of machine learning models. Various techniques are used to find the optimal parameter combination (Jabeur et al., 2024: 688). For hyperparameter tuning methods, there are approaches such as manual search, grid search, random search, Bayesian optimization, genetic algorithms, and particle swarm optimization (Emeç and Özcanhan, 2023: 81). In this study, grid search with 5-fold cross validation for time series was used for hyperparameter adjustment. Since the classical cross-validation method cannot be used, due to the sequential nature of time series, the TimeSeriesSplit function in the scikit-learn model_selection library, which is designed to split time series data sequentially, was run in GridSearchCV as a cross-validation method. The list of hyper-parameters to be adjusted, the search ranges and the optimal values obtained from the grid search are presented in Table 1.

Table 1. XGBoost Hyper Parameters for which Appropriate Values are Searched by the Grid Method

Hyper Parameter Name	Search Set	Appropriate Value
Maximum Tree Depth (max_depth)	[3,4,5,6, 7,8,9]	5
Learning Coefficient (learning_rate)	[0.05, 0.01, 0.5, 0.1, 0.2]	0.05
Number of Trees (n_estimators)	[50, 100,150, 200,250,300,350]	150

Grid search is the scanning of the search space by systematically trying all possible parameter value combinations to determine the best combination within a given hyperparameter search set. For this study, 7x7x5 different combinations were run with 5-fold cross-validation, and the maximum tree depth was set to 5, the learning coefficient was set to 0.05, and the number of trees, i.e., estimators, was set to 150 as the optimal values.

2.2. Data Set

For the purpose of the study the companies that went public on BIST in 2022, 2023, and 2024 are listed. As seen in Table 2, the sectors with the highest number of IPOs are technology, electricity, gas and water, metal goods, machinery, electrical appliances, transportation vehicles, and the basic metal industry in these years. Among these sectors, it was preferred to conduct the research in the technology sector, where the highest number of IPOs was realized in 2024. For this reason, the sample of the study consists of companies in the technology sector, whose IPOs were realized in 2024.

Table 2. Sectoral Information on IPOs by Year

Sectors	2022	2023	2024
Technology	4	2	3
Chemical, Pharmaceutical, Petroleum, Rubber and Plastic Products	4	3	-
Financial Institutions	7	13	-
Electricity, Gas and Water	5	6	2
Administrative and Support Service Activities	3	1	-
Agriculture Forestry and Fisheries	1	1	-
Metal Goods Machinery Electrical Equipment and Transportation Vehicles	4	6	2
Textiles, Clothing and Leather	3	-	1
Basic Metal Industry	4	2	3
Wholesale and Retail Trade	1	2	1
Transportation and Warehousing	1	1	2
Forest Products and Furniture	1	-	-
Construction and Public Works	1	-	-
Paper and Paper Products Printing	1	1	1
Food, Beverages and Tobacco	1	7	4
Stone and Soil Based	-	3	1
Real Estate Activities	-	-	1
Hotels and Restaurants	-	3	-
Education Health Sports and Entertainment Services	-	2	-
Mining and Quarrying	-	1	-
Total	41	54	21

Table 3 provides information on the firms in the technology sector that will have IPOs in 2024 and were selected as the sample.

Table 3. Information on the Firms Composing the Sample of the Study

Company Name	BIST Code	Initial Public Offering Date
Odine Solutions Teknoloji Tic. ve San. A.Ş.	ODINE	March 13-15, 2024
Pasifik Donanım ve Yazılım Bilgi Teknolojileri A.Ş.	PATEK	February 6-7, 2024
Altınay Savunma Teknolojileri A.Ş.	ALTNY	May 8-10, 2024

The data to be used in the analysis consists of the daily closing stock prices of FORTE (Forte Bilgi İletişim Teknolojileri ve Savunma Sanayi A.Ş.), which was the first public offering in 2023 and operates in the technology sector, between 15.06.2023 and 28.06.2024, the daily closing values of the BIST TECHNOLOGY and BIST PUBLIC OFFERING indices, and the first four-day closing stock prices of ODINE, PATEK and ALTNY, which were the first public offerings in 2024.

2.3. Analysis

In this study, which aims to predict the stock closing prices of the initial public offering firms in the next trading day in the short term, the XGBoost algorithm is preferred. Price prediction with XGBoost is coded using Python. The main libraries used in the study are Pandas, NumPy, XGBoost, and SciKit-Learn. The steps applied are as follows:

1. Data collection and preparation of the Training Dataset: The data were obtained from the Yahoo Finance (2024) and organized with the Pandas library. In the organization phase, the daily closing prices and dates to be used in the dataset were extracted as time series. The training set to train the XGBoost algorithm was created using the extracted data. For this purpose, the dataset was constructed using the daily stock closing prices of FORTE, a newly public company in the technology sector, between 15.06.2023 and 28.06.2024, along with the daily values of the BIST TECHNOLOGY and BIST PUBLIC OFFERING indices. This data formed the basis of the training set, where each record comprises the stock prices of the last four days as input and the stock price of the fifth day as output. The training set includes a total of approximately 265 daily records, spanning more than a year, which provides a sufficient volume of data to train a machine learning model such as XGBoost, known for its ability to learn from structured tabular data and relatively small datasets (Chen and Guestrin, 2016).

This study employs the sliding window approach to model the temporal dynamics of stock closing prices for companies following their IPOs. Given the inherently sequential and frequently volatile nature of stock price movements, particularly in the early post-IPO period, it is crucial to effectively capture short-term patterns and fluctuations. By using the closing prices from the first four trading days as input to predict the closing price on the fifth day, the sliding window method transforms raw time series data into a supervised learning framework. This transformation enables machine learning models to learn from recent temporal dependencies, thereby enhancing short-term forecasting performance. This approach is supported by existing literature which models time series forecasting as a sequence-to-one problem using sliding windows (Zhang et al., 1998; Brownlee, 2018; Hyndman et al., 2021).

An example of a nine-day record from the training dataset is presented in Table 4.

Table 4. Sample Records from Training Dataset

Date	BISTTEK	BISTHALK	INPUTS				OUTPUT
			t-3 (1st day)	t-2 (2nd day)	t-1 (3rd day)	t (4th day)	t+1 (5th day)
15.06.2023	47164,17	5354,74	14,66	16,12	17,73	19,5	21,44
16.06.2023	47443,39	5379,82	16,12	17,73	19,5	21,44	23,58
19.06.2023	46016,08	5175,5	17,73	19,5	21,44	23,58	25,92
20.06.2023	45158,12	5125,71	19,5	21,44	23,58	25,92	27,4
21.06.2023	44948,77	5106,98	21,44	23,58	25,92	27,4	28,2
22.06.2023	45988,89	5286,53	23,58	25,92	27,4	28,2	31,02
23.06.2023	47113,89	5422,69	25,92	27,4	28,2	31,02	34,12
26.06.2023	48417,39	5595,77	27,4	28,2	31,02	34,12	37,52
27.06.2023	49462,69	5598,89	28,2	31,02	34,12	37,52	41,26

2. *Data preprocessing:* The data in the training set were normalized using the MinMaxScaler class from the Preprocessing module of the SciKit-Learn library. The formula used in the calculation is given in equation 1.

$$X_{scaled} = \frac{X - X_{min}}{X_{max} - X_{min}} \quad (1)$$

3. *Preparing the Test Dataset:* In 2024, the closing prices of ODINE, PATEK and ALTNY, and the daily closing values of BIST TECHNOLOGY and BIST IPO indices from the day of IPO until July 2024 are used as test data. A separate test set is prepared for each firm. This testing approach simulates a real-world forecasting scenario in which a trained model is applied to previously unseen stocks to assess its generalization ability. The data for these companies were not included in the training process, ensuring a strict separation between training and testing phases.

In addition, this approach is aligned with similar studies such as Fischer and Krauss (2018) and Kim and Won (2018), which utilize sequential stock price data with windowed inputs to predict future values using machine learning models.

4. *Training and evaluation of the model:* The model was trained using the optimal combination of hyperparameters given in Table 1. The R^2 value of the trained model was 0.9324, and the MSE value was 6.0388.

5. *Model estimation and analysis:* The trained model is tested using the stock closing price data of 3 different firms with IPOs in 2024. Forecasts are obtained from the test data and compared with the realized end-of-day closing prices. The performance of the model for the test set is reported, and the related graphs are presented in Table 5 in the findings section.

3. Findings

As a result of the steps in the analysis phase, the mean squared error (MSE), mean absolute error (MAE), root mean square error (RMSE), values were calculated to measure the performance of the trained XGBoost machine learning model and were presented in Table 5. MSE value is calculated in equation 2, MAE value in equation 3, RMSE value in equation 4, and R^2 value in equation 5. In these equations, N = number of registrations, y_i = actual closing price of the

stock, $\hat{y}_i$ = stock closing price predicted by the XGBoost model, $\bar{y}$ = average of actual closing prices of the stock.

$$MSE = \frac{1}{N} \sum_{i=1}^N (y_i - \hat{y}_i)^2 \quad (2)$$

$$MAE = \frac{\sum_{i=1}^N |y_i - \hat{y}_i|}{N} \quad (3)$$

$$RMSE = \sqrt{MSE} \quad (4)$$

$$R^2 = 1 - \frac{\sum_{i=1}^N (y_i - \hat{y}_i)^2}{\sum_{i=1}^N (y_i - \bar{y})^2} \quad (5)$$

Table 5. Error Metrics of the XGBoost Model

Company Name	Error Metrics			
	MSE	MAE	RMSE	R ²
ODINE	6,2659	1,2288	2,5031	0,9565
PATEK	87,29436	6,026003	9,343145	0,9226
ALTNY	6,7358	0,9918	0,9919	0,9667

When the error metric values of the models established with the XGBoost algorithm are examined, it is evident that the company with the least difference between the predicted and actual values is ALTNY. However, the difference between the predicted value and the actual value was ± 2.5 for ODINE and ± 9.3 for PATEK. When R² values are analyzed, it is determined that the data fit the model with high coefficients of determination of 95.65%, 92.26%, and 96.67%. To identify periods in which the differences between the actual values and the predicted values deviate and to interpret which factors are responsible for these deviations, the graphical representation of these values is shown below for each firm.

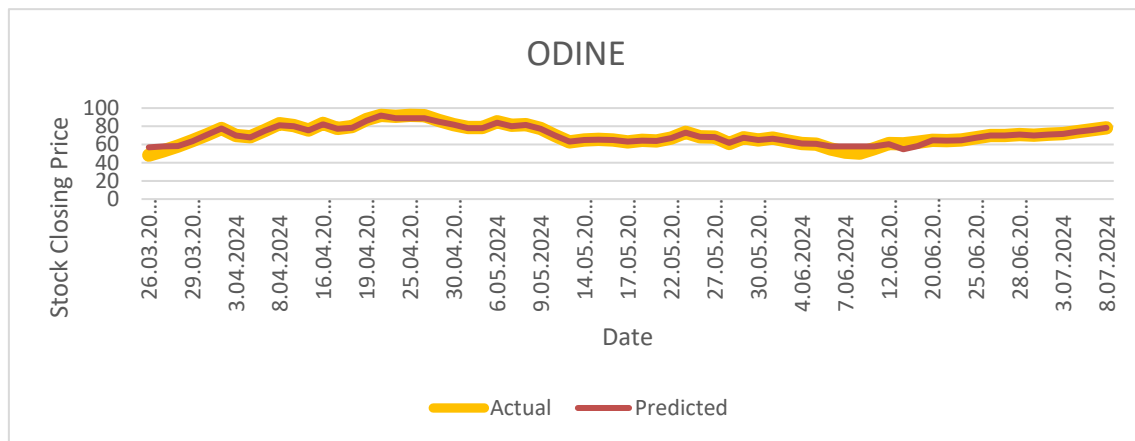


Figure 1. ODINE Stock Closing Price Prediction Graph with XGBoost Algorithm

Figure 1 shows the stock closing price prediction graph for ODINE. In Figure 1, the yellow line shows the actual daily closing prices of the firm, while the orange line shows the daily closing

prices predicted by the XGBoost algorithm. As seen in Figure 1, it is noteworthy that there is a deviation between the actual and predicted closing prices of the firm on March 26, 2024, and June 4-11, 2024. Before evaluating the reasons for these deviations, it would be useful to know some information about the firm and its initial public offering. This information has been compiled from the company's prospectus and the halkarz.com website and is listed below:

- The public offering price of the company, whose IPO dates are March 13-14-15, is 30 TL,
- Form of public offering is capital increase and joint sale,
- Public offering method is to collect demand with fixed price and equal distribution
- The brokerage method is best-effort brokerage,
- The number of shares offered to the public is TL 44,200,000,
- Consortium leaders TSKB / Yatırım Finansman Menkul Değerler A.Ş.,
- Free float is 40%,
- The funds raised through the IPO will be used 52.5%-62.5% for overseas investments, 30%-40% for working capital, and 5%-10% for financing new products and solutions,
- The date of commencement of operations of the company is reported as 30.12.1999.

There are numerous factors affecting the market price in IPOs, and these factors have been evaluated in various studies. The reason for evaluating these factors is to determine investors' confidence in the firm and their appetite for investment. Asset size, company age, total IPO amount, market return, IPOs ratio, and IPOs method are among the antecedent factors affecting the price in initial IPOs (Savaşkan, 2005: 15). Firms' high age and sectoral experience are seen as a reassuring factor for investors. Ritter (1991), Rosenboom (2012), Elma (2017) found a strong negative relationship between firm age and underpricing.

When ODINE is evaluated within the framework of these factors, it reveals that the age of the company is almost 25 years. Investors who see that the firm has been operating in the sector for a long time may expect that it will not be underpriced in the initial public offering, since they will face less uncertainty. According to Beatty and Ritter (1986), Rock (1986), Dongwei and Fleisher (1999), underpricing is often associated with future uncertainty. More than half of the funds provided by the firm as a result of the IPO will be used for investments, while 30-40% will be allocated to working capital. Investors mostly prefer that firms use the funds obtained from IPOs in new investments. An adverse situation may give negative signals to investors. Kirkulak and Davis (2005) argue that the pricing level in IPOs is largely determined by investor demand. In ODINE, although the ratio of funds to be used for new investments is relatively high, the amount to be kept as working capital is also substantial. This may have created a negative signaling effect for investors. Another noteworthy aspect of the firm's data is its 40% public float rate. It is still a high percentage, even if it is less than half, which may cause investors to feel a sense of ownership and belonging almost as much as the main shareholders. Therefore, this situation which reduces uncertainty may be perceived as a sign that the firm will not be underpriced. As a result, the possible reasons for the deviation between the predicted and realized stock prices in the first days of the firm's IPO can be interpreted.

When the possible reasons for the deviations between the actual and predicted prices between March 26 and June 4-11 are evaluated on a firm-by-firm basis and on the basis of financial developments in the country/world in Figure 1, the following situations stand out:

On March 21, 2024, ODINE's first trading day on BIST, ODINE disclosed its "Company General Information Form" to the Public Disclosure Platform (KAP, 2024) on March 26. In addition, as stated by Tacirler (2024), the price stabilization period for ODINE is 15 days after the shares start trading on BIST (<https://www.kap.org.tr/tr/sirket-bildirimleri/5941-odine-solutions-teknoloji-ticaret-ve-sanayi-a-s>; <https://www.kap.org.tr/tr/Bildirim/1296193>; <https://tacirler.com.tr/odine-solutions-teknoloji-ticaret-ve-san-as-odine>).

On May 29, June 7, June 10, and June 12, the company notified PDP that the circuit breaker application started during the transaction (<https://www.kap.org.tr/tr/sirket-bilgileri/ozet/5941-odine-solutions-teknoloji-ticaret-ve-sanayi-a-s>).

Although not specific to ODINE, the CRA announced that it has set June 11, 2024, as the date for the publication of the 2024 interim and annual financial reports of companies traded on the Istanbul Stock Exchange on the PDP, in line with the Capital Markets Board (CMB) announcements (<https://www.kap.org.tr/tr/sirket-bilgileri/ozet/5941-odine-solutions-teknoloji-ticaret-ve-sanayi-a-s>).

At its meeting held on May 23, CBRT kept the policy rate unchanged in line with expectations. On May 17, public austerity measures were announced. In May, MSCI world and emerging markets indices posted increases. The downturn in the US stock markets reversed on the back of the continued positive performance of technology companies, and the indices hit historic highs at the close of the month. The inflation rate increased in May, reaching its highest annual inflation level since November 7, 2022. In line with the accelerated portfolio investments in Turkey in May, domestic markets also followed a positive course and BIST-100 closed May with a 3.5% premium. Moreover, the 5-year CDS risk premium ended May at its lowest level since January 10, 2020 (Isbank, 2024).

All the developments listed above may have given some negative or positive signals to investors. As can be seen in Figure 1, there is a downward trend in the actual closing prices for a week following June 4. Therefore, it is thought that a large number of investors may have made buy-sell decisions affected by developments during the few days before June 4, leading to a sudden change in prices. On the other dates, there is a close similarity between the actual prices and the prices predicted by the XGBoost algorithm. In fact, the error metric values in Table 5 are also low for ODINE. This means that the model has lower forecasting errors. Figure 2, which shows the regression model and R^2 values established with the XGBoost algorithm for ODINE, is another indicator confirming this situation.

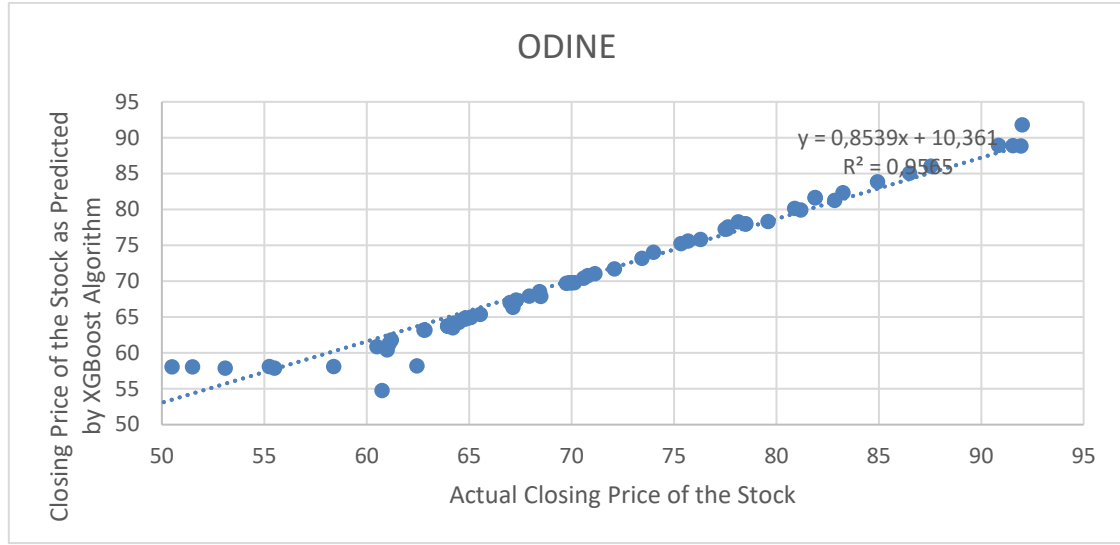


Figure 2. ODINE Stock Closing Price Prediction Model with XGBoost Algorithm

According to Figure 2, the R^2 value of the XGBoost algorithm for the stock price prediction of ODINE is 0.9565. Therefore, the regression prediction model fits the algorithm well.

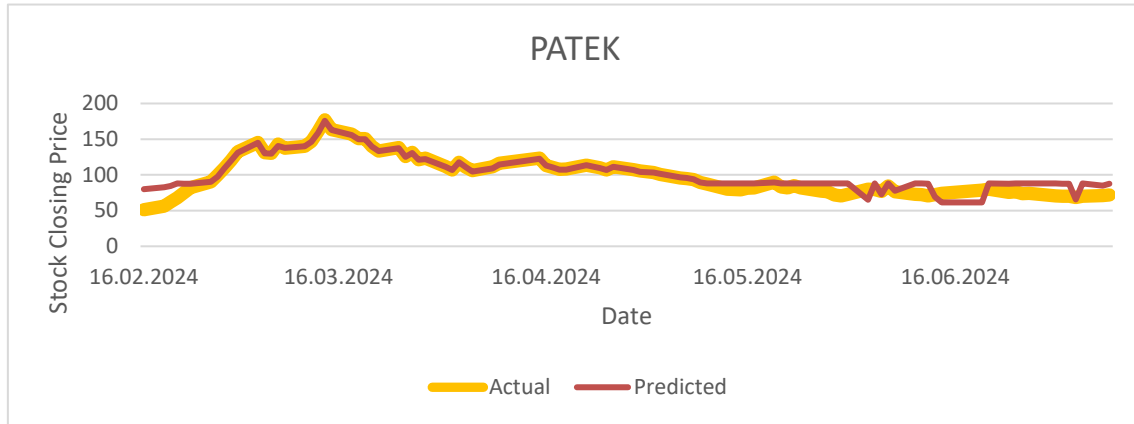


Figure 3. PATEK Stock Closing Price Prediction Graph with XGBoost Algorithm

Figure 3 shows the stock closing price prediction graph of PATEK. The yellow line in the figure represents the actual daily closing prices, and the orange line represents the daily closing prices predicted by the XGBoost algorithm. As shown in Figure 3, there are deviations between the actual and forecast prices of the firm in some periods between February 16-23, 2024, and May 31-July 5, 2024. Before evaluating the possible reasons for the deviations that occurred on the specified dates, some information that should be known about the company is summarized as follows, compiled from the company's prospectus and halkarz.com website:

- The company's IPO dates are February 6-7, 2024,
- IPO price is 35 TL,
- Form of public offering is capital increase and joint sale,
- The IPO method is to collect demand at a fixed price and distribute it equally,

- The brokerage method is best-effort brokerage,
- The number of shares offered to the public is TL 27,000,000,
- Consortium leader Halk Yatırım Menkul Değerler A.Ş.,
- Free float is 20.15%,
- The funds raised through the IPO will be used 45% for capital expenditures, 35% for R&D new product investments and 20% for working capital
- Date of establishment is 10.06.2015.

When evaluating PATEK in terms of the factors affecting the initial public offering price, it is noteworthy that the firm has a nine-year history. Since this situation indicates that the company has a relatively new period of activity, it may be perceived as uncertainty for investors. Therefore, there may be an expectation that the company will be assigned a lower valuation. On the other hand, the fact that only 20% of the funds raised through the public offering will remain as working capital may give a positive signal to investors (Savaşkan, 2005: 15). Therefore, this signal reduces the likelihood that the firm will be perceived by investors as obliged to go public because it cannot be self-sufficient. A firm with a relatively low IPO rate of 20.15% may send a negative signal to investors, suggesting that they may not see themselves as potential shareholders in the company. As stated in Keasey and Short (1992) and Chen et al. (2000), this is a factor that increases the expectation that the firm will be underpriced as a result of high management ownership.

In addition to these comments, when the dates on which the deviations between the actual closing prices and the closing prices predicted by the XGBoost algorithm occurred are evaluated on a company basis and on the basis of financial developments in the country/world, the following points come to the fore:

On February 21, 2024 the company notified PDP that the company's shares would not be subject to credit transactions from the beginning of the session on February 22, 2024 until the end of the session on March 21, 2024 in accordance with the Volatility Based Measure System (VBMS). The company also announced the appointment of a general manager and the purchase of financial assets on the same dates.

On May 30, 2024, it was reported to PDP that TİTRA Teknoloji A.Ş., a subsidiary of the company, increased its capital through a rights issue, Group B shares were transferred to the Venture Capital Investment Fund and the subsidiary rented a factory building and moved on May 31, 2024.

On June 7, June 10, and June 24, 2024 the company reported to PDP that circuit breaker application started during the transaction. In addition, it was reported on June 25 that the articles of association of the company were updated and on June 27 that no dividend distribution would be made and that the date of the general assembly meeting was announced (<https://www.kap.org.tr/tr/sirket-bilgileri/ozet/8acae2c58b2fa64e018d63b9afbd4e6c>; <https://www.kap.org.tr/tr/Bildirim/1297142>).

On July 5, PDP was notified that the continuous trading of the company's shares was suspended, single price order collection was started, and an explanation regarding related party transactions was disclosed to PDP.

Tacirler Yatırım stated that the price stabilization period for PATEK is 30 days after the shares start trading on BIST (<https://www.kap.org.tr/tr/sirket->

bilgileri/ozet/8acae2c58b2fa64e018d63b9afbd4e6c; <https://tacirler.com.tr/pasifik-donanim-ve-yazilim-bilgi-teknolojileri-a-s-patek-br-halka-arz-ediliyor>).

According to the July 1 report, the real sector confidence index in Turkey decreased by 2.6 points in June compared to the previous month. In addition, inflation expectations for July decreased. CBRT kept the policy interest rate unchanged Vakıfbank (2024)

The developments that are thought to have an impact on stock prices are listed above. For the firm with a price stabilization period of 30 days, the forecasts for the period after the initial public offering, did not match the actual prices as quickly as in ODINE. However, the period between June 4 and June 11, when prices deviated in ODINE, was also one of the periods when deviations occurred for PATEK. In addition, the disclosures made to the PDP at the end of May and June may have affected the price movements of the firm. Therefore, although the deviation for PATEK appears to be minimal in the medium term as can be seen from the error metrics given in Table 5, the predicted price level of the firm is somewhat far from the actual prices. This is particularly evident in the initial stages of the IPO and in the period after May 31st. The regression model and R^2 values in Figure 4 also support this finding.

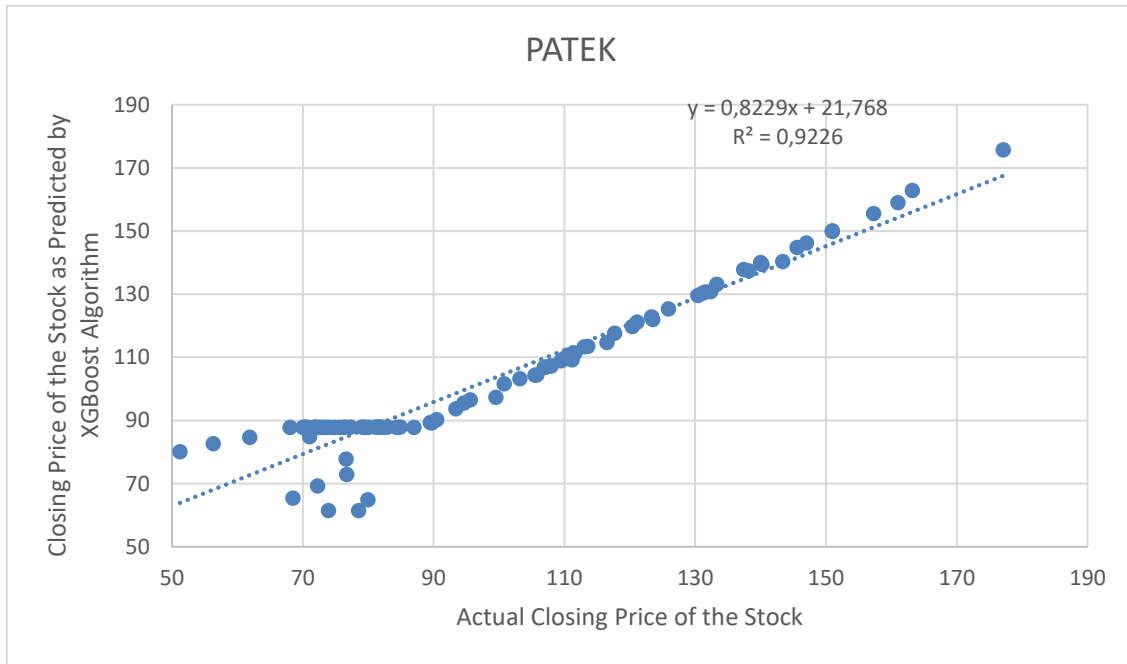


Figure 4. PATEK Stock Closing Price Prediction Model with XGBoost Algorithm

Figure 4 shows that the R^2 value of the XGBoost algorithm for the stock price prediction of PATEK is 0.9226. This result shows that the regression prediction model fit of the algorithm is still at a high level, although not as high as ODINE.

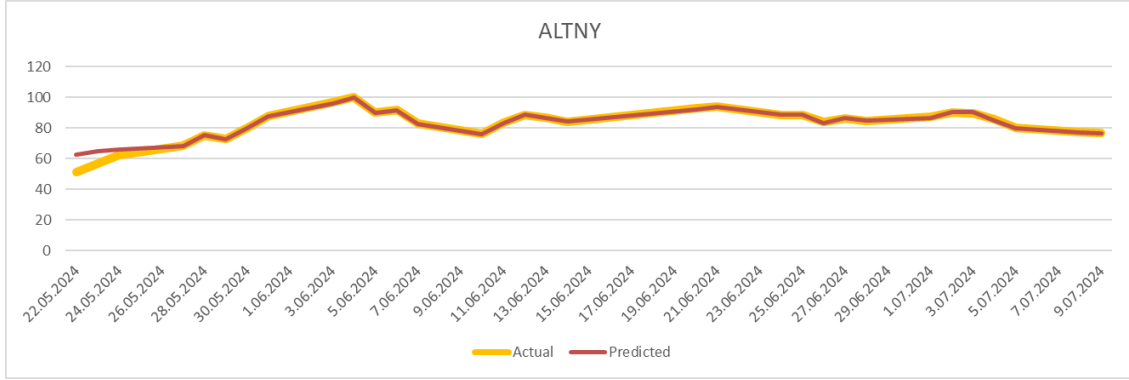


Figure 5. ALTNY Stock Closing Price Prediction Graph with XGBoost Algorithm

Figure 5 shows the stock closing price prediction graph of ALTNY. The yellow line in the figure represents the actual daily closing prices of the firm, while the orange line represents the daily closing prices predicted by the XGBoost algorithm. It is observed that ALTNY, the most recent IPO among the firms in the sample, has a deviation between the actual closing price and the predicted closing price only between May 22 and 24, 2024. Before moving on to the possible reasons for this deviation, the information gathered about the firm from the prospectus and the halkarz.com website can be listed as follows:

- The company's demand collection dates are May 8-10, 2024,
- IPO price is 32 TL,
- Form of public offering is capital increase and joint sale,
- The IPO method is to collect demand at a fixed price and distribute it equally,
- The brokerage method is best-effort brokerage,
- The number of shares offered to the public is TL 58,823,530,
- Consortium leaders TSKB / Ziraat Yatırım Menkul Değerler A.Ş./ Yatırım Finansman Menkul Değerler A.Ş.,
- Free float is 25%,
- Fund utilization areas are as follows: 50% investments in new facilities and production technologies, 15% investments in testing and verification technologies, R&D and product development, 5% investments in global sales and marketing network, 15% working capital, 5% financial debt payments, 10% acquisitions and/or establishment of joint ventures,
- The company's price stabilization transactions are 15 days from the start of trading of the shares on BIST,
- Date of establishment is 27.05.2014

When ALTNY, which has ten years of experience in the sector, is evaluated according to the factors affecting the initial public offering price, it may create an expectation of low pricing, as the age of the company creates a situation of uncertainty for investors. This interpretation is supported by various findings in the literature (Durukan, 2002; Rosenboom, 2012). In addition, the fact that the funds obtained as a result of the IPO will be mostly used for new investments may be perceived by investors as a positive signaling effect (Deb, 2013; Park et al., 2016). In addition, the firm's public offering ratio of 25% can be interpreted as indicating that there is no problem between the main shareholders. As can be seen in Figure 5, the deviation between the

actual and predicted stock prices of ALTNY, the last IPO from the technology sector until July 2024, when this study was prepared, is only in the initial public offering period. Even though the subsequent period is short, the actual and predicted prices are quite close to each other. It is noteworthy that, even between June 4 and 11, 2024 when there is a deviation between the prices of both ODINE and PATEK, the predicted prices of ALTNY are in line with the actual prices. In the early periods of the IPO, for example, it was reported that the company made notifications to the PDP on May 23, 2024 regarding the capacity increase, and on May 24, 2024 regarding the implementation of the volatility-based measure system on a per-share basis (<https://www.kap.org.tr/tr/Bildirim/1289988>; <https://www.kap.org.tr/tr/Bildirim/1290891>).

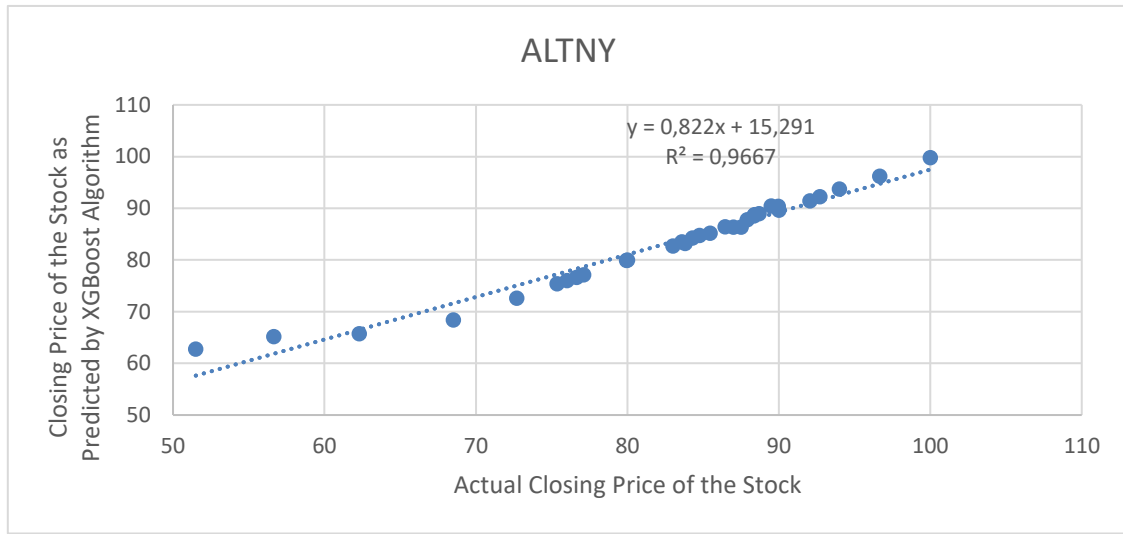


Figure 6. ALTNY Stock Closing Price Prediction Model with XGBoost Algorithm

Figure 6 shows the XGBoost regression model and R^2 values established with the XGBoost algorithm for ALTNY. Accordingly, the R^2 value in the XGBoost algorithm for the stock price prediction of the firm is 0.9667, indicating a strong model fit. As a result of the steps applied with the XGBoost algorithm, the predicted and realized closing prices of the firms in the sample for days ranging from five to ten are given in Table 6.

According to Table 6, the difference between the closing prices of each firm predicted by the XGBoost algorithm and the actual closing prices gradually decreased in the following days. The absolute values of this difference also decreased considerably and were found to be (11.16-8.83-4.78-0.30-0.71-0.20) for ODINE, (28.89-22.78-19.77-12.94-5.49-0.24) for PATEK and (11.26-8.48-3.45-0.11-0.05-0.11) for ALTNY.

Table 6. Actual and Predicted Price Information of the Sample Firms between Five and Ten Days

		Real	Predicted	Date
ODINE	Days	43.9	55.0630	26.03.2024
	Day 5	48.28	56.8128	27.03.2024
	Day 6	53.1	57.8805	28.03.2024
	Day 7	58.4	58.0943	29.03.2024
	Day 8	64.2	63.4837	1.04.2024
	Day 9	70.6	70.3944	2.04.2024
	Day 10	43.9	55.0630	26.03.2024
PATEK	Days	56.3	82.6366	19.02.2024
	Day 5	61.9	84.6820	20.02.2024
	Day 6	68.05	87.8220	21.02.2024
	Day 7	74.85	87.7996	22.02.2024
	Day 8	82.3	87.7936	23.02.2024
	Day 9	90.5	90.2512	26.02.2024
	Day 10	56.3	82.6366	19.02.2024
ALTNY	Days	51.5	62.7615	22.05.2024
	Day 5	56.65	65.1352	23.05.2024
	Day 6	62.3	65.7511	24.05.2024
	Day 7	68.5	68.3853	27.05.2024
	Day 8	75.35	75.4071	28.05.2024
	Day 9	72.7	72.5800	29.05.2024
	Day 10	51.5	62.7615	22.05.2024

4. Conclusion

IPOs, which are considered an important milestone in the history of the firm, provide various advantages, such as ease of financing and liquidity and paving an important path towards institutionalization. In addition, IPOs are of great importance for national markets. Especially in developing countries, IPOs contribute to the further development of the capital markets of these countries. From the investors' perspective, investing in stocks during the initial period plays an important role in generating positive returns. This is supported by the findings of Otlı and Ölmöz, 2011; Kurtaran 2013; Balıkçı and Tunçel, 2025 that investors generally experience positive returns in the first days.

The aim of the study is to make short-term price forecasts for IPOs in order for investors to achieve positive returns. For this forecast, a model was created with the XGBoost algorithm, and ODINE, PATEK, and ALTNY—companies which operate in the technology sector and completed their IPOs in 2024— were selected as the sample for the reasons stated in the methodology section of the study. A model was designed and a data set created for predicting the price on the fifth day after the initial public offering. After dividing the dataset into training and test datasets, the training dataset is further divided into input and output datasets. The closing stock prices of FORTE, a company operating in the technology sector and first offered to the public in 2023, for four days after the IPO date, along with the daily closing values of the BIST technology and BIST IPO indices, constitute the input of the training set. The closing stock prices of FORTE on the fifth day constitute the output of the training set. Therefore, when the model is given four days of stock closing prices and the aforementioned index values as input, it is expected to predict the price of the fifth day. The R^2 value of the trained model is 0.9324, which means that the model explains 93.24% of the variance. The reason for forecasting the fifth day price within the scope of the study is that the five-day period is typically considered short-term in the literature.

In IPOs, it is known that stock prices increase from the first trading day until the equilibrium point, where the investors who participate in the public offering find the profits obtained satisfactory, and the appetite of those who want to invest in stocks decreases. Although it is difficult to know when this point will occur, this point is generally estimated to occur between five and ten days (Düzer, 2020: 249; Yetim ve Koy, 2022: 949), sometimes, 15 days (Tunçay, 2019: Kahraman ve Coşkun, 2020: Brau ve Fawcett, 2006). After the analysis, it is observed that the difference between the predicted and realized closing prices of the firms in the sample (Table 6) for the days in the five to ten range decreases as the days pass.

Policy recommendations regarding the findings of the study can be listed as follows. The use of powerful machine learning algorithms such as XGBoost has significant potential to support investment decisions. Therefore, financial institutions and investors may prioritize training and infrastructure investments to increase the applicability of such models. In addition, forecasting models for the early performance of IPOs may provide investors with the opportunity to make more informed decisions. Accordingly, the results of such algorithms can be presented to investors in investment advisory services and strategies to reduce short-term risks can be developed. In addition, this study is a pioneering study in this field in the Turkish context by focusing on the short-term prediction of the stock prices of technology firms listed on Borsa Istanbul. The successful performance of the XGBoost algorithm suggests that it is a powerful tool for future financial forecasting research. While the literature has generally focused on long-term performance evaluations, this study extends the existing body of knowledge by focusing on short-term price forecasting. Modeling price fluctuations, especially in the first days after an IPO, can contribute to a better understanding of investor behavior. The development of a model specific to the technology sector fills an important gap in the literature to better understand sector-specific differences and is a valuable reference for the design of models that can be adapted to other sectors in the future.

In conclusion, which aims to make short-term price forecasts in IPOs, shows that the model is considered to be successful; this is evidenced by the high R^2 values. However, while the absolute values of the differences between the prices predicted by the algorithm and the realized prices were higher on the fifth day, these values were below 0.25 for each firm until the tenth day. Therefore, the predictive power of the model increases with time after the IPO. In addition, the application of the model in different sectors can be recommended for future studies.

Declaration of Research and Publication Ethics

This study, which does not require ethics committee approval and/or legal/specific permission, complies with research and publication ethics.

Researcher's Contribution Rate Statement

The authors declare that they have contributed equally to the article.

Declaration of Researcher's Conflict of Interest

There are no potential conflict of interest in this study.

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THE MULTIDIMENSIONAL EFFECT OF FINANCIAL DEVELOPMENT ON TOTAL FACTOR PRODUCTIVITY: EVIDENCE FROM CROSS-COUNTRY PANEL DATA*

Finansal Geliřmenin Toplam Faktör Verimlilięi Üzerindeki Çok Boyutlu Etkisi:
Ülkeler Arası Panel Verilerinden Elde Edilen Kanıtlar

Çaęatay VİřNE**^{ID} & Ramazan EKİNCİ***^{ID}

Abstract

Keywords:
Financial Development,
Financial Markets,
Financial Institutions,
Total Factor Productivity,
Panel Data,
Driscoll Kraay Standard Error,
Developing Countries

JEL Codes:
G3, G10, G15, G18,
G20, C23

This paper estimates the impact of financial development on total factor productivity (TFP) using panel data from 2002 to 2019. Employing the Driscoll-Kraay Standard Error (DKSE) approach, we analyze the relationship between financial development and its components (financial institutions and financial markets) with TFP. The results confirm the existence of a positive and significant relationship between financial development and TFP, suggesting that financial development plays a facilitating role in TFP. It was found that financial institutions have a positive and significant effect on TFP, while financial markets do not have a significant effect on TFP. Moreover, while the effect of financial development on TFP is positive and significant in developing countries, there is no clear evidence of such an effect in developed countries. Among the control variables included in the model, trade openness, foreign direct investment, and economic growth have a positive effect on TFP, while human capital has a negative effect. Furthermore, it is confirmed that institutional quality indicators also have a positive impact on TFP when included in the model. Our results suggest that policies favouring financial development should be pursued further in order to correct the mismatch in resource allocation and thus promote TFP growth.

Öz

Anahtar Kelimeler:
Finansal Geliřme,
Finansal Piyasalar,
Finansal Kurumlar,
Toplam Faktör Verimlilięi,
Panel Veri,
Driscoll-Kraay Standart Hatalı,
Geliřmekte Olan Ülkeler

JEL Kodları:
G3, G10, G15, G18,
G20, C23

Bu çalışmada finansal gelişmenin toplam faktör verimlilięi (TFP) üzerindeki etkisi 2002 ile 2019 yılları için panel veri analizi ile tahmin edilmektedir. Driscoll-Kraay standart hata (DKSE) yaklaşımını kullanarak, finansal gelişme ve alt bileşenleri (finansal kurumlar ve finansal piyasalar) ile TFP arasındaki ilişki analiz edilmektedir. Finansal gelişme ile TFP arasında pozitif ve anlamlı bir ilişkinin varlığını doğrulamakta ve finansal gelişmenin TFP üzerinde arttırıcı bir rol oynadığını ortaya koymaktadır. Dirençlilik analizi sonucunda finansal kurumların TFP üzerinde pozitif ve anlamlı bir etkisinin olduğu, öte yandan, finansal piyasaların TFP üzerinde anlamlı bir etkisinin olmadığı sonucuna ulaşılmıştır. Ayrıca, finansal gelişmenin TFP üzerindeki etkisi gelişmekte olan ülkelerde pozitif ve anlamlı iken, gelişmiş ülkelerde böyle bir etkiye dair net bir kanıt bulunamamıştır. Modelde yer alan kontrol değişkenleri arasında, ticaret açıklığı, doğrudan yabancı yatırımlar ve ekonomik büyüme TFP'yi pozitif yönde etkilerken, beşeri sermaye negatif bir etkiye sahiptir. Ayrıca, kurum kalite göstergelerinin modele dahil edildiğinde TFP üzerinde pozitif bir etkisi olduğu doğrulanmıştır. Bulgularımız finansal gelişmeyi destekleyen politikalara ağırlık verilmesi sonucunda, kaynak tahsisindeki uyumsuzluğun giderilerek TFP büyümesinin artırılabilceğini ortaya koymaktadır.

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1. Introduction

Total factor productivity (TFP) is vital for driving long-term economic growth and improving people's living standards within a country. In recent decades, many developing and emerging economies have witnessed notable productivity growth, largely driven by financial development. This has facilitated greater access to capital, encouraged innovation, and improved efficient allocation of resources (Levine, 2005). Financial development has been a driving force behind this progress, through strengthening of financial institutions, enhanced market liquidity, and better risk management, which have allowed firms to make more productive investments, contributing to overall economic growth (King and Levine, 1993). However, despite significant gains in the early 21st century, the trend of productivity growth seems to have slowed in recent years. As Adler et al. (2017) highlights, the pace of TFP growth has decelerated in several emerging economies, suggesting that the positive effects of financial development on productivity may be diminishing. New challenges, such as structural inefficiencies, market saturation, and global economic uncertainties, are clearly hindering further progress.

The relationship between financial development and TFP is a key topic for researchers, especially after the global financial crisis. Since then, many researchers and policymakers have directly challenged previously accepted notion that financial development is linked directly to total TFP growth. Before the crisis, it was generally accepted that financial system deepening and efficiency led to higher productivity and accelerated economic growth (King and Levine, 1993; Levine, 2005). However, in the aftermath of the crisis, this perspective has been contested by certain studies proposing that the impact of financial development on productivity is more intricate and context-specific. Specifically, unregulated expansion of financial systems and prevalence of risky lending practices resulted in deleterious effects on TFP in several countries following the crisis (Adler et al., 2017), underscoring the importance of financial stability for sustainable growth. These novel perspectives underline the necessity for a more nuanced understanding of the relationship between financial development and TFP, which may vary under different conditions.

A well-functioning financial market, which emerges because of financial development within a country, has been shown to lower transaction costs and allocate resources more effectively to high-productivity sectors. This, in turn, has been demonstrated to foster technological advancements and facilitate overall economic growth (Alfaro et al., 2009). Čihák et al. (2015) have suggested that financial development is shaped by both financial markets and institutions, with its success largely depending on their depth, accessibility, and efficiency. A robust financial system has also been shown to enhance a nation's capacity to adopt new technologies (Dabla-Norris et al., 2021).

A substantial body of empirical evidence indicates that effective financial markets enhance a country's capacity to integrate foreign technology, notably through foreign direct investment, which subsequently fosters productivity growth in the host country (Alfaro et al., 2009). Numerous countries have advocated for financial market development through reforms, including the liberalization of interest rates, enhanced credit distribution across various sectors, and extensive institutional and legal modifications. These reforms have been particularly significant in removing barriers that previously hindered the growth of the financial sector. In numerous nations, reforms have catalyzed the shift to market-based systems, reduced government intervention in financial markets, and improved the allocation of resources to the most efficient

sectors, thereby stimulating productivity growth. Following these reforms, emerging market economies have witnessed substantial financial deepening over the past decade (Sahay et al., 2015). However, recent years have brought attention to a slowdown in potential growth in certain emerging markets and developing economies (Dabla-Norris et al., 2021). This has raised critical questions about the influence of a country's financial structure and its level of development on the link between financial growth and productivity improvements.

Financial development has been identified as a significant catalyst for economic growth, enhancing the efficiency of the economic system. The positive correlation between economic growth and financial development is particularly pronounced in developing countries. Financially underdeveloped countries often find themselves entrenched in a cyclical pattern wherein inadequate financial development endangers economic performance, which in turn gives rise to further financial development challenges. In a nutshell, financial sector exerts a favourable influence on growth by mitigating poverty and augmenting welfare. Financial development facilitates entry into the credit market even for low-income households, thereby stimulating their economic activities, enhancing their ability to take advantage of investment opportunities, and promoting entrepreneurship (Wu et al., 2020: 2). The process of economic growth stems from advancements in the institutional structure of the economy, as well as from factors used in the production process and productivity improvements of these factors. The combination of productivity growth with economic growth establishes the fundamental economic foundations for sustained economic growth over time, as production becomes less dependent on inputs (Yalçınkaya, 2017: 42). TFP offers valuable insights into the supply side of the economy, encompassing strong welfare practices, technological progress measurement, competitiveness, and export performance (Bardaka et al., 2021). As a fundamental indicator used to evaluate countries' growth and development efforts, TFP explains the reasons for growth differences between countries and is also important for identifying which production factors are utilized more effectively in the production process. For countries aspiring to a higher level of welfare, exploring ways to use their resources appropriately and effectively is a common aspect of their growth efforts. In this growth effort, diversification and increase of consumption, alongside population and income growth necessitate seeking new resources on the one hand and ensuring the most efficient use of existing resources on the other (Vergil and Abasız, 2008: 160-161). Thus, achieving productivity improvements in the factors used in production is crucial for each economy. Therefore, identifying the factors influencing TFP and making improvements in these areas will increase the potential growth rate.

The aim of this study is to analyse the effect of financial development on TFP. In addition to financial development variables, six sub-headings of institutional quality indicators are included in the model. These are control of corruption, political stability, government effectiveness, regulatory quality, rule of law and absence of violence. Financial development indicators commonly used in the literature include ratios such as the ratio of money supply in circulation M2 to gross domestic product (GDP) or the ratio of credit volume to GDP, which measure the size of the financial system. However, the diversity of financial systems across countries highlights the need to consider more than one indicator to measure financial development. To this end, this study uses the broad financial development index developed by Sahay et al. (2015) and published in the IMF database, rather than the traditional development indicators generally accepted in the literature. This new index is a combination of two sub-indices: financial institutions (including banks, insurance companies, mutual funds, pension funds and

other types of non-bank financial institutions) and financial markets (mainly including stock and bond markets). The study analyses the influence of these two sub-indices on TFP, as well as the financial development index. The dataset covers the years 2002-2019 for a total of 78 developed and developing countries. The Driscoll-Kraay standard error (DKSE) approach is used to obtain empirical results. The DKSE approach is applied to panel data analysis. In the DKSE approach, the fixed effects model was selected by performing the Hausman test. DKSE is a robust approach against autocorrelation and cross-sectional dependence (CD). For the empirical results, we first analyzed the influence of financial development on TFP. Then, for the robustness analysis, we examined the impact of financial institutions and financial markets indices, which are sub-indices of financial development, on TFP. According to the findings, the financial development and financial institutions indices have significant and positive effects in almost all models. On the other hand, the financial market index is insignificant in each model. Among the control variables included in the model, trade openness, foreign direct investment, and economic growth have positive effects on TFP, while the human capital variable has a negative effect. The positive effect on TFP is also observed when institutional quality indicators are included in the model.

The remainder of the paper is organized as follows: Section 2 reviews the empirical literature. Section 3 provides a description of the data and control variables. Section 4 presents the empirical model. Section 5 explains the methodology. Section 6 discusses the empirical results, and Section 7 provides the robustness test. Section 8 concludes with the policy implications.

2. Literature Review

Endogenous growth theory posits that financial development can stimulate economic growth by promoting improvements in productivity (Guglielmo et al., 2003). However, recent research suggests that the strong correlation between financial development and growth has weakened in recent years (Sahay et al., 2015). This ambiguity surrounding the relationship between financial development and productivity growth highlights the necessity for further empirical investigation. In this study, the linkage between financial development and productivity growth in emerging market economies is re-evaluated. This section is outlined as follows: First studies examining the relationship between financial development and economic growth are reviewed; second, empirical evidence on the effect of financial development on TFP is discussed.

A considerable number of empirical studies have been conducted on the link between financial development and economic growth, yielding mixed results (Asteriou and Spanos, 2019; Botev et al., 2019). Beck et al. (2004) found that the development of the banking sector and stock markets positively affects economic growth. In a similar vein, Demirgüç-Kunt and Levine (2008) conducted a theoretically and empirically oriented examination of the effects of financial development on economic growth. The authors analysed the relationship between financial development and economic growth in greater depth by investigating the levels of financial system development and their relationship with economic growth in over 70 countries between 1960 and 2000, using regression analysis and panel data models. The results of the analysis demonstrate a positive correlation between financial development and economic growth, with this relationship being particularly pronounced in developing countries. Furthermore, the study identified financial intermediaries such as banks and capital markets, as playing a pivotal role in facilitating growth and productivity increases in various countries. Leita0 (2010) conducted a study encompassing

27 EU countries and five BRICS countries between 1980 and 2006, which revealed a positive correlation between economic growth and financial development. Adusei (2013) utilized the dynamic GMM method on a dataset comprising 24 selected African countries between 1981 and 2010, thereby confirming a positive relationship between economic growth and financial development. In his study, Bölükoğlu (2021) conducted a threshold analysis of the finance-growth relationship using a fixed-effects model and a dataset covering 100 countries from 1995 to 2018. The findings show that the finance-growth relationship is significant when the level of financial development is low; however, as the level of financial development increases, this relationship becomes insignificant. Batuo et al. (2018) stated that financial development and financial liberalization positively impact financial instability, while economic growth reduces financial instability. Sepehrdoust (2018) reported that the financial development index positively affects economic growth. The financial development index includes variables such as domestic investments, oil revenues, domestic credit payments of the private sector, and M3 money supply. Other studies conducted by Luintel and Khan (1999) and Li and Marinč (2018) also proclaim that there is a causal relationship between economic growth and financial development. Aydın (2019) investigated relationship between financial development and economic growth in the Fragile Five countries using the Westerlund co-integration method for the period 1992-2016. The study reveals a long-term relationship between financial development and economic growth. Additionally, the DOLS and FMOLS estimators demonstrate a positive and significant relationship between financial development and economic growth. In their study, Dogan et al. (2020) examined indicators related to the development of the stock market and banking sector, finding that stock market development has a significant and positive impact on economic growth. However, the development of the banking sector negatively affects economic growth. Cheng et al. (2021) showed that the connection between financial development and economic growth is negative, especially in high-income countries. Sethi et al. (2020) investigated the influence of globalization, financial development, economic growth, and energy consumption on environmental sustainability. According to their findings, as globalization and financial development increase, economic performance also improves, but this negatively affects environmental sustainability. Variables such as money supply, domestic credit to the private sector by banks, the total value of banks in the stock market, and the total capital of banks were used to measure financial development.

Despite extensive research on the linkage between finance and growth in the empirical literature, there remains a paucity of empirical evidence concerning the role of financial development in productivity growth in developing countries. In recent years, as potential growth rate of the global economy has slowed while financial depth has increased, the analysis of the link between financial development and productivity growth has become more importance. King and Levine (1993), for instance, identified a strong positive link between financial development and TFP, considering the growth rates of per capita GDP and per capita capital stock. Beck et al. (2000) demonstrated that financial development positively impacts TFP, which in turn triggers economic growth. Arestis et al. (2001) examined the effects of financial development on economic growth and TFP using cross-country panel data. The study was conducted using panel data covering 16 developing countries for the period 1970-1997. The authors' results show a financial development exerts a significant and positive influence on economic growth and TFP. Specifically, it was determined that financial intermediation fosters economic growth and TFP by ensuring the efficient allocation of investments and resources. Moreover, deepening and enhanced

efficiency of financial systems in developing countries were identified as significant factors in the improvement of economic performance. Guiso et al. (2004) analyzed data from developed and developing countries to assess how different financial systems impact overall productivity. The study found that countries with more developed financial systems experienced faster productivity growth. The authors pointed out that financial development enhances productivity by improving financial market efficiency, which leads to increased investment in high-productivity sectors. Xu (2011) investigated the relationship between financial development and firm-level TFP. The study used firm-level data across multiple countries to analyze how differences in financial development impact TFP. The findings revealed that financial development enhances firm-level TFP by enabling a more efficient allocation of resources toward the most productive firms and projects. Ezzahid and Elouaourti (2018) stated that financial development is conducive to economic growth, optimises the distribution of investments, and stimulates TFP, yet has a deleterious effect on saving behavior. The results show inconsistent findings across different income levels. Specifically, the results demonstrate that while financial development positively impacts TFP in lower-middle-income countries, it does not support TFP in low-income and upper-middle-income countries. Indicators of financial development included number of commercial bank branches, M2 money supply, domestic credit provided by the banking sector, and the number of ATMs. Yang (2019) noted that financial development positively contributes to economic growth through changes in physical capital stock and TFP. Indicators such as M3 money supply, private sector credit, the total value of banks in the stock market, and the share of government final consumption expenditures in GDP were used for physical capital. Calub (2011) argued that there is a negative relationship between financial development and TFP. Rehman and Islam (2023) undertook the CS-ARDL procedure for BRICS economies from 1990 to 2019 and found a positive relationship between financial infrastructure and TFP in both the short and long runs. Le et al. (2024) conducted an industry-based study of the US economy for the years 1977-1997, examining the effect of financial development on productivity. They asserted that financial development is an essential variable for increasing productivity in stagnant industries. Furthermore, they posited that policymakers must give due importance to financial development if economies are to experience an increase in economic growth. Bolbol et al. (2005) used period of 1974 to 2002 in Egypt to explore relationship between financial development indicators and TFP. They separated the financial development indicators into two categories—bank-based and market-based—and examined the connection between the two. TFP is positively impacted when bank-based measures are linked to GDP per capita. Ezzahid and Elouaourti (2018) examined the financial development and TFP relationship for 22 African countries during the period 2004-2014. They divided the countries into income groups, but did not find a positive effect in any income group except lower-middle income African countries. Although the effect is positive in the lower-middle income group, effect is also quite low. They attribute this to the underdevelopment of the financial sector. Spiegel (2000), Neimke (2003), and Yao (2011) are among other studies investigating the relationship between financial development and TFP.

3. Data

This research uses a panel dataset covering 78 countries (Appendix I) from 2002 to 2019. The choice of 78 countries was predicated on the availability of data on our variables, ensuring the robustness and credibility of our analysis. By including a wide range of countries from

different geographical regions and income levels, we aim to provide a comprehensive picture of the global financial landscape and generate insights with broad applicability. To further enhance our understanding, subgroup analyses are conducted, stratified by income levels. The countries are divided into two income categories: developed and developing, based on World Bank classifications. The data utilised in this study is drawn from various sources. Specifically, for productivity measures, TFP indices are extracted from the Penn World Table (PWT), specifically the latest version 10.0 by Feenstra et al. (2015). Within the PWT, there are two pertinent variables for TFP levels: TFP at constant national prices (2011=1) and TFP level at current PPPs (USA=1). According to Feenstra et al. (2015), TFP at constant national prices (2011=1) offers a comprehensive empirical assessment of productivity growth over time in each country and is thus employed as a proxy for TFP levels. The broader index for financial development is sourced from the World Bank's new database on financial development, known as the Global Financial Development Database, and is used to proxy financial development (FD).

The selection and measurement of financial development indicators remain an important topic of discussion. A large body of literature largely approximate financial development with a ratio of a broad measure of monetary aggregates (i.e., M1, M2, and M3) to GDP (Choong and Chan, 2011). The diversity of financial systems across countries means that multiple indicators are required to measure financial development accurately. To address the limitations of using single indicators as proxies for financial development (such as the ratio of private credit to GDP or stock market capitalization to GDP), we follow the studies of Ćihák et al. (2012) and Svirydzenka (2016), which propose the New Broad-based Index of Financial Development (Figure 1). According to Ćihák et al. (2012) and Svirydzenka (2016), financial development is categorized into two components: financial institutions (FI) and financial markets (FM), which are further divided into depth, access, and efficiency. Financial institutions index include banks, insurance companies, mutual funds, and pension funds, while financial markets index encompass stock and bond markets. Financial development is characterized by the integration of depth, access, and efficiency elements. Depth is defined as the size of the market, access refers to the ability to access financial services, and efficiency is defined as low costs and high output. (Svirydzenka, 2016).

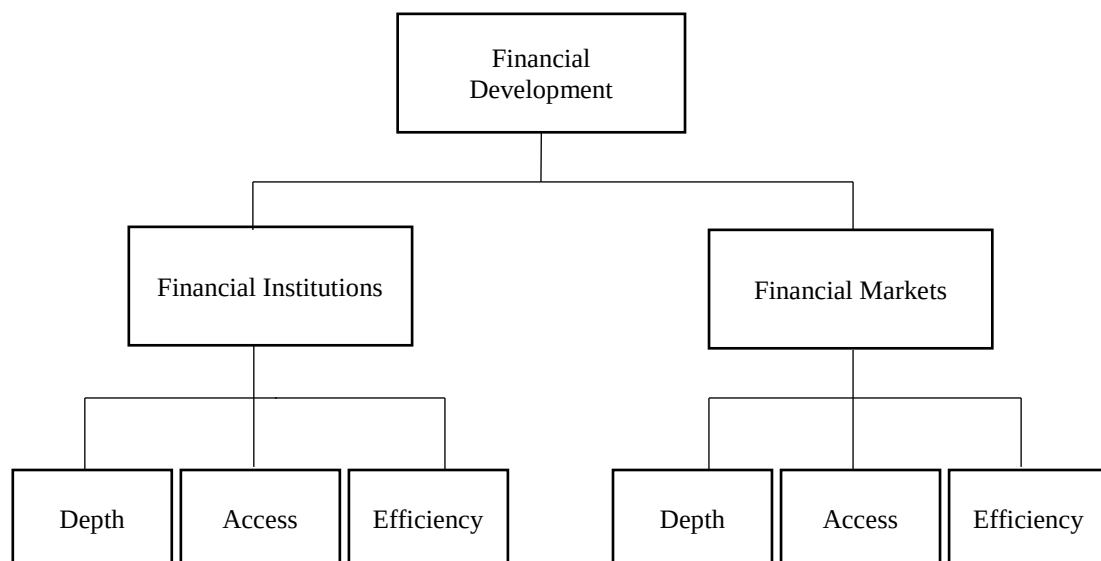


Figure 1. Financial Development Index
Source: Ćihák et al. (2012).

Concerning the control variables, trade openness, patent applications, and GDP growth are extracted from the World Development Indicators (WDI) database. Additionally, the human capital index is obtained from the PWT, while foreign direct investment data is collected from the International Monetary Fund (IMF) database, as provided by Lane and Milesi-Ferretti (2007), to proxy FDI inflows. Institutional indicators, including control of corruption, government effectiveness, regulatory quality, rule of law, political stability and absence of violence, and voice and accountability, are extracted from the Worldwide Governance Indicators database (WGI) by the World Bank. Table 1 outlines the variable definitions and their respective sources.

Table 1. Definition of Variables

Variables	Notation	Descriptions	Sources
Dependent Variable			
Total Factor Productivity	TFP	$\frac{\text{Total output}}{\text{Weighted average of inputs}}$	Penn World Tables version 10.0
Main Variable			
Financial Development	FD	See Figure 1	World Bank (Global Financial Development Database)
Control Variables			
Trade Openness	TO	$\frac{\text{Export} + \text{Import}}{\text{GDP}}$	WDI
Human Capital	HC	Human capital index based on years of schooling and return to education.	Penn World Tables version 10.0
Innovations	INO	Numbers of patent applications submitted by the resident and non-resident people from inner and outer parts of different countries	WDI
Foreign Direct Investment	FDI	Foreign direct investment, stock (% of GDP)	Lane and Milesi-Ferretti (2007)
GDP growth	GROWTH	The annual growth rate of domestic production in percentage.	WDI
Institutional Variables			
Institutional Quality	CORR GOV REG LAW STAB VOICE	(1) control of corruption, (2) government effectiveness, (3) regulatory quality, (4) rule of law, (5) political stability and absence of violence (6) voice and accountability	World Governance Indicator (WGI), 2020 by Kaufmann et al. (2010)

4. Empirical Model

This paper investigates the nexus between financial development and TFP. The dependent variable in panel data regressions is the natural log of TFP (lnTFP) in real terms (2017=constant prices). Here, we are interested cross-country level productivity. Following Čihák et al. (2012), our explanatory variable is the financial development. For robustness, we also use the financial institutions (FI) and financial markets (FM) to examine our hypothesis.

We employ the following model to explore the influence of FD on TFP:

$$\ln TFP_{it} = \alpha_{it} + \beta_1 \ln FD_{it} + \beta_2 Controls_{it} + \beta_3 Institutional\ variables_{it} + \varepsilon_{it} \quad (1)$$

where i and t represent the country and year, respectively, and ε denotes the error term, β_1 captures the effect of FD on TFP. We incorporate a set of control variables in Eq (1) that influence TFP, including trade openness (TO), human capital (HC), innovations (INO), foreign direct investment (FDI), GDP growth (GROWTH) and six institutional indicators. All variables were included in the model by taking their logarithms.

5. Econometric Methodology

5.1. Cross-sectional Dependence Test

Prior to studying panel data models, one of the most crucial things to look into is cross sectional dependency (CD), as this will determine which econometric techniques are most suited. (Le and Sarkodie, 2020). The underlying premise of the first-generation panel unit root tests is cross-sectional independence of nations. In actuality, though, this assumption is limited. Dependence of cross-sectionality and the macroeconomic time series of several nations may have been impacted by a single event (Munir et al., 2020). The LM test was proposed by Breusch and Pagan (1980) to test the null hypothesis that there is no CD in the panel data and to investigate CD in the data. Large cross section units in panels, however, might not be a good fit for the LM test. In order to address this shortcoming, Pesaran (2004) built the CD test using the subsequent statistic:

$$D = \sqrt{\frac{2T}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^N \frac{(T-k)\hat{p}_{ij}^2 - E[(T-k)\hat{p}_{ij}^2]}{var[(T-k)\hat{p}_{ij}^2]} \quad (2)$$

where $\hat{p}_{ij}$ is taken as the sample of the pairwise distribution coefficient of OLS residuals (Munir et al., 2020).

5.2. CADF Unit Root Test

One of the most important points of panel data analysis is stationarity. Unit root tests are performed to measure the stationarity of the series. The stationarity measurement varies depending on whether the data has CD. If there is CD, the second generation unit root test should be performed. In the current study, the second generation unit root test was applied. The most common tests for the second generation unit root test are the Cross-sectionally Augmented Dickey-Fuller (CADF) and CIPS test developed by Pesaran (2007). The reason for applying these tests is that the first generation unit root test does not make sense and is inefficient in the presence of a cross sectional dependence. Equation (3) contains the expression of the CADF test:

$$\Delta y_{i,t} = \alpha_i + b_i y_{i,t-1} + c_i \bar{y}_{t-1} + d_i \Delta \bar{y}_t + \varepsilon_{i,t} \quad (3)$$

where α_i is a deterministic term, $\bar{y}_t$ is the cross-sectional mean at time t , and $\bar{y}_{t-1}$ is the lagged level of the cross-section averages; i and t represent the country and year, respectively. Based on the average of the observed individual cross-section CADF statistics, Pesaran creates the CIPS test, a modified version of the IPS (Im Pesaran and Shin) t -bar test. The following is a derivation of the CIPS statistic according to Pesaran's (2007) notations:

$$CIPS = N^{-1} \sum_{i=1}^N CADF \quad (4)$$

5.3 Driscoll-Kraay Standard Errors (DKSE)

The fixed effect with DKSE technique is used in this study. DKSE are robust to heteroscedasticity, autocorrelation, and general types of CD, so they are widely preferred in cases with CD (Hoechle, 2007). The DKSE method performs better than methods dealing with N>T approaches. By calculating changes across countries, it creates estimates using fixed-effect models that solve the problem of heterogeneity bias. DKSE is a method that allows using non-parametric, unbalanced and balanced panel data (Driscoll and Kraay, 1998; Ridwan et al., 2024). There are two steps when applying the fixed effect estimator. In the first stage, all model variables are processed by transforming them into $z_{it} \in \{y_{it}, x_{it}\}$:

$$\bar{z}_{it} = z_{it} - \bar{z}_i + \bar{\bar{z}} \quad (5)$$

It is mentioning that within-estimator relates to OLS estimator of $\tilde{y}_{it} = \tilde{x}_{it}'\phi + \tilde{\varepsilon}_{it}$ is the second step. Pooled OLS estimator is used to estimate the transformed regression model in Equation (5) (Rehman and Islam, 2023; Ridwan et al., 2024).

6. Empirical Results and Discussion

6.1. Descriptive Statistics and Pairwise Correlations

The descriptive statistics presented in Table 2 offer valuable insights into the variables under consideration, based on 1404 observations. LNTFP shows a mean of 0.001, with a standard deviation of 0.108, indicating smallest coefficient of dispersion (0.108) demonstrating its minimal variability.

Table 2. Descriptive Statistics

Variables	Mean	SD	Min.	Max.
LNTFP	0.001	0.108	-0.567	0.752
LNFD	-0.906	0.586	-2.617	-0.003
LNTD	4.321	0.513	3.017	6.080
LNHC	1.029	0.213	0.292	1.470
LNINO	7.557	2.330	0.693	14.248
LNFDI	11.186	1.981	4.041	16.162
GROWTH	3.522	3.575	-15.136	26.170
LNCORR	3.985	0.601	-0.636	4.605
LNSTAB	3.776	0.751	0.005	4.605
LNGOV	4.095	0.476	1.455	4.605
LNREG	4.095	0.476	1.455	4.605
LNLAU	3.978	0.686	-0.756	4.605
LNVOICE	3.976	0.649	0.853	4.605
Observations	1404	1404	1404	1404

LNFD, with a mean of -0.906 and a standard deviation of 0.586, displays considerable variation among the included countries. LNTD, with a mean of 4.321 and a standard deviation of

0.513, suggests relatively stable trends across the years and sampled economies. LNHC, with a mean of 1.029 and a standard deviation of 0.213, exhibits less variability within the sample over the years. LNINO, with a mean of 7.557 and a standard deviation of 2.330, reveals a significant variability over the years and among sampled economies. LNFDI, with mean and standard deviation values of 11.186 and 1.981 respectively, suggests a high degree of FDI mobility across both time and countries. GROWTH, with mean and standard deviation values of 3.522 and 3.575 respectively, implies high mobility of growth across the years and sampled countries.

Table 3 presents the pairwise correlation matrix of the variables under analysis. Notably, all explanatory variables, except LNHC, exhibit significant and positive correlations with LNTFP. Specifically, the correlation coefficient between LNFD and LNTFP is positive, measuring 0.067, suggesting that financial development may correspond to increased TFP, in line with prior research. LNT0 and LNTFP display a positive association with a coefficient of 0.008, indicating a weak but positive relationship, implying that greater trade openness might be linked to elevated levels of TFP. Conversely, LNHC exhibits a negative correlation with LNTFP, with a coefficient of -0.083, indicating that higher human capital levels may potentially lead to reduced TFP. On the other hand, LNFDI demonstrates a positive correlation with LNTFP, recording a coefficient of 0.086, suggesting that countries with increased foreign direct investment levels may also experience higher TFP. Moreover, the positive correlation between GROWTH and LNTFP suggests that heightened economic growth could correspond to elevated TFP levels. Additionally, the positive correlations observed between institutional quality variables (LNCORR, LNSTAB, LNGOV, LNREG, LNLAW, LNVOICE) and LNTFP imply that nations with higher institutional quality might also exhibit higher levels of TFP.

Table 3. Correlation Matrix

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13
LNTFP (1)	1.00												
LNFD (2)	0.067	1.00											
LNT0 (3)	0.008	0.121	1.00										
LNHC (4)	-0.083	0.564	0.260	1.00									
LNINO (5)	0.078	0.520	-0.402	0.290	1.00								
LNFDI (6)	0.086	0.552	0.050	0.474	0.598	1.00							
GROWTH (7)	0.013	0.238	0.037	-0.266	-0.040	-0.187	1.00						
LNCORR (8)	0.021	0.438	0.266	0.484	0.084	0.375	-0.176	1.00					
LNSTAB (9)	0.010	0.391	0.373	0.535	-0.090	0.237	-0.166	0.658	1.00				
LNGOV (10)	0.114	0.441	0.313	0.581	0.213	0.480	-0.205	0.880	0.601	1.00			
LNREG (11)	0.164	0.521	0.333	0.518	0.097	0.388	-0.150	0.810	0.586	0.860	1.00		
LNLAW (12)	0.188	0.521	0.291	0.496	0.096	0.380	-0.163	0.890	0.609	0.885	0.879	1.00	
LNVOICE (13)	0.182	0.366	0.133	0.482	-0.023	0.193	-0.286	0.563	0.495	0.537	0.555	0.521	1.00

6.2. Results of Diagnostic Tests

6.2.1. Results of Cross-sectional Dependence)

To examine cross-sectional correlation, the CD test method proposed by Pesaran (2004) was employed using the relevant data. Table 4 suggests that except for regulatory quality (REG) at the 10% level, there's substantial CD across all variables, indicating that shocks in one nation impact the entire panel, prompting the need for additional second-generation tests.

The analysis, aiming to assess the correlation among cross-sectional variables, involved examining the p-values and test statistics for each explanatory variable. Rejecting the null

hypothesis of no CD indicates that variables are cross-sectionally dependent if their p-values fall below one of three significance levels (1%, 5% and 10%). According to Table 4, all variables except regulatory quality (REG) exhibit significant CD at the 1% level, signifying that shocks in one nation affect the entire panel.

Table 4. Test for Cross-sectional Dependence in Panel Time-series Data.

Variables	Pesaran CD-test	p-value	corr	abs (corr)
LNTFP	21.73***	0.000	0.093	0.556
LNFD	70.27***	0.000	0.302	0.512
LNT0	37.32***	0.000	0.163	0.498
LNHC	195.65***	0.000	0.842	0.915
LNINO	4.49***	0.000	0.024	0.466
LNFDI	197.02***	0.000	0.847	0.877
GROWTH	83.00***	0.000	0.358	0.395
LNCORR	2.88***	0.004	0.012	0.347
LNSTAB	6.87***	0.000	0.030	0.333
LNGOV	5.52***	0.000	0.028	0.285
LNREG	1.86*	0.063	0.008	0.374
LNLAU	7.52***	0.000	0.032	0.383
LNVOICE	4.37***	0.000	0.019	0.332

Note: *p <0.1, **p <0.05, ***p < 0.01.

6.2.2. Panel Unit Root Test

In present of cross-sectional correlation, this study performs a unit root test for each variable to verify data stationarity. Table 5 displays the unit root results obtained from the CIPS test by Im et al. (2003) and the CADF test by Pesaran (2007). These tests, employed to investigate the integration levels of the variables, offer insights into their stationarity properties. The findings indicate that LNTFP exhibits unit root (non-stationarity) both at constant and trend levels. Similarly, LNT0 and LNINO demonstrate non-stationarity at both constant and trend levels according to the CIPS test, suggesting first-order or I(1) integration for these variables. The CIPS test reveals that, except for LNHC at the trend level, all explanatory variables are stationary at both constant and trend levels. Meanwhile, the CADF test indicates that all variables, except LNT0, LNSTAB, LNREG, LNLAU, and LNVOICE, are stationary at the constant level. Moreover, LNFD, LNFDI, and LNGOV are stationary at the trend level according to the CADF test. These findings are consistent between the CIPS and CADF tests, indicating a mixed order of integration across the variables.

Table 5. Results of the CIPS and CADF Panel Unit Root Tests.

Panel A: Results of the CIPS Panel Unit Root Test

Variables	Constant		Constant and Trend	
	Levels	Δ	Levels	Δ
LNTFP	-1.183	-3.060***	-1.754	-3.564***
LNFD	-2.641***	-4.605***	-3.058***	-4.650***
LNT0	-1.137	-3.187***	-2.191	-3.315***
LNHC	-2.398***	-4.623***	-1.948	-2.269**
LNINO	-1.848	3.810***	-2.352	-3.797***
LNFDI	-2.583***	-3.458***	-2.672**	-3.551***
GROWTH	-2.653***	-4.840***	-3.032***	-4.802***
LNCORR	-2.255***	-4.225***	-2.557**	-4.139***
LNSTAB	-2.029*	-4.509***	-2.698**	-4.575***
LNGOV	-2.535***	-4.408***	-3.027***	-4.314***
LNREG	-2.014*	-4.474***	-2.775***	-4.476***
LNLAU	-2.124**	-4.355***	-2.505*	-4.427***
LNVOICE	-2.084**	-4.454***	-2.921***	-4.429***

Panel B: Results of the CADF Panel Unit Root Test

LNTFP	-0.901	-2.073**	-1.744	-2.540**
LNFD	-2.093**	-3.268***	-2.667**	3.409***
LNT0	-1.118	-2.561***	-1.993	-2.710***
LNHC	-2.619***	-4.378***	-1.846	-2.835***
LNINO	-2.015*	-2.736***	2.343	-2.919***
LNFDI	-2.265***	-2.900***	-2.808***	-2.894***
GROWTH	-2.006*	-3.167***	-2.465	-3.146***
LNCORR	-2.081**	-2.762***	-2.275	-2.905***
LNSTAB	-1.678	-2.904***	-2.020	-3.289***
LNGOV	-2.331***	-3.404***	-2.729***	-3.461***
LNREG	-1.605	-2.727***	-2.159	-2.813***
LNLAU	-1.968	-2.819***	-2.128	2.932***
LNVOICE	-1.474	-2.848***	-2.400	-2.967***

Note: *p < 0.1, **p < 0.05, ***p < 0.01.

6.3. Results of Regressions Estimations and Discussion

This section presents the findings from the regression analysis for all countries included in analysis. Also, for robustness check, the analysis is conducted for both developed and developing countries. Table 6 illustrates the results of DKSE, investigating the impact of FD on TFP along with control variables such as TO, HC, INO, LNFDI, GROWTH and institutional quality variables (CORR, STABILITY, GOVERN, REG, LAU, VOICE).

Table 6. Results of Fixed Effect with DKSE (Overall Countries)

Dependent Var. LNTFP	Model-1	Model-2	Model-3	Model-4	Model-5	Model-6	Model-7
Main Variable							
LNFD	0.090*** (0.019)	0.103*** (0.014)	0.100*** (0.018)	0.090*** (0.017)	0.104*** (0.017)	0.105*** (0.017)	0.103*** (0.017)
Control Variables							
LNT0	0.032*** (0.012)	0.025** (0.012)	0.022** (0.009)	0.023** (0.010)	0.016* (0.009)	0.020* (0.011)	0.017* (0.009)
LNHC	-0.278*** (0.039)	-0.309*** (0.033)	-0.357*** (0.029)	-0.329*** (0.036)	-0.350*** (0.026)	-0.360*** (0.025)	-0.381*** (0.029)
LNINO	-0.005 (0.005)	-0.005 (0.005)	-0.002 (0.004)	-0.004 (0.004)	-0.003 (0.004)	-0.003 (0.004)	-0.002 (0.005)
LNFDI	0.026*** (0.002)	0.028*** (0.003)	0.031*** (0.004)	0.029*** (0.003)	0.030*** (0.003)	0.030*** (0.004)	0.033*** (0.004)
GROWTH	0.003*** (0.000)	0.003*** (0.000)	0.003*** (0.000)	0.004*** (0.000)	0.004*** (0.000)	0.004*** (0.000)	0.004*** (0.000)
Institutional Variables							
LNCORR	0.060*** (0.018)	0.075*** (0.014)					
LNSTABILITY	0.013*** (0.000)		0.017*** (0.003)				
LNGOVERN	0.057** (0.023)			0.085*** (0.019)			
LNREG	-0.005 (0.012)				0.030** (0.013)		
LNLAU	-0.004 (0.010)					0.024** (0.011)	
LNVOICE	0.003 (0.026)						0.012 (0.021)
Cons.	-0.565*** (0.096)	-0.309*** (0.090)	-0.057*** (0.042)	-0.353*** (0.123)	-0.083 (0.085)	-0.059 (0.080)	-0.010 (0.089)
Obs.	1218	1218	1218	1218	1218	1218	1218
N	75	75	75	75	75	75	75
R-squared	0.219	0.207	0.188	0.202	0.185	0.185	0.182
F-ind (all u _i =0)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CDTest (Pesaran, 2004)	7.176 (0.000)	11.008 (0.000)	11.860 (0.000)	7.300 (0.000)	8.325 (0.000)	7.345 (0.000)	13.092 (0.000)
Hausman Test	138.36***	80.95***	48.93***	119.43***	84.26***	91.82***	63.43***
Autocorrelation							
Modified Bhargava et al. DW	0.175	0.174	0.163	0.169	0.161	0.161	0.160
Baltagi-Wu LBI	0.472	0.469	0.471	0.471	0.464	0.467	0.469
Heteroskedasticity							
Modified Wald chi2 (75)	63461.94 ***	74438.00 ***	98768.26* **	47482.57 ***	1.2e+05 ***	2.3e+05 ***	91895.38 ***
Multicollinearity							
VIF	4.09	2.32	2.15	2.47	2.25	2.25	2.12

Notes: Robust standard errors are in parentheses. *** p < 0.01, ** p < 0.05, and * p < 0.1

The outcomes of the DKSE for the baseline regressions described in Equation 1 are presented in Table 6, which displays the coefficients of each variable and their standard errors (in parentheses). In the study, seven different models (Model-1 to Model-7) were estimated. Model-

1 comprises the all variables and shown with in the second column. The other models (Model-2 to Model-7) consider the effect of financial development on TFP, along with the control variables and the individual effect of each institutional variable. According to the findings of DKSE, the effect of financial development on TFP is positive and significant at a 5 % significance level for all models. For example, in Model-1, the coefficient value of FD is 0.090, which revealed that a 1 % increase in FD will increase TFP by 0.090 %. The positive coefficient means that FD increases TFP by transferring resources to the right places and making them efficient (Han and Shen, 2015). Financial development can be achieved through the development of bank-based financial systems. One of the reasons underlying the positive influence of FD on TFP is the provision of financial services that can promote productivity (Ezzahid and Elouaourti, 2018). The promotion of financial intermediation with a private sector focus and the provision of increased market access to domestic and international financial intermediaries are further reasons why FD benefits TFP (Guillaumont Jeanneney et al., 2006).

The effect of TO on TFP is positive and significant, indicating that TO enhances TFP. Our empirical results are in line with economic theory and confirm the general assertion that there exists a positive and significant relationship between trade openness and TFP growth for the economy as a whole. This positive impact is mainly explained by trade theory, which maintains that trade results in a positive and sustained effect on economic growth due to increased efficiencies in the allocation of resources and economies of scale (Grossman and Helpman, 1991; Obstfeld and Rogoff, 1996). According to the international trade theory, greater trade implies higher openness, which facilitates the adoption of more efficient production techniques, ultimately leading to faster growth in TFP. This finding aligns with the pioneering research of Miller and Upadhyay (2000) and Abizadeh and Pandey (2009).

Regarding HC, we found that human capital coefficient is statistically significant but has a negative sign, suggesting that a higher level of human capital leads to a lower TFP growth. Contrary to endogenous growth theories (Romer, 1990; Aghion and Howitt, 1992), which describe human capital as the engine of growth through innovation, several studies, however, find no evidence that human capital is an important positive determinant of TFP growth in developing countries (e.g., Falvey et al., 2007; Madsen et al., 2010). These findings prove the hypothesis of Vandenbussche et al. (2006). The hypothesis of Vandenbussche et al. (2006) addresses the role of human capital in economic growth and TFP. In this study, the authors argue that the contribution of human capital to a country's economic growth is primarily driven by innovation and imitation, which are facilitated by highly educated individuals. Vandenbussche et al. (2006) also suggest that lower levels of education in developing countries may limit the implication of human capital on TFP. In other words, an economy composed of individuals with only basic education may lack the capacity to innovate and adopt technological advancements, leading to a limited effect on TFP. Previous studies by Ezzahid and Elouaourti (2018) support the existence of a negative relationship between HC and TFP. Kijek and Kijek (2020) speculate that this inverse relationship may be due to over investment in human capital. Similarly, according to Miller and Upadhyay (2000), TFP and human capital are negatively correlated in low-income nations.

The coefficient of innovation (INO, patent applications) is negative and not significant. Contrary to expectations, several factors can explain the insignificance of the innovation coefficient. First, there may be a nonlinear relationship between innovation and TFP. The existing literature believed that the influence of innovation on TFP improvement and economic growth may be nonlinear, depending upon several relevant factors such as financial support, human

capital, etc. (Nicholas, 2009; Dabla-Norris et al., 2012; Zanello et al., 2016; Brown et al., 2017; Park, 2018). Second, innovation may have heterogeneous effects on TFP. As the research of Zhao and Liu (2011) shows, there are obvious differences in the effects of invention patents and non-invention patents on TFP under different innovation levels.

The empirical results show that foreign FDI contributes to TFP positively. The positive effect of FDI can be explained by the fact that FDI encourages the use of new technologies thanks to capital deployment and thus can have an impact on TFP (Arısoy, 2012). The positive relationship between FDI and TFP is supported by the earlier studies including Damijan et al. (2007), Herzer (2011) and Herzer (2012).

We examine the impact of each institutional quality indicator (IQ) on TFP both jointly and separately. To address potential multicollinearity issues that may arise when using all institutional indicators together (Model-1), we also estimate individual models (Model-2 to Model-7) that consider the influence of each institutional indicator separately. The results of Model-1 show that all variables, except REG, LAW, and VOICE, are positive and statistically significant. The positive relationship between STAB and TFP is reported in the literature by Altun (2016) and Uddin et al. (2017). Alam et al. (2017) find a significantly positive effect of GOVERN on economic growth. Apart from Model-1, when examining the effects of each institutional indicators individually, we find strong evidence confirming a positive impact, except for Model-7, which includes the VOICE coefficient. Several recent studies have demonstrated that institutional factors can boost productivity development by guaranteeing resource reallocation efficiency and promoting a favorable economic climate for investment, even when reverse causality is possible. (Hall and Jones, 1999; Acemoglu and Johnson, 2003; Acemoglu et al., 2004; Easterly 2006).

The Hausman tests conducted for each model lead to rejection of the null hypothesis, favoring the fixed effects model in all instances. However, inference from panel data might suffer from biases stemming from CD, heteroscedasticity, or serial correlation. Hence, diagnostic tests are employed to assess these issues and determine the model's robustness. Specifically, Modified Wald test, Modified Bhargava, Franzini, and Narendranathan Durbin Watson, and Baltagi-Wu LBI tests are utilized to test for heteroscedasticity and auto-correlation assumptions in fixed effects models. Pesaran CD tests are employed to identify CD. The null hypothesis of the heteroscedasticity test posits the absence of heteroscedasticity, while the alternative hypothesis suggests its presence. As presented in Table 6, the fixed effects model rejects the null hypothesis of no heteroscedasticity via the modified Wald test. In a word, heteroscedasticity issues are detected across all models (1 to 7). To examine autocorrelation in the model, both the Durbin-Watson test by Bhargava, Franzini, and Narendranathan, and the locally best invariant (LBI) test by Baltagi-Wu are utilized. Both the Modified Bhargava et al. Durbin Watson and Baltagi-Wu LBI tests assess the hypothesis that the autocorrelation coefficient equals zero ($p = 0$). If the value is less than 2, it suggests that there is a positive autocorrelation. In all models, the test values fall below 2, indicating the presence of autocorrelation in the fixed effects model. The Pesaran (2004) CD test results indicate the presence of correlation between countries. To address these challenges, robust estimators are recommended. The Driscoll and Kraay estimator is chosen for this study due to its solid empirical support and its effective handling of cross-sectional dependency, autocorrelation, and heteroscedasticity issues. Additionally, the Variance Inflation Factor (VIF) values in Table 6 are all below 10, suggesting that the models do not suffer from severe multicollinearity, in accordance with established literature. Diagnosis tests reveal the

satisfactory fitness of the chosen models. In the following, we conduct two robustness checks on the main specification used in this study.

7. Robustness Checks

7.1. Financial Development Sub-index (Financial Institutions and Financial Market)

Tables 7 and 8 present the results of a robustness check, where the estimates of Equation (1) are replicated using the components of financial development (financial institutions, financial markets) to check for alternative financial development indicators. As can be seen, results remain very stable for financial institutions (FI) variable in Table 7. The diagnosis statistics do not significantly differ from those reported in the previous table.

Table 7. Results of Fixed Effect with DKSE (Overall Countries)

Dependent Var. LNTFP	Model-1	Model-2	Model-3	Model-4	Model-5	Model-6	Model-7
Main Variable							
LNFI	0.118*** (0.018)	0.130*** (0.019)	0.131*** (0.021)	0.120*** (0.017)	0.136*** (0.020)	0.136*** (0.020)	0.135*** (0.020)
Control Variables							
LNTO	0.043** (0.014)	0.038** (0.013)	0.003** (0.011)	0.035*** (0.011)	0.030*** (0.011)	0.034** (0.013)	0.031*** (0.011)
LNHC	-0.309*** (0.039)	-0.342*** (0.031)	-0.388*** (0.026)	-0.362*** (0.033)	-0.376*** (0.027)	-0.388*** (0.022)	-0.411*** (0.026)
LNINO	-0.007 (0.005)	-0.007 (0.005)	-0.005 (0.004)	-0.006 (0.004)	-0.006 (0.004)	-0.006 (0.004)	-0.005 (0.004)
LNFDI	0.021*** (0.002)	0.023*** (0.003)	0.025*** (0.003)	0.023*** (0.003)	0.023*** (0.003)	0.024*** (0.003)	0.026*** (0.003)
GROWTH	0.004*** (0.000)	0.004*** (0.000)	0.004*** (0.000)	0.004*** (0.000)	0.004*** (0.000)	0.004*** (0.000)	0.004*** (0.000)
Institutional Variables							
LNCORR	0.054*** (0.016)	0.069*** (0.013)					
LNSTABILITY	0.012*** (0.003)		0.016*** (0.003)				
LNGOVERN	0.047** (0.021)			0.074*** (0.018)			
LNREG	-0.001 (0.011)				0.034*** (0.011)		
LNLAU	-0.003 (0.009)					0.025** (0.010)	
LNVOICE	0.007 (0.024)						0.017 (0.020)
Cons.	-0.479*** (0.058)	-0.222** (0.105)	0.022 (0.059)	-0.238** (0.102)	-0.027 (0.092)	-0.006 (0.098)	-0.037 (0.064)
Obs.	1218	1218	1218	1218	1218	1218	1218
R- squared	0.238	0.229	0.212	0.223	0.212	0.211	0.209
F-probability	0.000	0.000	0.000	0.000	0.000	0.000	0.000
N	75	75	75	75	75	75	75

Notes: Robust standard errors are in parentheses. *** p < 0.01, ** p < 0.05, and * p < 0.1

According to the results, FI is significant at the 1% significance level and has a positive effect on TFP in the model that includes all countries. FI variable is an important indicator for

TFP. Supporting this result, Iqbal and Daly (2014) argues institutions are indispensable for the economy and that the less corruption there is, the more the economy is linked to growth. Acemoglu et al. (2001) argues countries with bad institutions will have poor economic performance. According to Ugur (2010), FI is also a good indicator in terms of economic sustainability and adds FI has a positive effect on TFP.

Table 8 presents the analysis where the financial development variable is replaced by the financial market (FM) variable. Looking at the results, it can be observed that the FM variable is insignificant in all models. While TO is significant and positive in all models, HC is significant and negative, as seen in other analyses. INO remains insignificant. FDI and GROWTH are again significant and positive. Among the institutional variables, CORR, STAB, and GOVERN were significant and positive in Model-1, while REG, LAW, and VOICE were found to be insignificant. Except for VOICE in Model-7, all institutional variables were significant.

Table 8. Results of Fixed Effect with DKSE. (Overall Countries)

Dependent Var. LNTP	Model-1	Model-2	Model-3	Model-4	Model-5	Model-6	Model-7
Main Variable							
LNFM	0.009 (0.008)	0.011 (0.008)	0.009 (0.008)	0.009 (0.008)	0.008 (0.008)	0.009 (0.009)	0.009 (0.008)
Control Variables							
LNTO	0.038*** (0.011)	0.031*** (0.010)	0.028*** (0.007)	0.029*** (0.009)	0.022*** (0.007)	0.025** (0.009)	0.023*** (0.007)
LNHC	-0.257*** (0.045)	-0.290*** (0.041)	-0.336*** (0.035)	-0.305*** (0.045)	-0.331*** (0.031)	-0.343*** (0.030)	-0.365*** (0.035)
LNINO	-0.002 (0.004)	-0.002 (0.004)	-0.000 (0.004)	-0.001 (0.004)	-0.000 (0.004)	-0.000 (0.004)	-0.000 (0.004)
LNFDI	0.033*** (0.002)	0.036*** (0.003)	0.038*** (0.005)	0.035*** (0.003)	0.038*** (0.004)	0.038*** (0.004)	0.041*** (0.004)
GROWTH	0.003*** (0.000)	0.003*** (0.000)	0.003*** (0.000)	0.003*** (0.000)	0.003*** (0.000)	0.003*** (0.000)	0.003*** (0.000)
Institutional Variables							
LNCORR	0.057*** (0.018)	0.077*** (0.014)					
LNSTABILITY	0.016*** (0.004)		0.021*** (0.004)				
LNGOVERN	0.075** (0.025)			0.100*** (0.021)			
LNREG	-0.005 (0.012)				0.032** (0.014)		
LNLA	-0.009 (0.010)					0.023* (0.013)	
LNVOICE	0.010 (0.025)						0.018 (0.020)
Cons.	-0.844*** (0.104)	-0.541*** (0.104)	-0.299*** (0.049)	-0.614*** (0.145)	-0.322*** (0.088)	-0.289*** (0.080)	-0.268*** (0.078)
Obs.	1218	1218	1218	1218	1218	1218	1218
R- squared	0.198	0.177	0.159	0.180	0.154	0.154	0.152
F-probability	0.000	0.000	0.000	0.000	0.000	0.000	0.000
N	75	75	75	75	75	75	75

Notes: Robust standard errors are in parentheses. *** p < 0.01, ** p < 0.05, and * p < 0.1

7.2. Different Income Groups (Developed and Developing Countries)

To evaluate the robustness of the main estimate, we re-estimated the regression separately for different income groups to validate the interpretation of the findings. Table 9 and Table 10 show the estimation results for developed and developing countries, respectively.

Table 9 includes models with 31 developed countries. In the analysis that includes only developed countries, the FD variable is significant only in Model-2, Model-3, Model-4, and Model-7, while it is insignificant in Model-1, Model-5, and Model-6. On the other hand, TO and GROWTH are significant and positive. While HC is negative and significant, INO is insignificant. Among the institutional variables, REG and LAW are positive and significant, whereas the CORR variable is negative and significant. However, STAB, GOVERN, and VOICE are insignificant. When the institutional variables are included separately, they all exhibit a significant and positive effect on TFP.

Table 9. Results of Fixed Effect with DKSE (Developed)

Dependent Var. LNTFP	Model-1	Model-2	Model-3	Model-4	Model-5	Model-6	Model-7
Main Variable							
LNFD	0.035 (0.042)	0.085** (0.041)	0.087* (0.045)	0.085** (0.041)	0.049 (0.041)	0.051 (0.038)	0.085* (0.043)
Control Variables							
LNT0	0.113*** (0.023)	0.099*** (0.030)	0.089** (0.036)	0.009** (0.033)	0.115*** (0.027)	0.108*** (0.025)	0.090*** (0.032)
LNHC	-0.180*** (0.051)	-0.103* (0.060)	-0.181*** (0.053)	-0.142** (0.066)	-0.151** (0.058)	-0.153** (0.062)	-0.147* (0.077)
LNINO	-0.025*** (0.004)	-0.025*** (0.006)	-0.021*** (0.005)	-0.025*** (0.006)	-0.024*** (0.005)	-0.026*** (0.004)	-0.022*** (0.005)
LNFDI	-0.002 (0.006)	0.002 (0.006)	0.007 (0.007)	0.003 (0.007)	0.001 (0.006)	-0.002 (0.006)	0.006 (0.007)
GROWTH	0.003*** (0.000)	0.002*** (0.000)	0.002*** (0.000)	0.002*** (0.000)	0.002*** (0.000)	0.003*** (0.000)	0.002*** (0.000)
Institutional Variables							
LNCORR	-0.084* (0.044)	0.260*** (0.050)					
LNSTABILITY	0.014 (0.016)		0.042* (0.021)				
LNGOVERN	-0.006 (0.059)			0.383*** (0.094)			
LNREG	0.144* (0.059)				0.406*** (0.071)		
LNLAU	0.596*** (0.105)					0.617** (0.073)	
LNVOICE	-0.041 (0.064)						0.133** (0.052)
Cons.	-2.853*** (0.330)	-1.278*** (0.290)	-0.258 (0.187)	-1.783*** (0.507)	-1.968*** (0.341)	-2.818*** (0.420)	-0.704*** (0.254)
Obs.	529	529	529	529	529	529	529
R- squared	0.468	0.248	0.212	0.294	0.310	0.455	0.214
F-probability	0.000	0.000	0.000	0.000	0.000	0.000	0.000
N	31	31	31	31	31	31	31

Notes: Robust standard errors are in parentheses. *** p <0.01, ** p <0.05, and * p <0.1

Table 10 includes models with 44 developing countries. According to the estimation results, FD, INO, FDI, GROWTH, CORR, STAB, and GOVERN are significant and positive in every model in which they are included. Huang and Lin (2009) also obtained a similar result for FD. On the other hand, HC appears to be significant but negative in every model. Furthermore, the REG, LAW, and VOICE variables were not found to be significant in any model they were included in.

Table 10. Results of Fixed Effect with DKSE (Developing)

Dependent Var. LNTFP	Model-1	Model-2	Model-3	Model-4	Model-5	Model-6	Model-7
Main Variable							
LNFD	0.102*** (0.029)	0.119*** (0.021)	0.121*** (0.025)	0.111*** (0.023)	0.127*** (0.023)	0.127*** (0.023)	0.125*** (0.027)
Control Variables							
LNT0	0.023 (0.025)	0.016 (0.023)	0.009 (0.025)	0.010 (0.021)	0.004 (0.020)	0.005 (0.022)	0.005 (0.021)
LNHC	-0.374*** (0.041)	-0.398*** (0.040)	-0.447*** (0.044)	-0.423*** (0.042)	-0.463*** (0.037)	-0.469*** (0.041)	-0.475*** (0.041)
LNINO	0.010** (0.004)	0.010** (0.005)	0.010** (0.005)	0.009** (0.004)	0.010** (0.005)	0.010** (0.005)	0.010** (0.005)
LNFDI	0.033*** (0.004)	0.033*** (0.004)	0.035*** (0.005)	0.034*** (0.004)	0.035*** (0.004)	0.036*** (0.005)	0.037*** (0.005)
GROWTH	0.004*** (0.000)	0.004*** (0.000)	0.004*** (0.000)	0.004*** (0.000)	0.004*** (0.000)	0.004*** (0.000)	0.004*** (0.000)
Institutional Variables							
LNCORR	0.058** (0.016)	0.060*** (0.013)					
LNSTABILITY	0.012*** (0.004)		0.012* (0.003)				
LNGOVERN	0.038* (0.021)			0.056*** (0.014)			
LNREG	-0.012 (0.016)				0.008 (0.009)		
LNLAU	-0.014 (0.011)					0.004 (0.010)	
LNVOICE	0.004 (0.029)						0.008 (0.024)
Cons.	-0.396** (0.180)	-0.221 (0.146)	0.009 (0.105)	-0.182 (0.128)	0.064 (0.116)	0.075 (0.137)	0.051 (0.164)
Obs.	688	688	688	688	688	688	688
R- squared	0.243	0.233	0.217	0.224	0.214	0.214	0.214
F-probability	0.000	0.000	0.000	0.000	0.000	0.000	0.000
N	44	44	44	44	44	44	44

Notes: Robust standard errors are in parentheses. *** p < 0.01, ** p < 0.05, and * p < 0.1

8. Conclusion and Policy Recommendations

This paper explores the critical role of financial development in driving TFP. Financial systems, encompassing both financial institutions and markets, play essential role in fostering economic growth by improving resource allocation, facilitating access to capital, and supporting innovation. Despite significant progress in financial development in many emerging economies, challenges remain in fully realizing the potential of financial systems to drive productivity growth.

This study outlines key policy recommendations aimed at enhancing the impact of financial development on TFP.

In this paper, we use a cross-country panel data model and conduct an empirical study on the effect of financial development on TFP growth in 78 developed and developing countries. With CD present, DKSE approach was used in panel data analysis. In the DKSE approach, the fixed effects model was selected by performing the Hausman test. In the empirical analysis stage, we first analyzed the effect of financial development on TFP. Then, for the robustness analysis, we examined the effect of financial institutions and financial markets variables, which are sub-indexes of financial development, on TFP. The conclusions are drawn as follows: (1) In general, financial development has a significantly positive effect on TFP growth, and the test results show good robustness for different financial development indexes; (2) In terms of components of financial development, financial institutions have a positive and significant effect on TFP growth, while financial markets do not have a significant effect on TFP; (3) Between the control variables included in the model, trade openness, foreign direct investment, and economic growth have a positive effect on TFP, while the human capital variable has a negative effect on TFP. Furthermore, it has been found that institutional quality indicators have a positive effect on TFP when included in the model; (4) Our empirical findings are strongly robust across for different income groups countries namely, developed and developing.

The above-mentioned results have significant implications for policymaking. According to the findings of this paper, financial development plays a crucial role in enhancing TFP in emerging economies, serving as a key driver for long-term economic growth (King and Levine, 1993; Beck et al., 2007). By adopting policies that expand financial access, improve market efficiency, strengthen financial institutions, and support human capital development, governments can create a financial system that fosters innovation and effective resource allocation. Additionally, financial sector reforms and strategic public-private partnerships can accelerate productivity growth (Čihák et al., 2012). Ultimately, these policies can maximize the influence of financial development on TFP, contributing significantly to sustainable economic development in emerging markets.

Another policy recommendation can be made regarding institutional indicators. According to the generally accepted view, high institutional quality tends to boost productivity in the economy (Acemoglu et al., 2004). However, the extent to which this occurs may vary depending on the variables used and the country groups included in the model. Based on the results, the following policies are suggested to achieve this productivity increase: (1) If institutional quality is strong, it will attract foreign investment due to the presence of robust institutions. This increase in foreign investment can create job opportunities, boost economic activities, and foster economic growth. (2) Establishing rule of law that ensures fair contracts will support economic growth and enhance productivity. This will also encourage entrepreneurship and provide an environment conducive to increased productivity. (3) A transparent environment should be created by combating corruption and reducing or eliminating bureaucratic obstacles. As a result of these policies, economic growth and productivity increases can be achieved.

Finally, this study has some limitations that will give us future research directions. In this study, we used TFP for dependent variable. But we can test the robustness of our baseline model specification using an alternative dependent variable, such as; TFP growth and TFP obtained from parametric and non-parametric techniques. Also, we used only a few macroeconomic

determinants of TFP, but ignored many macroeconomic variables affect TFP such as; inflation, geopolitical risk, exchange rate volatility, unemployment rate, government expenditure, etc. Thus, possible future research can include these variables to examine TFP.

Declaration of Research and Publication Ethics

This study which does not require ethics committee approval and/or legal/specific permission complies with the research and publication ethics.

Researcher’s Contribution Rate Statement

The authors declare that they have contributed equally to the article.

Declaration of Researcher’s Conflict of Interest

There is no potential conflicts of interest in this study.

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APPENDIX

Table A1. Country Samples

Developed		Developing	
Australia	Slovak Republic	Argentina	Mexico
Austria	Slovenia	Bolivia	Morocco
Belgium	Spain	Botswana	Namibia
Canada	Sweden	Brazil	Nigeria
Cyprus	Switzerland	Bulgaria	Panama
Czech Republic	United Kingdom	Cameroon	Peru
Denmark	United States	Chile	Philippines
Finland		China	Poland
France		Colombia	Qatar
Germany		Costa Rica	Romania
Greece		Croatia	Russian Fed.
Iceland		Dominican Republic	Rwanda
Ireland		Ecuador	Saudi Arabia
Israel		Egypt	Senegal
Italy		Guatemala	South Africa
Japan		Hungary	Sri Lanka
Korea, Rep.		India	Thailand
Latvia		Indonesia	Tunisia
Lithuania		Jamaica	Türkiye
Luxembourg		Jordan	Ukraine
Netherlands		Kazakhstan	Uruguay
New Zealand		Kenya	Venezuela
Norway		Malaysia	Zambia
Singapore		Mauritius	

Source: Own elaboration based on the IMF (2023).

ANALYSIS OF AGRICULTURAL PERFORMANCE OF BRICS COUNTRIES AND TÜRKİYE WITH CRITIC-BASED GREY RELATIONAL ANALYSIS METHOD

BRICS Ülkeleri ve Türkiye'nin Tarımsal Performansının CRITIC Tabanlı Gri İlişkiel Analiz Yöntemi ile Analizi

Ahmet İNKAYA*^{ID} & Mahmut MASCA**^{ID}

Abstract

This study aims to evaluate the agricultural performance of BRICS countries (Brazil, Russia, India, China, and South Africa) and Türkiye using CRITIC (Criteria Importance through Inter-Correlation) and GRA (Grey Relational Analysis) approaches. The following criteria are applied to assess each country's agricultural performance: Livestock Production, Primary (Ton/Population), Crop Production, Primary (Ton/Population), Gross Production Value (constant 2014-2016 thousand US\$) (Value/Hectare), Self-sufficiency in Agriculture (Export/Import) (%), Methane (CH₄) Emission from Agriculture (Value/Agricultural Land) in million metric tonnes of carbon dioxide equivalents (Mt CO₂e), Employment in Agriculture (as a percentage of total employment), and Fertilizer Consumption (kilograms per hectare of arable land), Arable Land (% of land area). The years 2000, 2010, and 2022 are all included in the analysis. According to the GRA approach, South Africa had the worst agricultural performance in all reviewed years. While Russia had the highest rank in 2000, Brazil rose to the top ten years later, in 2010, its rank remained unchanged in 2022. Specifically, the top and bottom-ranked nations remain unchanged from 2010 to 2022. In terms of Türkiye, it ranked fourth in all studied years.

Öz

Bu çalışmanın amacı, CRITIC (Kriterler Arası Korelasyon Yoluyla Kriter Önemi) ve GRA (Gri İlişkiel Analiz) yaklaşımlarını kullanarak, BRICS ülkeleri (Brezilya, Rusya, Hindistan, Çin ve Güney Afrika) ve Türkiye'nin tarımsal performansını değerlendirmektir. Her ülkenin tarımsal performansını değerlendirmek için aşağıdaki kriterler uygulanmıştır: Hayvancılık Üretimi, Birincil (Ton/Nüfus), Bitkisel Üretim, Birincil (Ton/Nüfus), Gayri Safi Üretim Değeri (sabit 2014-2016 bin ABD\$) (Değeri/Hektar), Tarımsal Öz Yeterlilik (İhracat/İthalat) (%), Tarımsal Metan (CH₄) Emisyonu (Değeri/Tarımsal Arazi) milyon metrik ton karbondioksit eşdeğeri (Mt CO₂e), Tarımsal İstihdam (toplam istihdamın yüzdesi olarak) ve Gübre Tüketimi (hektar başına ekilebilir arazi kilogramı), Ekilebilir Arazi (% arazi alanı). Analize 2000, 2010 ve 2022 yılları dahil edilmiştir. GRA yaklaşımına göre, Güney Afrika incelenen tüm yıllarda en kötü tarımsal performansa sahiptir. Rusya 2000 yılında en yüksek sıraya sahipken, Brezilya on yıl sonra 2010'da zirveye yükselmiş, sıralaması 2022'de değişmemiştir. Özellikle, en üst ve en alt sıradaki ülkeler 2010'dan 2022'ye değişmeden kalmıştır. Türkiye, incelenen tüm yıllarda dördüncü sırada yer almıştır.

Keywords:

Agriculture,
Multi-Criteria
Decision Making
Techniques,
BRICS Countries

JEL Codes:

Q10, C44, P52

Anahtar Kelimeler:

Tarım, Çok Kriterli
Karar Verme
Teknikleri, BRICS
Ülkeleri

JEL Kodları:

Q10, C44, P52

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1. Introduction

Agriculture, which has always made its presence and importance felt due to meeting the nutritional needs of people, is a strategic, political, and economic sector that all countries in the world pay attention to. The industrial sector, which rose to prominence with the start of the international development race and the concept of development after the Second World War, has caused agriculture to be neglected, especially in developing countries. This situation has also brought about disruptions in the development process. The food price crisis of 2007 and the fragility of global food supply chains during the 2019-2021 pandemic reminded us that the agricultural sector is sensitive and critical today, bringing it to the forefront again. The protectionist and nationalist policies implemented in the agricultural sector have shown an increasing trend in this process.

The social and economic changes experienced are exciting to all sectors globally. On the one hand, developments that mainly manifest themselves with concerns about high efficiency require advanced technology. On the other hand, they have begun to shape agricultural and economic policies that may impact climate change, sustainability, food supply security, efficient use of water resources, employment, and price stability. While the world population continues to grow, the need for agricultural products is increasing day by day; in this context, the tendency for water resources to shrink and developments that may limit productivity and production, such as global warming/climate change, are causing concern, and are placing the sector in a critical position to a great extent.

Countries must use natural resources to be self-sufficient in agricultural foreign trade and increase competitiveness. Developed countries have already completed their industrialization processes, while developing countries have entered the industrialization process without completing this process. Rapid and uncontrolled industrialization creates adverse, severe effects on the environment. Policymakers must interpret, analyze, and understand all these problems and development trends. Policymakers must closely follow all these developments on a regional, national, and global scale.

While neo-liberal policies are excluded from the agricultural field in developed countries, developing countries are forced to implement these policies through several international organizations. This situation negatively affects their agricultural competitiveness and performance. Therefore, it would be a more accurate approach to evaluate the agricultural performances of developed and developing countries separately.

Türkiye and the BRICS nations—Brazil, Russia, India, China, and South Africa—share specific economic characteristics. These parallels stem from their positions in the global economy, dynamic economic structures in particular industries, and status as developing nations. In this context, this study will attempt to measure the agricultural performances of developing countries, BRICS countries, and Türkiye, using CRITIC-based GRA analysis. This study is not an analysis measuring the performance of countries' agricultural production but rather presents a holistic approach that addresses the agricultural sector in terms of production, consumption, employment, productivity, and environmental dimensions. Several policy recommendations will be made based on the findings obtained from the analysis.

In previous MCDM analyses (TOPSIS, ARAS, ELECTRE, GRA, etc.), the importance levels of the criteria were determined subjectively by taking expert opinion. Later, objective

weighting methods such as CRITIC, Entropy, LOPCOW, Standard Deviation, etc., were developed and combined with MCDM methods. The fact that the objective weighting methods do not require different data in their application, i.e., they use the same decision matrix as in the ranking method, has facilitated the frequent use of these methods together. A distinctive feature of this study is that it uses the CRITIC method, which is one of the objective weighting methods, together with the GRA method used in rankings. The agricultural performance of Türkiye and the BRICS countries was examined using the CRITIC and GRA methodologies. This hybrid model is developed using the CRITIC and GRA approaches. The importance of agricultural performance criteria was assessed using the CRITIC approach. The countries were ranked based on their agricultural performance using the GRA approach.

MCDM methods do not show a causal relationship as in econometric models (Granger causality analysis, time series analysis, panel data analysis). The MCDM methods do not identify the relationship between variables. As a result, it cannot be applied to forecast future events using cause-and-effect relationships. Several policy suggestions can be offered to improve the performance of underperforming nations. It is, therefore, not used for testing hypotheses. These methods enable the ranking of the best-performing solutions according to preset standards.

In MCDM analyses, a single year of data is usually used to determine the ranking of the alternatives subject to the study in the relevant year. In this case, the ranking for the relevant year does not contain information about the past status of the alternatives. For example, in a single-year analysis with 10 alternatives, it is not possible to make a judgment about whether an alternative ranked 5th in the relevant year rose from 10th place or fell from 1st place. The distinctive feature of this study is the use of three data sets for the years 2000, 2010, and 2022 (no data are available after this year) at approximately 10-year intervals to determine how far nations have progressed during that time. In addition, it takes a certain period of time for the agricultural policies implemented in a country to be reflected in the agricultural performance of that country and for their results to fully emerge. The periodic determination of the data used in the study provides the opportunity to observe the developments that may emerge in the relevant period. The originality of this study and its contribution to the literature can be summarized as follows: (i) There are very few studies that conduct agricultural analysis with MCDM methods, but there are no studies that rank countries according to their agricultural performance using a hybrid MCDM method (CRITIC-GRA). (ii) There are no studies that rank BRICS countries according to their agricultural performance. (iii) It is the study that uses the most criteria in agricultural performance analysis. In this respect, it has the potential to inspire future studies. (iv) In the analysis, the agricultural performance of countries is addressed not only according to the amount of production, but also in a multi-faceted macro dimension by considering productivity, agricultural production potential, self-sufficiency, employment, and environmental effects of production. (v) Unlike other studies, not only data from one year but three separate datasets with an interval of approximately 10 years were used. This method provided the opportunity to observe the change in agricultural performance of countries over time from a comparative static analysis perspective.

A review of the literature, an explanation of the data, the stages involved in the CRITIC and GRA methodologies, the results, the sensitivity analysis, and a conclusion are all included in the following chapters.

2. Literature Review

There is no study in the literature that analyzes the agricultural performance of countries using the CRITIC-GRA method. Therefore, after specifying the studies on agricultural performance using other methods, information will be given about the studies that use the CRITIC GRA method in different areas.

The paper was written by Madiyoh et al. (2021) to assess the performance of the agriculture sector in ASEAN nations, pinpoint policy shortcomings, investigate competitive advantages, and direct food and nutrition policies. The TOPSIS approach was used in the study to examine secondary time series data spanning ten ASEAN nations from 1967 to 2016. In 1967, according to the data, Thailand, the Philippines, and Indonesia were the most prosperous nations in terms of agricultural policy performance. However, Malaysia has become a leader in recent years, with its industrial sector using financial investments to drive agricultural success.

Gürlük and Uzel (2016) examined the historical success of agro-environmental and economic policies to ensure food security in Germany, France, the Netherlands, and Türkiye. Using the TOPSIS method, countries were ranked according to sustainability criteria.

The above two studies that can be associated with agricultural performance used TOPSIS, one of the MCDM methods. In these studies, the weights were determined by the authors by preferring the subjective method instead of the objective criterion weight determination methods. Other studies using the CRITIC GRA method in different fields are listed below:

Brodny and Tutak (2023) evaluated EU nations' levels of digital maturity in the 2015 Three Seas Initiative. Using the CRITIC GRA technique, the study calculated the digital maturity indices to assess the degree of adoption of Industry 4.0 technology in various nations. According to the findings, Hungary, Romania, and Bulgaria have the lowest degrees of digital maturity, while the Czech Republic, Lithuania, and Estonia have the highest levels.

Through the Brazilian Antarctic Program, Almeida et al. (2022a) seek to support the Naval Administration in choosing volunteer officers for open positions in Antarctica. In order to rank possible candidates, the CRITIC-GRA-3N method combines the CRITIC method for establishing criteria weights with the GRA with three normalizations. Value-focused thinking is utilized to determine the most appropriate criteria.

Almeida et al. (2022b) focus on assisting a Rio de Janeiro microbusiness in allocating available funds. After defining investment alternatives and evaluation criteria using Value-Focused Thinking (VFT), the CRITIC-GRA-3N method ranks the investment options using the GRA with three normalizations and the CRITIC method for determining criteria weights.

Xu et al. (2020), in their analysis of worldwide ship total loss data from 2013 to 2017, employ GRA and CRITIC techniques to look at the connections between contributory elements such as ocean areas, accident causes, and ship types. Three levels of each contributing component are distinguished, and by mixing these levels, several scenarios are produced.

Geeri et al. (2024) use Computational Fluid Dynamics (CFD) simulations to study how input parameters, like spear locations and pressure levels, affect output parameters, such as outlet velocity, outlet pressure, and tangential force component, to determine how well a Pelton wheel performs. These parameters' contribution to the Pelton wheel's performance was evaluated using

several optimization approaches, including GRA, TOPSIS, Taguchi Design of Experiments (DoE), and CRITIC.

Junior et al. (2024) use the CRITIC-GRA-3N approach to rate and choose suppliers and distributors to improve the Supply Chain Management (SCM) of an auto parts dealership in Guaratinguetá-SP. The new approach outperformed the original CRITIC and GRA techniques in terms of consistency and proved straightforward, useful, and efficient in locating and ranking substitute sources.

Liu et al. (2023) address shortcomings in current state-of-health calculation techniques by proposing a thorough battery health evaluation indicator based on actual electric car data. The indicator is created by using GRA with the enhanced CRITIC weighting approach.

Miao et al. (2018) evaluate environmental factors, population exposure, and capacities to determine China's population's susceptibility to geological disasters. An index system was created using the CRITIC and GRA methodologies to assess how vulnerable provincial administrative units are to calamities such as debris flows and landslides.

Nguyen et al. (2020) use a mix of MCDM techniques, such as the CRITIC approach, GM(1,1) grey model first-order one variables, and GRA, to examine the evolution of electric car sales and market share across 14 nations. While the CRITIC technique establishes the objective weights of variables annually, the GM(1,1) model predicts future sales based on historical data.

Qi (2021) presents a new multi-attribute group decision-making (MAGDM) method that combines intuitionistic fuzzy sets (IFSs) and GRA to assess the development potential of cultural and creative industry parks. The CRITIC technique addresses the subjective unpredictability frequently present in these assessments by determining the criteria weights.

Saeheaw (2022) looks into optimizing several parameters in the Nd: YAG laser welding process by integrating the GRA-based Taguchi method with the CRITIC method for objective weighting. Six parameters were optimized to improve weld strength and minimize weld width: beam diameter, laser power, flow rate, welding speed, laser offset, and pulse form.

Based on financial data, Silva et al. (2023) suggest an integrated multi-criteria decision-making (MCDM) model that combines GRA and CRITIC approaches to choose investment portfolios. The model uses ten financial parameters from literature research to assess 190 companies listed on the Brazilian stock exchange.

Singh et al. (2023) use a brass C360 electrode to micro-EDM drill aluminum 6061 and examine how operational parameters like capacitance, voltage, feed rate, and rotation speed affect material removal rate, tool wear, overcut, and taper angle. The best process parameters are found using a novel hybrid optimization technique incorporating Taguchi, GRA, and CRITIC. In order to improve the multi-response results, the experiment used a Taguchi L18 orthogonal array. GRA was used to evaluate the responses, and CRITIC was used to determine the weighting values for each response.

Wei et al. (2020) investigate how probabilistic uncertain linguistic MAGDM problems with unknown attribute weights can be solved using the GRA method. The CRITIC approach objectively determines attribute weights based on expected values.

Zhou et al. (2024) offer a hybrid decision-making model that enhances decision stability and dependability in transport safety engineering by combining CRITIC, GRA, and Gaussian

mixture model (GMM) with a multiple restart simulation. In order to improve resilience, the model embeds a simulation, which solves problems that the classical GMM encounters, like uncertain initialization and local optima.

Altıntaş (2021) uses the CRITIC-based GRA method to study the innovation performance of the Black Sea Economic Cooperation Organization member countries. Based on the component values identified in the Global Innovation Index (GII) for 2020, the CRITIC-based GRA was used to assess the innovation performances of the concerned nations.

A study by Çilek et al. (2024) examine the connection between dividend yield and profitability rates of businesses listed on the Borsa Istanbul Dividend 25 index between 2020 and 2022. The objective weighing method, known as the CRITIC method, was used to weight the evaluation criteria. The organizations' grey connection degrees were sorted from largest to smallest using the GRA approach based on their profitability rates.

Keleş (2023) focuses on 42 nations' sustainable transportation over the period 2015-2020 based on eight economic, social, and environmental parameters. Out of 42 countries, Norway, Switzerland, Russia, Romania, and Lithuania ranked in the top five for sustainable transportation. Montenegro came in last, according to the results of the GRA method used to assess the alternatives.

Gök Kısa (2021) uses a GRA approach based on CRITIC to assess the renewable energy (RE) resources in the TR83 region. In order to do this, RE resources in the TR83 region were assessed using the CRITIC-based GRA approach, and their performance was ranked.

Türkoğlu et al. (2023) use CRITIC-based GRA and WASPAS software to assess the logistics performance of G20 nations. As a result, it was obtained within the G20 member countries and used to develop a decision matrix. The CRITIC method was used to calculate the logistics performance variable indices of the countries in question, and the GRA and WASPAS methodologies were used to conduct the ranking analysis.

Baki (2024) compares the innovation performances of BRICS countries with the CRITIC and GRA methods in his study. In the first stage of the application, the importance levels of the criteria are obtained with the CRITIC method. In the second stage, the countries are ranked according to their innovation performance through GRA.

3. Data and Methodology

3.1. Data

In this study, the agricultural performance of Türkiye and BRICS countries was ascertained using an integrated CRITIC-based GRA method. The CRITIC method provides the objective weights of the criteria that will be used in the GRA method to rank the countries. The GRA Method measures each country's agricultural performance and ranks the countries. The dataset has been obtained from the Food and Agriculture Organization (FAO, 2024) and the World Bank (2024) Database. Eight agricultural performance criteria for the years 2000, 2010, and 2022 for each country have been used in the computations to see the changes in performance through the years.

Criteria for determining the country's agricultural performance are as follows: Livestock Production, Primary (Ton/Population), Crops Production, Primary (Ton/Population), Gross Production Value (constant 2014-2016 thousand US\$) (Value/Hectare), Self-sufficiency in Agriculture (Export/Import) (%), Methane (CH₄) Emission from Agriculture (Mt CO₂e), Employment in Agriculture (% of total employment) (modeled ILO estimate), Fertilizer Consumption (kilograms per hectare of arable land), Arable Land (% of land area). The first five criteria have been adapted from Madiyoh et al. (2021). The use of fertilizer consumption as a criterion for measuring agricultural performance was adapted from Gürlük and Uzel (2016). The authors have added the rest of the criteria to make a more robust analysis since there are other indicators of agricultural performance. The data on Methane (CH₄) Emissions from Agriculture (Mt CO₂e), Employment in Agriculture (% of total employment) (modeled ILO estimate), and Fertilizer Consumption (kilograms per hectare of arable land) have been downloaded from the World Bank database, and others from the FAOSTAT (2024) database. As can be noticed, the criteria chosen in the study represent many aspects of agriculture since they reflect production capacity, consumption capacity, productivity, and environmental effects of agriculture. Thus, this study will not rank the countries according to the amounts of their agricultural production but to agricultural performance, reflecting all aspects of agriculture. The agricultural performance criteria, abbreviations, and directions are listed in Table 1.

Table 1. Criteria, Abbreviations, and Directions

No.	Criteria	Abbreviation	Direction
1	Livestock Production, Primary (Ton/Population)	LPP	Maximum
2	Crop Production, Primary (Ton/Population)	CPP	Maximum
3	Gross Production Value (constant 2014-2016 thousand US\$) (Value/Hectare)	GPV	Maximum
4	Employment in Agriculture (% of total employment) (modeled ILO estimate)	EAG	Maximum
5	Self-sufficiency in Agriculture (Export/Import) (%)	SSA	Maximum
6	Fertilizer Consumption (kilograms per hectare of arable land)	FER	Maximum
7	Arable Land (% of land area)	ARL	Maximum
8	Methane (CH ₄) Emission from Agriculture (Mt CO ₂ e) (Value/Agricultural Land (Hectare))	EMI	Minimum

Source: FAOSTAT (2024), World Bank (2024).

Benefit criteria are those included in Table 1 with the numbers 1, 2, 3, 4, 5, 6, and 7; the higher the performance score, the higher the criterion value. The number 8 stands for the cost criterion, and a higher performance score is associated with a lower criterion value. The definition and direction of all criteria, as well as their linkages with agricultural performance, can be explained as follows. The definitions of the criteria are taken from the FAOSTAT and World Bank websites.

Livestock Production, Primary: Primary livestock products are made from both living and killed animals. Meat, raw fats, offal, and fresh hides and skins are all products of slain animals. Live animal products include milk, eggs, honey, beeswax, and animal-derived fibers. In order to make cross-country comparisons more meaningful, the amount of production divided by population is included in the analysis. In order to ensure food security, improve nutrition, reduce poverty, and spur economic growth, livestock production is a crucial part of global agriculture.

The direction of this criterion should be maximum, which means higher values imply better performance.

Crop Production, Primary: Primary crop production data are the actual yields harvested from fields, orchards, and gardens without having undergone any real processing, apart from cleaning; they do not include harvesting and threshing losses or the portion of the crop that is not collected for whatever reason. Thus, production encompasses both the amounts of the commodity sold in the market and the amounts used or consumed by the producers. An essential part of agriculture, which ensures the world's food security, is crop production. The direction of this criterion should be maximum.

Gross Production Value: The production value is calculated as the monetary amount of agricultural output at the farm gate. The value has been divided into agrarian land to show the agricultural revenues obtained per hectare. The direction of this criterion should be maximum for better performance.

Employment in Agriculture: Individuals of working age are considered employed if they engaged in any activity that produced goods or services for compensation or monetary benefit, regardless of whether they were actively working during the designated period or not, due to factors such as a temporary job absence or alternative work arrangements. This sector incorporates farming, hunting, forestry, and fishing as its primary components. Agriculture is the second greatest source of employment worldwide after services. The direction of this criterion should be maximum.

Self-sufficiency in Agriculture: The capacity of a nation or region to generate enough food and agricultural products to meet its own needs without depending on imports is known as agricultural self-sufficiency. Since it highlights the significance of local agricultural production in guaranteeing a steady supply of food for the populace, this idea is strongly related to food security, sustainability, and economic independence. The direction of this criterion should be maximum.

Fertilizer Consumption: Fertilizer consumption quantifies how much plant nutrition is utilized for each unit of arable land. Fertilizers give plants the vital minerals they require for healthy growth, including potassium, phosphorus, and nitrogen. Crops would fall short of their potential without these nutrients, producing lower yields and lower quality. The direction of this criterion should be maximum.

Arable Land: Land that can be plowed and used for crop cultivation is referred to as arable land. In general, it excludes areas that are densely forested, excessively stony or rocky, poorly drained, or prone to flooding. Arable land is essential to the production of food and agriculture worldwide. It acts as the base for agricultural cultivation, offering the resources required for food production and harvest. The direction of this criterion should be maximum.

Methane (CH₄) Emissions from Agriculture: Tropical forest and other vegetation fires, industrial production, landfills, wastewater treatment facilities, and agricultural operations are the main sources of methane emissions. The global warming potential is typically used to quantify the emissions in carbon dioxide equivalents, allowing for a comparison of the effective contributions of various gases. Compared to one kilogram of carbon dioxide, one kilogram of methane traps 21 times as much heat in the Earth's atmosphere in 100 years.

The Earth's radiative equilibrium is upset when man-made greenhouse gases are added to the atmosphere. The Earth's surface temperature is rising as a result, and this has an impact on global agriculture, climate change, and sea level rise. CO₂ emissions come from burning wood and garbage, burning coal, oil, and gas for energy, as well as from industrial activities like making cement. The average rate at which a certain pollutant is released from a particular source, concerning the intensity of a particular activity, is known as emission intensity. Comparing the environmental effects of various fuels or activities is another use for emission intensities. Carbon intensity and emission factor are related words that are frequently used interchangeably. A nation's carbon dioxide emissions are just one measure of its greenhouse gas emissions. Gases like methane and nitrous oxide should be considered for a more comprehensive understanding of a nation's role in climate change. In an agricultural economy, this is especially crucial. There is a lot of curiosity about how carbon dioxide affects the environment. The majority of the greenhouse gases causing climate change and global warming are carbon dioxide (CO₂). Methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF₆), and all other greenhouse gases can be compared, and their respective and combined contributions to global warming can be calculated by converting them to carbon dioxide (or CO₂) equivalents.

3.2. CRITIC Method

Diakoulaki et al. (1995) conducted the first study to document the CRITIC method. This method creates objective weights by compiling actual data for each evaluation criterion. The objective weighting of the CRITIC technique is the most significant aspect, as it is determined by incorporating the inter-criteria correlation and the standard deviation of the criteria rather than the subjective outcomes of the expert opinions (Kargi, 2022: 365).

Some advantages of the CRITIC technique include the following (Zardari et al., 2015); (i) The weights determined consider conflict and contrast intensity, which are incorporated into the decision problem's structure, (ii) The developed approach can be easily translated into an algorithmic version and is predicated on examining the assessment matrix to extract all of the data contained in the evaluation criteria, (iii) The weights derived from the CRITIC approach were found to capture the information that the criterion in the multi-criteria problem conveys.

The procedures that must be adhered to when employing the CRITIC technique are detailed below (Diakoulaki et al., 1995: 765):

Step 1: To display *i* alternatives to be ranked and *j* criteria, a decision matrix of dimension *m* × *n* is initially constructed using Equation (1).

$$X = \begin{bmatrix} x_{01} & x_{0j} & \dots & x_{0n} \\ x_{i1} & x_{ij} & \dots & x_{in} \\ \dots & \dots & \dots & \dots \\ x_{m1} & x_{mj} & \dots & x_{mn} \end{bmatrix}; i = 0,1, \dots, m \text{ and } j = 1,2, \dots, n \quad (1)$$

Step 2: The normalization process is now carried out using the formulas in Equation (2) for the benefit criterion and Equation (3) for the cost criterion in the decision matrix.

$$r_{ij} = \frac{x_{ij} - x_j^{\min}}{x_j^{\max} - x_j^{\min}}; i = 0,1, \dots, m \text{ and } j = 1,2, \dots, n \quad (2)$$

$$r_{ij} = \frac{x_j^{\max} - x_{ij}}{x_j^{\max} - x_j^{\min}} ; i = 0, 1, \dots, m \text{ and } j = 1, 2, \dots, n \quad (3)$$

Step 3: The degree of relationship between the criteria is determined by calculating the correlation coefficient between the criteria pairs using Equation (4) following the normalization step.

$$\rho_{jk} = \frac{\sum_{i=1}^m (r_{ij} - \bar{r}_j)(r_{ik} - \bar{r}_k)}{\sqrt{\sum_{i=1}^m (r_{ij} - \bar{r}_j)^2 \cdot \sum_{i=1}^m (r_{ik} - \bar{r}_k)^2}} ; k = 1, 2, 3, \dots, n \quad (4)$$

Step 4: Each criterion's standard deviation is obtained using Equation (5).

$$\sigma_j = \sqrt{\frac{\sum_{i=1}^m (r_{ij} - \bar{r}_j)^2}{m - 1}} \quad (5)$$

Step 5: At this point, Equation (6) uses the values determined in Equations (4) and (5) to determine the total information values of each criterion.

$$C_j = \sigma_j \sum_{k=1}^n (1 - \rho_{jk}) \quad (j, k = 1, 2, \dots, n) \quad (6)$$

Step 6: Equation (7) is used in the final step to determine the importance weights of each criterion.

$$w_j = \frac{C_j}{\sum_{k=1}^n C_j} \quad (j, k = 1, 2, \dots, n) \quad (7)$$

3.3. GREY Relational Analysis Method

Grey relational analysis, a method for ranking, classifying, and making decisions, has become one of the subheadings of grey system theory in scientific studies. Julong Dung's 1982 study "Control Problems of Gray Systems" was the first to introduce grey theory in Thailand. With subheadings including grey relational analysis, grey modeling, grey estimation, and grey decision-making, the grey theory is applied in various domains in the literature (Dinçer, 2019: 61).

In comparison to other statistical methods, the grey relational analysis method has the following advantages: it requires a small sample size, yields effective results with uncertain data, does not require any probability distribution of the data, measures the grey relational coefficient, and requires fewer operations (Atan et al., 2020: 63).

The relationship between the series to be compared can be computed numerically using the Grey Relational Analysis method, which can be used to measure the relationship between two

series logically and numerically. The relationship degree that is determined as a result of the operations carried out is known as the grey relationship degree (Wang et al., 2004).

The GRA method's application stages are explained below (Wen, 2004; Zhai et al., 2009: 7076).

Step 1: Creating the Decision Matrix

Equations 8 and 9 help create a decision matrix with m alternatives and n criteria.

$$X = \begin{bmatrix} x_1(1) & x_1(2) & x_1(n) \\ x_2(1) & x_2(2) & x_2(n) \\ \vdots & \vdots & \vdots \\ x_m(1) & x_m(2) & x_m(n) \end{bmatrix} \quad (8)$$

$$x_i = (x_i(j), \dots, x_i(n)), i = 1, 2, \dots, n \quad (9)$$

$x_i(j)$ shows the value of the i^{th} alternative ($i = 1 \dots m$) according to the j^{th} criterion ($j = 1 \dots n$).

Step 2: Generation of Reference Sequence and Comparison Matrix

At this stage, reference series are determined according to minimum or maximum values. If the criterion requires benefit/maximization, the reference series value of the relevant criterion is the maximum of the alternative series; if it involves cost/minimization, the minimum value of the appropriate criterion. The purpose of creating the reference series is to determine the closest alternatives to the reference series, which are determined by the minimum and maximum values according to the study. The determined reference series is placed in the decision matrix's first row, thus creating the comparison matrix.

$$x_0 = (x_0(j)), j = 1, 2, \dots, n \quad (10)$$

The $x_0(j)$ value in Equation 10 shows the best value of the j^{th} criterion among the normalized values to be obtained in the next stage.

Step 3: Normalization of Decision Matrix

Since the series used in decision problems are measured in different units, a normalization process must be performed to make them comparable. In other words, if the series in question are in broad ranges, "normalization" must be applied by pulling them to smaller ranges. In the normalization process, three different equations are used depending on whether the benefit, cost, or optimal value is preferred.

If the higher is the better (benefit situation), the normalization process is done using Equation 11.

$$x_i^* = \frac{x_i(j) - \min_j x_i(j)}{\max_j x_i(j) - \min_j x_i(j)} \quad (11)$$

If the lower is the better (cost situation), the normalization process is formulated using Equation 12.

$$x_i^* = \frac{\max_j x_i(j) - x_i(j)}{\max_j x_i(j) - \min_j x_i(j)} \quad (12)$$

Equation 13 is utilized in the study to conduct a normalization process based on the researcher's optimal value rather than cost and benefit scenarios.

$$x_i^* = \frac{|x_i(j) - x_{0b}(j)|}{\max_j x_i(j) - x_{0b}(j)} \quad (13)$$

The $x_{0b}(j)$ value is the optimal value determined by the researcher and shows the target value of the j^{th} criterion.

The optimal value can take values in the range, $\min_j x_i(j) \leq x_{0b} \leq \max_j x_i(j)$.

After the normalization process, all values obtained will be between 0 and 1. The normalization matrix created after the operations is shown in Equation 14. x_i^* represents the normalization matrix.

$$x_i^* = \begin{bmatrix} x_1^*(1) & x_1^*(2) & x_1^*(n) \\ x_2^*(1) & x_2^*(2) & x_2^*(n) \\ \vdots & \vdots & \vdots \\ x_m^*(1) & x_m^*(2) & x_m^*(n) \end{bmatrix} \quad (14)$$

Step 4: Creating the Absolute Value Matrix

The value of the absolute difference between the normalized values of the reference series and the values of the normalized decision matrix is shown in Equation 15.

$$\Delta_{0i}(j) = |x_0^*(j) - x_i^*(j)| = \begin{bmatrix} \Delta_{01}(1) & \Delta_{01}(2) & \Delta_{01}(n) \\ \Delta_{02}(1) & \Delta_{02}(2) & \Delta_{02}(n) \\ \vdots & \vdots & \vdots \\ \Delta_{0m}(1) & \Delta_{0m}(2) & \Delta_{0m}(n) \end{bmatrix} \quad (15)$$

Step 5: Creating the Grey Relational Coefficient Matrix

The values in the grey relational coefficient matrix are obtained using Equations 16 and 17.

$$\gamma_{0i}(j) = \frac{\Delta_{\min} + \zeta \Delta_{\max}}{\Delta_{0i}(j) + \zeta \Delta_{\max}} \quad (16)$$

$$\Delta_{\max} = \max_i \max_j \Delta_{0i}(j) \text{ and } \Delta_{\min} = \min_i \min_j \Delta_{0i}(j) \quad (17)$$

The ζ parameter in Equation 11 is the distinguishing coefficient between 0 and 1. The reason for using the ζ parameter is the necessity of regulating the difference between Δ_{0i} and $\Delta_{\max}$. In this context, the ζ parameter eliminates the possibility of $\Delta_{\max}$ being the most extreme value in the data series. It has been observed in the literature that the ζ parameter generally takes a value of 0.5.

Step 6: Grey Relational Grade

Grey relational grades are calculated using two different formulas for cases where the criteria have equal weights and different weights.

If all criteria have equal weight, it can be calculated with Equation 18, and if the criteria have different weights, it can be calculated with Equation 19.

$$\Gamma_{0i} = \frac{1}{n} \sum_{j=1}^n \gamma_{0i}(j), i = 1, \dots, m \quad (18)$$

$$\Gamma_{0i} = \sum_{j=1}^n [w_i(j) \gamma_{0i}(j)], i = 1, \dots, m \quad (19)$$

After calculating the grey relational grades, a ranking is made among the series according to their similarity to the reference series. The alternative with the highest grey relational grade is accepted as the best alternative.

4. Findings

The CRITIC approach established the criteria weights in this section. After that, the GRA technique was used to rank the BRICS countries and Türkiye based on their agricultural performance in 2000, 2010, and 2022. Every calculation about the GRA and CRITIC methodologies was completed using the Excel application. FAOSTAT and the World Bank databases provided the data used in this section.

The empirical results reported herein should be considered in the light of some limitations. It is possible to create a more comprehensive scale by increasing the criteria that can be used to measure agricultural performance. For example, criteria related to agricultural support programs implemented in countries, indicators related to agricultural modernization and machine use, indicators related to irrigation opportunities, indicators related to agricultural planning, indicators related to digitalization in agriculture, etc. However, the limited data on these issues limits the scope of the study. It is possible to apply many methods to determine the importance levels of the criteria used. One of these methods was selected in the study and its calculation steps were mentioned. Although the results of several other methods were also examined during the sensitivity analysis, the calculation steps related to each method were not included. In addition, although there are many MCDM methods other than GRA in the ranking of countries, only one of them and its calculation steps were presented. MCDM methods make a ranking among alternatives for a certain period according to certain criteria. This method does not create a trend for the future, but it is possible to make policy recommendations to the relevant countries according to the ranking results. Again, with this method, it is not possible to determine, for example, how much a certain increase in fertilizer use will increase crop production or agricultural revenue. For such analyses, it will be necessary to use different econometric methods.

4.1. Results of the CRITIC Method

Using the CRITIC Method, the importance of the criteria is objectively determined when comparing the performance levels of agriculture across countries. According to the CRITIC method calculations, the highest score represents the most important criterion's percentage weight for each year. These weights are used in the GRA method to determine each country's rank in the related year. The decision matrix used in calculations for both the CRITIC method and the GRA method is the same and is presented in the appendix. Tables related to the other stages of the calculations are not included in the text due to the large amount of space they take up. However,

they will be sent if requested by the reader. The weights obtained by the CRITIC method for the years 2000, 2010, and 2022 are shown in Table 2.

Table 2. Importance Level of Criteria by the CRITIC Method

Criteria	2000 Value	Rank	Criteria	2010 Value	Rank	Criteria	2022 Value	Rank
EAG	0.1424	1	EMI	0.1538	1	EMI	0.1519	1
EMI	0.1420	2	EAG	0.1333	2	GVP	0.1493	2
LPP	0.1328	3	LPP	0.1327	3	ARL	0.1295	3
GVP	0.1278	4	GVP	0.1290	4	EAG	0.1295	4
ARL	0.1256	5	ARL	0.1267	5	LLP	0.1250	5
FER	0.1136	6	FER	0.1120	6	FER	0.1128	6
CPP	0.1097	7	CPP	0.1083	7	SSA	0.1019	7
SSA	0.1061	8	SSA	0.1043	8	CPP	0.1000	8

Note: ARL: Arable land (% of land area), CPP: Crops Production, Primary (Ton/Population), EAG: Employment in agriculture (% of total employment) (modeled ILO estimate), EMI: Methane (CH₄) Emission from Agriculture (Mt CO₂e) (Value/Agricultural Land Hectare), FER: Fertilizer consumption (kilograms per hectare of arable land), GPV: Gross Production Value (constant 2014-2016 thousand US\$) (Value/Hectare), LPP: Livestock Production, Primary (Ton/Population), SSA: Self-sufficiency in Agriculture (Export/Import) (%).

According to Table 2, the most important criterion is employment in agriculture in 2000, with a rate of 14,24%, but emissions from agriculture in 2010 and 2022 rates of 15.38% and 15,19%, respectively. Self-sufficiency in agriculture is the least important criterion, with rates of 10,61% in 2000, 10,43% in 2010, and Crop production at 10% in 2022.

4.2. Results of Grey Relational Analysis Method

This study examined the value of data spanning almost a decade to determine the progress made by countries throughout the reviewed time. The data covers the years 2000, 2010, and 2022. The scores and rankings of the countries by the GRA Method on agricultural performance for the related years can be seen in Table 3. The CRITIC method calculated the criteria weights used in the GRA method. So, the results come from the CRITIC-based GRA model, an integrated MCDM model recently used in academic research.

Table 3. Scores and Rankings of Counties by Grey Relational Analysis Method

Countries	2000 Values	Rank	Countries	2010 Values	Rank	Countries	2022 Values	Rank
Russia	0.5880	1	Brazil	0.6118	1	Brazil	0.6400	1
India	0.5767	2	Russia	0.5869	2	Russia	0.5778	2
Brazil	0.5762	3	India	0.5567	3	India	0.5727	3
Türkiye	0.5291	4	Türkiye	0.5102	4	Türkiye	0.5478	4
China	0.5229	5	China	0.5042	5	China	0.4984	5
S. Africa	0.4679	6	S. Africa	0.4603	6	S. Africa	0.4617	6

Table 3 shows that Russia had the best agricultural performance, and South Africa had the worst in 2000. Ten years later, in 2010, Brazil came to the first rank and South Africa to the last. In 2022, the rank did not change. Namely, the first- and last-ranked countries are the same as in 2010. As for Türkiye, it was in the fourth rank in all studied years. The countries' position changes

throughout the years can also be observed from the table. In 2000, Russia was the country with the highest agricultural performance. However, it decreased to the second rank in 2010 and 2022. Brazil's position attracted attention since it was in the third rank in 2000, but increased rapidly to the first rank in 2010 and stayed at the top in 2022. India had the second rank in 2000 but decreased to third in 2020 and stayed at the same rank in 2022. South Africa and China had similar ranks. China had the fifth rank, and South Africa followed it with the sixth rank in all the years reviewed.

This study can be compared with Madiyoh et al. (2021), which we were inspired. Madiyoh et al. (2021) analyzed the agricultural performance of ten ASEAN countries using the TOPSIS method, using the criteria of total agricultural production value of the land, self-sufficiency of animal products, self-sufficiency of crop products, rural population rate, greenhouse gas emissions from agriculture, and value of foreign trade in agricultural products. In our study, the employment in agriculture criterion was used instead of the rural population rate, and methane (CH₄) emissions from the agriculture criterion were used instead of greenhouse gas emissions from agriculture. In our study, in addition to the above criteria, the arable land criterion was used to measure agricultural production potential, and fertilizer consumption criterion was used to measure productivity. While the analysis in question was carried out for ASEAN countries with the TOPSIS method, our study was carried out with the CRITIC-GRA method for BRICS and Türkiye. While the criterion weights were determined subjectively by the authors in Madiyoh et al. (2021), in our study, the criterion weights were determined with the CRITIC method, which is one of the objective criterion weight determination methods. While no sensitivity analysis was conducted in Madiyoh et al. (2021), a sensitivity analysis was conducted in our study.

4.3. Sensitivity Analysis and Examination of GRA Results

The MCDM method's outcomes heavily rely on the criteria' weight coefficient values, or the proportional weights given to each criterion. Generally, the results of MCDM approaches should be followed by an investigation of their sensitivity to these changes, since sometimes, a minor change in the weight coefficients of the criterion causes the final selections to alter. A sensitivity analysis was conducted to determine how the ranking of alternatives would shift if the weights assigned to the criterion were altered (Pamućar and Ćirović, 2015).

The sensitivity analysis of the GRA method was carried out using different criterion weights obtained from different objective weighting methods. For this purpose, in addition to the CRITIC method, the Entropy, LOPCOW (Logarithmic Percentage Change-driven Objective Weighting), and standard deviation methods were used. Finally, a situation in which each criterion was equally weighted was also included in the analysis. The criterion weights obtained using these methods for the years 2000, 2010, and 2022 are given in Table 4.

Table 4. Criterion Weights Obtained by Different Weighting Methods, 2000, 2010, 2022

2000					
	CRITIC	ENTROPY	LOPCOW	STD DEV	EQUAL
LPP	0,1328	0,0666	0,0960	0,1204	0,1250
CPP	0,1097	0,0756	0,0678	0,1004	0,1250
GPV	0,1278	0,1471	0,1237	0,1323	0,1250
EAG	0,1424	0,0875	0,1025	0,1262	0,1250
SSA	0,1061	0,0993	0,1769	0,1296	0,1250
FER	0,1136	0,1721	0,1221	0,1381	0,1250
ARL	0,1256	0,1907	0,0670	0,1268	0,1250
EMI	0,1420	0,1610	0,2440	0,1261	0,1250
2010					
	CRITIC	ENTROPY	LOPCOW	STD DEV	EQUAL
LPP	0,1327	0,0398	0,1285	0,1087	0,1250
CPP	0,1083	0,1345	0,0347	0,1124	0,1250
GPV	0,1290	0,1105	0,1506	0,1347	0,1250
EAG	0,1333	0,0818	0,1319	0,1201	0,1250
SSA	0,1043	0,2194	0,0731	0,1340	0,1250
FER	0,1120	0,1490	0,1294	0,1354	0,1250
ARL	0,1267	0,1365	0,0698	0,1263	0,1250
EMI	0,1538	0,1285	0,2819	0,1283	0,1250
2022					
	CRITIC	ENTROPY	LOPCOW	STD DEV	EQUAL
LPP	0,1250	0,0401	0,1396	0,1091	0,1250
CPP	0,1000	0,1024	0,0547	0,1163	0,1250
GPV	0,1493	0,1117	0,1603	0,1339	0,1250
EAG	0,1295	0,0828	0,1330	0,1201	0,1250
SSA	0,1019	0,2750	0,0427	0,1275	0,1250
FER	0,1128	0,1185	0,1548	0,1323	0,1250
ARL	0,1295	0,1419	0,0575	0,1299	0,1250
EMI	0,1519	0,1277	0,2573	0,1310	0,1250

When the criteria weights are determined using various objective weight determination methods, the differences among these methods are significant. In 2000, the EAG (Employment in Agriculture) criterion ranked first with 14.24% using the CRITIC method, the ARL (Arable Land) was at 19.07% using the Entropy method, the EMI (Methane (CH₄) Emissions from Agriculture) accounted for 24.4% with the LOPCOW method, and the FER (Fertilizer Consumption) had 13.81% according to the Standard Deviation method. In the equal-weight method, each criterion was assigned a weight of 12.5%.

In 2010, the EMI (Methane (CH₄) Emissions from Agriculture) criterion ranked first with 15.38% using the CRITIC method, followed by SSA (Self-sufficiency in Agriculture) at 21.94% with the Entropy method, EMI (Methane (CH₄) Emissions from Agriculture) at 28.19% with the LOPCOW method, and FER (Fertilizer Consumption) at 13.54% using the Standard Deviation method. In the Equal-weight method, each criterion was allocated a weight of 12.5%.

In 2022, the EMI (Methane (CH₄) Emissions from Agriculture) criterion was ranked first with 15.19% using the CRITIC method, SSA (Self-sufficiency in Agriculture) with 27.5% in the Entropy method, EMI (Methane (CH₄) Emissions from Agriculture) with 25.73% in the LOPCOW method, and GPV (Gross Production Value) with 13.39% in the Standard Deviation method. In the equal-weight method, each criterion was assigned a weight of 12.5%.

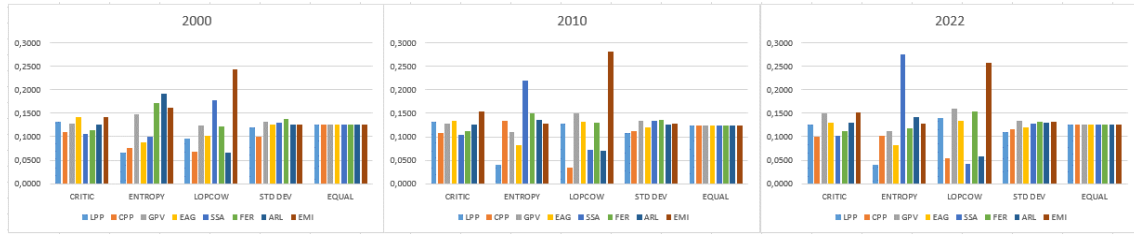


Figure 1. Criteria Weights by Different Methods (2000, 2010, 2022)

The weight values derived from the CRITIC method, the Standard Deviation method, and the equal-weight approach are quite similar, as shown in Figure 1; however, the weights derived from the Entropy and LOPCOW approaches differ. When the weights obtained with the LOPCOW method are examined, it is noteworthy that the EMI criterion differs significantly from the weights of other criteria in the three periods examined. In the Entropy method, it is seen that the weight of the SSA criterion differs from the weights of other criteria in 2010 and 2022.

Countries were ranked by integrating the criteria weights obtained with the CRITIC, Entropy, LOPCOW, Standard Deviation, and Equal-weight methods with the GRA method. The sensitivity analysis results on how the GRA method responds to changes in the criteria weights are given in Table 5.

Table 5. GRA Method Sensitivity Analysis Results

2000					
	CRI_GRA	ENT_GRA	LOP_GRA	STD_GRA	EQU_GRA
Brasil	3	3	2	2	1
Russia	1	1	1	1	2
India	2	2	6	3	3
China	5	5	5	5	5
S. Africa	6	6	4	6	6
Türkiye	4	4	3	4	4
2010					
	CRI_GRA	ENT_GRA	LOP_GRA	STD_GRA	EQU_GRA
Brasil	1	1	2	1	1
Russia	2	2	1	2	2
India	3	3	6	3	3
China	5	5	4	4	5
S. Africa	6	6	5	6	6
Türkiye	4	4	3	5	4
2022					
	CRI_GRA	ENT_GRA	LOP_GRA	STD_GRA	EQU_GRA
Brasil	1	1	2	1	1
Russia	2	3	1	2	2
India	3	2	4	3	3
China	5	5	5	5	5
S. Africa	6	6	6	6	6
Türkiye	4	4	3	4	4

When Table 5 is examined, it is seen that the rankings obtained from the CRITIC-GRA method in the relevant years are largely similar to the results obtained from the Entropy-GRA method. In addition, the results of the Standard Deviation-GRA method and the Equal Weights-

GRA method are almost the same. It is noteworthy that the results of the LOPCOW-GRA method differ from the other methods. The weight rankings obtained with the LOPCOW method also differed from the other methods. Namely, according to the LOPCOW method, Methane (CH₄) Emissions from Agriculture were determined as the most important criterion by far from the other criteria in the relevant three years. This situation seems to have caused the results of the LOPCOW-GRA method to differ from the results of the other methods. Therefore, it is possible to say that the GRA method is sensitive to changes in the criterion weights.

5. Conclusion

Brazil, Russia, India, China, and South Africa are the five leading emerging economies of the BRICS international economic alliance. Due to their similar economic potential, these nations hope to unite and have a bigger voice in the global economy. These nations are regarded as major actors because of their size, quick development, and strategic significance in the global economy.

This study used the CRITIC-based GRA approach to examine the agricultural performance of the BRICS countries and Türkiye. The CRITIC approach was used to establish the criteria's importance, and the countries were ranked based on their agricultural performance in 2000, 2010, and 2022. The reason for choosing three different years is to monitor the changing trend of the agricultural performance of the countries over time. This is a multifaceted agricultural performance analysis that covers a wide range of agricultural topics, including production, consumption, employment, agricultural potential, productivity, self-sufficiency, and the environment, rather than comparing nations based on the production of particular items.

If an expert had been consulted to define the criteria weights, this study might have been finished without the use of the CRITIC approach. However, this scenario may have been questioned because subjectivity would have been involved. A hybrid strategy known as the CRITIC-GRA model was created to lessen the possible criticisms that can be aimed at this issue. The CRITIC method is one of the objective weight determination strategies that has been widely used in recent years.

According to the CRITIC technique, employment in agriculture is the most significant factor in 2000 and agricultural emissions in 2010 and 2022, while self-sufficiency in agriculture in 2000 and 2010 and crop production in 2022 are the least significant criteria. According to the GRA Method, Russia ranked first in 2000 for agricultural performance. However, Brazil topped the list in both 2010 and 2022. South Africa was ranked lowest in all studied years. Regarding Türkiye, it had the fourth rank in 2000 and stayed at the same rate in 2010 and 2022.

Brazil's success can be attributed to its agricultural policies, which have been in effect since the 1990s. Brazil is among the nations that have made great strides in exporting and producing agricultural goods. An information technology-focused division of the Brazilian Agricultural Research Agency has created a range of computerized systems for use in fundamental research and agro-industrial applications since 1991. Despite a decline in Brazil's agricultural labor market, the advancements in agro-industrial technological systems with Agriculture 4.0 have increased the demand for more specialized personnel. As part of Agriculture 4.0, artificial neural networks are used in Brazil to estimate soybean harvest and determine the ideal planting area size. Brazilian programs known as "BovChain" use big data and cloud computing to control socio-environmental aspects. These apps connect buyers, investors, slaughterhouses, and farmers. The real-time

monitoring of herds and commercial transactions within a shared digital market facilitates accountability and environmental management of agricultural and animal production chains. In terms of precision agriculture, Brazil has also advanced significantly. In this context, applications have been developed in smart irrigation, pesticide optimization, satellite surveillance, and computational visualization of crops and animals. A Brazilian platform named "Agrosmart" is another example that stands out in this context. Its goals are to improve product performance and lessen its influence on the environment (Aydınbař, 2024: 526).

The following can be said about South Africa having the lowest performance. This country has one of the largest agricultural lands in the world, with 96 million hectares of agricultural land. However, extraordinary heatwaves and the absence of rain at critical times affect not only summer planting areas, but also the livestock industry in the country. The recurrence of drought effects in the country continues to exist as a long-term risk factor for the agricultural sector (Meza et al., 2021)

The agricultural performance of low-performing nations will improve if they implement measures to lower agricultural emissions and boost productivity, self-sufficiency, per capita consumption of agricultural products, agricultural production, and arable land.

Declaration of Research and Publication Ethics

This study, which does not require ethics committee approval and/or legal/specific permission, complies with the research and publication ethics.

Researcher's Contribution Rate Statement

The authors declare that they have contributed equally to the article.

Declaration of Researcher's Conflict of Interest

There are no potential conflicts of interest in this study.

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APPENDIX

Decision Matrix, 2000

Country/Criteria	EMI	LPP	CPP	GPV	EAG	SSA	FER	ARL
Brasil	1,40064E-06	0,227021771	2,7767537	0,533830289	15	286,30	144,5168104	5,437573431
Russia	3,56876E-07	0,270182882	0,8731284	0,322427497	14	25,40	287,4484879	7,592419179
India	2,75452E-06	0,081768868	0,6978594	1,173913524	60	195,45	103,7861182	54,12704873
China	1,2388E-06	0,083685714	0,9377889	1,900355335	50	126,44	11,41717722	12,69706
S.Africa	2,60892E-07	0,099416829	1,037276	0,181136306	21	141,36	53,5983203	11,3857999
Türkiye	7,26303E-07	0,187712512	1,5600961	1,42661627	37	103,72	87,66943675	30,95773294

EMI: Methane (CH₄) Emission from Agriculture (Mt CO₂e) (Value/Agricultural Land Hectare), **LPP:** Livestock Production, Primary (Ton/Population), **CPP:** Crops Production, Primary (Ton/Population), **GPV:** Gross Production Value (constant 2014-2016 thousand US\$) (Value/Hectare), **EAG:** Employment in agriculture (% of total employment) (modeled ILO estimate), **SSA:** Self-sufficiency in Agriculture (Export/Import) (%), **FER:** Fertilizer consumption (kilograms per hectare of arable land), **ARL:** Arable land (% of land area)

Decision Matrix, 2010

Country/Criteria	EMI	LPP	CPP	GPV	EAG	SSA	FER	ARL
Brasil	1,78274E-06	0,308261142	4,8733455	0,807546945	11	647,81	202,7967653	6,150291811
Russia	3,06273E-07	0,29631289	0,893888	0,369003313	8	18,45	425,2393478	7,428098287
India	2,96537E-06	0,107990323	0,7030008	1,602930285	51	216,72	179,0358769	52,80826318
China	1,23078E-06	0,116549254	1,1216851	2,579383919	37	49,52	15,72450246	12,81035593
S.Africa	2,93113E-07	0,132548035	0,8284638	0,239619779	17	116,60	53,77802601	10,33146757
Türkiye	7,40798E-07	0,232383583	1,4255284	1,860068697	24	116,57	98,3756547	27,7847797

EMI: Methane (CH₄) Emission from Agriculture (Mt CO₂e) (Value/Agricultural Land Hectare), **LPP:** Livestock Production, Primary (Ton/Population), **CPP:** Crops Production, Primary (Ton/Population), **GPV:** Gross Production Value (constant 2014-2016 thousand US\$) (Value/Hectare), **EAG:** Employment in agriculture (% of total employment) (modeled ILO estimate), **SSA:** Self-sufficiency in Agriculture (Export/Import) (%), **FER:** Fertilizer consumption (kilograms per hectare of arable land), **ARL:** Arable land (% of land area).

Decision Matrix, 2022

Country/Criteria	EMI	LPP	CPP	GPV	EAG	SSA	FER	ARL
Brasil	2,00542E-06	0,783180765	10,011142	1,101242886	9	962,22	363,0017726	6,657229958
Russia	2,86319E-07	0,721576295	3,793978	0,592582624	6	90,45	397,6634511	7,428098287
India	3,14181E-06	0,334382394	1,7162437	2,390578085	43	151,07	193,2275591	51,9468813
China	1,22334E-06	0,276034043	2,6855376	3,264454707	23	31,19	28,21271034	11,50847311
S.Africa	2,57419E-07	0,324990817	1,8306842	0,310874913	19	167,48	91,46647417	9,892093744
Türkiye	1,38506E-06	0,710496587	3,0269593	3,085078738	17	106,60	114,5730415	26,23858218

EMI: Methane (CH₄) Emission from Agriculture (Mt CO₂e) (Value/Agricultural Land Hectare), **LPP:** Livestock Production, Primary (Ton/Population), **CPP:** Crops Production, Primary (Ton/Population), **GPV:** Gross Production Value (constant 2014-2016 thousand US\$) (Value/Hectare), **EAG:** Employment in agriculture (% of total employment) (modeled ILO estimate), **SSA:** Self-sufficiency in Agriculture (Export/Import) (%), **FER:** Fertilizer consumption (kilograms per hectare of arable land), **ARL:** Arable land (% of land area).

THE MUTUAL RELATIONSHIP BETWEEN FINANCIAL INCLUSION AND EFFECTIVENESS OF MONETARY POLICY: EVIDENCE FROM UPPER-MIDDLE-INCOME COUNTRIES

Finansal Kapsayıcılık ile Para Politikası Etkinlięi Arasındaki Karşılıklı İlişki: Üst-Orta Gelirli Ülkelerden Kanıtlar

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Abstract

Enhancing financial inclusion is crucial for achieving global objectives such as sustainable growth, improved societal welfare, and poverty reduction. Due to its importance, financial inclusion has recently become a key policy issue and a widely studied topic. This study investigates the relationship between financial inclusion and monetary policy in upper-middle-income countries using the Two-Step System GMM and Panel Granger Causality methods. The findings reveal a bidirectional negative relationship between inflation and financial inclusion. Inflation negatively affects financial inclusion, while an increase in financial inclusion has a reducing effect on inflation. Additionally, digitalization, regulatory quality, and money supply positively affect financial inclusion, while the growth of money supply and deposit interest rates increase inflation. According to Granger causality analysis, there is a causality running from financial inclusion to the inflation rate. Accordingly, policymakers in upper-middle-income countries are advised to adopt balanced monetary policies and consider that increasing financial inclusion can help mitigate the adverse effects of inflation.

Öz

Finansal kapsayıcılığın artırılması; sürdürülebilir büyüme, toplumsal refahın yükseltilmesi ve yoksulluğun azaltılması gibi küresel hedeflere ulaşmada kritik bir unsurdur. Bu önem doğrultusunda, finansal kapsayıcılık son yıllarda küresel bir politika öncelięi ve literatürde sıkça incelenen bir konu haline gelmiştir. Bu çalışma, üst-orta gelirli ülkelerde finansal kapsayıcılık ve para politikası arasındaki ilişkiyi İki Aşamalı Sistem GMM ve Panel Granger Nedensellik yöntemleriyle incelemektedir. Bulgular, enflasyon ile finansal kapsayıcılık arasında çift yönlü negatif bir ilişki olduğunu göstermektedir. Enflasyon finansal kapsayıcılığı negatif yönde etkilerken, finansal kapsayıcılıktaki artışta enflasyonu düşürücü etki yapmaktadır. Ayrıca dijitalleşme, düzenleyici kalite ve para arzı finansal kapsayıcılığı pozitif yönde etkilerken, para arzındaki büyüme ve mevduat faizleri enflasyonu artırmaktadır. Granger nedensellik sonuçları, finansal kapsayıcılıktan enflasyona doğru bir nedensellik olduğunu göstermektedir. Bu doğrultuda, üst-orta gelirli ülkelerdeki politika yapıcılara dengeli para politikaları benimsemeleri ve finansal kapsayıcılığın enflasyon üzerindeki olumsuz etkileri hafifletebileceğini dikkate almaları önerilmektedir.

Keywords:

Financial
Inclusion,
Monetary Policy,
Dynamic Panel
Data Analysis.

JEL Codes:

C23, F65, E52,
G18.

Anahtar

Kelimeler:

Finansal
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Politikası,
Dinamik Panel
Veri Analizi

JEL Kodları:

C23, F65, E52,
G18

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1. Introduction

Financial Inclusion (hereinafter FI), defined as the ability to provide financial services to all segments of the population at an accessible cost, has recently emerged as a significant policy focus for both policymakers and global economic institutions. Widely acknowledged as a cornerstone of economic empowerment, FI is increasingly seen as a critical strategy for addressing poverty (Ozili, 2020). The World Bank (2022) describes FI as ensuring that individuals and businesses have access to affordable, practical financial products and services—including bank accounts, credit, savings, payments, and insurance—that cater to their needs while being delivered responsibly and sustainably. In alignment with this vision, G20 nations have reinforced their pledge to advance FI globally by adhering to the “G20 High-Level Principles for Digital FI”.

As supported by the academic literature, promoting FI has many societal benefits. Foremost among these contributions are enabling people to manage their financial liabilities efficiently, reducing poverty, and promoting financial stability and economic growth (Honohan, 2008; Bruhn and Love, 2014; Neaime and Gaysset, 2018; Von Fintel and Orthofer, 2020). Moreover, it increases household savings (Aportela, 1999), enables better financial risk management (Naceur et al., 2015), promotes women's empowerment within the social structure (Ashraf et al., 2010; Swamy, 2014), and reduces child labor (Beegle et al., 2003).

Studies indicate that FI contributes directly to eight of the Sustainable Development Goals (SDGs) (Murshed et al., 2023). Evidence suggests that FI plays a significant role in alleviating poverty (Burgess and Pande, 2005; Marron, 2013; Mushtaq and Bruneau, 2019; Chao et al., 2021), ending hunger (Fowowe, 2020), improving health and well-being (Asadullah et al., 2014; Tian and Kling, 2021), reducing gender inequality (Prina, 2015; Kazemikhasragh et al., 2022), energy efficiency and sustainability (Sadorsky, 2010; Kahouli, 2017; Ouyang and Li, 2018; Qu et al., 2020; Yao et al., 2021; Manko and Watkins, 2022; Yu and Tang, 2023), creating decent work opportunities (Honohan, 2008), reducing all forms of inequality (Fouejieu et al., 2020; Omar and Inaba, 2020) and environmental development (Le et al., 2020; Shahbaz et al., 2022; Liu et al., 2022).

Existing literature highlights a range of obstacles to individuals' access to financial products and services. These barriers stem from various socioeconomic and sociocultural factors, including low income, geographical limitations, insufficient technological infrastructure, the unavailability of suitable financial products, high costs associated with financial services, limited financial literacy, distrust in financial institutions, religious considerations, and a perceived lack of need for financial services (Beck et al., 2009; Demirgüç-Kunt and Klapper, 2013; Naceur et al., 2015; CAFI, 2018; Schuetz and Venkatesh, 2020). Individuals unable to access or utilize financial products and services face financial exclusion (Sinclair, 2013). This exclusion contributes to a cycle of poverty by exacerbating income inequality (Beck et al., 2007). Furthermore, financial exclusion is not confined to developing nations but also impacts disadvantaged populations and underprivileged regions within developed countries (Demirgüç-Kunt and Klapper, 2013; Gallego-Losada et al., 2023). According to Célerier and Matray (2019), nearly 40% of the global population lacks access to bank accounts, and even in the United States—boasting the highest FI levels—30% of low-income individuals remain excluded from the financial system.

At this juncture, the concept of digital finance (DF), born out of technological advancements, has emerged as a powerful mechanism to overcome physical obstacles to FI

(Liaquat et al., 2022). While the integration of technology and finance is not new, the most transformative shift has been the advent of sophisticated connectivity and storage innovations like big data, artificial intelligence, blockchain, and cloud computing (Arner et al., 2020). Broadly speaking, DF encapsulates the digitization of financial systems, encompassing all forms of electronic financial services and products—such as lending, payments, investments, insurance, and financial information—delivered to individuals and businesses via digital platforms (Gomber et al., 2017; Ozili, 2018). According to the Global Findex 2021 report, digitalization has led to significant increases in the FI rate, with millions of adults opening and using accounts. Globally, the percentage of adults holding a financial account has climbed to 76%, with the figure reaching 71% in developing economies (Demirgüç-Kunt et al., 2022). The proliferation of internet access and smartphone technology has facilitated the availability of diverse financial products and services to users, including those previously unbanked, paving the way for the emergence of Digital FI (Gallego-Losada et al., 2023). In this context, digital financial services provide a distinct opportunity to promote FI, particularly for marginalized segments of society, by offering customized financial solutions that address their needs while mitigating challenges related to costs, distance, and transparency (Kulkarni and Ghosh, 2021).

Due to its dynamic nature, FI can be influenced by many micro and macro factors and can have an impact on these dynamics. According to Khan (2011), by facilitating access to finance, FI can improve the quality and reduce the cost of services from banks for small-scale firms. These considerations can play a crucial role in enhancing the profitability of businesses and increasing welfare. Previous studies suggest that increasing official savings would help reduce the cost of credit and help business expansion. This situation helps to increase the resilience of small and large enterprises.

In regions where FI is robust, a significant portion of the economy transitions into the formal sector, contributing to the shrinking of the informal economy. This condition enables the effective implementation of monetary policy (hereinafter MP) (El Bourainy et al., 2021). As previously discussed, FI provides multiple contributions, one of which is widely recognized as enhancing the efficacy of MP. Ensuring price stability is regarded as one of the core objectives of central banks. An efficient MP plays a crucial role in achieving this objective. Given that a high level of FI can induce significant shifts in the financial behavior of both households and firms, it becomes imperative for the successful execution of MP and for central banks to maintain stability within the financial system.

For example, Galí et al. (2004) draw attention to the fact that a certain segment of society is far from the financial system when evaluating the effectiveness of MP. According to them, it is challenging for those who are not involved in the financial system to be directly affected by interest rate policies. Therefore, low FI weakens the effectiveness of the MP.

An enhancement of FI, as observed by Mbutor and Uba (2013), promotes savings and investment, thereby strengthening the stability of financial institutions to economic shocks. Furthermore, it holds significant importance in narrowing the savings-investment gap and reduces reliance on foreign capital. Anarfo et al. (2019) highlight that the main objective of MP is to stimulate economic growth and aggregate demand. However, one of the key determinants in achieving this goal is the level of FI. Given that financial systems function as conduits for MP, an enhancement in FI amplifies the efficacy of MP and influences inflation dynamics. Additionally, FI can increase the responsiveness of aggregate demand to changes in interest rates.

These interdependencies render the relationship between MP and FI critical for policymakers and researchers. The inability to clearly define this relationship often compels policymakers to prioritize one policy over the other, adding complexity to the subject and making it a significant area of interest for scholarly inquiry.

FI is increasingly recognized as a critical policy element due to its potential contributions to sustainable growth and stability, reducing inequality, financing SMEs, promoting digital finance, and consequently curbing the informal economy. However, insufficient FI can weaken the effectiveness of MP by limiting transmission mechanisms. Although upper-middle-income countries (UMIC) possess relatively developed financial systems, it is difficult to argue that they have achieved full effectiveness in terms of FI. Moreover, for these countries to attain their fundamental goal of transitioning to high-income status, both FI and the effectiveness of MP must improve. Examining the mutual relationship between FI and the effectiveness of MP becomes particularly relevant in this context. To address this need, the study clearly formulates the following key research questions in the introduction: (i) What is the nature of the relationship between FI and MP effectiveness in UMICs? (ii) Does FI influence inflation dynamics, and vice versa? To our knowledge, no prior study has explored this relationship specifically in UMICs. Therefore, this study aims to conduct an in-depth analysis of the interplay between FI and the effectiveness of MP within the framework of UMICs. The findings are expected to contribute to filling a significant gap in the academic literature while also providing valuable insights for policymakers in shaping regulatory and policy decisions.

FI holds strategic importance not only for the efficiency of the financial system but also for promoting social equity, enhancing economic participation, and supporting sustainable growth. UMICs, in their efforts to achieve higher income status and broader development goals, must ensure widespread access to financial services. In this context, FI should not be viewed merely as a unidirectional development indicator but as a dynamic component that also shapes the effectiveness of MP. The main motivation of this study lies in understanding this mutual interaction and contributing to the more effective use of policy tools accordingly. This study provides critical insights for central banks and economic authorities. It offers an empirical framework for understanding the extent to which FI influences the implementation of MP and the achievement of macroeconomic objectives. Moreover, by examining the relationship between FI and structural factors such as digitalization and regulatory quality, it delivers valuable implications for regulatory bodies, DF platforms, and private sector actors operating in the financial technology space. In this regard, the study not only contributes to the theoretical literature but also serves as a practical guide for various stakeholders in their policy development and strategic planning efforts.

2. Literature Review

Given its significant importance, FI has become a critical area of research for numerous national and international organizations, scholars, and practitioners. A review of the FI literature reveals a focus on the drivers of FI, the development of measurement methodologies, and the effects of FI on various macroeconomic and microeconomic variables. Despite the growing interest in the impact of FI on MP in recent years, the literature on this topic remains relatively limited.

The work by Galí et al. (2004) serves as a foundation for many subsequent studies in this domain. They explored the impact of individuals who are excluded from the financial system—non-savers and non-borrowers—on the effectiveness of MP, positing that access to financial systems plays a crucial role in the effectiveness of MP. Mbutor and Uba (2013) analyzed the effect of FI on MP in Nigeria from 1980-2012 and concluded that FI negatively affects inflation, thereby increasing MP effectiveness. A similar conclusion was reached by Mehrotra and Yetman (2014) in their study of 130 countries. They argued that FI significantly influences inflation and that the effectiveness of MP tends to be higher in countries with greater levels of FI. As such, optimal MP is highly sensitive to FI.

Lenka and Bairwa (2016), in their analysis of the SAARC countries between 2004 and 2013, observed that FI increases the effectiveness of MP and is instrumental in achieving price stability. Anarfo (2019) also reached similar conclusions, noting that FI impact on the inflation rate and other macroeconomic indicators in sub-Saharan African countries from 1990-2014, with the effect on inflation generally being negative. El Sherif (2019) investigated the impact of FI on MP effectiveness in Egypt and found that FI negatively affects inflation in both the short and long term, with a reciprocal causal relationship between FI and inflation. Similarly, Saraswati et al. (2020), in their study of Indonesia from 2009 to 2018, concluded that FI has a positive impact on inflation in both the short and long term, although the effects of FI shocks on inflation are not permanent. El Bourainy et al. (2021) found that FI has a negative impact on inflation and enhances the effectiveness of MP across 37 developing countries. Jungo et al. (2022) explored the relationship between FI and the effectiveness of MP in Sub-Saharan Africa and the Latin American & Caribbean regions for the period 2005-2018, determining that FI positively influences effectiveness of MP in Sub-Saharan Africa but has a negative effect in the Latin American & Caribbean region.

Although much research suggests a positive connection between FI and effectiveness of MP, a few studies present contrary findings. For example, Di Bartolomeo and Rossi (2007) explored the effectiveness of MP in countries with low financial system participation. They argued that participation in financial markets diminishes the effectiveness of MP and that an increase in the number of individuals without access to credit markets improves effectiveness of MP. Similarly, Lapukeni (2015) reported that FI undermined the effectiveness of MP in Malawi between 2001 and 2013. Ascari et al. (2011) argued that financial market participation does not significantly affect MP, and Evans (2016b) found no impact of FI on MP in African countries from 2005 to 2014. Instead, he suggested that the effectiveness of MP drives FI. Furthermore, Suman (2017), in his review of FI literature between 2008 and 2017, noted that most studies focused on the impact of FI on economic growth, emphasizing the scarcity of studies examining the effects of FI on MP and recommending further research in this area.

When the FI literature is broadly examined, it becomes evident that it has witnessed significant expansion over the years. A considerable body of literature focuses on the determinants of FI and its relationship with macroeconomic variables. However, while extensive research exists on FI and its broader macroeconomic implications, relatively limited attention has been given to its direct impact on the effectiveness of MP. Existing studies typically adopt either country-specific empirical analyses or broad comparative studies encompassing multiple income groups. Country-specific research primarily investigates the unique dynamics of a single economy, providing detailed insights into how FI influences MP transmission. In contrast, large-scale comparative analyses explore the macroeconomic consequences of FI at a global level.

Despite the growing body of research in this field, FI's role in shaping the effectiveness of MP has yet to be comprehensively examined within UMICs. In this study, however, this relationship is thoroughly investigated within the context of UMICs.

3. Research Methodology

3.1. Data Set

This study investigates the nexus between FI and the effectiveness of MP in UMICs for the period 2010–2020. The research initially aimed to encompass all UMICs; however, due to data limitations for certain countries during the relevant period, the final dataset consisted of 24 UMICs between 2010 and 2020. Accordingly, two research models were developed. In the first model, the dependent variable is the FI index (FII). While single indicators can be used in FI studies, indices that capture the accessibility, usability, and utilization dimensions of FI provide a more comprehensive representation. Therefore, FII was calculated to measure FI across multiple dimensions. In the second model, following the relevant literature (e.g., Anarfo, 2019; Saraswati, 2020; El Bourainy et al., 2021; Jungo et al., 2022 etc.), the inflation rate was selected as the dependent variable, serving as a key indicator of effectiveness of MP. To enhance the robustness of the models and improve the reliability of the results, control variables were incorporated based on both empirical findings and theoretical frameworks. Detailed information on the variables used in the study is presented in Table 1.

Table 1. Information of the Variables Used in the Study

Symbol	Variables	Data Source
FII	(D1): Number of commercial bank branches per 100,000 adults (D2): Number of ATMs per 1,000 km ² (D3): Outstanding loans from commercial banks (% of GDP)	FAS
INF	Inflation, consumer prices (annual %)	WDI
FFI	Financial freedom index	Heritage Foundation
DF	Number of ATMs per 100,000 adults	FAS
PERGRW	GDP per capita growth (annual %)	WDI
MONEY	Broad money growth (annual %)	WDI
QUALITY	Regulatory Quality (country score between -2.5 and 2.5)	WGI
DEPINT	Deposit interest rate (%)	WDI
STAB	Political stability and absence of terrorism/violence (country score between -2.5 and 2.5)	WGI
CCOR	Control of corruption (country score between -2.5 and 2.5)	WGI
MOBIL	Mobile cellular subscriptions (per 100 people)	WDI

Note: WGI: Worldwide Governance Indicators. WDI: World Development Indicators. FAS: Financial Access Survey.

Firstly, the multidimensional FII is calculated with sub-indices (D1, D2 and D3) following Sarma (2008) as follows;

$$Di = \frac{A_i - m_i}{M_i - m_i} \quad (1)$$

A_i : The level value of dimension i,

m_i : The minimum value of dimension i,

M_i : The maximum value of dimension i.

After each sub-index is calculated in this way, the FII including these sub-indices is calculated as follows.;

$$FII = 1 - \frac{\sqrt{(1 - d_1)^2 + (1 - d_2)^2 + (1 - d_3)^2}}{\sqrt{3}} \quad (2)$$

In Eq. 1, d_i takes a value between 0 and 1; the higher the value of d_i , the higher the success of the relevant unit in that dimension. Then, FII, which is calculated by including the three sub-indices, takes a value between 0 and 1. When this value approaches 0, it means that FI decreases, and when it approaches 1, it means that FI increases (Sarma, 2008).

Table 2 presents descriptive statistics for the variables preferred in the study. When the data in the table are analyzed, it is seen that the average GDP per capita growth in UMICs in the relevant period is around 1.7%. The average inflation level in these countries is 4.11%, and the average deposit interest rate is 5.09%. The level of financial freedom in these countries is around 55 points. Furthermore, the average regulatory quality is 0.154.

Table 2. Descriptive Statistics of Variables

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
D1	264	21.02648	13.45771	5.1	91.9
D2	264	27.98019	18.85022	.65	83.19
D3	264	44.28	19.07867	15.91	120.66
FII	264	.5635254	.0669486	.442	.7955
DF	264	59.62114	30.70304	18.76	185.41
MONEY	264	10.39038	7.234445	-3.74833	62.0543
DEPINT	264	5.090379	3.825435	.01	25.41
MOBIL	264	117.0341	27.32763	48.90232	185.407
INF	264	4.116652	4.909425	-2.595	55.412
FFI	264	55.37879	10.56613	30	70
PERGRW	264	1.740976	4.153311	-17.17671	9.823415
STAB	264	-.1419528	.5703773	-2.009063	1.111055
QUALITY	264	.1545808	.3866198	-.7754207	1.038354
CCOR	264	-.2296448	.4889838	-1.099215	1.003351

Table 3 presents the correlation matrix of the variables. The correlation matrix is used to verify whether the model suffers from a multicollinearity problem.

Table 3. Correlation Matrix

Variable	FII	INF	DF	CCOR	DEPINT	MOBIL	MONEY	PERGRW	STAB	QUALITY
FII	1.0									
INF	-0.2	1.0								
DF	0.3	0.1	1.0							
CCOR	0.1	-0.1	-0.1	1.0						
DEPINT	0.1	0.4	0.2	-0.0	1.0					
MOBIL	0.2	0.1	0.4	0.3	-0.1	1.0				
MONEY	-0.1	0.6	0.1	-0.1	0.4	-0.0	1.0			
PERGRW	0.1	-0.1	-0.1	-0.0	0.1	-0.1	-0.1	1.0		
STAB	0.0	-0.1	-0.2	0.5	-0.4	0.2	-0.3	-0.1	1.0	
QUALITY	0.4	-0.3	0.0	0.5	-0.1	0.3	-0.1	0.2	0.1	1.0

The results indicate that the FII is negatively correlated with INF and MONEY. Furthermore, INF exhibits a negative relationship with the variables CCOR, PERGRW, STAB

and QUALITY, while it shows a positive correlation with DF, DEPINT, MOBIL, and MONEY. The correlation coefficients between INF and the independent variables range between 0.1 and 0.6. These values suggest that there is no severe multicollinearity problem among the explanatory variables.

In addition, the Variance Inflation Factor (VIF) values are employed to further assess the presence of multicollinearity. A VIF value below 5 is generally considered indicative of the absence of multicollinearity. As shown in Table 4, all variables have VIF values below this threshold, suggesting that none of the explanatory variables exhibit multicollinearity concerns.

Table 4. VIF

Variable	VIF
FII	1.05
INF	1.68
DF	1.27
CCOR	1.47
DEPINT	1.45
MOBIL	1.40
MONEY	1.58
PERGRW	1.08
STAB	1.69
QUALITY	1.58

3.2. Research Method and Model Design

Dynamic panel data estimators incorporate the lagged value of the dependent variable as an explanatory variable within the model, which facilitates the assessment of how previous values of the dependent variable influence its current period. This inclusion enables the examination of temporal dependencies and dynamic relationships within the data. The Two-Step System GMM estimator developed by Arellano and Bover (1995) and Blundell and Bond (1998) is considered to be one of the most up-to-date and advanced estimators of dynamic panel data estimators, which largely overcomes the existence of different unit-specific effects and the endogeneity problem. Moreover, this estimator is resistant to problems such as heteroskedasticity and autocorrelation. Since more instrumental variables are used in this estimator, the efficiency of the investigated models also increases. Therefore, the Two-Step System GMM estimator was preferred in this study.

GMM is particularly effective in addressing causality and endogeneity issues in short panel data settings. In this context, cross-sectional dependence was not directly incorporated into the model. One of the main reasons for this is that the instrumental variables used—particularly the lagged values of the independent variables—have the capacity to indirectly account for common shocks (Roodman, 2009).

Based on the existing theoretical and empirical literature (Mehrotra and Yetman, 2014; Lenka and Bairwa, 2016; Evans, 2016a; Evans, 2016b; Ozili, 2018; Neaime and Gaysset, 2018; Anarfo et al., 2019; Saraswati et al., 2020; El Bourainy et al., 2021; Murshed et al., 2023; Al-Samadi, 2023, etc.), Model 1 is developed to assess the impact of the effectiveness of MP on FI, while Model 2 examines the effect of FI on the effectiveness of MP.

Model 1;

$$FII_{it} = \partial_0 + \beta_1 FFI_{it-1} + \beta_2 INF_{it} + \beta_3 DF_{it} + \beta_4 QUALITY_{it} + \beta_5 MONEY_{it} + \beta_6 PERGRW_{it} \quad (3)$$

Model 2;

$$INF_{it} = \alpha_0 + \alpha_1 INF_{it-1} + \alpha_2 FII_{it} + \alpha_3 MONEY_{it} + \alpha_4 DEPINT_{it} + \alpha_5 PERGRW_{it} + \alpha_6 STAB_{it} + \alpha_7 CCOR_{it} + \phi_i + v_t + u_{2it} \quad (4)$$

In the analysis models, i is the unit dimension, t is the time dimension, α_0 and ∂_0 are the model constant terms and u_{1it} , u_{2it} are errors. $\beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7$ are the coefficients of the variables in Model 1. $\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5, \alpha_6, \alpha_7$ are the coefficients of the variables in Model 2. ϕ_i is unobservable effect and v_t indicates time-specific factor.

To investigate the causality between the variables in the study, a panel causality approach has been applied. For this purpose, the Panel Vector Autoregressive (VAR) model has been utilized. Within the scope of the study, the panel VAR models established for Model 1 (5) and Model 2 (6) are as follows:

$$FII_{it} = \delta_0 + \sum_{j=1}^k \theta_j \Delta FII_{it-j} + \sum_{j=1}^k \beta_j INF_{it-j} + \sum_{j=1}^k \partial_{1j} DF_{it-j} + \sum_{j=1}^k \partial_{2j} QUALITY_{it-j} + \sum_{j=1}^k \partial_{3j} MONEY_{it-j} + \sum_{j=1}^k \partial_{4j} PERGRW_{it-j} + \sum_{j=1}^k \partial_{5j} MOBIL_{it-j} + u_{1t} \quad (5)$$

$$INF_{it} = \mu_0 + \sum_{j=1}^k \phi_j \Delta INF_{it-j} + \sum_{j=1}^k \gamma_j FII_{it-j} + \sum_{j=1}^k \delta_{1j} MONEY_{it-j} + \sum_{j=1}^k \delta_{2j} DEPINT_{it-j} + \sum_{j=1}^k \delta_{3j} PERGRW_{it-j} + \sum_{j=1}^k \delta_{4j} STAB_{it-j} + \sum_{j=1}^k \delta_{5j} CCOR_{it-j} + u_{2t} \quad (6)$$

In eq. 5 and 6 established for model 1 and model 2, δ_0 and μ_0 represent the constant parameters, while u_{1t} and u_{2t} denote the error terms. The coefficients of the variables in Eq.5 are represented by $\theta_j, \beta_j, \partial_{1j}, \partial_{2j}, \partial_{3j}, \partial_{4j}, \partial_{5j}$. Similarly, the coefficients of the variables in eq.6 are represented by $\phi_j, \gamma_j, \delta_{1j}, \delta_{2j}, \delta_{3j}, \delta_{4j}, \delta_{5j}$. For the estimated panel VAR models, the lag length is denoted by k , and the appropriate lag length has been determined by the Schwarz information criterion.

4. Results and Discussions

Table 5 reports the results of the cross-sectional dependence test for the variables. Based on the outcomes of multiple tests, the null hypothesis, which assumed no cross-sectional dependence among the variables, was rejected at the 1% significance level. These results indicate that all the variables exhibit cross-sectional dependence. As a next step, the presence of unit roots in the variables was assessed through the Pesaran (2007) panel unit root test, which incorporates cross-sectional dependence.

Table 5. Results of Cross-Section Dependence Tests

Variables	Breusch-Pagan LM	Pesaran Scaled LM	Bias-corrected Scaled LM	Pesaran CD
FII	1412.487* (0.000)	48.372* (0.000)	47.172* (0.000)	16.809* (0.000)
DF	1618.272* (0.000)	57.131* (0.000)	55.931* (0.000)	25.163* (0.000)
INF	546.381* (0.000)	11.508* (0.000)	10.308* (0.000)	8.489* (0.000)
QUALITY	842.545* (0.000)	24.114* (0.000)	22.914* (0.000)	-0.009 (0.992)
MONEY	381.704* (0.000)	4.499* (0.000)	3.299* (0.001)	6.709* (0.000)
DEPINT	711.907* (0.000)	18.553* (0.000)	17.353* (0.000)	6.482* (0.000)
STAB	774.365* (0.000)	21.212* (0.000)	20.012* (0.000)	0.489 (0.625)
CCOR	830.213* (0.000)	23.589* (0.000)	22.389* (0.000)	-1.197 (0.231)
PERGRW	1534.965* (0.000)	53.585* (0.000)	52.385* (0.000)	37.509* (0.000)
MOBIL	1058.269* (0.000)	33.296* (0.000)	32.096* (0.000)	7.950* (0.000)

Note: * indicates significance at the 1% level. The values included in parenthesis indicate the probability values.

Table 6 presents the results of the panel unit root test. According to the panel unit root test results, the null hypothesis that FII, INF, MONEY, and MOBIL variables have a unit root has been rejected at least at the 5% significance level. These results indicate that these variables are stationary. Since the DF, QUALITY, PERGRW, DEPINT, STAB, and CCOR variables have a unit root, their first differences have been taken. Consequently, it has been determined that these differenced variables are stationary.

Table 6. Results of Panel Unit Root Test

Variables	Statistics
FII	-2.929***
DF	-1.647
INF	-3.047***
QUALITY	-1.513
MONEY	-2.465**
PERGRW	-2.032
MOBIL	-2.551**
DEPINT	-1.661
STAB	-1.895
CCOR	-1.800
Δ DF	-4.290***
Δ QUALITY	-2.512**
Δ PERGRW	-2.600***
Δ DEPINT	-2.841***
Δ STAB	-2.619***
Δ CCOR	-2.579**

Note: ***, **, * significance at the 1%, 5% and 10% levels, respectively. The significance levels are - 2.58 for 1%; -2.33 for 5%, and -2.21 for 10%, respectively. Δ indicates the first difference of the series Δ denotes the first difference of the series.

This section of the study presents the results of the analyses conducted for Model 1 and Model 2 using the Two-Step System GMM method. Table 7 displays the results obtained from these analyses. The findings for the model 1 reveal that the lagged value of FII has a positive effect on the current period FII at the 1% significance level. This result confirms the validity of employing the dynamic panel data methodology in this study. The inflation rate exerts a statistically significant negative impact on FI at the 5% significance level, which is consistent with the findings of Evans (2016a), Kouladoum et al. (2022), and Al-Samadi (2023), who also

reported that inflation negatively influences FI. Regarding control variables, digitalization in the financial sector has a positive effect on FI at the 10% significance level, while regulatory quality positively impacts FI at the 5% significance level. These findings align with those of Van et al. (2022). Additionally, the growth in money supply exerts a significant impact on FI at the 1% significance level, supporting the conclusions of Jungo et al. (2022) and El Sherif (2019), who similarly argued that money supply positively affects inflation.

For the model 2, the results indicate that the lagged value of inflation has a statistically significant positive effect on current period inflation at the 1% significance level. Moreover, FII negatively affects inflation at the 5% significance level. This finding corroborates the results of various studies in the literature, including Mbutor and Uba (2013), Mehrotra and Yetman (2014), Lenka and Bairwa (2016), Anarfo (2019), El Sherif (2019), Saraswati et al. (2020), Jungo et al. (2022), and El Bourainy et al. (2021). The growth in money supply and the deposit interest rate, both included as control variables, exert a positive and statistically significant effect on inflation. These results are consistent with the findings of Lapukeni (2015), Evans (2016b), Jungo et al. (2022), and El Bourainy et al. (2021).

Table 7. GMM Results

Dependent: FII	Model 1	Dependent: INF	Model 2
FII _{t-1}	.7336958 (0.000)***	INF _{t-1}	.2406972 (0.001)***
DF	.000152 (0.091)*	FII	-8.021825 (0.039)**
INF	-.0008681 (0.028)**	MONEY	.3024042 (0.099)*
QUALITY	.0222141 (0.012)**	DEPINT	.2849913 (0.028)**
MONEY	.000536 (0.000)***	PERGRW	-.0388552 (0.494)
FFI	-.0003228 (0.287)	STAB	-.9859665 (0.183)
PERGRW	-.0001024 (0.637)	CCOR	-.1641093 (0.878)
MOBIL	-.0000477 (0.599)		
C	.1596809 (0.025)**	C	3.158685 (0.231)
Wald T.	0.000	Wald T.	0.000
AR(1)	0.008	AR(1)	0.108
AR(2)	0.342	AR(2)	0.190
Hansen T.	0.158	Hansen T.	0.194
Instrument Variable S.	17	Instrument Variable S.	17
Number of Observations	240	Number of Observations	240

Note: Coefficients are given outside the parentheses, and *, **, *** indicate 10%, 5%, and 1% significance levels, respectively.

Table 8 displays the results of the panel Granger causality tests for Model 1 and Model 2. The findings for model 1 reveal that FII is a Granger cause of INF at the 5% significance level. Evidence of bidirectional causality is observed between FII and MONEY, at least at the 10% significance level. The results further suggest that FII causes DF, while QUALITY influences FII, both at the 10% significance level. No causality is detected between FII and the PERGRW and MOBIL variables. For Model 2, the results indicate a one-way causality from FII to INF at

the 5% significance level. Additionally, bidirectional causality between INF and PERGRW is found to be significant at the 5% significance level.

Table 8. Panel Granger Causality Results

Model 1			Model 2		
Null Hypothesis	Test Statistic	p-value	Null Hypothesis	Test Statistic	p-value
FII → INF	4.853**	0.029	INF → FII	1.667	0.198
INF → FII	1.668	0.198	FII → INF	4.853**	0.027
FII → MONEY	2.731*	0.099	INF → MONEY	0.002	0.968
MONEY → FII	8.649***	0.004	MONEY → INF	1.064	0.304
FII → DF	2.827*	0.094	INF → PERGRW	3.916**	0.049
DF → FII	1.760	0.186	PERGRW → INF	4.215**	0.041
FII → QUALITY	0.013	0.908	INF → DEPINT	0.085	0.771
QUALITY → FII	3.710*	0.055	DEPINT → INF	0.142	0.707
FII → PERGRW	0.251	0.617	INF → STAB	0.262	0.609
PERGRW → FII	0.536	0.465	STAB → INF	0.146	0.703
FII → MOBIL	1.528	0.218	INF → CCOR	0.019	0.891
MOBIL → FII	2.664	0.104	CCOR → INF	0.012	0.914

Note: ***, **, * signify 1%, 5% and 10% significance levels, respectively.

5. Conclusion and Policy Recommendations

In today's world, it is believed that FI makes significant contributions to many SDGs, such as sustainable growth, poverty reduction, gender equality, and preventing the informal economy. These issues are increasing the importance of FI day by day. Due to this importance, both national authorities and international organizations like the World Bank, as well as policymakers are developing strategies and taking significant steps to increase FI. Based on this importance, this study has investigated the relationship between FI and the effectiveness of MP in UMICs and reached important results.

When the findings obtained in the scope of the study are evaluated together, there are several key points. One of the most significant points is the mutual relationship between inflation and FI, which is consistent with Jungo et al. (2022). According to the findings, FI is negatively influenced by inflation, and at the same time, FI has a negative impact on inflation. The level of inflation is considered a significant indicator of the success of MP. According to the widespread view in the literature, increased participation in the financial system, i.e., increased FI, increases the effectiveness of MP by enabling MP implementations to affect more people directly. The findings of this study are consistent with this view. On the other hand, effective MP encourages participation in the financial system and increases FI. Increased FI, in turn, increases the effectiveness of MP and significantly affects price stability.

The findings related to the control variables are as follows. Digitalization within the financial sector exerts a positive influence on FI; however, this nexus remains statistically weak. Despite the weak association, the integration of technological advancements into the financial system facilitates significantly easier access to financial services. This enhanced accessibility can, in turn, bolster FI. Therefore, in regulatory reforms aimed at fostering FI, technological factors should be regarded as a critical consideration. The expansion of the money supply contributes positively to FI. This result can be attributed to the reflection of an increased money supply in the form of deposits held in banks. Additionally, regulatory quality also exerts a positive impact on FI. Regulatory quality is an important indicator that reflects the government's ability to make

regulations to support and develop the private sector. In this regard, improving the quality of regulations can enhance efficiency and transparency in the financial system, reducing market inefficiencies. This, in turn, increases the likelihood of FI. Interest rates have a positive impact on inflation. This effect can be evaluated in two different ways. Firstly, from the perspective of supply-side inflation, an increase in lending interest rates can raise costs, potentially leading to an increase in the general price level. Secondly, since the study uses deposit interest rates as an interest rate indicator, an increase in deposit interest rates can be seen as increasing disposable income, leading to an increase in total demand and, consequently, an increase in the general price level. The results indicate that the growth in money supply is positively related to inflation, consistent with theoretical expectations. It is generally accepted that an increase in money supply can lead to an increase in total demand, which in turn can lead to an increase in the general price level.

The findings highlight the mutual relationship between FI and the effectiveness of MP, emphasizing the need for a cohesive and integrated policy approach in UMICs. Policies aimed at enhancing FI should prioritize expanding digital financial services, improving regulatory quality, increasing financial literacy, and reducing barriers to banking access. Strengthening fintech infrastructure and mobile banking can foster broader participation in the formal financial system, leading to more efficient transmission of MP measures across different economic segments. At the same time, maintaining inflation stability is crucial, as high inflation negatively affects FI by reducing the real value of savings, discouraging long-term investments, and increasing borrowing costs. Policymakers should implement credible inflation-targeting frameworks, ensure exchange rate stability, and balance money supply growth to prevent inflationary pressures from undermining FI. A well-coordinated monetary and fiscal policy mix is essential for achieving both price stability and sustainable FI expansion. Given the inverse relationship between FI and MP effectiveness, regulatory frameworks should account for their interplay to optimize policy outcomes. Central banks must enhance FI monitoring mechanisms, leverage financial technology for data-driven decision-making, and align FI initiatives with broader monetary objectives.

Despite its contributions, this study has certain limitations. First, although the initial aim was to cover all UMIC, data availability limited the sample to 24 countries over the period 2010–2020. Future research could broaden the scope by including more countries and longer time spans, provided that consistent data become accessible. Second, while a composite FI index was used to reflect multiple dimensions of inclusion, qualitative aspects such as financial literacy, trust in financial institutions, or informal finance usage were not included due to data constraints. Future studies may incorporate such variables through alternative data sources or case study approaches. Finally, while robust econometric techniques like Two-Step System GMM and Panel Granger Causality were applied, further research could explore alternative methodologies or conduct subgroup analyses to validate and enrich the empirical findings.

Declaration of Research and Publication Ethics

This study which does not require ethics committee approval and/or legal/specific permission complies with the research and publication ethics.

Researcher's Contribution Rate Statement

The authors declare that they have contributed equally to the article.

Declaration of Researcher's Conflict of Interest

There is no potential conflicts of interest in this study.

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THE FACTORS INFLUENCING BANKS' RISK-TAKING BEHAVIOR: EVIDENCE FROM THE TURKISH BANKING INDUSTRY *

Bankaların Risk Alma Davranışını Etkileyen Faktörler: Türk Bankacılık
Sektöründen Kanıtlar

Erdal DEMİR** & Yüksel AYDIN***

Öz

Bu arařtırma, 2010-2023 dönemi için Türkiye'deki ticari bankaların risk almasını etkileyen faktörleri ampirik olarak analiz etmektedir. Geliřtirilen panel veri regresyon modellerinde banka risk alma ölçütü olarak ters Z skoru kullanılırken, bağımsız deęişken olarak çeřitli banka düzeyi ve makro düzey deęişkenler kullanılmıştır. Bu makalede geliřtirilen modeller, tüm bankaları içeren ana örneklem ve oluřturulan alt örneklem için ayrı ayrı tahmin edilmiştir. Sabit etkili regresyonlardan elde edilen sonuçlara göre, banka büyüklüęü, banka sermayesi, banka mevduatı ve net faiz marjı deęişkenleri ana örneklem açısından banka risk alma düzeyini azaltma eğilimindedir. Ancak likidite riski, kredi riski, enflasyon oranı, ekonomik büyüme ve COVID-19 pandemi krizi banka risk alma düzeyini artırma eğilimindedir. Halka açık, halka açık olmayan, yerli ve yabancı bankalardan oluřan alt örneklemlerden elde edilen bulgular, banka büyüklüęü, banka sermayesi ve net faiz marjının banka risk alma düzeyini azaltma eğiliminde olduęunu göstermektedir ki bu da ana örneklemde elde edilen bulguları desteklemektedir. Son olarak, bu makalenin sonuçları, bankaların risk alma davranışlarının kontrol edilmesi, bankacılık sektöründe istikrarın saęlanması ve sürdürülebilir bir bankacılık sektörünün oluřturulması açısından banka yönetimi, düzenleyici mekanizmalar ve politika yapıcılar için önemli çıkarımlara sahiptir.

Abstract

This research employs an empirical approach to analyse the factors affecting the risk-taking of commercial banks in Turkey for the period 2010-2023. The inverse Z score was utilised as a measure of bank risk-taking in the developed panel data regression models, while various bank-level and macro-level variables were employed as independent variables. The developed models in this article are estimated separately for the main sample, which includes all banks, and for the sub-samples that have been formed. According to the results based on fixed effects regressions, bank size, bank capital, bank deposit and net interest margin variables tend to reduce the level of bank risk taking in terms of the main sample. However, liquidity risk, credit risk, inflation rate, economic growth and the COVID-19 pandemic crisis tend to increase the level of bank risk taking. Findings from subsamples of listed, non-listed, domestic and foreign banks indicate that bank size, bank capital and net interest margin tend to reduce the level of bank risk taking, which supports the findings from the main sample. Finally, the results of this article have important implications for bank management, regulatory mechanisms and policy makers in terms of controlling the risk-taking behavior of banks, ensuring stability in the banking sector and building a sustainable banking sector.

Anahtar

Kelimeler:

Banka Risk Alma,
Ticari Bankalar,
Türk Bankacılık
Sistemi,
Panel Veri
Analizi

JEL Kodları:

G21, G32, C33

Keywords:

Bank Risk
Taking,
Commercial
Banks,
Turkish Banking
System,
Panel Data
Analysis

JEL Codes:

G21, G32, C33

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1. Introduction

The banking industry is of pivotal importance to the economy, as it performs several key functions. Firstly, banks accept deposits from individuals and businesses, safeguarding these assets while paying interest to depositors. They then use these deposits to provide loans and advances, facilitating economic activities such as business expansion, construction, and consumer spending (Işık et al., 2025). Additionally, banks create credit, which increases the money supply and supports economic growth. They also offer payment and settlement systems, enabling smooth financial transactions.

Banking is an industry that is inherently associated with risk. Financial institutions are susceptible to a multitude of risks in the course of their operations (Isik and Bolat, 2016; Chen et al., 2018). These risks encompass credit risk, characterized by the potential for borrowers to default on their loan obligations; market risk, stemming from volatility in interest rates, exchange rates, and asset prices; liquidity risk, which pertains to the inability to meet short-term financial obligations; operational risk, arising from internal process failures or external events; reputational risk, which can damage a bank's public image and customer trust; compliance risk, related to violations of laws and regulations; and systemic risk, where the failure of one institution can trigger a broader financial crisis (Adhikari and Agrawal, 2016; Erdinç and Gurov, 2016).

Understanding and managing these risks is crucial for banks to ensure their stability and profitability (Işık and Belke, 2017). By effectively identifying, assessing, and mitigating risks such as credit, market, liquidity, operational, reputational, compliance, and systemic risks, banks can safeguard their financial health and maintain customer trust (Danisman and Demirel, 2019; Nur, 2022). Robust risk management practices enable banks to navigate economic uncertainties, capitalize on growth opportunities, and avoid significant losses. This proactive approach not only enhances the bank's resilience but also contributes to the overall stability of the financial system, fostering sustainable economic development (Martínez-Malvar and Baselga-Pascual, 2020; Mercan, 2021).

Banks' risk-taking tendencies can also drive innovation and economic growth by providing essential funding and credit, but excessive risk-taking can lead to financial instability, negatively impacting banking activities, various economic sectors, and overall economic sustainability (Diaconu and Oanea, 2014; Danisman and Demirel, 2019). When banks engage in high-risk activities without adequate safeguards, they expose themselves to potential defaults, market volatility, and liquidity crises. This can result in significant financial losses, reduced lending capacity, and operational disruptions (Baselga-Pascual et al., 2015; Albaity et al., 2019). The ripple effects of such instability can spread to businesses that rely on bank financing, leading to reduced investments, job losses, and economic downturns. Furthermore, the broader economy can suffer from decreased consumer confidence and spending, ultimately hindering sustainable growth and development. Therefore, maintaining a balanced approach to risk-taking is essential for the long-term health of both the banking sector and the economy as a whole. Understanding these dynamics is crucial for policymakers and financial institutions aiming to create a resilient banking system. Therefore, effective risk management practices are essential to balance the benefits of risk-taking with the need to maintain financial stability (Akbar et al., 2017; Ashraf, 2017).

The aim of the present research is to determine the variables affecting the risk-taking behaviour of banks through panel data regression analysis. For this objective, the annual data of

22 commercial banks operating in the Turkish banking system for the period 2010-2023 were analysed with the Fixed Effects regression model proposed by Driscoll-Kraay (1998).

The existing research makes three contributions to the extant bank literature. Firstly, it is the first study, to the best of the researchers' knowledge, to explore the factors influencing the risk-taking behaviour of Turkish commercial banks. Secondly, for methodological reasons, bank-level and macro-level factors affecting banks' risk-taking propensity were modelled together in the analysis of Turkish banks using a panel fixed-effect estimation model. Furthermore, the employed estimation methodology minimizes bank-specific effects. Thirdly, the risk-taking model was estimated separately for both the main sample including all banks and the sub-samples created to investigate whether there were differences in risk-taking among banks. Lastly, the influence of the COVID-19 pandemic crisis on the risk-taking level of Turkish banks has also been investigated in the current study.

The remainder of this research is divided into a further 5 sections. Section 2 reviews the literature on bank risk taking and explains the research gap. Section 3 presents the data and the research methodology. Section 4 presents the empirical findings and finally, Section 5 concludes the manuscript.

2. Literature Review

This section is divided into two subsections. The first subsection examines the articles in the literature to date that examine banks' risk-taking behavior. The second subsection then assesses the critical research gaps in the banking literature.

2.1. Past Papers Examining the Factors Influencing Banks' Risk-Taking

In this subsection, as seen in Table 1, earlier studies investigating the factors affecting banks' risk-taking behavior are briefly summarized.

Table 1. Past Studies Examining the Factors Influencing Banks' Risk-Taking Behavior

Study	Analysis Period	Scope	Methodology	Risk Measure	Result
Chaibi and Ftiti (2015)	2005–2011	280 commercial banks in France and Germany	Two-step system GMM	Credit risk (non-performing loan ratio)	Results show that both micro and macro variables have significant effects on banks' credit risk.
Isik and Bolat (2016)	2006–2012	20 commercial banks in Turkey	Pooled OLS, Random Effects, and Fixed Effects panel data regression estimators	Credit risk (non-performing loan ratio)	Credit risk is influenced more by bank-level variables and the 2008 global financial crisis than by macro variables.
Adhikari and Agrawal (2016)	1994–2010	1459 banks in the USA	Fixed Effects panel data regression analysis	-Standard deviation of stock returns - Bankruptcy risk measured by Z-score	Findings indicate that local religiosity reduces banks' risk-taking tendencies.
Işık and Belke (2017)	13 commercial banks in Turkey	2006–2015	Arellano-Froot-Rogers panel data estimator	Liquidity risk	According to the findings, liquidity risk is significantly affected by both macro and micro level variables.
Ahamed (2021)	2005–2018	23 banks in Bangladesh	Pooled OLS and Random Effects panel data estimators	Liquidity risk	Liquidity risk is negatively related to bank size but positively related to capital adequacy and return on assets.
Akbar et al. (2017)	2003–2012	276 financial sector firms including FTSE-listed banks	System GMM	-Standard deviation of stock returns - Bankruptcy risk measured by Z-score	The study reports that board independence and CEO duality reduce bank risk.
Albaity et al. (2019)	2006–2015	276 banks in MENA countries	Two-step system GMM	-Non-performing loans -Bankruptcy risk measured by Z-score	Results show that banks facing lower competition tend to take less credit and bankruptcy risk.

Tablo 1. Continue

Study	Analysis Period	Scope	Methodology	Risk Measure	Result
Ashraf (2017)	1998–2007	34021 observations from banks operating in 98 countries	Pooled panel OLS estimator	-Operational risk based on deviations in interest income -Bankruptcy risk measured by Z-score	Results indicate that political institutions encourage higher risk-taking in banks.
Baselga-Pascual et al. (2015)	2001–2012	204 commercial banks operating in 14 European countries	Two-step system GMM	-Non performing loans -Bankruptcy risk measured by Z-score	The study finds that less concentrated markets, lower interest rates, higher inflation rates, and economic crises increase bank risk.
Chen et al. (2018)	2005–2016	31 commercial banks in China	Fixed Effects panel data regression analysis	Credit risk	Findings indicate that financial inclusion increases the ratio of non-performing loans.
Diaconu and Oanea (2014)	2008–2012	13 commercial banks in Romania	Pooled panel OLS estimator	Bankruptcy risk measured by Z-score	Findings indicate that economic growth and interest rates reduce bank bankruptcy risk.
Dias (2020)	2011–2015	Over 1,800 banks from 135 countries	Cross-sectional regression analysis	Bankruptcy risk measured by Z-score	The study reports an inverse U-shaped relationship between capital adequacy and bank risk-taking (measured by Z-score).
Erdoğan and Gurov (2016)	2000–2011	35 European countries	Difference and system GMM	Credit risk measured by non-performing loans	Findings confirm that the intensive use of internal ratings in the post-crisis period leads to a statistically significant decrease in total non-performing loans.
Danisman and Demirel (2019)	2007–2015	25 developed countries	Fixed Effects estimator	-Bankruptcy risk -Operational risk -Liquidity risk	The study finds that capital requirements are the most effective regulatory tool in reducing bank risk and that these requirements are more effective in reducing risk for banks with greater market power. It also finds that higher operating restrictions in developed markets significantly increase bank risk, but this risk increase is mitigated for banks with greater market power.

Tablo 1. Continue

Study	Analysis Period	Scope	Methodology	Risk Measure	Result
Ghenimi et al. (2020)	2005–2015	49 commercial and 27 participation banks in MENA countries	Two-step system GMM	Liquidity risk	Results show that bank-specific variables affect liquidity risk in both banking systems, while macroeconomic factors determine liquidity risk for conventional banks. Additionally, liquidity risk for Islamic banks is not affected by macroeconomic variables.
Martínez-Malvar and Baselga-Pascual (2020)	1999-2013	Latin American banks	Two-step system GMM	Bankruptcy risk measured by Z-score	Results show that commercial banks with strong capital structures and high liquidity are less risky.
Mercan (2021)	2006-2014	Georgian banks	Pooled panel OLS, Random Effects, and Fixed Effects estimators	-Bankruptcy risk measured based on Z score -Credit risk	According to the findings, bank capital increases bank risk while bank profitability decreases bank risk.
Mohamad and Jenkins (2020)	2011–2019	197 banks from 16 MENA countries	Fixed Effects estimator	Credit risk	Results indicate a positive relationship between corruption and non-performing loans.
Nur (2022)	2000-2020	7 banks listed on the Borsa Istanbul Bank Index	Panel cointegration and causality analysis	Bankruptcy risk measured by Z-score	The findings of the study indicated the presence of a long-term cointegration relationship between the variables. Furthermore, the study concluded that there exists a unidirectional causality relationship from risk-taking tendency to profitability and from liquidity deficiency to risk-taking tendency.

2.2. Research Gap

A detailed examination of previous studies on bank risk-taking behavior in the literature indicates two important research gaps. The first research gap is related to previous studies conducted in the Turkish banking sector. In two of these studies, credit and liquidity risks were used as dependent variables. The other study, which used bankruptcy risk as dependent variable, focused on cointegration and causality relationship using a sample of only 7 banks. To fill this gap, we used a balanced panel of 22 commercial banks operating in the Turkish banking sector for the period 2010-2023. This is of great importance for generalizing the obtained results to the banking sector. The second critical research gap is related to the methodology used in previous studies. Previous articles have examined the factors affecting the risk-taking behaviour of banks using pooled OLS, Random Effects and Fixed Effects, difference GMM, system GMM or 2SLS panel data regression estimators. To fill this heading, we used the Fixed Effects regression model proposed by Driscoll-Kraay (1998) estimator. As is known, this estimator produces robust and reliable estimation results in cases where there is heterogeneity, autocorrelation, heteroscedasticity and cross-sectional dependence. Besides, the up-to-date nature of the data employed in this research is of critical importance for stakeholders and practitioners in the banking sector in determining the factors affecting risk-taking behaviour in the developing and transforming banking sector.

3. Methodology

3.1. Dataset

The present research aims to estimate the effects of micro and macro factors on the risk-taking behaviour of commercial banks. To this end, an annual data from 22 commercial banks operating in the Turkish banking sector during the period 2010-2023 is examined. The data is in the form of a balanced panel, thus commercial banks with missing data during the research period and other banks (participation banks and investment and development banks) are excluded from the study's scope. Table 2 presents details on used sample. Additionally, Table 3 gives the detailed definitions of the variables used in the analyses.

Table 2. Commercial Banks Included in the Research

No.	Commercial Bank	No.	Commercial Bank
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	15	Citibank A.Ş.
2	Türkiye Halk Bankası A.Ş.	16	Denizbank A.Ş.
3	Türkiye Vakıflar Bankası T.A.O.	17	HSBC Bank A.Ş.
4	Akbank T.A.Ş.	18	ICBC Turkey Bank A.Ş. (Tekstilbank)
5	Anadolubank A.Ş.	19	ING Bank A.Ş.
6	Fibabanka A.Ş. (millenium) eurobanka	20	QNB Finansbank A.Ş.
7	Şekerbank T.A.Ş.	21	Turkland Bank A.Ş. (mng)
8	Turkish Bank A.Ş.	22	Türkiye Garanti Bankası A.Ş.
9	Türk Ekonomi Bankası A.Ş.		
10	Türkiye İş Bankası A.Ş.		
11	Yapı ve Kredi Bankası A.Ş.		
12	Alternatifbank A.Ş.		
13	Arap Türk Bankası A.Ş.		
14	Burgan Bank A.Ş. (Eurobank tekfen)		

Table 3. Definitions of the Variables

Variables	Symbol	Calculation	Expected sign
Panel A: Dependent Variable			
Bankruptcy Risk	BR	1/Z-score=1/((ROAA +BE)/SD of ROAA) ROAA= return on average assets BE=Bank equity to total assets ratio SD=Standard deviation	
Panel B: Bank Level Independent Variables			
Bank size	Ln(assets)	Natural logarithm of total assets	+/-
Bank age	Ln(age)	Bank age Ln(age) Natural logarithm of bank age	-
Bank capital	CAR	Capital adequacy ratio	-
Bank deposit	BD	Bank deposit to total assets ratio	-
Credit risk	CR	Ratio of non-performing loans to total gross loans	+
Liquidity risk	LR	1/ratio of liquid assets to total assets	+
Interest margin	NIM	(Interest income-interest expenses)/total assets	-
Panel C: Macro Level Independent Variables			
Inflation rate	INF	Consumer Price Index (% change)	+/-
Economic growth	EG	Gross Domestic Product (% change)	+/-
Panel D: Crisis Variable			
COVID-19	CVD	Dummy variable that takes the value 1 for 2020 and 2021 and 0 for other years	+

3.2. Empirical Models

The aim of the current research is to determine the variables that affect the risk-taking behaviour of banks. The panel data model developed for this purpose is given below:

$$(BR)_{it} = \alpha + \sum_{j=1}^7 (BLIV)_{it} \zeta_j + \sum_{j=1}^2 (MLIV)_t \delta_j + \psi(CVD)_t + \varepsilon_{it} \quad (1)$$

In equation (1), the subscripts “i” and “t” represent individual banks and years, respectively; α is the constant term of the regression model; $(BR)_{it}$ is the dependent variable of the model and represents the risk-taking tendency of banks (bankruptcy risk). This variable is measured as the inverse of the Z score variable (1/Z score), in line with previous literature. Therefore, high values of this variable indicate that the bank’s risk increases or its stability decreases; $(BLIV)_{it}$ and $(MLIV)_t$ represent the bank-level and macroeconomic-level control variables, respectively. The bank-level variables are bank size, bank age, bank capital, bank deposits, credit risk, liquidity risk, and interest margin, respectively. The macroeconomic variables are inflation rate and economic growth. In addition, the COVID-19 pandemic crisis is added to Eq. (1) through a dummy variable. This dummy variable takes the value of “1” for 2020 and 2021 and the value of “0” for other years. The parameters α , ζ , δ and ψ are the coefficients to be estimated. $\varepsilon_{it} = \lambda_t + \eta_i + \mu_{it}$ are the error terms of the models. In this equation, η_i represents the fixed effects specific to banks that are unobserved and do not change over time, λ_t represents the time effects, and μ_{it} represents the random error term with a mean of zero ($E(\mu_{it})=0$) and a variance that does not change ($Var(\mu_{it})=\sigma^2$). The panel data regression model expressed in Eq. (1) has been estimated and reported separately for both the main sample including all banks and the subsamples created.

Following the estimation results for the main sample, two sub-samples are created for various criteria (i.e., being registered in BIST and capital structure) and it is checked whether the effects in the main sample changed when the sub-samples were taken into account. First, the banks in the main sample are divided into two groups as listed and unlisted banks. Second, the banks in the main sample are divided into two groups as domestic and foreign banks by taking into account their capital structures.

3.3. Estimation Procedure

The slope coefficients (α , ζ , δ and ψ) of the panel data regression model expressed in Equation 1 can be estimated employing panel data estimators such as Ordinary Least Squares (OLS), Random Effects (RE), and Fixed Effects (FE). However, OLS does not take into account the bank-specific fixed effects (η_i), making it a weak estimator. In this study, the Hausman Specification test was used to select the most appropriate estimator between RE and FE. In the Hausman Specification test, the null hypothesis states that the RE estimator is valid, while the alternative hypothesis states that the FE estimator is valid. Since the null hypothesis of the Hausman Specification test was rejected at the 5% or 1% significance levels in the estimated main and sub-regression equations, the FE estimator was preferred for all model estimations. Following this step, autocorrelation, heteroskedasticity, and cross-sectional dependence tests were conducted to examine the assumptions related to errors in the FE models. The Wooldridge test, which tests the null hypothesis that there is no first-order autocorrelation in the model errors, was used to check for autocorrelation. The Modified Wald test, which tests the null hypothesis that the variance of the errors is constant, was utilized to check for heteroskedasticity. To test for cross-sectional dependence, the Pesaran CD test, which tests the null hypothesis that there is no cross-sectional dependence in the model errors, was applied. In the final stage of the estimation strategy, if autocorrelation and heteroskedasticity problems were detected in the error terms of the models, the classical FE estimator was used to address these issues. However, if autocorrelation, heteroskedasticity, and cross-sectional dependence problems were detected in the error terms of the models, the FE estimator proposed by Driscoll-Kraay (1998) was implemented to solve these issues. The Driscoll-Kraay FE estimator can be applied to both balanced and unbalanced panels. Additionally, this estimator provides reliable, efficient, and consistent estimation results in cases where $N > T$.

4. Empirical Findings

4.1. Summary Statistics

In Table 4, the mean, median, standard deviation, minimum and maximum values, skewness coefficient, kurtosis coefficient, and the number of observations for each variable are presented. The dependent variable of this research, bankruptcy risk (BR), has an average value of approximately 0.31. This variable ranges between 0.147 and 3.479 and has a standard deviation of 0.282. The bank-level variables included in the analysis— $\ln(\text{assets})$, $\ln(\text{age})$, CAR, BD, CR, LR, and NIM—have mean values of 10.777, 3.802, 11.082, 63.541, 4.383, 0.044, and 2.826, respectively. At the macroeconomic level, the variables INF and EG have mean values of 18.316 and 5.852, respectively.

Table 4. Summary Statistics Turkish Commercial Banks

	Mean	Median	SD	Minimum	Maximum	Skewness	Kurtosis	Observation
BR	0.314	0.267	0.282	0.147	3.479	7.627	70.419	308
Ln(assets)	10.777	10.855	1.882	6.798	14.844	-0.036	2.245	308
Ln(age)	3.802	3.638	0.545	2.639	5.075	0.375	2.297	308
CAR	11.082	10.783	3.301	3.702	26.819	0.729	4.408	308
BD	63.541	63.049	9.796	26.064	87.534	-0.312	3.833	308
CR	4.383	3.54	4.824	0.088	48.588	5.822	46.36	308
LR	0.044	0.042	0.019	0.014	0.12	1.093	4.79	308
NIM	2.826	2.807	1.486	-6.531	8.024	-0.587	9.914	308
INF	18.316	10.018	18.999	6.472	72.309	2.028	5.618	308
EG	5.852	5.237	3.119	0.819	11.439	0.314	2.203	308
CVD	0.143	0	0.350	0	1	2.041	5.167	308

4.2. Multi-collinearity Analysis

Within the framework of panel data regression analysis, it is first necessary to test whether there is a multi-collinearity problem among the independent variables. This is because high correlations among independent variables can cause the estimators to produce biased and inconsistent coefficient estimates. In this research, Spearman correlation analysis and the Variance Inflation Factor (VIF) analysis were conducted to test for multi-collinearity among independent variables. The findings of the Spearman's rank correlation coefficients for all pairs of variables are reported in Table 5, while the results of the VIF analysis are presented in Table 6. The results in Table 5 indicate that the highest calculated correlation between any pair of independent variables is 0.74. This finding is important as it suggests that there is no significant multi-collinearity problem in the regression models. As is well known, multi-collinearity is generally considered an issue when the correlation coefficient between variable pairs is 0.80 or higher. Secondly, an examination of the VIF results reported in Table 6 reveals that none of the variables have a VIF value greater than 5. This result supports the findings from the correlation analysis and indicates that multi-collinearity is not a significant issue for the regression models used in this study.

Table 5. Correlation Matrix

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) İR	1.00										
(2) ln(assets)	-0.16*	1.00									
(3) ln(age)	-0.08	0.70*	1.00								
(4) CAR	-0.09	-0.37*	-0.16*	1.00							
(5) BD	0.21*	-0.10	0.10	0.12	1.00						
(6) CR	0.74*	-0.19*	-0.16*	0.04	0.18*	1.00					
(7) LR	0.02	0.40*	0.22*	-0.35*	-0.05	0.08	1.00				
(8) NIM	-0.32*	-0.11	-0.02	0.43*	0.02	-0.26*	-0.27*	1.00			
(9) INF	0.07	0.33*	0.13	-0.14	0.18*	-0.11	0.11	-0.01	1.00		
(10) EG	-0.04	-0.11	-0.07	-0.03	-0.05	-0.15*	-0.33*	0.13	-0.12	1.00	
(11) CVD	0.07	0.14	0.08	-0.19*	0.04	0.14	0.16*	-0.19*	-0.05	0.10	1.00

Note: * p<0.01

Table 6. VIF Coefficients

	VIF	1/VIF
Ln(assets)	3.07	0.325960
Ln(age)	2.23	0.448049
CAR	1.63	0.611839
BD	1.23	0.814194
CR	1.34	0.747322
LR	1.77	0.564988
NIM	1.55	0.643442
INF	3.06	0.327240
EG	2.95	0.339307
CVD	2.74	0.364730
Mean VIF	2.26	

4.3. Cross-Section Dependency Analysis

In the existing work, cross-sectional dependency test was performed on a variable basis. For this purpose, the presence of cross-sectional dependence for each variable are examined employing the CD test proposed by Pesaran (2015, 2021). The results of the Pesaran CD test are presented in Table 7. In the CD test, the null hypothesis states that there is weak cross-sectional dependence. Considering Table 7, it is concluded that the null hypothesis is rejected for all variables. This finding indicates that there is a strong cross-sectional dependence for all variables.

Table 7. Pesaran (2015, 2021) CD Test Findings

	CD Statistics	Probability
BR	2.26**	0.024
Ln(assets)	53.83***	0.000
Ln(age)	56.84***	0.000
CAR	18.21***	0.000
BD	9.91***	0.000
CR	25.94***	0.000
LR	18.82***	0.000
NIM	17.49***	0.000
INF	56.87***	0.000
EG	56.87***	0.000

Note: In the CD test, the null (Ho) hypothesis is established as there is weak cross-sectional dependence, whereas the alternative (H1) hypothesis is established as there is strong cross-sectional dependence. * p<0.1, ** p<0.05, *** p<0.01

4.4. Second Generation Panel Unit Root Test (CIPS)

After conducting the cross-sectional dependence test, the time series properties of the variables included in the regression models are examined. For this purpose, the CIPS (Cross-Sectionally Augmented IPS) panel unit root test, proposed by Pesaran (2007), is employed. As one of the second-generation panel unit root tests, the Pesaran CIPS test differs from first-generation panel unit root tests by accounting for cross-sectional dependence. The results of the CIPS panel unit root test are reported in Table 8. Based on the results presented in Table 8, the null hypothesis, which states that the variables contain a unit root, is rejected for all variables in both models with a constant and models with a constant and trend. This finding indicates that all variables included in the analysis are stationary at their levels and do not contain a unit root.

Table 8. Pesaran (2007) CIPS Panel Unit Root Test Findings

	Constant Model	Constant & Trend Model
	CIPS Statistics	CIPS Statistics
BR	-2.845***	-3.259***
Ln(assets)	-2.331**	-2.762**
Ln(age)	-2.205**	-3.725**
CAR	-2.415***	-2.960***
BD	-2.334**	-2.762**
CR	-2.386***	-3.341***
LR	-3.120***	-3.249***
NIM	2.235**	-2.815**
INF	2.210**	2.761**
EG	2.210**	2.761**
	-2.07 (%10)	-2.60 (%10)
Critical values	-2.17 (%5)	-2.70 (%5)
	-2.34 (%1)	-2.89 (%1)

Note: In the CIPS test, the null hypothesis is “the variable contains a unit root”. The critical values given at the bottom of the table for the case of N and T = (22,14) are taken from the study of Pesaran (2007).

* p<0.1, ** p<0.05, *** p<0.01.

4.5. Estimation Results

Table 9 reports the estimation results of the panel data model expressed in Eq. (1) for the main sample for all banks included in the analysis. According to the diagnostic test results presented in the lower part of Table 9, it is decided that the SE estimator is the most appropriate estimator in estimating the regression model in Eq. (1) (Hausman test). Then, three tests (autocorrelation, heteroskedasticity and cross-sectional independence) are conducted regarding the errors of the SE model. The findings of all three tests indicate that there are significant deviations from the assumptions regarding the errors of the SE model. Hence, the Driscoll-Kraay SE estimator is used in estimating the coefficients of the model expressed in Eq. (1) to correct the relevant deviations.

As seen in Table 9, a negative and significant relationship at 1% level of significance is reported between the Ln (assets) variable representing bank size and bankruptcy risk (BR). Similarly, Dias (2020), Ashraf (2017), Martínez-Malvar and Baselga-Pascual (2020) reported a negative relationship between bank size and bank risk-taking. Our finding, which is inconsistent with the results reported by Baselga-Pascual et al. (2015) and Mercan (2021), suggests that that bankruptcy risks will decrease as banks grow. A negative and significant relationship at 1% level of significance is observed between the CAR variable representing bank capital and BR. This finding, which is consistent with the results reported by Baselga-Pascual et al. (2015) and Martínez-Malvar and Baselga-Pascual (2020), suggests that banks with higher capital levels have lower bankruptcy risks. Similarly, a negative and significant relationship at 1% level of significance is determined between the NIM variable representing interest margin and BR. The present finding aligns with the conclusions drawn by Dias (2020), which indicate that financial institutions with high interest margins are associated with reduced bankruptcy risks in comparison. The estimated coefficient of liquidity risk was found to be positive and significant. This result, which is similar to the findings of Dias (2020), indicates that banks with higher liquidity risk tend to increase bank risk.

When the estimation results are examined in terms of macroeconomic variables, it is concluded that inflation rate (INF) and economic growth (EG) have a positive effect on

bankruptcy risk, that is, they increase the bankruptcy risk. This finding reveals that increasing inflation and economic growth trigger the bankruptcy risk that banks are exposed to. Ashraf (2017), Danisman and Demirel (2019) and Baselga-Pascual et al. (2015) reported in their study that inflation decreases (increases) bank stability (risk), whereas GDP increases (decreases) bank stability (risk). However, Diaconu and Oanea (2014) and Mercan (2021) reported in his study that neither inflation nor GDP had a significant effect on bank risk. Similarly, insignificant coefficients regarding GDP and inflation variables are also found in the study conducted by Martínez-Malvar and Baselga-Pascual (2020).

In addition, a positive and significant relationship was found between the CVD variable representing the COVID-19 pandemic and BR at the 1% significance level. This finding reveals that the pandemic crisis caused an increase in bankruptcy risk. Danisman and Demirel (2019) reported a positive relationship between the crisis dummy variable and bank risk-taking behavior in their study. However, no significant relationship is found between the BM variables representing Ln(age) and bank deposits and BR.

Table 9. Estimation Results (Whole Sample)

	Coefficient	Standard Error	t-statistic	Probability
Ln(assets)	-0.2366691***	0.0117501	-20.14	0.000
Ln(age)	0.09458	0.1077789	0.88	0.390
CAR	-0.0276***	0.00660	-4.17	0.000
BD	-0.00147	0.000944	-1.56	0.135
CR	0.0370***	0.00742	4.98	0.000
LR	1.285***	0.206	6.23	0.000
NIM	-0.0354***	0.00992	-3.56	0.002
INF	0.0266***	0.00415	6.39	0.000
EG	0.220***	0.0417	5.27	0.000
CVD	2.022***	0.395	5.12	0.000
Constant term	0.484***	0.11562	4.19	0.000
Hausman	54.62***			
Autocorrelation	23.717***			
Heteroskedasticity	8738.98***			
Cross-sectional dependence	9.350***			
Within Group R ²	0.6021			
F-statistic	102.94***			
Number of banks	22			
Number of observations	308			
Panel estimator	Driscoll-Kraay Fixed Effects (DK FE) estimator			

Note: Bank and time effects are included in the regression models through dummy variables. However, the coefficients related to these are not reported. In the Hausman test, the null hypothesis is that the Random Effects estimator is a valid estimator. Autocorrelation was checked with the Wooldridge test. In this test, the null hypothesis is that the errors within units are temporally uncorrelated. Heteroscedasticity is tested with the Modified Wald test. In this test, the null hypothesis is that the error variance does not differ across cross-sectional units. Cross-sectional dependence is tested via Pesaran's CD test. In this test, the null hypothesis is that the errors across cross-sectional units are uncorrelated. In the F test, the null hypothesis is that the model is insignificant. In this test, the null hypothesis is that there is no dependence between cross-sections. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Following the estimation results for the main sample, sub-samples are formed for various criteria (i.e., being registered in BIST and capital structure) and it is checked whether the effects

in the main sample changed when the sub-samples were taken into account. The estimation results of the model in Eq. (1) in terms of sub-samples are presented in Table 10.

Table 10. Estimation Results (Sub-Samples)

	Non-listed Banks (Model I)	Listed Banks (Model II)	Domestic Banks (Model III)	Foreign Banks (Model IV)
Ln(assets)	-0.254*** (0.0139)	-0.232*** (0.0295)	-0.0866*** (0.0149)	-0.390*** (0.0235)
Ln(age)	0.00995 (0.161)	-0.379** (0.136)	-0.541*** (0.122)	0.115 (0.376)
CAR	-0.0210* (0.00997)	-0.0344*** (0.00884)	-0.0104** (0.00391)	-0.0379** (0.0124)
BD	-0.000746 (0.000967)	-0.000460 (0.00139)	0.00396*** (0.00104)	-0.00142 (0.00117)
CR	0.0376*** (0.00793)	0.0179* (0.00851)	0.000148 (0.00771)	0.0365*** (0.00665)
LR	2.419*** (0.366)	0.0530 (0.465)	0.361 (0.333)	0.320 (0.887)
NIM	-0.0373*** (0.0121)	-0.0338** (0.0123)	-0.0329** (0.0136)	-0.0431** (0.0141)
INF	0.0283*** (0.00579)	0.0437*** (0.00554)	0.0278*** (0.00517)	0.0423*** (0.0131)
EG	0.232*** (0.0564)	0.402*** (0.0538)	0.280*** (0.0515)	0.339** (0.127)
CVD		-0.0677 (0.0531)	3.788*** (0.496)	2.586*** (0.446)
Constant term		0.460** (0.153)	1.020*** (0.141)	0.666*** (0.130)
Hausman		18.07**	33.95***	31.70***
Autocorrelation		20.501***	35.940***	21.371***
Heteroskedasticity		1990.98***	210.23***	147.83***
Cross-sectional dependence		4.582***	1.068	2.296**
Within Group R ²		0.6233	0.4432	0.4802
F-statistic		123.34***	8.52***	103.26***
Number of banks		13	9	11
Number of observations		182	126	154

Note: Bank and time effects are included in the regression models through dummy variables. However, the coefficients related to these are not reported. In the Hausman test, the null hypothesis is that the Random Effects estimator is a valid estimator. Autocorrelation was checked with the Wooldridge test. In this test, the null hypothesis is that the errors within units are temporally uncorrelated. Heteroscedasticity is tested with the Modified Wald test. In this test, the null hypothesis is that the error variance does not differ across cross-sectional units. Cross-sectional dependence is tested via Pesaran's CD test. In this test, the null hypothesis is that the errors across cross-sectional units are uncorrelated. In the F test, the null hypothesis is that the model is insignificant. In this test, the null hypothesis is that there is no dependence between cross-sections. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

According to the estimation results of Models I, II, III and IV from Table 10, there is a negative and significant relationship between bank size and bank risk taking level, which also supports the result in the main sample. Unlike the main sample, Model II and III estimation results show that there is a significant inverse relationship between the age of banks and the risk of bankruptcy. This indicates that as banks age, their tendency to go bankrupt will relatively decrease. However, it should be noted that this finding is valid for listed and domestic banks. The estimation results of all models indicate that there exists a significant inverse relationship between

bank capital and bankruptcy risk. This finding is in line with the result obtained from the main sample. The estimated coefficient of bank deposits was found to be significant only in the sample of banks including domestic banks. This finding regarding domestic banks indicates that increasing bank deposits will also increase the risk of bankruptcy. Similar to the result based on the main sample, increases in credit and liquidity risks for non-listed banks increase the risk of bankruptcy. However, this relationship was not observed in other sub-samples. Furthermore, no significant relationship was found between credit risk or liquidity risk and bankruptcy risk in the sample of domestic banks. Additionally, the estimated coefficient of the NIM variable was found to be negative and significant in all subsamples. This finding is similar to the results obtained from the main sample where all banks were included. In other words, increasing interest margins are inversely related to banks' risk-taking tendencies.

The estimated coefficients of the INF and EG variables are positive and statistically significant for all subsamples, which is in the same direction as the result obtained from the main sample where all banks are included. In the main sample, it was reported that the COVID-19 pandemic crisis increased the bankruptcy risk of banks. However, this finding is only valid for the two subsamples including domestic and listed banks. There is no significant relationship between the pandemic crisis and the bankruptcy risk for non-listed banks and foreign banks.

5. Conclusion

In the current work, the impact of micro and macro factors on banks' risk-taking behavior was analyzed utilizing annual data of 22 commercial banks in the Turkish banking sector for the period 2010-2023. The research employed the inverse Z-score as a measure of banks' risk taking. The bank-level variables included in the analysis were bank size, bank age, bank capital, bank deposits, credit risk, liquidity risk and net interest margin, respectively. The independent variables at the macro level are inflation rate and economic growth. In addition to these variables, a dummy variable is added to the regression models to represent the COVID-19 pandemic crisis.

In this study, which analyses the risk-taking behavior of banks, the main sample, which includes all banks, was first used for estimation purposes. Two subsamples were then created. The first sub-sample includes listed and unlisted banks. In the second sub-sample, banks are divided into two groups: domestic and foreign banks. The purpose of creating the sub-samples is to compare the results of the main sample and the sub-sample and to determine whether there is a significant difference between the samples. This is of great importance for the regulatory authorities, policymakers, and other stakeholders related to the banking sector.

Considering the panel data analysis results in terms of the main sample, it has been determined that bank size, bank capital, bank deposits and net interest margin tend to reduce the risk taking levels of banks. However, the variables such as credit risk, liquidity risk, inflation rate, economic growth, and pandemic crisis tend to increase the risk-taking levels of banks.

When the estimation results are examined in terms of sub-samples, the coefficients of bank size, bank capital and net interest margin variables are found to be negative and significant, which are the same as the main sample findings. Considering the sub-samples created, the effect of bank deposits on risk taking was found to be positive and significant only in the local banks sample. It was concluded that credit risk triggered the bankruptcy risk in all samples except the domestic banks sample. As for liquidity risk, the estimated coefficient of this variable was found to be

statistically significant only for non-listed banks. The positive relationship observed between the variables representing inflation and economic growth in the sub-samples and the bankruptcy risk is consistent with the main sample. Finally, it was concluded that the COVID-19 pandemic crisis increased the bankruptcy risk only for listed and domestic banks.

The findings of this research have important implications for bank management, regulatory mechanisms and policy makers in terms of controlling the risk-taking behavior of banks, ensuring stability in the banking sector and building a sustainable banking sector.

A strong negative relationship between capital adequacy (CAR) and bankruptcy risk was found across all models. Thus, regulators should enforce higher capital requirements, especially for banks with aggressive risk-taking strategies. In addition, banks should increase retained earnings and reduce excessive dividend payouts to maintain strong capital buffers.

Unlisted banks are more vulnerable to credit and liquidity risks, which increases the risk of bankruptcy. In this case, banks can apply stricter liquidity coverage ratio requirements and encourage stable funding sources rather than relying on short-term deposits. In addition, for unlisted ones, risk assessment models should be well maintained and conservative credit policies should be adopted. Besides, regulators should apply stricter credit classification rules to prevent asset quality deterioration.

The results show a negative and significant relationship between bank size and bankruptcy risk across all models. This suggests that larger banks are generally more stable, likely due to economies of scale, diversified portfolios, and better access to funding. However, bank size alone does not eliminate risk—as seen in past financial crises, large banks can still fail due to excessive risk-taking (e.g., "Too Big to Fail" problem).

Higher deposit levels in domestic banks increase risk, possibly due to asset-liability mismatches. Regulators should evaluate the sufficiency of deposit insurance schemes to prevent deposit-driven instability. Domestic banks should diversify funding sources instead of over-reliance on deposits. Additionally, these banks may use long-term funding mechanisms such as bond issuance or capital market instruments.

The pandemic increased bankruptcy risk only in domestic and listed banks. Given this finding, sector-specific emergency liquidity support mechanisms could be developed for public and local banks. Furthermore, these banks could be allowed to restructure loans for sectors in distress during crises (e.g. tourism, small businesses).

Higher NIM consistently reduces bankruptcy risk in all models, indicating that profitability is crucial for resilience. Banks should optimize operating costs and digital transformation to maintain higher interest margins. Furthermore, policymakers should balance interest rate regulations to prevent excessive pressure on bank profitability.

Inflation and economic growth positively impact bank risk-taking across all models. Regulators should require banks to hold additional capital buffers during economic booms to cushion risks during downturns. Moreover, central banks should closely monitor credit expansion during high-growth periods to prevent excessive risk-taking.

The first limitation of this study is related to the fact that the sample used for the analysis consists of only Turkish banks. Therefore, the findings cannot be generalized for the banking sectors of other countries. Another limitation is related to the time period covered by the study.

In future studies, alternative variables representing the risk-taking behaviors of banks (i.e., leverage risk, portfolio risk, interest income risk, non-interest income risk, operational risk) can be used to add depth to the research topic. In addition, an analysis can be made that includes an international comparison, which can make an important contribution to the literature in terms of generalizing the results.

Declaration of Research and Publication Ethics

This study which does not require ethics committee approval and/or legal/specific permission complies with the research and publication ethics.

Researcher's Contribution Rate Statement

The authors declare that they have contributed equally to the article.

Declaration of Researcher's Conflict of Interest

There is no potential conflicts of interest in this study.

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EXPORTS AND TOURISM DEMAND: EVIDENCE OF A STRONG LINK DISRUPTED BY PANDEMIC RESTRICTIONS*

İhracat ve Turizm Talebi: Pandemi Döneminde Zayıflayan Güçlü Bir Bağ

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Abstract

Keywords:
Tourism-
Trade Nexus,
Exports and
Tourism
Demand,
Tourism
Demand
Function,
Panel Data
Analysis.

JEL Codes:
F14, Z30, C13

This study empirically examines the relationship between inbound tourism demand and foreign trade for Türkiye by employing panel data analysis to estimate a tourism demand function that incorporates an export variable alongside conventional determinants. The results reveal that a 10% increase in exports corresponds to a 2.11% rise in tourist arrivals. This positive linkage is attributed to strengthened interpersonal networks, enhanced transportation infrastructure, and greater destination visibility fostered by trade relations. However, this link does not follow a linear pathway. While exports robustly impact tourism under normal conditions, the influence vanishes during crises with mobility restrictions. COVID-19 restrictions caused a structural break for the tourism-trade nexus of Türkiye. The insignificant export-pandemic interaction term employed in the econometric model proves that trade loses its stimulating effect on tourism during international mobility crises. Key findings also highlight that GDP and population size of source countries are the primary determinants of Türkiye's tourism demand, and exports exert a larger effect than relative prices. Results suggest that policymakers should adopt alternative strategies independent from international mobility conditions to sustain the tourism sector in such shocks, and export promotion may be more effective than price competitiveness strategies in stimulating demand.

Öz

**Anahtar
Kelimeler:**
Turizm ve
Ticaret
İlişkisi, İhracat
ve Turizm
Talebi, Turizm
Talep
Fonksiyonu,
Panel Veri
Analizi

JEL Kodları:
F14, Z30, C13

Bu çalışma geleneksel değişkenlerin yanında ihracat değişkeni içeren turizm talep fonksiyonunu panel veri analizi ile tahmin ederek, Türkiye'ye yönelik turizm talebi ve dış ticaret ilişkisini ampirik olarak incelemektedir. Sonuçlar; ihracattaki %10'luk artışın ülkeyi ziyaret eden turist sayısını %2.11 artırdığını göstermektedir. Bu pozitif ilişki ticaret bağları sonucunda gelişen; kişiler arası bağlara, ulaşım altyapısına ve destinasyon bilinirliğine bağlanmaktadır. Ancak bu bağlantı doğrusal bir patika izlememektedir. İhracat normal zamanlarda turizmi güçlü bir şekilde etkilese de bu etki hareketliliğin sınırlandığı kriz durumlarında ortadan kalkmaktadır. COVID-19 kısıtlamaları Türkiye'nin turizm ve ticaret bağlantısında yapısal bir kırılmaya neden olmuştur. Ekonometrik modelde yer alan istatistiksel olarak anlamsız ihracat ve pandemi etkileşim değişkeni ticaretin uluslararası hareketliliğin sınırlandığı krizlerde turizmi canlandıramadığını kanıtlamaktadır. Temel bulgular ayrıca kaynak ülke GSYİH'si ve nüfusunun Türkiye'ye yönelik turizm talebinin birincil belirleyicileri olduğunu ve ihracatın göreceli fiyatlara göre talep üzerinde daha büyük etkiye sahip olduğunu göstermektedir. Sonuçlar bu tip şok durumlarında politika yapıcılarının turizm sektörünü desteklemek için uluslararası mobilité koşullarından bağımsız stratejiler geliştirmelerini ve ihracat teşviklerinin fiyat rekabetçiliğine yönelik stratejilere kıyasla talebi uyarmada daha etkili olduğunu ileri sürmektedir.

* A study conducted for the Central Bank of the Republic of Türkiye titled "The Effects of Foreign Trade on Foreign Exchange Earnings: The Case of Tourism Sector" provided the empirical basis for this research. Original study has been intensively refined and elaborated with this manuscript.

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1. Introduction

The literature extensively documents the positive economic effects of tourism as a pivotal sector in generating foreign exchange earnings. By facilitating foreign currency inflows, improving living standards, augmenting tax revenues, and creating employment opportunities due to its labour-intensive characteristics, the sector significantly contributes to national economic development. Given the widespread consensus on the importance of economic diversification and the expansion of foreign exchange reserves, tourism is widely regarded as a viable mechanism to advance these objectives. As one of the fastest-growing industries worldwide, it has become a key policy instrument to foster development in numerous countries (Matthew et al., 2018). When foreign exchange revenues derived from tourism are allocated toward the importation of capital goods or necessary production inputs, the sector functions as an effective financing mechanism for a country's import expenditures, which contribute to broader economic welfare (Balaguer and Cantavella-Jorda, 2010). Since tourism directly influences regional development, policies enhancing tourism infrastructure generate spillover effects and cause growth not only in tourist destinations but also across broader regions (Jovanovic and Ilic, 2016). Furthermore, taxation of tourism is particularly advantageous for developing countries facing budget constraints and seeking to reduce their dependence on other tax sources (Gooroochurn and Sinclair, 2005).

Given tourism's substantial economic contributions, understanding the determinants of tourism demand, which is defined as consumers' willingness and capacity to purchase tourism services at specified prices and time periods, is critical. This demand is shaped by both quantifiable and non-quantifiable factors (Dwyer et al., 2020). One of the tools employed to assess the impact of these factors on tourism demand is the demand function, which mathematically expresses the relationship between the factors and the quantity of tourism demand (Lim, 2006). Although various studies have extensively examined the impact of determinants such as income levels, transportation costs, relative prices, exchange rates, and consumer preferences on tourism demand, the relationship between tourism demand and foreign trade remains comparatively underexplored in the literature.

The main arguments regarding the ways in which foreign trade and, particularly, exports enhance tourism demand for a location can be grouped into three parts. First, trade between two countries facilitates the formation of various networks among their residents. Second, the realization of foreign trade necessitates the presence of well-developed transportation and communication infrastructures, which are also crucial for the tourism sector. And last, foreign trade activities increase international recognition of the participating countries. (Suresh and Tiwari, 2017).

The determinants of tourism demand are predominantly characterized by economic and demographic factors. Economic conditions, especially the income levels of prospective tourists, constitute the primary driver of tourism demand. Empirical research demonstrates a positive correlation between higher income levels and increased tourism demand, as greater disposable income enhances individuals' propensity to travel (Wakimin et al., 2018; Pinjaman and Pawan, 2021). Additionally, the price elasticity of tourism services plays a critical role since regions that offer competitive prices are more likely to attract tourists (Rodriguez et al., 2018). In this framework, macroeconomic stability and growth are essential for nurturing a beneficial environment for tourism (Darani and Asghari, 2018; Momanyi, 2023). As for the demographics,

a larger population in the sending country typically results in a higher number of tourists traveling abroad. Research shows that population factor has a strong correlation with the number of tourists visiting other countries which confirms that as the population increases the likelihood of outbound tourism increases as well (Fida, 2023). This phenomenon is particularly evident in countries with growing middle classes where increased disposable income allows more individuals to travel internationally (Bobi and Cimpoeu, 2021).

A salient finding within this emerging body of research suggests that trade openness exerts a positive influence on tourism demand. Enhanced trade activities correlate with improved international tourism performance, as trade relations tend to generate heightened destination awareness and stimulate tourist interest among potential visitors (Darmawan et al., 2020). The facilitation of goods and services through trade can create a more favourable environment for tourism. In this context, increase in foreign trade between locations strengthens economic ties and visibility of the tourism destination in global markets. Notably, the literature demonstrates that foreign trade can serve as a catalyst for tourism by reducing operational costs and promoting consumer awareness of tourism services in other countries (Mudiyanselage et al., 2022). This relationship is reciprocal; as tourism grows, it can also stimulate trade by increasing demand for local products and services among foreign visitors (El- Sahli, 2017).

Studies that examine the influence of foreign trade on tourism are a growing area in the literature. Tourism demand has been analysed in studies through various econometric models that incorporate diverse macroeconomic variables. However, it is clear that using comprehensive models that account for the relation between tourism and trade to provide more valid estimates of demand is a necessity. With that in mind, ranking the factors that affect tourism demand for a location is highly important. A comprehensive understanding of the determinants most significantly influencing tourism demand enables policymakers and industry stakeholders to optimize resource allocation and strategic prioritization. The identification of key demand drivers facilitates the development of targeted interventions to enhance the most impactful factors, which helps to maximize a country's visitor attraction potential and tourism revenue generation. Thus, establishing a hierarchical ranking of these determinants supports the formulation of precise strategies. For example, should economic variables such as income levels emerge as predominant, marketing initiatives could be tailored to higher-income demographics or premium tourism experiences. Conversely, if transportation infrastructure and accessibility prove more influential, strategic investments could be directed toward improving destination connectivity. This analytical framework additionally fosters cross-sectoral collaboration, particularly between tourism and trade sectors, which are the central focus of this research. Such a holistic approach can lead to more integrated policies that enhance overall tourism performance

This study, which aims to examine the relationship between exports and inbound tourism demand for Türkiye, with a particular focus on whether this linkage remains robust during periods of severe economic disruption like the COVID-19 pandemic, is innovative in several aspects. While existing theoretical frameworks suggest that exports can stimulate tourism through various channels such as business travels, cultural exchanges, and enhanced destination visibility, the empirical validity of this relationship in emerging market contexts, especially under crisis conditions, remains insufficiently explored (Massidda and Mattana, 2012). Türkiye presents a compelling case for this investigation due to its dual reliance on tourism and exports as the main drivers of economic growth.

This study strives to estimate whether a statistically significant and economically meaningful relationship exists between Türkiye's export activity and its inbound tourism demand during stable non-crisis periods. Also, the study attempts to evaluate the resilience of this relationship during the COVID-19 pandemic, when unprecedented mobility restrictions and global travel disruptions disproportionately affected tourism relative to trade. Specifically, the study aims to quantify the extent to which the tourism-trade nexus weakens or collapses under crisis conditions.

The findings have important implications for both theory and policy. Theoretically, they contribute to the broader literature on the interconnectedness of trade and tourism by highlighting how a contextual factor like an external shock may mediate this relationship. From a policy perspective, the results can inform the design of more resilient tourism and trade strategies, particularly in emerging economies vulnerable to global disruptions. If the link between trade and tourism proves to be fragile during crises, policymakers may need to prioritize alternative demand drivers, such as concentrating on domestic tourism, to mitigate the sector's vulnerability to crises.

By focusing on Türkiye's experience during the pandemic, this study provides timely insights into how economies heavily reliant on both tourism and trade can navigate future crises. The analysis not only tests the generalizability of the hypothesis that exports influence tourism in emerging market settings but also offers a framework for understanding how different types of shocks may asymmetrically affect connected economic sectors. Ultimately, the research aims to bridge an important gap in the literature by providing empirical evidence on the stability and crisis resilience of the relation between foreign trade and tourism in a policy relevant context.

In addition to these primary objectives, the study has been designed to fill other gaps in the literature. Firstly, the number of studies examining tourism demand characteristics for Türkiye using a traditional demand function is quite limited. While Aslan et al. (2008), Kaya and Canlı (2013), Özcan (2015), and Karaoğlu (2019) have estimated tourism demand functions for Türkiye, researchers did not include foreign trade variables among the independent variables. Only the study by Görmüş and Göçer (2010) incorporated foreign trade as a dependent variable in the demand function. However, the authors' analysis is limited to the years 2000 to 2006, which is a period that no longer reflects Türkiye's current macroeconomic and foreign trade landscape. Additionally, the dummy variables they used are the events that are now outdated. An extraordinary event like COVID-19, which severely impacted global tourism demand, highlights the need to reexamine the connection between tourism and trade.

And secondly, this study aims to rank the factors that affect tourism demand towards Türkiye by their impact. Few studies in the relevant literature focused on this area. And as to our knowledge, the ones that did so have not incorporated foreign trade variables into their models. For instance, Akay et al. (2016) reported that the national income of source locations is the most significant variable in explaining tourism demand, followed by the exchange rate deviations. Cankurt and Subaşı (2016) did not explicitly rank the factors affecting tourism demand but made clear that the economic factors are the leading ones. Likewise, Ulucak et al. (2020) ranked economic factors as the most influential. According to their study, the per capita income of both the origin country and Türkiye, along with the relative exchange rate, were the most significant positive determinants of tourism demand. Thus, while there are multiple studies that analyse numerous factors influencing tourism demand, few have systematically ranked

these factors, and even fewer have integrated foreign trade variables into their models. This lack of research in the field underlines the significance of this study. Because the incorporation of foreign trade variables is crucial as it recognizes the mutual interaction of tourism and exports. Prior studies, such as the one by Tatođlu and Göl (2019), have acknowledged the relationship between tourism and international trade and noted a positive correlation between them. But the researchers did not delve deeply into how these trade variables can be systematically integrated into a tourism demand model. Moreover, our approach of ranking the factors affecting tourism demand provides a structured framework that can guide policy makers and stakeholders in the tourism sector. While some studies have identified key determinants such as income levels, exchange rates and security concerns, they often lack a comprehensive ranking based on empirical evidence.

2. Literature Review

2.1. The Link Between Foreign Trade and Tourism Demand

The literature presents two primary arguments regarding the link between tourism and international trade. The first argument posits that tourism drives and gives momentum to foreign trade activities. The core rationale behind this argument is that the tourists identify potential trade opportunities in the countries they visit and subsequently capitalize on these opportunities after their vacation. Tourists may also recognize that certain goods or services from the countries they visit could be marketed in their own countries, and this may facilitate cross-border trade. The second argument suggests that trade mainly fosters tourism. Existing trade relations between countries stimulate tourist flows by ensuring the accessibility of familiar products or services from the tourists' home country in the destination country, thus supporting tourism activities. Also, individuals who visit a region for trade purposes often share their experiences with their family and friends, and this mobility potentially fosters touristic activities. Because previous visits to a region or recommendations from family and friends significantly boost tourist visits to that region (Kumar et al., 2015).

The hypothesis that trade fosters inbound tourism demand suggests that existing commercial relationships between countries stimulate subsequent tourism flows through multiple channels. At its core, this framework suggests that international trade acts as a catalyst for tourism development by reducing informational asymmetries, enhancing destination familiarity, and improving cross-border infrastructure. The hypothesis challenges conventional tourism demand models by emphasizing how economic integration precedes and facilitates travel mobility rather than merely responding to it. Trade relationships necessitate frequent visits and logistical coordination, and they help to establish travel corridors between partner countries. Trade partnerships often align with shared cultural attributes that lower psychological barriers to tourism. The presence of familiar products or services in destination markets further enhances tourist comfort (Shahbaz et al., 2015; Luo et al., 2022).

From this perspective, the main driver of inbound tourism of a country in which trade relations play a role is through exports. The literature provides compelling evidence that a country's exports can stimulate its inbound tourism demand through mechanisms such as increased international visibility, positive cultural exchange, and the promotional effect of exporting high-value commodities, products, and services (Easton, 1998; Bae et al., 2017).

Export activities boost domestic product demand and enhance the country's international image, and stimulate inbound tourism. They generate positive externalities that enhance a nation's international image and stimulate demand through improved destination perception (Tsounis et al., 2022). Likewise, exports of cultural products can influence tourism significantly, by narrowing the bridge of cultural gaps and generating interest in a country's cultural offerings (Chen et al., 2023).

By contrast, international tourism theoretically enhances the visibility of local products in global markets, therefore increasing import demand. Business travel, which constitutes about 15% of global tourism, significantly facilitates export and import flows. The rise in business travel fosters greater trade volume and tourism activity (Suresh and Tiwari, 2017). Assuming a causal relationship where trade influences tourism, business trips are crucial for developing trade relations by identifying opportunities that lead to further visits from other traders. Over time, these commercial travels can evolve into tourism-oriented trips as consumer interest increases (Bahar and Baldemir, 2008). The notion that international travel influences trade is referred to as the Marco Polo Effect. Since Marco Polo's journey between Europe and Asia, the first recorded business trip in the world, opened new trade routes and strengthened economic ties between countries. According to this effect, successful business trips can prompt additional traders to visit and establish new relationships, and they may also transform into recreational trips if accompanied by family or friends. Furthermore, imported products can spark consumer interest in their countries of origin. However, analysing the interaction between trade and tourism necessitates consideration of the dramatic changes in the global trade system and the process of globalization. The gradual removal of global trade barriers and restrictions on cross-border mobility over the years has catalysed the development of international trade and tourism. Similarly, significant improvements in global communication and advancements in tourism infrastructure have intensified the interaction between these sectors (Kulendran and Wilson, 2000; Santana-Gallego et al., 2015).

2.2. Economic and Demographic Determinants of Tourism Demand

Existing research consistently identifies economic factors like income levels and relative prices as the most critical determinants of tourism demand. Empirical evidence robustly demonstrates that higher national income in origin countries positively correlates with increased outbound tourism flows. This relationship stems from the fundamental tendency of economic agents to allocate greater discretionary spending to travel when disposable incomes rise (Stepchenkova and Eales, 2010). The use of panel data analysis is prevalent in this context, allowing researchers to assess the link between income and tourism demand across multiple countries and time periods (Nugraha and Naylah, 2023). Pricing has been found as another critical economic factor affecting tourism demand. Research indicates that fluctuations in tourism prices, like accommodation and transportation costs, significantly impact consumer behaviour. For example, studies utilizing econometric models have demonstrated that tourism demand is sensitive to price changes since higher prices generally lead to decreased demand. This relationship makes it clear that the importance of price competitiveness in attracting tourists is crucial, and destinations must monitor their prices relative to their alternatives (Sauer et al., 2021). As an example, a study conducted by Ghosh (2021) on inbound international

tourism demand in Australia highlighted that both local and global economic policy uncertainties, which often affect pricing, play a significant role in shaping tourism demand.

Another important economic factor ranked as important to affect tourism demand for a particular location in the literature is exchange rates. Alleyne et al. (2020), conducted a disaggregated analysis of tourism demand and found that fluctuations in real effective exchange rates significantly affect tourist arrivals, particularly in the context of the United States. The study utilized multivariate conditional volatility regressions modelling to assess the relationship between exchange rate volatility and tourism demand, and the results showed that a stronger domestic currency typically leads to decreased inbound tourism as it makes travel more expensive for foreign visitors. Additionally, Kuo et al. (2012), employed a dynamic Almost Ideal Demand System approach to model Japanese tourism demand for Asian destinations and found that exchange rate changes significantly impact tourists' expenditure patterns. Similarly, relative prices between the origin country and the tourist destination are also critical in determining tourism demand. In this regard, price competitiveness is vital since tourists tend to switch to alternative and cheaper destinations when faced with higher relative prices. An increase in relative prices could lead to a significant decline in tourist arrivals (Mangion et al., 2005). Zhang's analysis of Chinese inbound tourism concluded that relative prices, which are basically the prices standardized by exchange rates, serve as a robust proxy for tourism pricing (Zhang, 2019). On the other hand, some studies have integrated both relative and alternative prices into their analyses. For instance, the research by Esquivias et al. (2021) utilized an ARDL model to investigate the roles of income, relative price competitiveness, and substitution prices in determining tourism demand towards Indonesia. The findings indicate that both exchange rates and relative prices significantly impact tourism demand.

Demographic characteristics such as the population of tourist sources play a major role in determining the level of tourism demand. Li et al. (2019) utilized a panel smooth transition regression approach to analyse how demographic structures affect outbound demand. The study revealed that demographic factors such as median age and population significantly influence travel patterns. Authors underlined that understanding the demographic composition of potential tourists is essential for predicting tourism demand. Krasniqi (2023) concluded that the strong positive correlation between the population of source countries and outward tourism demand for the receiving countries makes demography the most important factor for estimating tourism demand. The analysis revealed that an increase in the population of a country of origin goes hand in hand with a corresponding increase in tourist arrivals to the destination country.

According to the studies conducted to explore tourism and trade dynamics in Türkiye, the most critical factors affecting tourism demand have been those that have economic and demographic characteristics. For instance, Ulucak et al. (2020) used a gravity model to analyse the dynamics of tourism demand in Türkiye. The study incorporated the KOF globalization index to assess how globalization influences tourism development. The findings indicate that both economic factors, like income levels, exchange rates, and globalization, significantly impact demand. Keskin (2019) applied the Seemingly Unrelated Regression Method to estimate tourism demand for Türkiye from selected countries over a 17-year time period. This method allows for the simultaneous estimation of multiple equations and helps to capture the interdependencies among different tourist source markets. The results of the study reveal that the economic conditions in source countries are the most important factors affecting tourism demand for Türkiye. In a study by Ağazade (2021), a two-stage system generalized method of

moments model was employed to estimate the impact of various factors on tourism demand. The study found that income levels and exchange rates positively influence demand, while terror threats have a significant negative impact particularly in the short term. Altin and Uysal (2014) developed an economic sentiment indicator and incorporated it into their analysis of tourism demand determinants for Türkiye. Using ARIMA and ARDL bound test approaches, the study found that the economic sentiment along with traditional variables such as exchange rates and interest rates significantly influence tourism demand. The study concludes that analysing the consumer sentiment of tourists is a valuable tool to employ for predicting tourism trends.

2.3. Tourism-Trade Nexus

Among the studies examining the nature and strength of the connection among tourism and international trade, Kadir and Jusoff (2010) analysed Malaysia, and Fry et al. (2010) focused on South Africa using cointegration and causality tests. Both studies found that increases in exports, imports, and total foreign trade led to higher revenues in the tourism sector. In research specifically addressing Türkiye, some studies identified a one-way causality from foreign trade to tourism demand (Çalışkan et al., 2010; Terzi and Tütüncü, 2010), while other studies found a bidirectional causality between the two variables (Özcan and Yorgancılar, 2016; Tandoğan and Genç, 2016). A recent study conducted by Ölmez and Tarakçı (2024) investigated the causality from trade variables to international tourist influx for the twenty most visited countries worldwide, and it was found that for four countries, causality runs from trade to tourist arrivals, and for three countries, causality runs from tourist arrivals to trade. On the other hand, bidirectional causality was found for only one country, which suggests that both tourism and trade stimulate each other.

Although numerous papers estimate the aspects affecting tourism demand for specific locations using tourism demand functions, there are very few studies that include variables related to foreign trade in these functions to measure the link between foreign trade and tourism demand. Habibi et al. (2009) conducted a study estimating tourism demand for Malaysia and found that a 1% increase in exports corresponded to a 0.20% rise in demand, indicating a positive relationship between the variables. Similarly, Leita (2010) estimated the tourism demand function for Portugal and concluded that a 1% increase in total foreign trade increased tourist arrivals by 0.118%. Surugiu et al. (2011) included the foreign trade variable in their tourism demand function for Romania, and they found it positive and statistically significant at the 1% level. The study concluded that a 1% increase in foreign trade was accompanied by a 0.466% increase in tourist arrivals. Chaisumpunsakul and Pholphirul (2018) examined Thailand's tourism demand function using three models incorporating total trade, export, and import variables to assess the impact of foreign trade. They reported that a 1% increase in total foreign trade raises tourist arrivals by 0.080%. The study by Karimi et al. (2015) suggests that trade openness is a critical factor influencing international tourism demand. The authors conducted a cointegration analysis to demonstrate that FDI, real exchange rates, inflation, and trade openness can effectively predict international tourism demand for ASEAN countries. Their findings suggest that enhancing trade openness can lead to increased tourist arrivals and which helps to foster economic growth through the tourism sector. Wong and Tang (2015) investigated the connection between tourism demand and trade openness in Singapore. The

authors utilized multiple causality tests to analyse both aggregate and country-level data and found a significant positive correlation between increased international trade and tourism demand. Their findings suggest that as trade activities expand, they enhance the accessibility and attractiveness of Singapore as a tourist destination. This relationship shows the importance of trade liberalization in fostering tourism growth and authors argued that policies promoting trade openness could effectively stimulate the tourism sector and contribute to economic development in small open economies. Similarly, Golembiski and Majewska (2018) utilized a gravity model to analyse the effects of transport infrastructure on international inbound tourism in Poland. Researchers found that trade agreements and partnerships significantly enhance tourism flows by improving transportation links and reducing travel costs. The analysis suggests that countries with stronger trade ties tend to experience higher levels of traveller flows, and this tendency may be utilised as a mechanism to magnify demand.

Even though there are relatively few studies estimating tourism demand for Türkiye using tourism demand function, these studies typically did not include variables related to foreign trade (Aslan et al., 2008; Kaya and Canlı, 2013; Özcan, 2015; Karaoğlu, 2019). Inclusion of foreign trade variables in the tourism demand function for Türkiye appears to be rare. One notable exception is the study conducted by Görmüş and Göçer (2010), where tourism demand for Türkiye from 32 selected countries during the period 2000-2006 was analysed. According to their findings, the foreign trade variable exhibited a positive and statistically significant relationship with tourism demand. Since this study has a temporal scope and includes the data from 2000 to 2006, we address the necessity to revise Türkiye's tourism demand dynamics given the significant structural shifts in its macroeconomic conditions and foreign trade patterns the country has experienced in subsequent years.

In contrast with these findings, the hypothesized causal relationship between foreign trade expansion and tourism demand growth remains contested in the literature. Other researchers provided counter-evidence regarding the issue. In their seminal work, Shan and Wilson (2001) found a two-way causality between international travel and trade in China which indicates a bidirectional relationship rather than a simple causal link. Ozer Balli et al. (2019) observed that export volume does not have a robust causality link with tourism demand for several of New Zealand's trading associates, especially for wealthier countries like Japan and the United States. Instead, they found that airline seat capacity was a more important factor in determining tourism demand for these particular countries. These findings suggest that the repercussions of foreign trade are context-dependent, and may be influenced by factors such as economic development, geographical distance, and transportation infrastructure.

Despite the well-established emphasis on economic determinants in shaping tourism demand, the potential influence of foreign trade remains rather underexplored in empirical research. While studies consistently prioritized conventional indicators, few integrated foreign trade dynamics into their analytical frameworks. Our research addresses this gap by explicitly including exports as a determinant of tourism demand. Also, we aim to determine whether the tourism-trade nexus follows a linear relationship across all periods or undergoes substantial shifts during exogenous shocks like the COVID-19 pandemic, which may decouple trade activity from tourism demand.

3. Data and Methodology

The research model developed in this study investigates the relationship between tourism and exports using a tourism demand function. The methodological framework of the model draws from previous studies by Leita0 (2010), Surugiu et al. (2011) and Chaisumpunsakul and Pholpirul (2018). Equation 1 shows the demand function utilised in this study.

$$\begin{aligned} \log(TUR)_{i,t} = & \beta_0 + \beta_1 \log(Export)_{i,t} + \beta_2 (RP)_{i,t} + \beta_3 \log(GDP)_{i,t} \\ & + \beta_4 \log(POP)_{i,t} + \beta_5 \log(TUR_{t-1})_{i,t} + \beta_6 (Pandemic)_t \\ & + \beta_7 (Pandemic * \log(Export))_{i,t} + \varepsilon_{i,t} \end{aligned} \quad (1)$$

All independent variables in the regression equation are expressed in logarithmic form, except for the variable related to relative prices which is an index number and has a base value of 100, along with dummy variables. The dependent variable measures the logarithm of tourist arrivals to Türkiye from country *i* in year *t*. β_0 represents the constant term in the model, while $\varepsilon_{i,t}$ denotes the error term. The exports represents the logarithm of the sum of exports between Türkiye and country *i* in year *t*.

The primary focus of this research is to analyse the relationship between tourism demand and exports which is the principal explanatory variable in the model. However, additional control variables, widely acknowledged in the literature for their impact on tourism demand, have been incorporated into the equation. One such control variable is $(RP)_{i,t}$ which assesses the influence of price level disparities between Türkiye and country *i* on tourism demand in year *t*. The variable was calculated using following formula:

$$RP_{i,t} = \frac{CPI_{Turkey}}{CPI_{Country\ i}} \quad (2)$$

Since literature states that the products of the sector follow the law of demand (Han et al., 2006; Nguyen, 2022), it was anticipated that an increase in the overall price level would negatively impact tourism demand for Türkiye, reflected by negative β_2 coefficients. The variable $\log(GDP)_{i,t}$ substitutes the logarithm of country *i*'s GDP per capita in year *t*. Since tourism is typically considered a normal good (Crouch, 1992; Smeral, 2012), higher GDP levels among origin countries were expected to positively influence tourism demand, indicated by positive β_3 coefficients. $\log(Population)_{i,t}$ denotes the logarithm of country *i*'s population in year *t*. Reflecting the viewpoint that a hike in the population of countries of origin enhances tourism demand for a specific location (Hanafiah and Harun, 2010; Khan, 2020), it was anticipated that a higher population in country *i* would positively affect tourism demand for Türkiye, as revealed by positive β_4 coefficients. $\log(TUR_{t-1})_{i,t}$ represents the logarithm of tourist arrivals to Türkiye from country *i* in year *t*-1. Including lagged dependent variables in regression serves to gauge the impact of habitual travel patterns on tourism demand. (Witt and Martin, 1987).

The $(Pandemic)_t$ variable functions as a dummy variable assigned the value of 1 during the years 2020 and 2021, encompassing the period of the COVID-19 pandemic. Its inclusion in the research aims to appraise the pandemic's impact. Given the significant reduction in international mobility and the contraction of the tourism sector during the epidemic, it was anticipated that the coefficient β_6 associated with this dummy variable would be negative.

The variable $(Pandemic * \log(Export))_{i,t}$ is another dummy variable employed to evaluate how changes in exports during the pandemic years of 2020 and 2021 affected tourism demand

for Türkiye. The dummy explicitly isolates the COVID-19 pandemic as an exogenous shock to test if the export-tourism relationship deviates from its pattern when confronted with extreme mobility restrictions. In this regard, the interacting dummy serves as a test for structural instability during shocks.

The time span is limited over the period 2011-2022 to evaluate the tourism demand function for Türkiye. Since the study mainly targets to estimate the impact of exports on tourism demand, the sample was limited to the 20 most prominent partners in Türkiye's foreign trade during the examined period. Table 1 shows the top 20 trade partners of Türkiye for the period 2011 to 2022 and the shares of these countries in Türkiye's foreign trade.

Table 1. Sample Countries and Their Share in Türkiye's Foreign Trade (2011-2022)

Rank	Country	Share (%)	Rank	Country	Share (%)
1	Germany	9,61	11	UAE	2,25
2	Russia	7,70	12	The Netherlands	2,07
3	China	7,05	13	Switzerland	1,92
4	USA	5,47	14	India	1,91
5	Italy	5,12	15	South Korea	1,87
6	United Kingdom	4,19	16	Belgium	1,81
7	France	3,84	17	Romania	1,69
8	Spain	3,06	18	Polond	1,60
9	Iraq	3,04	19	Israel	1,46
10	Iran	2,71	20	Ukraine	1,41

Source: Constructed by the authors by using IMF Direction of Trade statistics.

Tourist arrival statistics for Türkiye from its trade partner countries were sourced from the CBRT database. Data on total nominal exports between Türkiye and these trade partners were gathered from the International Monetary Fund's Direction of Trade portal and presented in millions of US dollars at current prices. GDP data for Türkiye's trade partners were obtained from the World Bank Database, calculated by using Purchasing Power Parity (PPP) and denominated in US Dollars. Annual Consumer Price Index (CPI) values and total population statistics for Türkiye and its trade partners were also extracted from the World Bank database.

4. Empirical Findings

Panel data analysis can be conducted using both static and dynamic models. Dynamic models like the Arellano-Bond GMM method (Arellano and Bond, 1991) require lagged variables as instruments, and that can lead to overfitting and weak instruments in small samples (Piper, 2015). Since our dataset covers only 11 years, we deemed dynamic models inapplicable for our research. Static models such as Fixed Effects, Random Effects, and Hausman-Taylor methods examine contemporary relationships between variables, and they are ideal for assessing immediate impacts. Hausman-Taylor method allows estimation of time-invariant variables even when some regressors are correlated with individual effects. But this estimator demands knowledge of which variables are correlated or uncorrelated with unobserved effects, and that is often arbitrary (Baltagi et al, 2003). Hence, we decided to choose between Fixed and Random Effect estimators. Random Effects assumes unobserved individual effects, like country-specific effects are uncorrelated with the independent variable. But if unobserved effects such as cultural ties and historical relationships are correlated with the independent variable, estimates become

biased and inconsistent (Baltagi, 2008). On the other hand, Fixed Effects controls for unobserved heterogeneity and produces unbiased estimates even if unobserved effects correlate with regressors. The main disadvantage of this method is that factors like geographic distance or historical ties are absorbed by the estimator and cannot be analysed (Collischon and Eberl, 2020).

Thus, we decided to use the Fixed Effects method since the geographical distance between Türkiye and source countries is not included in the research model, and the method provides estimators by controlling time-invariant regressors. But to prove the robustness of this choice, the Hausman test (Hausman, 1978) was executed to select between the Fixed Effects and Random Effects methods. This test’s null hypothesis posits that the differences among the parameters are not systematic, which indicates that the convenient estimator for the model is the Random Effects method. Conversely, the alternative hypothesis suggests that the differences among the parameters are systematic, which favours the use of the Fixed Effects method as the appropriate estimator.

Based on the test result, the chi-square probability value (p) from the Hausman test was found to be 0.001, which is less than the significance level of 0.05. Therefore, we rejected the null hypothesis with a 1% margin of error, which means that the differences among the parameters are systematic. Consequently, the Random Effects method is deemed inconsistent for the model, and the appropriate estimator chosen is the Fixed Effects method.

The findings of the analysis conducted using the Fixed Effects method for the model are presented in Table 2.

Table 2. Results of Panel Data Analysis

Independent Variables	Dependent Variable: $\log(\text{TUR})_{i,t}$						
$\log(\text{Export})_{i,t}$	0.135 (0.267)	0.198 (0.159)	0.227 (0.137)	0.237 (0.122)	0.236 (0.122)	0.234** (0.044)	0.211* (0.073)
$(\text{RP})_{i,t}$		-0.047 (0.369)	-0.028 (0.666)	-0.067 (0.362)	-0.053 (0.470)	-0.084 (0.135)	-0.091 (0.107)
$\log(\text{GDP})_{i,t}$			-0.188 (0.623)	-0.100 (0.798)	-0.112 (0.775)	0.750** (0.014)	0.821*** (0.008)
$\log(\text{POP})_{i,t}$				1.349 (0.260)	1.315 (0.272)	4.205*** (0.000)	4.269*** (0.000)
$\log(\text{TUR}_{t-1})_{i,t}$					0.000 (0.216)	0.000 (0.231)	0.000 (0.160)
$(\text{Pandemic})_t$						-1.026*** (0.000)	-2.083*** (0.010)
$(\text{Pandemic} * \log(\text{Export}))_{i,t}$							0.125 (0.185)
Constant	11.956*** (0.000)	11.507** (0.000)	13.183*** (0.000)	-11.793 (0.600)	-11.158 (0.619)	- 71.321*** (0.000)	- 73.000*** (0.000)

Note: ***, ** and * symbols refer to 1%, 5% and 10 % significance levels.

Analysis was initially employed for exploring the relationship between the dependent variable, which is tourist arrivals, and the main explanatory variable, exports. Subsequently, regression was conducted with the inclusion of supplementary control variables outlined in the study. According to the findings, the coefficient of the exports is 0.211 in the final specification

of the model. The estimator for this variable is statistically significant at the 10% level. Thus, a 10% rise in exports between Türkiye and its trade partners correlates with a 2.11% increase in the total number of tourists visiting Türkiye. This result supports the link between tourism and trade observed in prior studies and may likely arise from stronger business ties and heightened destination visibility through commercial networks. Likewise, improved transportation and logistical linkages like expanded flight routes or shipping connections due to trade growth may reduce travel costs and barriers, which stimulate tourism flows.

Among the control variables, the coefficient for the $(RP)_{i,t}$ variable reflecting relative price differences between countries was determined to be -0.091, but not significant. This may reflect limited within-country variation in prices or measurement challenges. While we cannot rule out a null effect, the point estimate is economically non-negligible, and we retain the variable given its theoretical importance. In this regard, we argue that a 10% increase in the level of relative prices in Türkiye coincides with around a 0.91% decrease in the total number of tourists visiting the country. This outcome supports the validity of the general law of demand in tourism for Türkiye.

The coefficient for the income variable was estimated as 0.821 and is statistically significant at the 1% level. This implies that a 10% rise in the incomes in the country of origin leads to a 9.12% increase in tourist arrivals to Türkiye. The fact that the demand elasticity is less than unity suggests that tourism demand for Türkiye is income-inelastic. This could reflect that Türkiye is perceived as a mid-range or non-luxury destination, where tourism growth does not fully keep pace with rising incomes in origin countries. Alternatively, it may indicate that higher-income tourists prefer more exclusive destinations, while the country continues to attract a steady but not proportionally expanding share of travellers as incomes rise.

The coefficient for the population variable was estimated as 4.269, which indicates that a 10% increase in the population of the country of origin leads to a 42.69 % surge in tourist arrivals. This strong positive effect, significant at the 1% level, aligns with the expectation that larger populations naturally generate more potential tourists. The magnitude of the coefficient suggests that Türkiye is a highly attractive destination for a broad demographic, possibly due to its affordability, cultural appeal, and geographic accessibility. This finding is consistent with studies showing that population growth in source markets is a key driver of tourism demand, particularly for mass-market destinations.

On the other hand, the coefficient for the lagged tourist arrivals variable was found to be statistically insignificant, with a point estimate close to zero. This suggests that past tourist flows do not significantly influence current arrivals, which contrasts with some tourism demand models where persistence through habit formation or network effects plays a role (Witt and Martin, 1987; Song et al., 2003). The absence of lag dependence may imply that Türkiye's tourism demand is primarily driven by contemporary economic factors which are included in the model.

The coefficient of the pandemic dummy variable, which took the value of 1 in 2020 and 2021, when the effects of the COVID-19 epidemic were heavily felt, took the value of -2.083 and came up as significant at the 1% level. This indicates that the COVID-19 pandemic led to a substantial decline in tourism demand for Türkiye. Additionally, the interaction term is used to assess the supplementary effect of changes in foreign trade on tourism demand for Türkiye

during the Covid-19 period, yielding a coefficient of 0.120. However, this coefficient was not statistically significant.

The interaction term between exports and the pandemic dummy yields a positive coefficient, which suggests that exports continued to support tourism demand during the crisis, consistent with theoretical expectations. However, the effect is statistically insignificant. This finding indicates that the relationship lacked robustness in pandemic disruptions. While the nominal directionality aligns with pre-crisis trends, the absence of significance implies that mobility restrictions effectively decoupled the export-tourism nexus during this period. The results show that while exports typically drive tourism demand, this relationship weakens significantly during extreme shocks that limit travel mobility.

When we compare the variables based on their impact on tourism demand, it can be seen that the leading factor is income in the country of origin, and it is followed by the population of the source countries. The significance and magnitude of the coefficient of the export variable are larger than the variable, which is the proxy of relative prices. This may be the result of Türkiye’s positioning as a low and mid-cost tourism destination. Most interestingly, Türkiye’s export activity exhibits a robust positive relationship with tourism inflows, which reinforces the idea that foreign trade stimulates tourism and highlights the role of commercial linkages in driving travel flows. These findings advocate for Türkiye to strategically prioritize trade partnerships with high-income and populated countries to bolster tourism growth resilient to crises, rather than focusing on short-term price competitiveness.

5. Conclusion and Policy Suggestions

This study utilizes panel data analysis to empirically examine the relationship between inbound tourism demand and foreign trade for Türkiye. The econometric framework specifically estimates a tourism demand function that incorporates a foreign trade-related variable along with conventional determinants. The analysis of the model indicates that a 10% increase in exports between Türkiye and its trading partners results in a 2.11% increase in the total number of tourists visiting Türkiye.

The results illustrate that exports, which serve as the key explanatory variable, exert a statistically significant positive influence on Türkiye's tourism demand. This finding corroborates earlier work by Chaisumpunsakul and Pholphirul (2018), Surugiu et al. (2011), and Habibi et al. (2009). The observed relationship suggests that bilateral trade relations stimulate tourism demand through strengthening interpersonal networks between trading countries, developing transportation and communication infrastructure critical for tourism mobility, and enhancing Türkiye's international visibility as a destination.

The assessment of the tourism demand function points out that the price elasticity of tourism demand for Türkiye is less than one, which is the case of inelasticity. These findings support the established view that price elasticity of tourism demand tends to be lower in developing economies relative to their developed counterparts (Eilat and Einav, 2004). This outcome positions Türkiye as a developing country with price competitiveness in international tourism since the country is minimally affected by price fluctuations. The income elasticity of demand, while close to one, is also inelastic. Gunter and Smeral (2016) observed that before the 2000s, the income elasticity coefficient of tourism demand was significantly higher than one for

many global tourist destinations. However, since the mid-2000s, this elasticity has been declining steadily. Authors attribute this trend to an increase in saving tendencies due to precautionary measures, as the global economic slowdown has heightened uncertainties about the future. In such an environment, consumers face liquidity constraints and prioritize basic needs over luxury goods like tourism. This trend has resulted in tourism demand's income elasticity falling below one. Additionally, the study concludes that an increase in the population of source countries raises the number of tourists traveling to Türkiye, whereas consumer habits do not significantly impact Türkiye's tourism demand.

But most importantly, this study provides critical insights into the dynamics between Türkiye's exports and inbound tourism demand with a special focus on crisis conditions. For this purpose, a dummy variable for the pandemic period and an interacting dummy of exports and pandemic are employed. The negative and statistically significant coefficient of the pandemic dummy variable captures the effect of COVID-19 mobility restrictions on Türkiye's tourism demand. This dummy, which shows the severity of the pandemic's impact on the tourism demand for Türkiye, isolates other economic factors and solely quantifies pandemic-related barriers on tourism like border closures and quarantine mandates. The significance of this dummy also confirms that the pandemic caused a structural break in Türkiye's tourism demand function. Unlike temporary fluctuations, this shock permanently altered the sector's responsiveness to traditional drivers like income, population, relative prices, etc.

The interacting dummy regarding exports during the COVID-19 period has a positive sign, which aligns with the hypothesis that exports foster tourism demand. But the variable lacks significance. The coefficient statistically demonstrates that the marginal effect of exports on tourism demand vanished during the pandemic period, and exports failed to stimulate tourism demand. From this context, it can be argued that the link between exports and tourism does not follow a linear pathway but could be distorted by exogenous shocks.

All these results support the idea that exports stimulate tourism during stable periods by showing a robust and positive relationship. Yet, this linkage weakens during exogenous shocks characterized by mobility restrictions. The dynamics of Türkiye's exports and tourism during the pandemic period highlight the fragility of this theoretical linkage under exogenous shocks. While exports demonstrated resilience, declining only marginally from 181 billion USD (2019) to \$170 billion (2020) before surging to \$225 billion in 2021, tourism demand collapsed catastrophically and decreased from 45 million annual visitors in 2019 to 13 million in 2020. Tourist arrivals recovered to just 24 million, which is far below the pre-crisis annual average of 34 million and failed to converge to its historical trend even by 2022, despite partial easing of restrictions in 2021. This asymmetry aligns with our econometric findings, which reveal that exports failed to stimulate tourism demand during the crisis. The persistent mobility constraints disrupted the trade-tourism link.

Within this framework, the COVID-19 pandemic served as a natural experiment and revealed that while Türkiye's exports demonstrated resilience, inbound tourism demand was severely impacted and recovered only partially. This asymmetry emphasizes the conditional nature of the tourism-trade channel since commercial activities can stimulate tourism only when paired with functional global mobility. The findings challenge assumptions of linear complementarity and instead emphasize the vulnerability of tourism to Black Swan events like geographical conflicts or pandemics that do not equally constrain trade.

Our findings clearly show that the GDP of source countries ranks as the most significant determinant of the tourism demand towards Türkiye. In other words, there is a strong correlation between the economic prosperity of these nations and their citizens' propensity to travel abroad. This conclusion aligns with existing literature, which emphasizes income as a critical driver of tourism demand since higher GDP levels facilitate greater disposable income for potential travellers. Following GDP, the population size of the source countries emerges as the second most influential factor. A larger population not only increases the number of potential tourists but also reflects a demographic structure that may be more inclined to travel internationally.

Interestingly, our analysis indicates that exports have a higher substantial influence on demand than relative prices for Türkiye, and price differentials rank third in this hierarchy. These findings challenge traditional views that prioritize price competitiveness as a primary driver of tourism. Though this study advocates that factors such as trade relations and economic openness significantly influence travel patterns. In addition, this insight suggests that strategies based on currency depreciation may not be the most effective approach to enhance tourism demand. Instead, it is imperative for the country to leverage its foreign trade dynamics as a strategic tool to stimulate tourism. By expanding its trade hinterland, Türkiye can foster stronger economic ties with potential tourist-generating markets, and this enables the flow of visitors to increase. In other words, as Türkiye's level of openness through international trade rises, tourism demand for the country is positively affected. In this context, expanding liberal trade policies and reducing restrictions on foreign trade will act as a catalyst for tourism demand.

The robust link between exports and tourism demand during stable periods gives a compelling rationale for policymakers to allocate government subsidies to initiatives that promote exports. Since these policies not only magnify exports but also cause a rise in tourism demand as an externality. Policymakers should also design cross-sectoral incentives that simultaneously boost export activity and tourism visibility. For example, Türkiye's thriving export industries could be leveraged in international tourism, which creates a feedback loop where trade success enhances destination appeal. Türkiye's cultural exports, like globally successful television shows and movies, give the country critical soft power to penetrate targeted source markets. Also, prioritizing infrastructure projects that serve both trade and tourism purposes, such as expanding cargo and passenger airports or developing new trade corridors through trade agreements, would be a sound idea. These approaches would maximize the multiplier effects of export growth on tourism.

Given the central idea of this research that exports fail to boost tourism demand during crises with strict mobility restrictions, policymakers should adopt alternative strategies independent from international mobility conditions to sustain the sector. In order to support businesses during such crises, local tourists may be incentivised through tax deductions like temporary exemptions of VAT. For instance, the government of Thailand applied a campaign called “We Travel Together” during COVID-19 that subsidised accommodation, air travel, and other amenities for Thai tourists and received favourable appraisal by locals (Dalferro, 2022).

Since Türkiye's tourism demand is critically determined by population size and income levels of the source countries, to leverage demand, policymakers should adopt segmented strategies that target high-income, low-population markets for premium experiences and that target highly populated developing markets for mass tourism. By aligning policies with the

population and income characteristics of origin countries, Türkiye can optimize arrivals, maximize revenue per tourist, and reduce reliance on any single market.

While this study provides valuable insights into the export-tourism nexus in Türkiye, certain limitations should be acknowledged. Firstly, the analysis focuses primarily on aggregate exports and tourism data, and this may mask variations between sectors. For instance, to see whether cultural exports generate stronger tourism spillovers than industrial goods would provide important results for the efficiency of the link between trade and tourism for Türkiye. Secondly, tourism demand was proxied by tourist arrivals, and that neglects the economic value of those arrivals. Using tourist expenditures of the respective trading partners would yield more accurate estimates of the demand characteristics. However, this data is not disseminated for Türkiye. And thirdly, findings are conditioned on Türkiye's unique position as a middle-income economy. Replicating this analysis in structurally distinct economies like small island tourism states, which depend solely on tourism, might give different results. Future studies could extend this work by disaggregating exports by sectors to identify high-synergy industries for targeted policy interventions and replicating the study across other developing economies to disentangle Türkiye-specific effects from broader patterns. Moreover, comparing crisis impacts in economies with varying degrees of export diversification and tourism dependency would offer empirically tested guidance for policy formulation.

Declaration of Research and Publication Ethics

This study which does not require ethics committee approval and/or legal/specific permission complies with the research and publication ethics.

Researcher's Contribution Rate Statement

The authors declare that they have contributed equally to the article.

Declaration of Researcher's Conflict of Interest

There are no potential conflicts of interest in this study. All opinions and views presented in this study are solely attributable to the authors and do not reflect the views of the affiliated institutions.

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THE RELATIONSHIP BETWEEN THE SECTORAL STRUCTURE OF FEMALE EMPLOYMENT AND ECONOMIC GROWTH AND INCOME DISTRIBUTION IN TÜRKİYE: EMPIRICAL EVIDENCE FROM FOURIER-BASED COINTEGRATION AND CAUSALITY ANALYSES

Türkiye’deki Kadın İstihdamının Sektörel Yapısı ile Ekonomik Büyüme ve Gelir Dağılımı Arasındaki İlişki: Fourier Tabanlı Eşbütünleşme ve Nedensellik Analizlerinden Ampirik Kanıtlar

Ash ÖZEN ATABEY*  & Mustafa KARAKUŞ** 

Abstract

Keywords:

Female
Employment,
Sectoral
Structure,
Economic
Growth,
Income
Distribution

JEL Codes:

J16, J23,
O11, O15,
C32

This study aims to evaluate the contribution of female labour force to the economy in a more comprehensive framework by analysing the relationship between the sectoral structure of female employment in Türkiye and economic growth and income distribution. Using data from the Turkish economy (1991–2023), the study employs FADL and RALS-FADL cointegration tests to analyze long-term relationships and the Fourier Toda-Yamamoto test to assess causality. The findings indicate significant long-run relationships between women's employment in total, services, industry, and agriculture with economic growth and income distribution. While increased female employment in all sectors improves income distribution, agricultural employment negatively impacts economic growth, and the effect of total female employment on growth remains limited. The causality analysis findings reveal that income distribution is a determining factor for female employment in the service sector and total female employment, while industrial female employment is effective on income distribution. There is also evidence that economic growth affects women's employment in the agricultural sector. These findings indicate that policies targeting female employment have sectorally differentiated impacts on economic growth and income distribution, thus underscoring the necessity for sector-specific targeted strategies.

Öz

Anahtar

Kelimeler:

Kadın
İstihdamı,
Sektörel Yapı,
Ekonomik
Büyüme,
Gelir
Dağılımı

JEL Kodları:

J16, J23,
O11, O15,
C32

Bu çalışmada, Türkiye'deki kadın istihdamının sektörel yapısı ile ekonomik büyüme ve gelir dağılımı arasındaki ilişkiyi analiz ederek, kadın işgücünün ekonomiye olan katkısının daha kapsamlı bir çerçevede değerlendirilmesi amaçlanmaktadır. Türkiye ekonomisine ait 1991-2023 verileri kullanılarak yapılan çalışmada, değişkenler arasındaki uzun dönemli ilişkiler FADL ve RALS-FADL eşbütünleşme testleriyle, nedensellik ilişkisi ise Fourier Toda-Yamamoto testi ile analiz edilmiştir. Elde edilen bulgular toplam, hizmet, sanayi ve tarım sektörlerindeki kadın istihdamı ile ekonomik büyüme ve gelir dağılımı değişkenleri arasında uzun dönemli ilişkiler bulunduğunu göstermektedir. Analiz sonuçlarına göre, tüm sektörlerdeki ve toplam kadın istihdamındaki artış gelir dağılımını iyileştirirken, tarım sektöründeki kadın istihdamı ekonomik büyümeyi olumsuz etkilemekte ve toplam kadın istihdamının büyüme üzerindeki etkisi sınırlı kalmaktadır. Nedensellik analizi bulguları, gelir dağılımının hizmet sektöründe ve toplam kadın istihdamı üzerinde belirleyici bir faktör olduğunu, sanayi sektöründeki kadın istihdamının ise gelir dağılımı üzerinde etkili olduğunu ortaya koymaktadır. Ayrıca, ekonomik büyümenin tarım sektöründeki kadın istihdamını etkilediğine dair ampirik kanıtlar elde edilmiştir. Bu bulgular, kadın istihdamına yönelik politikaların ekonomik büyüme ve gelir dağılımı üzerindeki etkilerinin sektörel düzeyde farklılık gösterdiğini ortaya koymakta olup, politika yapıcılar için sektörel bazda hedeflenmiş stratejiler geliştirilmesi gerekliliğine vurgu yapmaktadır.

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1. Introduction

Economic growth and income distribution are key parameters of national development. Labour market efficiency and demographic diversity play a critical role in optimising these parameters. Female employment is an endogenous determinant in reducing income asymmetries by increasing economic productivity, and the integration of women into the labour force positively affects both individual welfare and macroeconomic dynamics (Goldin, 2014; World Bank, 2020).

In the literature, the impact of women's employment on economic growth has been addressed through different theoretical frameworks. Becker's (1991) human capital theory assumes that individuals' education, skills and experience play a critical role in maximising economic returns. Within this context, a rise in women's educational attainment strengthens their economic autonomy and transforms socio-economic structures by increasing their participation in the labour market. In the traditional family model, it is common for women to be allocated to childcare and domestic work, whereas in modern societies, women are employed in jobs with higher income potential due to higher levels of education. However, factors such as interrupted career patterns and motherhood in the labour market increase the likelihood of women experiencing wage disadvantages. Becker (1991) predicts that the expansion in education and job opportunities will reduce this wage asymmetry over time. On the other hand, feminist economic approaches emphasise that women's labour is not limited to market activities, and also makes important contributions to non-market production processes such as domestic labour, care services and volunteer work. Folbre (2009) argues that traditional economic models do not adequately take women's labour into account and that women's economic contributions are ignored. According to her, updating economic policies with a gender perspective and implementing regulations that support women's employment will strengthen both economic growth and social justice. Similarly, Kabeer (2016) emphasizes that female labor force engagement promotes economic growth, but economic growth does not always increase women's employment. Especially in economies of lower and middle development, women mostly work in low-paid and precarious jobs, and their access to the labour market is restricted due to patriarchal norms. Women's employment fuels economic growth by supporting household welfare and productivity. However, for this process to be effective, state policies and social support mechanisms that support gender equality are needed (Kabeer, 2016). In this framework, increasing women's employment should be considered as an essential component of economic development and income distribution.

The integration of women into the labor force generates positive outcomes for economic expansion and poverty reduction (OECD, 2017). In this context, the OECD (2013) stresses the urgent need for developing and emerging economies to tackle the gendered dimensions of poverty. The organization advocates for development assistance to prioritize gender equality and women's economic empowerment, particularly within productive sectors.

The positive correlation between female employment and economic growth is further strengthened by the adoption of gender equality policies. According to the 'Women, Business and the Law 2020' report, equal representation of women in the labour market increases household incomes, facilitates children's access to education and contributes to increased social welfare. Moreover, greater participation of women in economic life encourages innovation, increases economic diversity and contributes to sustainable growth. However, in many countries, the legal

and institutional barriers that women face in the labour market impede the full realization of this positive impact (World Bank, 2020). Therefore, strengthening policies to increase women's employment is considered a critical requirement for economic growth and social welfare.

Eliminating gender-based labour force participation gaps offers significant opportunities for economic growth, although they vary across countries (OECD, 2017). High female employment rates in advanced economies are positively correlated with per capita income and economic stability. However, the economic effects of female employment are heterogeneous depending on sectoral dynamics (Gaddis and Klasen, 2014).

To analyze the effects of female employment on economic growth and income distribution holistically, it is crucial to examine the historical development and sectoral transformation of women's participation in the labour force in Türkiye. To properly evaluate the progress made during the Republican era, the structure of female labour inherited from the Ottoman Empire must also be considered (Makal, 2010: 17). In the Ottoman Empire, "female labour was concentrated in areas such as agriculture, home-based production, and weaving, and gradually moved to small workshops and factories. In the late 19th century and during World War I, the decrease in male labour force led to Muslim women becoming more visible in industrial production (Quataert, 1999; Sussitzki, 1966; Makal, 2010). The results of the 1913-1915 Industrial Census show that approximately one third of the labour force in the industrial sector is made up of women and that this employment is concentrated especially in the textile and food sectors (Ökçün, 1970).

With the declaration of the Republic, the social position of women was strengthened through legal and institutional reforms. The 1926 Turkish Civil Code granted women equal rights in areas such as marriage, divorce and inheritance; educational reforms increased the participation of girls in education, and opened the way for women to be employed in sectors such as health, education, and public administration (İnce Yenilmez, 2023; İzgi Balcı and Akdeniz, 2011). In addition, regulations such as maternity leave and equal pay for equal work have supported women's participation in the labour market (Şenol and Mazman, 2013).

The 1927 Industrial Census data show that 23.7% of workers over the age of 14 in enterprises employing 4 or more workers were women. In large enterprises under the Law on the Encouragement of Industry, the rate of female workers hovered around 24-25%; female labour was largely concentrated in the weaving sector (Tökin, 1946; Makal, 2002). Following the 1936 Labour Law, the ratio of women among wage earners was 18.89% in 1937, while this rate increased to 17.59% in 1947 (Prime Ministry Directorate General of Statistics, 1945).

The sectoral distribution of women's labour is a legacy inherited from the Ottoman Empire. According to the data under the Labour Law, 84.4% of women were employed in the weaving, food, beverage, and tobacco sectors in 1937 and 87.6% in 1943 (Prime Ministry Directorate General of Statistics, 1945). These data show that women's labour was largely concentrated in the weaving and agricultural product processing sectors.

The decline in the male labour force during the Second World War led to an increased share of women and children in industrial production. The 1940 National Protection Law facilitated the employment of women and children (Makal, 2010: 36). By 1943, the proportion of girls among working children between the ages of 12-16 had increased to 45.92%, and when girls and women were considered together, the total proportion of women rose to 29% (Prime Ministry General Directorate of Statistics, 1945; Makal, 2010: 24). The general conclusion that can be drawn from

these developments is that women's participation in the labour force increased due to legal and institutional reforms in the Republican period, however, the sectoral distribution of women's labour continued to be largely concentrated in traditional sectors and became more visible in industrial production, especially during periods of war and crisis.

Table 1. Distribution of Employment by Gender and Economic Sectors in Türkiye (1995-2000) (%)

Gender	Years	Agriculture	Mining	Manufacturing	Electricity, Gas and Water	Construction	Trade Restaurants and Hotels	Transport and Storage	Financial Institutions	Services
Female	1955	95,6	0.0	2,3	0.0	0.0	0,2	0,1	0,1	1,1
	1960	95.0	0.0	2,7	0.0	0.0	0,1	0,1	0,2	1,4
	1965	94,1	0.0	1,5	0.0	0.0	0,1	0,1	0,2	2.0
	1970	89.0	0,1	5,1	0.0	0,2	0,5	0,3	0,6	3,3
	1975	87,5	0.0	4,3	0.0	0,1	0,8	0,3	0,9	4,9
	1980	86,5	0.0	4,6	0.0	0,1	0,8	0,4	1,2	5,8
	1985	85,6	0.0	4,5	0.0	0,1	1,2	0,5	1,4	6,4
	1990	81,3	0.0	6,7	0,1	0,1	1,7	0,5	2.0	7,4
	2000	75,2	0.0	6,6	0,1	0,2	3,7	0,7	2,9	10,5
Male	1955	63,6	0,9	8,7	0,2	2,9	4,3	2,7	0,4	6,3
	1960	61,1	1.0	9,6	0,2	3,7	4,5	3,1	0,5	7,8
	1965	58,4	1.0	10,5	0,3	4,1	3,9	3,3	0,6	8,7
	1970	52,3	1,2	10,9	0,2	4,8	7,2	3,9	1,3	15,5
	1975	53,3	1.0	11.0	0,2	5.0	7,1	4,4	1,6	14,8
	1980	42.0	1,2	14,5	0,3	6,8	9,2	4,6	2.0	18,4
	1985	41,2	1,1	14,4	0,2	5,9	10,3	4,7	2,3	19,1
	1990	36,3	0,9	14,9	0,5	8,1	11,7	5,1	2,7	18,9
	2000	32,4	0,6	16.0	0,5	7,2	13,2	4,8	3,3	21,8

Source: Turkish Statistical Institute (TURKSTAT), 2012.

Table 1 presents the gender distribution of employment by economic activity in Türkiye for the period 1955-2000. Upon analyzing the table, it is evident that women were predominantly concentrated in the agricultural sector. While 95.6 percent of women were employed in agriculture in 1955, this proportion decreased to 75.2 percent by 2000. In contrast, the share of women in the manufacturing industry saw a modest increase; employment in the manufacturing sector rose from 2.3 percent in 1955 to 6.6 percent in 2000. In sectors such as electricity, gas and water, female employment remained quite low throughout the period.

Regarding male employment, sectoral differentiation was considerably more pronounced. While the employment rates of men employed in agriculture decreased from 63.6 percent in 1955 to 32.4 percent in 2000, their employment rates in the industrial and service sectors experienced significant increases. Notably, male employment in the manufacturing and construction sectors consistently exceeded female employment throughout this period. In conclusion, despite a general shift in Türkiye 's employment structure from agriculture towards industry and services between 1955 and 2000, women's participation in this transformation was relatively limited. Consequently, the sectoral diversity of the female labor force remained low, and gender-based segregation persisted.

In Türkiye, TurkStat reorganized its employment data according to the NACE classification in the 2000s to align with European Union (EU) standards and consequently aggregated employment statistics under broader categories such as Agriculture, Industry,

Construction and Services instead of sub-sectors such as mining and manufacturing (TURKSTAT, 2024).

Table 2. Distribution of Employment by Gender and Economic Sectors in Türkiye (2005-2024) (%)

Years	Female				Male			
	Agriculture	Industry	Construction	Services	Agriculture	Industry	Construction	Services
2005	46.7	16.5	0.5	36.3	18.6	23.0	7.3	51.0
2010	40.2	16.4	0.9	42.5	16.9	23.0	8.6	51.5
2015	30.6	15.5	0.9	53.0	15.7	22.2	10.0	52.1
2020	23.1	15.9	0.8	60.2	15.3	22.6	8.0	54.0
2024	18.8	16.5	1.0	63.7	12.8	22.8	9.4	55.0

Source: TURKSTAT, 2024.

Table 2 presents the gender-based distribution of employment by economic activity in Türkiye for the period 2005-2024. Upon analyzing the data for the 2005-2024 period, a significant change has occurred in the sectoral distribution of both male and female employment. The employment rate for men witnessed a decrease in the agricultural sector from 18.6 percent in 2005 to 12.8 percent in 2024, while the service sector experienced an increase from 51.0 percent to 55.0 percent during the same period. Concurrently, male employment in the construction sector also increased, rising from 7.3 percent to 9.4 percent. Conversely, the industrial sector exhibited relative stability at 23 percent, characterized by minor fluctuations.

The sectoral transformation in female employment is clearly evident in Table 2 and Figure 1. Notably, the proportion of women employed in the agricultural sector experienced a significant decline, decreasing to 18.8 percent in 2024 from 46.7 percent in 2005. Conversely, female employment in the service sector demonstrated a substantial increase from 36.3% to 63.7%, indicating an increasing concentration of the female labor force in services. The share of women's employment in the industrial sector remained relatively stable, fluctuating between 16 and 17 percent, while the share in construction experienced a marginal increase from 0.5 percent to 1.0 percent. To summarize, agriculture's contribution to employment for both men and women has declined rapidly, with the service sector becoming the predominant area of employment for both genders. However, the shift of women from agriculture to services has been markedly faster and more pronounced. These findings suggest that in the post-2000 period, the inter-sectoral transformation in Türkiye. These results demonstrate that both the inter-sectoral transformation and the structural change in women's employment have been more pronounced in Türkiye in the post-2000 period.

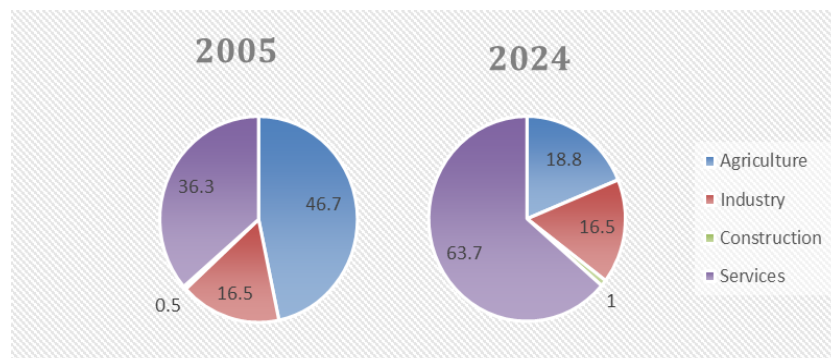


Figure 1. Breakdown of Female Employment by Sector (%)

Source: TURKSTAT, 2024.

This sectoral breakdown suggests that women's high representation in the services sector contributes to sectoral growth, while limited participation in industry and agriculture may limit growth potential. Reasons for sectoral differentiation include education level, gender roles and legal regulations (OECD, 2017).

Sectoral differences in women's employment require a comprehensive analysis of the effects on economic growth and income distribution. Blau and Kahn (2017) argue that the constraints faced by women in the industrial sector reinforce gender-based inequalities and lead to low-paid occupations. The glass ceiling effect, occupational discrimination and limited career opportunities can make it difficult for women to access high-paying positions (SOFA Team and Doss, 2011). In this context, analysing women's employment on a sectoral basis is an important requirement for labour market policies.

The Inverted-U Hypothesis advanced by Simon Kuznets (1955) in his 1955 study explains the relationship between economic growth and income inequality. According to the hypothesis, income inequality exhibits a pattern of escalation during the stages of economic growth, subsequently transitioning to a phase of reduction upon reaching a defined economic threshold. This hypothesis can be adapted to analyse the effects of female employment on income distribution and economic growth. In what the hypothesis defines as the ‘Early Development Phase’ female employment may increase especially in the industrial and service sectors as economies transition from agriculture to industry. However, the concentration of women mostly in low-paid jobs, gender-based wage differences, and inequalities in the labour market may cause income distribution to deteriorate further initially (Demirtaş and Yayla, 2017). In the ‘Intermediate Development Phase’, with the continuation of economic growth, women's higher level of education, greater integration into the labour market, and the adoption of policies towards gender equality can contribute to the reduction of income inequality (Günay and Bener, 2011). In the ‘Advanced Development Phase’, an increase in female employment, especially in high-skill areas such as the service sector, may result in a more balanced income distribution and sustainable economic growth (Bussman, 2009). In this context, the study examines in detail the relationship between the sectoral structure of female's employment and economic growth and income distribution.

This study examines the relationship between the sectoral structure of women's employment and economic growth and income distribution in the Turkish economy using data spanning the period 1991-2023. The remainder of the study provides a comprehensive review of the relevant literature, followed by a detailed explanation of the dataset and the methodological approach. Following the findings and discussion sections, the conclusions and policy recommendations are presented.

2. Literature Review

The effects of female's employment on economic growth and income distribution have long been the focus of academic research. Studies in this field analyse the effects of female's labour force participation on both growth dynamics and social inequalities using different methodological approaches.

In the literature, the impact of female's employment on economic growth has been analysed in various studies. Er (2012), using 1998-2008 data for 187 countries, finds that female

employment has a positive effect on growth. Kutluay řahin (2022) reached a similar conclusion in 31 European countries for the period 2009-2020. Verme (2015), Goldin (1994) and Olivetti (2013) have revealed a U-shaped pattern in the association between women's participation in the labour force and economic development in different geographies (MENA, more than 100 countries and the USA), which means that participation decreases during the initial phases of development, followed by a subsequent increase.

Tam (2011) and Tsani et al. (2013) also investigated the impact of female employment on growth. Tam (2011) confirmed that female employment increases with income growth, while Tsani et al. (2013) empirically proved the contribution of female employment to development in Southern Mediterranean countries. Dursun and Damadoęlu (2020) stated that female labour force participation in the Southern Mediterranean is associated with growth, but is affected by cultural factors. These studies reveal the complex and context-specific effects of female employment on economic growth. To better understand this complexity, it is helpful to focus on women's entrepreneurship, a significant subset of women's employment, and explore global trends in this area. The Mastercard Index of Women Entrepreneurs (MIWE) 2022 report highlights significant heterogeneity in global women's entrepreneurship and identifies the structural factors that underlie these differences. The report attributes the success of top-performing countries such as the United States, New Zealand, Canada, and Israel to inclusive financial ecosystems, enhanced access to education and digital skills, and legal and institutional regulations that promote gender equality. In these countries, women's access to finance, institutional support mechanisms, and family-friendly workplace policies are key facilitators of entrepreneurship (Mastercard, 2022).

In contrast, high rates of women's entrepreneurship are observed in developing countries like Uganda and Botswana, where limited formal employment opportunities and economic necessity drive the trend. In this context, women's entrepreneurial activities tend to be small-scale and subsistence-oriented. The report highlights this structural distinction by emphasizing that in developed countries, women's entrepreneurship results from "choice" and systematic support, while in developing countries, it is primarily driven by "necessity."

Studies on Türkiye have extensively examined the impact of employment on economic growth, considering gender-based employment dynamics and regional disparities. Empirical studies investigating the sectoral growth-employment relationships in the Turkish economy clearly distinguish between sectors where growth translates into employment and those where it does not. Applying a causality test, Akcan and Azazi (2022) determined that growth in the service, construction, and agriculture sectors leads to an increase in employment. In contrast, their causality analysis revealed that growth alone does not create employment in the industrial sector. Similarly, Aksoy (2013) found a positive causality between growth and employment increase in the manufacturing and tourism-trade sectors, while indicating that growth in the energy sector reduces employment. At the regional level, Akıncı and Yılmaz (2013), in their study based on Shift-Share analysis, found that employment increases in the industry and services sectors positively affect regional development. They reported a generally negative trend in the agricultural sector, with the Marmara and Aegean sub-regions exhibiting high development performance, driven by both national trends and regional competition dynamics. Furthermore, they noted that employment growth in Eastern Anatolia and the Black Sea region did not sufficiently support development. The crucial role of the industrial sector in growth and productivity has been confirmed by Arısoy (2013) and Mercan and Kızılkaya (2014) within the framework of Kaldor's growth laws. Both studies, through cointegration and error correction

analyses with quarterly data, identified long-term and positive relationships between industrial production, labor productivity, and total factor productivity. Altun and İşleyen (2019) found that there was a long-term cointegration between industrial sector employment and economic growth through cointegration and causality tests, and that employment growth in the industrial sector supported growth. Dinç (2022) showed that there is a unidirectional causality from the agricultural sector to economic growth using the extended Toda-Yamamoto test with the Bootstrap approach, whereas a bidirectional causality exists between the service sector and economic growth. Telli Üçler (2022) found that growth causes employment in the industrial and service sectors through causality analysis, but no significant relationship was found with the agricultural sector. Kopuk and Meçik (2020) identified a unidirectional causality from the agricultural sector to GDP through cointegration and causality analyses, and a bidirectional causality exists between agriculture and the manufacturing industry, while no direct relationship was found between the manufacturing industry and economic growth. Turhan and Erdal (2022) also found that economic growth increases agricultural employment, and agricultural employment affects general employment; however, no significant causality from general employment to GDP was observed through causality analyses. Yıldırım and Engeloğlu (2023) determined a long-term relationship between agricultural sector employment and fluctuations in growth using latent cointegration methods. They found that employment decreases in the construction sector support growth, and employment increases in the services sector cause decreases in growth. Özgün (2023) revealed a long-term relationship between service employment and economic growth using the cointegration test, with the services sector primarily driven by growth according to the causality test.

The contribution of women’s employment to economic growth in Türkiye, which is the central focus of our study, warrants special attention. Kutluay Şahin (2022) demonstrated using panel data that a 1% increase in women’s employment results in a 0.95% increase in GDP. Özocaklı and Palandökenlier (2024), in their demographic-based analysis, found that manufacturing increases employment among both men and young women. Meanwhile, Pata (2018) concluded through asymmetric causality tests that women’s employment supports growth primarily through the services sector.

Women’s educational attainment and labour market participation have important effects on economic growth and income distribution. Lorgelly and Owen (1999) emphasised that investments in women’s education contribute directly and indirectly to economic growth and that gender differences should be examined more carefully in growth models. Uyanık and Yeşilkaya (2021) analysed the effects of employment rates of women by education level on income inequality in European Union countries, and they empirically proved that employment of women who are high school graduates increases inequality. In contrast, the employment of female who are higher education graduates decreases it.

Unemployment, labour market regulations, and global economic shocks have long been among the topics discussed due to their effects on income distribution. Mocan (1999) and Nolan (1986) have shown that unemployment increase income inequality and that labour market imbalances deepen economic inequalities. These findings are also supported by the relationship between international trade and wage inequality proposed by Helpman et al. (2010). Trade opening widens the distribution of firm income and initially increases wage inequality, but in the long run, inequality may decrease if trade openness exceeds a certain threshold (Helpman et al., 2010). Roberts and Tran (2022) analyse the impact of expanding global production and labour policies on income disparity, and find that labour market regulations increase inequality in the

global South, while they decrease it in the global North by encouraging unionisation. Checchi and García-Peñalosa (2008) examine the effects of labour market institutions on income inequality and find that strong labour market regulation can reduce inequality but increase unemployment rates. Cysne (2009) found that increases in structural unemployment lead to higher income inequality. Aktaş (2021), in his panel Tobit analysis with data from 60 countries, determined that indicators such as the employment rate, investment, and the Human Development Index reduce income inequality. Conesa and Wang (2023) find that differences in sectoral income distribution in China increase income inequality in the long run. Deffo et al. (2024) examine the impact of the COVID-19 pandemic on income inequality in Cameroon, and find that families with unemployed heads of households are more affected during crisis periods. Giupponi et al. (2024) found that minimum wage policies in the United Kingdom led to a compression in the wage distribution, but did not lead to a significant decline in employment rates. These studies show that the effects of labour market policies on income distribution are complex and context-specific.

The interplay between income distribution, employment, and unemployment is significantly influenced by labor's share of income and the level of access to labor markets. Augmented unemployment rates and the structural characteristics of employment directly impact levels of inequality. Indeed, Aydın (2025), through cointegration analysis, determined that the trend of deindustrialization diminished the proportion of labor income in total value added, thereby exacerbating income inequality. The increase in the Gini coefficient, coupled with the contraction of industrial employment and production shares post-2014, further substantiates this finding. On the other hand, Duman (2019), in his long-term assessment of the relationship between functional and individual income distribution, found that despite the decrease in the share of labor in income, a relative improvement in individual income inequality was observed due to social transfers and tax policies. The study also revealed that even with increased wage incomes, income derived from employers, interest, and real estate exhibited increasing concentration among high-income strata. This situation disrupted income distribution and limited the potential of employment growth to reduce inequality. Utilizing the Nonlinear Autoregressive Distributed Lag (NARDL) model, Oktay (2019) determined that only shocks leading to increased unemployment exerted significant and adverse effects on income inequality. Kalaycı and Öztürk (2017), using cointegration tests, variance decomposition, and impulse-response analyses, examined the macroeconomic factors affecting income distribution inequality in Türkiye. Their findings indicated that while the unemployment rate exhibited a statistically significant effect on income distribution, its impact was comparatively limited when juxtaposed with other variables such as inflation, education expenditures, foreign direct investment, and external debt.

Studies conducted in Türkiye on women's employment, income distribution, and sectoral development dynamics address the relationship between gender equality, regional imbalances, and economic growth from a multidimensional perspective. These studies reveal both the position of women in the labor market at the micro level and their connections to macroeconomic indicators. In this context, research focusing on the sectoral concentration and spatial distribution of women's employment shows that the service sector is a primary employment area for women. The analysis conducted by Altuğ and Almammadlı (2025), employing the Location Quotient (LQ) method and spatial mapping techniques on SGK data for the period 2004-2020, revealed a concentration of women's employment in service sectors such as education, healthcare, finance, and hospitality within Türkiye. Their findings indicated that women's employment remained constrained in male-dominated sectors, including industry and construction. Conversely,

employment, initially localized in western regions, diffused towards eastern and inland areas, a trend attributed to public policies. While notable regional concentrations were identified in the finance, education, and hospitality sectors, healthcare and social services exhibited a more balanced distribution. Consequently, regional disparities in employment between women and men have diminished, and spatial inequalities have been reduced. This finding is further supported by a comprehensive report prepared by Durceylan Kaygusuz et al. (2023) using data from the 2004-2021 Turkish Statistical Institute (TurkStat) Household Labor Force Surveys and the 2018 World Values Survey. The report highlights that, despite an increase in female labor force participation after 2008, it still remains below the OECD average; there are significant differences in participation rates between regions such as the Black Sea and Southeast Anatolia; NEET (Not in Education, Employment, or Training) rates among young women in the 15-24 age group remain high; structural discrimination persists due to wage inequality and the low representation of women in managerial positions; and that COVID-19 and natural disasters have made women more vulnerable compared to men.

Studies investigating the impact of women’s employment on economic growth and income distribution commonly suggest an inverse relationship between increased female employment and income inequality. Akyol Özcan (2023), in a panel study encompassing 19 EU countries including Türkiye, demonstrated that a 1% increase in female labor force participation resulted in a 1.6% decrease in Türkiye’s Gini coefficient. A study focusing specifically on Türkiye by Akyol et al. (2019) found that while industrial sector growth reduces unemployment, it concurrently increases income inequality. This suggests that industrial production has contradictory effects on income distribution: although it increases employment, it is insufficient to achieve income equality. Similarly, Turgut (2019), in a literature review drawing upon Turkish data, emphasized that women are disproportionately employed in lower-paid, insecure, and informal jobs compared to men, thereby deepening female poverty and exacerbating income inequality.

The interplay between labor market dynamics (employment, unemployment, sectoral structure), economic growth, and income distribution has been extensively analyzed in both national and international scholarly works. General findings indicate that while the industrial sector contributes to economic expansion, its efficacy in mitigating income inequality remains limited, whereas the service sector is notable for its capacity to generate employment. Although the impact of the agricultural sector has diminished, a unidirectional relationship with growth persists. Within this context, women’s employment emerges as a salient determinant in the nexus between growth and inequality. Internationally, female labor force participation is observed to support economic growth, and notably, the employment of women with higher education contributes to the reduction of income inequality. Studies focusing on Türkiye reveal a long-term relationship between women’s employment in the service sector and economic expansion, while this connection is tenuous in the industrial sector and unidirectional in agriculture. The positive impacts on income parity are contingent upon structural factors such as sectoral concentration, NEET rates, and regional imbalances. Methodologically, these relationships have been scrutinized at sectoral and regional levels utilizing panel data analysis, cointegration tests, Granger and Toda-Yamamoto causality analyses, Shift-Share analyses, and spatial distribution modeling. The overarching trend indicates that women’s employment is a fundamental factor for equitable and inclusive growth.

In light of the general trends and debates in the existing literature, although extensive studies have been conducted on the effects of women’s employment on economic growth and

income distribution, these studies generally address women's employment through holistic indicators. In contrast, this study provides a more in-depth analysis by disaggregating the effects of women's employment across the agriculture, industry, and service sectors within the Turkish context. While most studies (e.g., Kutluay Şahin, 2022; Özocaklı and Palandökenlier, 2024; Pata, 2018; Akyol Özcan, 2023; Turgut, 2019) generally focus on aggregate employment or general gender-based indicators, this study examines the impact of sectoral concentration on economic growth and income distribution in greater detail. Furthermore, a time-sensitive analytical framework is presented using a long-term dataset (1991-2023) that encompasses critical periods such as the global financial crisis and the post-pandemic era. Methodologically, the study adopts an approach that accounts for structural breaks and nonlinear relationships through the application of Fourier ADL, RALS-FADL, and Fourier Toda-Yamamoto tests. Despite the existence of numerous studies examining the relationships between women's employment, economic growth, and/or income distribution, a gap remains in the literature regarding research that simultaneously addresses these three variables at the sectoral level while applying the aforementioned Fourier-based econometric methods. Therefore, this study aims to fill these gaps in the literature and make an original contribution by applying Fourier-based econometric methods to the sectoral relationships between women's employment, economic growth, and income inequality. It is anticipated that the breadth of the dataset, the comprehensiveness of its temporal scope, and the in-depth methodological approach of this research will reinforce the study's originality and its contribution to the literature.

3. Model, Data Set and Empirical Method

This section details the empirical model, data set and methods used in this study. To determine the effects of female's employment on economic growth and income distribution, a sectoral analysis framework was created and advanced time series methods were used. The methodological approach of the study aims to identify the long-run relationships and causal link between variables, and the results of the analysis aim to contribute to the formulation of policy recommendations on female employment.

3.1. Model and Data Set

The integration of women into the workforce exhibits a direct correlation with both economic expansion and distributional equity, serving as a critical determinant for achieving gender parity and sustainable development objectives. Female labour force participation is recognized not merely as an ancillary driver of economic growth, but also as a catalyst for socio-economic transformations that influence income disparities. While conventional growth paradigms typically treat female employment as a subset of aggregate labour, contemporary development frameworks underscore the multifaceted implications of female labour on both economic growth trajectories and inequality patterns (Kabeer, 2016; Seguino, 2000).

To examine the sectoral (services, industry, agriculture) and aggregate impacts of women's employment on income distribution and economic growth, this study employs a set of established and widely accepted indicators. Table 3 provides comprehensive details regarding the variables incorporated in this analysis.

Table 3. Information on variables

Variables	Symbol	Log Symbol
Women Employment Indicators		
(Source: (ILO, 2025; World Bank, 2025a))		
Percentage of female workforce employed in service sector (The share of women in total employment)	HiZ	LnHIZ
Percentage of female workforce engaged in industrial activities sector (The share of women in total employment)	SAN	LnSAN
Percentage of female workforce employed in agricultural sector sector (The share of women in total employment)	TAR	LnTAR
Female employment-to-population ratio (15+) (The share of female population aged 15 and above)	TOP	LnTOP
Income Distribution Indicator (Source: Solt, 2019)		
Gini Coefficient (gini_mkt: Gini index estimate based on equivalized (square root scale) household market income (before taxes, before transfers))	GINI	LnGINI
Economic Growth Indicator (Source: World Bank, 2025b)		
Per capita Gross Domestic Product (constant 2015 US dollars)	GDP	LnGDP

The time period from 1991 to 2023 was chosen as the analysis period, and these variables were selected to analyze the long-run effects of women's employment on income distribution and economic growth. The reason for choosing this time period is that it encompasses significant structural transformations in the global economy, providing an opportunity to analyze policy changes regarding women's employment. Moreover, since the most recent and complete data range covered by the datasets used is limited to this period, the analysis was conducted between these dates. Consequently, this temporal frame aligns optimally with the research's delineated parameters and objectives. The study analyzes two basic equations (Equations (1) and (2)):

$$LnGINI_t = \beta_0 + \beta_1 LnHIZ_t + \beta_2 LnSAN_t + \beta_3 LnTAR_t + \beta_4 LnTOP_t + \varepsilon_t \quad (1)$$

$$LnGDP_t = \beta_0 + \beta_1 LnHIZ_t + \beta_2 LnSAN_t + \beta_3 LnTAR_t + \beta_4 LnTOP_t + \varepsilon_t \quad (2)$$

In the analyses, natural logarithmic transformation of variables was applied to improve the data structure, to express relationships in elasticity terms, and to increase the statistical reliability of the model. Log transformation enables direct interpretation of percentage changes and increases the validity of the model by reducing heteroskedasticity (Greene, 2012; Wooldridge, 2013). It also makes error terms more consistent by normalizing right-skewed distributions (Gujarati and Porter, 2009).

Log transformation alleviates the multicollinearity problem by compensating for large scale differences (Enders, 2014) and facilitates the analysis of growth rates (Stock and Watson, 2015), making it a powerful tool in econometric analysis. For this reason, the natural logarithmic transformation of variables was applied in the analyses to obtain more robust and interpretable results.

To ascertain the existence of a long-term equilibrium relationship among the variables, this research employed the FADL and RALS-FADL cointegration tests. Complementing the analysis of long-run associations, the FTY test was used to explore causal linkages between the variables.

3.2. Empirical Method

This research utilises advanced econometric methods to analyze the influence the impact of sectoral (services, industry, and agriculture) and aggregate female employment on income

distribution and economic growth in the Turkish context. These methods address the properties of time-series stationarity, the existence of long-term equilibrium associations, and the nature of short-term adjustments. The methods used and their significance are summarized below:

Stationarity Tests: Within the scope of unit root tests, the stationary properties of the variables were assessed by applying the Fourier ADF (FADF) test. Unlike conventional unit root tests, the FADF test provides more reliable results, accounting for structural discontinuities within the time series (Enders and Lee, 2012).

Cointegration Analysis: FADL test and RALS-FADL test were used to identify the long-term association. These methods minimize the effect of structural breaks on the test power and make it possible to detect the long-run relationships between variables more precisely (Banerjee et al., 1998; Yılanıcı, 2019).

Cointegration Coefficient Estimation: After identifying the long-run relationship, we estimate the long-run coefficient using the Fully Modified Least Squares (FMOLS) method. The FMOLS method is widely preferred in cointegration models as it produces asymptotically consistent estimates even with small sample sizes (Phillips and Hansen, 1990).

Error Correction Model (ECM): If the existence of cointegration relationship is detected, the short-run dynamics between variables are analyzed by constructing ECM. ECM shows how long it takes to correct deviations from the long-run equilibrium and reveals how variables offset their effects on each other over time (Engle and Granger, 1987).

Causality Test: The FTY test was applied to examine the causality relationships between the variables. This test is an extension of the traditional Toda-Yamamoto test with Fourier transforms and is important because it can identify reliable causal relationships despite the presence of structural breaks in the series (Toda and Yamamoto, 1995; Tsong et al., 2016).

The applied methods are selected in accordance with the statistical properties of the variables and provide strong results in determining both short-run and long-run relationships. In particular, Fourier-based tests minimize the errors that may arise because traditional methods ignore structural breaks and provide more reliable results. The long-run coefficients obtained with the FMOLS method provide important findings on the sign and strength of the linear association among variables.

Enders and Lee extended the traditional ADF unit root test by integrating the Fourier function and introduced this method to the literature. The FADF unit root test does not require prior information about the timing, frequency or pattern of structural changes. The essential aspect of applying this test is to determine the optimal frequency value of the Fourier function. The data generation process of this test can be expressed as follows (Equation 3) (Enders and Lee, 2012):

$$y_t = c + py_{t-1} + \gamma t + \varepsilon_t \quad (3)$$

where, y_t is the dependent variable, c is the constant term, p is the coefficient of the lagged dependent variable, γ is the time trend, ε_t is the error term. The deterministic component $a(t)$ is modeled as shown in Equation (4):

$$a(t) = a_0 + \sum_{k=1}^n a_k \sin\left(\frac{2\pi kt}{T}\right) + \sum_{k=1}^n \beta_k \cos + \left(\frac{2\pi kt}{T}\right) \quad (4)$$

In this formulation; T is the total sample size, n denotes the number of Fourier components and the condition $n \leq \frac{T}{2}$ must be satisfied.

The main objective of this model is to represent the changes in structural breaks over time in a more flexible structure. Thanks to Fourier functions, structural transformations can be integrated into the model in the form of fluctuations instead of sharp changes, thus providing more reliable forecasts for trending data sets.

Gregory and Hansen highlighted that overlooking structural breaks may result in misleading conclusions in cointegration analyses and developed a new test that allows for regime changes (Gregory and Hansen, 1996a, 1996b). Subsequent studies used dummy variables to identify sharp structural changes but missed gradual structural changes, leading to the development of more sophisticated tests using Fourier functions (Hatemi-J, 2008; Maki, 2012). Banerjee et al. (2017) introduced a modified cointegration test that incorporates structural changes through a Fourier model and allows for better analysis of long-term relationships (Tsong et al., 2016; Yilanci, 2019).

Banerjee et al. (1998, 2017) revised the cointegration test equation developed by themselves with a Fourier function to take structural changes into account. In this context, they proposed the FADL model (Equation (5)):

$$\Delta y_{1t} = d(t) + \delta_1 y_{1,t-1} + \gamma' y_{2,t-1} + \alpha \Delta y_{2t} + e_t \quad (5)$$

$d(t)$ The deterministic term as a function of time, represented by the symbol is defined in Equation (6):

$$d(t) = \beta_0 + \Phi_1 \sin\left(\frac{2\pi kt}{T}\right) + \Phi_1 \cos\left(\frac{2\pi kt}{T}\right), \quad (6)$$

Here t represents the time variable, T represents the total sample size, and k represents a predetermined number of frequency components. The optimal k was determined by selecting the value that minimized the sum of squared residuals. Substituting this expression in equation (5), the test equation (Equation (7)) takes the following form:

$$\Delta y_{1t} = \beta_0 + \phi_1 \sin\left(\frac{2\pi kt}{T}\right) + \phi_1 \cos\left(\frac{2\pi kt}{T}\right) + \delta_1 y_{1,t-1} + \gamma' y_{2,t-1} + \alpha \Delta y_{2t} + e_t \quad (7)$$

The test statistic expressed in Equation (8) is utilized to assess the validity of the null hypothesis of non-cointegration (Yılancı et al., 2023):

$$t_{ADL} = \frac{\hat{\delta}_1}{se(\hat{\delta}_1)} \quad (8)$$

Here; $\hat{\delta}_1$ is the ordinary least squares (OLS) estimator and $se(\hat{\delta}_1)$ is the standard error of this estimator.

The FADL cointegration test disregards the information that can be obtained from higher moments that arise when the residual terms are not normally distributed (Yılancı et al., 2023). This may reduce the power of the test and affect the reliability of the results. Studies by Lee et al. (2015) and Oh et al. (2020) suggest that taking into account the distributional properties of the residual terms can increase the statistical power of cointegration tests.

In light of these methodological developments, the model developed by Banerjee et al. (2017) is extended based on Im and Schmidt (2008) and estimated using the Residual Extended Least Squares (RALS) method instead of the OLS method. The RALS method is a simple test procedure and, unlike traditional methods, does not require predetermining the underlying functional form.

Lee et al. (2015) show that the statistical power of RALS-based tests increases significantly when the error terms are not normally distributed and yield similar results to traditional methods when the error terms follow a normal distribution. Thanks to these features, the RALS method provides more reliable and robust results, especially in time series analysis with structural changes and abnormally distributed errors.

To enhance the robustness of the FADL cointegration test regression, Equation (7) is augmented with an additional term expressed in Equation (9) below:

$$\hat{\omega}_t = [\hat{u}_t^2 - \hat{m}_2, \hat{u}_t^3 - \hat{m}_3 - 2\hat{m}_2\hat{u}_t]'$$
 (9)

Here $\hat{\omega}_t$, refers to the residuals obtained from Equation 7. The first term is valid in the absence of heteroskedasticity in the data. On the other hand, the second term increases the predictive power of the model. However, if the distribution of error terms is not normal, the forecasting performance of the model may be negatively affected. In this case, the statistical efficiency of the model can be improved by making the above additions to Equation (7) as expressed in Equation (10).

$$\Delta y_{1t} = \beta_0 + \phi_1 \sin\left(\frac{2\pi kt}{T}\right) + \phi_2 \cos\left(\frac{2\pi kt}{T}\right) + \delta_1 y_{1,t-1} + \gamma' y_{2,t-1} + \alpha \Delta y_{2t} + \hat{\omega}_t \gamma + \zeta_t$$
 (10)

Consequently, the RALS-FADL test statistic is derived through the estimation of Equation (8) by OLS and calculating the t-statistic for $\phi_1 = 0$ as τ_{RLM} . Equation (11) presents the asymptotic distribution of the test statistic:

$$\tau_{RLM} \rightarrow \rho \tau_{LM} + \sqrt{1 - \rho^2} Z$$
 (11)

This method allows for a more accurate and reliable cointegration analysis by taking structural breaks into account.

It is a prerequisite for both the FADL and RALS-FADL cointegration tests that the variables are integrated of order one, i.e. they are expected to have an I(1) process. In this framework, our models can be defined as shown in Equations (12) and (13):

$$\begin{aligned} \Delta \ln GINI_t = & \beta_0 + \phi_1 \sin\left(\frac{2\pi kt}{T}\right) + \phi_1 \cos\left(\frac{2\pi kt}{T}\right) + \delta_1 \ln GINI_{t-1} + \gamma' \ln H\dot{I}Z_{t-1} \\ & + \alpha \Delta \ln H\dot{I}Z_t + \gamma' \ln SAN_{t-1} + \alpha \Delta \ln SAN_t + \gamma' \ln TAR_{t-1} \\ & + \alpha \Delta \ln TAR_t + \gamma' \ln TOP_{t-1} + \alpha \Delta \ln TOP_t + \alpha \Delta y_{2t} + e_t \end{aligned}$$
 (12)

$$\begin{aligned} \Delta \ln GDP_t = & \beta_0 + \phi_1 \sin\left(\frac{2\pi kt}{T}\right) + \phi_1 \cos\left(\frac{2\pi kt}{T}\right) + \delta_1 \ln GDP_{t-1} + \gamma' \ln H\dot{I}Z_{t-1} \\ & + \alpha \Delta \ln H\dot{I}Z_t + \gamma' \ln SAN_{t-1} + \alpha \Delta \ln SAN_t + \gamma' \ln TAR_{t-1} \\ & + \alpha \Delta \ln TAR_t + \gamma' \ln TOP_{t-1} + \alpha \Delta \ln TOP_t + \alpha \Delta y_{2t} + e_t \end{aligned}$$
 (13)

The FTY test is performed by estimating the models as formulated expressed in Equations (10) and (11). In the application of the test, the most appropriate model is selected by first determining the lag length and Fourier frequency value (k). Then, the best model is constructed by using the parameters that minimize the Akaike (AIC), Schwarz (BIC), and Hannan-Quinn (HQIC) information criteria. In the final stage, bootstrap simulations, following the methodology of Nazlioglu et al. (2016), are implemented to determine the required critical values for the test.

The FTY causality test is a method that aims to analyze causality relationships without considering structural breaks, by extending the traditional Toda-Yamamoto (1995) Granger causality test with the Fourier approach. This approach, proposed by Nazlioglu et al. (2016), stands out as an effective tool for capturing gradual structural changes, especially in economic time series.

The main advantage of this method is that it does not require a priori knowledge of the dates, numbers, and shapes of structural breaks and can model them using Fourier series. While traditional methods usually use dummy variables to model sudden (sharp) breaks, the Fourier approach offers a more flexible structure, making it possible to model smooth transitions over time. The FTY test extends the traditional VAR ($p+d$) model by adding Fourier components and flexibly captures how structural changes manifest in the series. The model can be defined in Equation (14) (Nazlioglu et al., 2016):

$$y_t = a_0 + y_{1k} \sin \frac{2\pi kt}{T} + y_{2k} \cos \frac{2\pi kt}{T} + \beta_1 y_{t-1} + \dots + \beta_{p+d} y_{t-(p+d)} + \varepsilon_t \quad (14)$$

Here; a_0 is the constant term parameter, $1\gamma k$ and $2\gamma k$ represent the width and location of frequencies respectively, k is the Fourier frequency, T is the sample size, $1\gamma k$ and $2\gamma k$ represent the width and location of frequencies respectively, and y_t represents the possible structural changes.

The use of the F-statistic instead of the Wald test produces more reliable results in small samples. Critical values determined using bootstrap simulation techniques make the test more robust in small samples and increase the flexibility of the model against unit root and cointegration problems. Therefore, the FTY test overcomes the limitations of traditional methods and provides a more reliable causality test that takes into account structural changes in time series analysis (Nazlioglu et al., 2016).

The Fourier-based cointegration and causality tests employed in this study (FADL, RALS-FADL, and Fourier Toda-Yamamoto) were selected to model the effects of structural breaks in economic time series. The Fourier transform provides flexibility in detecting low-frequency and nonlinear fluctuations in the deterministic structure of series, thus allowing for analysis without the need for pre-specification of the number or timing of breaks (Enders and Lee, 2012b: 196; Becker et al., 2006). In this regard, the impacts of structural transformations, such as financial crises, global shocks, and the pandemic, experienced during the period 1991–2023, have been directly incorporated into the model. However, while Fourier-based methods offer flexibility in modeling structural breaks and nonlinear trends in time series, they also possess certain methodological limitations. Christopoulos and Leon-Ledesma (2010: 1090-1091) point out that while the Fourier function is effective in capturing time-varying means and low-frequency fluctuations, it may be less effective in detecting sudden and high-frequency structural breaks. Additionally, it is stated that frequency constraints may create analytical challenges in interpreting

the components and that caution is required when translating the results into economic and political implications. These limitations are consistent with the findings of Rodrigues and Taylor (2009), who suggest that the Fourier approach is more suitable for temporary and mild breaks.

4. Findings

Before analyzing the cointegration relationship between income distribution, women's employment (in total, service, industry, and agriculture sectors), and economic growth in Türkiye, it is essential to establish the variables' integration order. A fundamental requirement of the chosen cointegration test is that all variables achieve stationarity at their first difference, denoted as I(1). To this end, the FADF unit root test, developed by Enders and Lee (2012a), is employed. Traditional unit root tests often overlook potential structural changes within the data, leading to reduced statistical power when such breaks are present. Recognizing this limitation, Enders and Lee (2012a) extended the standard ADF test to incorporate the possibility of multiple smooth transition structural breaks in the stationarity assessment.

Table 4. Findings of the FADF

Variables	Test Statistic	k	l	Model with constants		
				Critical Values		
				%1	%5	%10
LnHIZ	-1.5377	2	0	-3.97	-3.27	-2.91
LnSAN	-1.4890	2	1	-3.97	-3.27	-2.91
LnTAR	1.4266	2	0	-3.97	-3.27	-2.91
LnTOP	-3.2963	1	0	-4.42	-3.81	-3.49
LnGINİ	-3.0859	1	1	-4.42	-3.81	-3.49
LnGDP	-0.2855	1	0	-4.42	-3.81	-3.49
ΔLnHIZ	-4.6335***	1	0	-4.42	-3.81	-3.49
ΔLnSAN	-6.8831***	2	1	-3.97	-3.27	-2.91
ΔLnTAR	-5.7696***	2	0	-3.97	-3.27	-2.91
ΔLnTOP	-5.0083***	2	0	-3.97	-3.27	-2.91
ΔLnGINI	-3.4900**	1	0	-4.42	-3.81	-3.49
ΔLnGDP	-5.4999***	1	0	-4.42	-3.81	-3.49

Variables	Test Statistic	k	l	Model with Constant and Trend		
				Critical Values		
				%1	%5	%10
LnHIZ	-2.3881	1	0	-4.95	-4.35	-4.05
LnSAN	-3.7774	1	0	-4.95	-4.35	-4.05
LnTAR	-1.5955	1	0	-4.69	-4.05	-3.71
LnTOP	-3.1721	1	0	-4.69	-4.05	-3.71
LnGINİ	-2.9644	1	1	-4.95	-4.35	-4.05
LnGDP	-3.0781	1	0	-4.95	-4.35	-4.05
ΔLnHIZ	-4.5665**	2	0	-4.69	-4.05	-3.71
ΔLnSAN	-7.4526***	1	1	-4.95	-4.35	-4.05
ΔLnTAR	-4.6494**	1	0	-4.95	-4.35	-4.05
ΔLnTOP	-5.6483***	2	0	-4.69	-4.05	-3.71
ΔLnGINI	-3.8852**	2	1	-4.69	-4.05	-3.71
ΔLnGDP	-5.4790***	2	0	-4.69	-4.05	-3.71

Note: The critical values for the FADF test were derived from Enders and Lee (2012). Statistical significance is denoted by ***, **, and *, corresponding to levels of 1%, 5%, and 10%, respectively. The parameter "l" represents the optimal lag length, and 'k' denotes the number of frequencies chosen.

Drawing upon the FADF test results delineated in Table 4, the stationarity properties of the variables were examined under both constant and constant-trend models. Given that the test statistics for all variables failed to fall below the critical thresholds, it is determined that each variable displays unit root characteristics, leading to the conclusion of non-stationarity. Similarly, under the constant and trend model, all variables exhibit non-stationarity in levels.

However, after first-order differences were applied to the variables, all test statistics fell below the critical thresholds, thus confirming the stationarity of the variables for both the models with a constant and with both constant and trend.

These findings suggest that the variables exhibit non-stationarity. at their level values but exhibit stationary properties after the application of first differences. Hence, the analysis concludes that the variables are integrated of degree one, and it is methodologically appropriate to apply cointegration tests (FADL and RALS-FADL) to examine the relationships in the long term.

Table 5. Findings of the Cointegration Tests (FADL and RALS-FADL Tests)

Dependent Variables:	Opt. Frequency (k)	Number of independent variables (n)	Min AIC	Test Statistic	Rho
LnGINI					
FADL	2	4	-10.614	-3.827512	0.577
RALS-FADL				-4.958509**	
Dependent Variable: LnGDP	Opt. Frequency (k)	Number of independent variables (n)	Min AIC	Test Statistic	Rho
FADL	3	4	-4.983	-4.894706***	0.596
RALS-FADL				-8.090093**	

Note: Statistical significance is denoted by ***, **, and *, corresponding to levels of 1%, 5%, and 10%, respectively. The critical values utilized in this study are derived from the work of Yılancı et al. (2023).

Table 5 reports the results derived from the FADL and RALS-FADL tests, which examine the long-run cointegration between LnGINI and LnGDP and sectoral female employment and total female employment variables (ΔLnHIZ , ΔLnSAN , ΔLnTAR , ΔLnTOP). The findings support the cointegration relationship between the variables

Results pertaining to LnGINI indicate, that the FADL test is not statistically significant, but the RALS-FADL test supports cointegration. This suggests that the long-term impact of female employment on income distribution inequality may be weaker or vary by sector. FADL and RALS-FADL tests for LnGINI yielding different results shows the importance of not relying on a single method in cointegration analysis. Using different tests together increases the reliability of the model and allows for a more robust analysis of the long-term relationships between variables. In Veli Yılancı's (2023) study, it is emphasized that the RALS-FADL test exhibits greater statistical power and is more reliable than the traditional FADL test. In the study, unlike the FADL test, the RALS-FADL test is designed to correct non-normality and small sample problems. The simulation analyses conducted in the study are used to demonstrate that the RALS-FADL test has a higher test power and can detect the cointegration relationship more accurately. Moreover, it is stated that the FADL test can give false-negative results under structural breaks, but the RALS-FADL test provides more reliable results by better modeling such structural breaks. Consequently the RALS-FADL test provides a more robust cointegration analysis compared to

the traditional FADL test by correcting for possible distortions in the error terms and taking structural breaks into account (Yılcancı et al., 2023).

The findings for the LnGDP variable strongly confirm a cointegration association. The FADL test statistic is -4.894706, providing strong evidence of cointegration at the 1% significance level. In contrast, the RALS-FADL test result of -8.090093 indicates a statistically significant cointegration relationship at the 5% level. The findings indicate a long-term cointegration relationship between LnGDP and other variables.

Table 6. Long-Run Coefficients (FMOLS)

Dependent Variable	Independent Variable	Coefficient	Std. Dev.	Test Statistic	Probability
lnGINI	LnHIZ	-0.229379	0.016730	-13.71075***	0.0000
	LnSAN	-0.059585	0.013992	-4.258540***	0.0002
	LnTAR	-0.192849	0.015980	-12.06838***	0.0000
	LnTOP	-0.071298	0.016841	-4.233607***	0.0003
	Fixed Term	5.640226	0.163194	34.56150***	0.0000
lnGDP	LnHIZ	0.226300	0.139057	1.627387	0.1157
	LnSAN	0.031762	0.116299	0.273109	0.7869
	LnTAR	-0.273542	0.132822	-2.059462**	0.0496
	LnTOP	0.248344	0.139980	1.774143*	0.0878
	Fixed Term	8.143982	1.356455	6.003873***	0.0000

Note: Statistical significance is denoted by ***, **, and *, corresponding to levels of 1%, 5%, and 10%, respectively.

The ADL and RALS-FADL tests provide empirical evidence supporting the cointegration relationship among sectoral and aggregate female employment, income distribution and economic growth. Accordingly, FMOLS method was employed to estimate long-run coefficients and quantify the impact of women's employment-related variables on LnGINI and LnGDP, with the results presented in Table 6.

The FMOLS estimation results, as detailed in Table 4, demonstrate a statistically significant inverse relationship between LnHIZ, LnSAN, LnTAR, LnTOP, and LnGINI. A percentage point increase of one in LnHIZ decreases LNGINI by 0.229%, while LnTAR and LnSAN decrease it by 0.193% and 0.059%, respectively. LnTOP decreases income inequality by 0.071%.

FMOLS estimations reveal that the role of female employment in economic growth differs across sectors. The estimates empirically support that the empirical findings that LnHIZ and LnSAN have a positive effect on LnGDP are not statistically significant, LnTAR has a negative effect of 0.273% on LnGDP and LnTOP has a positive effect of 0.248% on LnGDP.

Following the determination of long-run coefficients for the analyzed models, an error correction model was utilized for the purpose of examining short-run dynamics. The corresponding results are presented in Table 7. The error correction terms (ECTt-1) in Table 7 are statistically significant as a measure of the speed of correction. This finding suggests that the error correction mechanism works and imbalances are eliminated over time. The ECM results reveal the short-term effects of female employment on income inequality and economic growth and the long-term equilibrium process. According to the findings in Table 7. LnHIZ, LnSAN, LnTAR and LnTOP exhibit a statistically significant negative effect on LnGINI. In particular, it is observed that an increase in LnHIZ and LnTAR significantly decreases LnGINI. In contrast, the

Table 7 shows that the observed effects of LnHIZ, LnSAN, LnTOP, and LnTAR on LnGDP are statistically insignificant.

Table 7. Findings of the ECM Test

Dependent Var.	Independent Var.	Coefficients	Test Statistic
DlnGINI	Cons.	-0.000	-0.277
	DLnHIZ(-1)	-0.112***	-4.081
	DLnSAN(-1)	-0.029**	-2.679
	DLnTAR(-1)	-0.118***	-4.068
	DLnTOP(-1)	-0.032**	-2.120
	ECT _{t-1}	-0.363**	-2.706
DlnGDP	Cons.	0.015	1.461
	DLnHIZ(-1)	0.149	0.610
	DLnSAN(-1)	0.152	0.699
	DLnTAR(-1)	-0.203	-0.788
	DLnTOP(-1)	0.108	0.825
	ECT _{t-1}	-0.477***	-2.761

Notes: Statistical significance is denoted by ***, **, and *, corresponding to levels of 1%, 5%, and 10%, respectively. The symbol 'D' represents the first difference of the corresponding variable. Lag length optimization was achieved through the application of the Akaike Information Criterion (AIC).

To examine the causal relationships among the variables, the FTY test, as proposed by Nazlioglu et al. (2016), was employed. The findings from this test are comprehensively detailed in Table 8.

Table 8. Findings of the FTY Test

Hypothesis	Optimal Frequency	Test Statistic	Boots. Pro.Value.
lnHIZ $\leftrightarrow$ lnGINI	1	6.821	1.190
lnSAN $\rightarrow$ lnGINI	1	10.331*	0.082
lnTAR $\leftrightarrow$ lnGINI	1	7.694	0.157
lnTOP $\leftrightarrow$ lnGINI	2	8.995	0.105
lnGINI $\rightarrow$ lnHIZ	1	10.016**	0.080
lnGINI $\leftrightarrow$ lnSAN	1	2.221	0.711
lnGINI $\leftrightarrow$ lnTAR	1	5.939	0.244
lnGINI $\rightarrow$ lnTOP	2	24.716***	0.002
lnHIZ $\leftrightarrow$ lnGDP	1	2.727	0.120
lnSAN $\leftrightarrow$ lnGDP	1	2.574	0.648
lnTAR $\leftrightarrow$ lnGDP	2	6.802	0.202
lnTOP $\leftrightarrow$ lnGDP	2	1.329	0.853
lnGDP lnHIZ $\leftrightarrow$	1	0.706	0.405
lnGDP lnSAN $\leftrightarrow$	1	5.168	0.316
lnGDP lnTAR $\rightarrow$	2	14.906**	0.033
lnGDP lnTOP $\leftrightarrow$	2	0.615	0.962

Note: Statistical significance is denoted by ***, **, and *, corresponding to levels of 1%, 5%, and 10%, respectively. Bootstrap p-values were estimated via 10,000 simulations.

When the findings in Table 8 are evaluated, it is determined that a unidirectional causal relationship originates from LnGINI to LnHIZ and LnTOP, but there is no significant relationship in the opposite direction. Furthermore, a unidirectional causal relationship is observed from LnSAN to LnGINI and there is no significant causality relationship between LnGDP and LnHIZ,

LnSAN and LnTOP. Finally, in the light of the data in the table, it is ascertained that a statistically significant causal influence exists from LnGDP to LnTAR.

5. Conclusion, Discussion and Recommendations

In this study, the relationship between the sectoral structure of women's employment and economic growth and income distribution in Turkey is analyzed using data on women's employment in different sectors (services, industry, agriculture) as well as overall women's employment. The research period is 1991-2023, which covers a period of intense structural transformations in the global economy and policy changes towards women's employment.

Firstly, the stationarity properties of the variables were assessed using the FADF unit root test., and when the first differences were found to be stationary, long-run relationships were estimated with the FADL and RALS-FADL methods and long-run coefficients were estimated with the FMOLS method. In addition, causality relationships between variables were analysed with the FTY causality test. The Fourier-based methods used in this study offer significant advantages in modeling the effects of structural breaks, but they may fall short, particularly in capturing sudden and high-frequency breaks (Christopoulos and Leon-Ledesma, 2010). This limitation in the interpretability of Fourier-based methods for policymakers has been taken into account, and the results have been evaluated in line with the direction and significance levels provided by the econometric tests.

Cointegration tests confirm that female employment in different sectors (services, industry, agriculture) and total female employment have a long-run relationship with income distribution and economic growth. The income distribution analysis reveals that female employment accross all sectors leads to a more equitable income distribution. In particular, female employment in the service and agricultural sectors is found to have a more pronounced effect. FMOLS estimates indicate that a 1% rise in female employment within the service sector reduces the Gini coefficient by 0.23%, while 1% rise in female employment within the agricultural sector reduces it by 0.19%. While an increase in female industrial sector employment exhibits a limited influence effect and decreases the Gini coefficient by 0.059%, an increase in total female employment leads to an improvement in income distribution by 0.071%. These findings indicate that an increase in female employment can be an effective mechanism for reducing social inequalities in the long run by reducing social exclusion. Indeed, the literature also indicates that women's labor force participation, particularly for individuals with higher education levels, has a reducing effect on income inequality (Uyanık and Yeřilkaya, 2021; Akyol Özcan, 2023), while employment in the industrial sector, although it increases production, can deepen inequality (Akyol et al., 2019; Turgut, 2019).

The findings of the analysis, in which economic growth serves as the dependent variable, suggest that female employment in the service and industrial sectors does not exert a statistically significant impact on economic growth. Within the scope of the analysis, it was identified that the rise in female employment within the agricultural sector adversely influences economic growth, with this negative impact quantified at 0.273%. This provides evidence hat women's employment in the agricultural sector is predominantly concentrated in low-productivity segments, highlighting the necessity for structural adjustments within the sector. In this regard, the study aligns with the literature that suggests the contribution of women's employment to economic

growth is sensitive to contextual factors (Pata, 2018; Özoçaklı and Palandökenlier, 2024). However, it does not fully align with the findings of Kutluay Şahin (2022), which indicate that a 1% increase in women's employment leads to a 0.95% increase in GDP. This discrepancy may arise from the study's unique methodological approach based on sectoral disaggregation, as well as variations in the dataset, analytical method, and time periods covered.

The results of causality analyses indicate the correlation between income inequality and women's employment differs across sectors. Income distribution is found to be an important factor affecting women's employment in the service sector and total women's employment. In this context, it is concluded that income distribution is a determining factor in women's employment, but changes in women's employment do not directly affect income distribution. In the industrial sector, the existence of a unidirectional relationship between women's employment and income inequality was determined, and it was concluded that the increase in women's employment affects income distribution, but there is no significant reverse causality effect. These findings largely align with the literature suggesting that women's employment in the industrial sector is influenced by supply-side factors such as production processes, technological structure, and labor demand (Blau and Kahn, 2017). Furthermore, the observation that women's employment tends to be concentrated in low-wage, temporary, or unskilled jobs (Seguino, 2000) suggests that macroeconomic variables, such as income inequality, may have a limited impact on women's employment decisions. Standing (1999) and Kabeer (2015), by emphasizing the male-dominated nature of the industrial sector, the limited social support mechanisms, and prevailing gender norms, provide insight into the structural reasons why improvements in income inequality do not necessarily lead to an increase in women's employment.

The causality test results for the economic growth variable confirm that there is no statistically significant causal relationship between the service sector, industrial sector, total female employment, and economic growth. This finding supports the view that women's employment does not directly lead to economic growth but rather exerts indirect and context-specific effects. In the literature, studies such as those by Goldin (1994) and Olivetti (2013), which suggest a non-linear, U-shaped relationship between female labor force participation and economic development, partially contrast with this finding. This implies that Türkiye's demographic and sectoral structure may not align with the stages of development posited in these models. However, a unidirectional causal link was identified, running from economic growth to female employment in the agricultural sector. This suggests that employment dynamics in the agricultural sector are highly sensitive to economic fluctuations and that the growth process plays a crucial role in shaping female labour force participation in this sector. The structural characteristics of the agricultural sector, such as low productivity levels, significant seasonal fluctuations in production processes, and widespread informal employment, create a favorable environment for sectoral expansions driven by economic growth to increase the demand for female labor (SOFA Team and Doss, 2011; Blau and Kahn, 2017). These mechanisms triggered by growth dynamics may contribute to the increase in female employment in the agricultural sector; however, the nature of this increase should be carefully evaluated in terms of women's position in the labor market and working conditions. Although no direct evidence has been found regarding the causal relationship between income inequality and female employment, the findings of Dinç (2022) and Kopuk and Meçik (2020), which identified a unidirectional causality from the agricultural sector to economic growth, highlight the potential impact of the employment structure in this sector on macroeconomic outcomes. On the other hand, the findings of Turhan and Erdal

(2022), which indicate that economic growth increases agricultural employment, present a different perspective regarding the direction of causality and underscore the need for a multidimensional evaluation of intersectoral dynamics.

The findings of the study reveal that the impacts of women's employment on economic growth and income distribution exhibit significant sectoral differences. Therefore, policy recommendations focus on empirically supported intervention areas, avoiding general directives.

The study identifies a negative impact of women's employment in the agricultural sector on economic growth, while a unidirectional causality relationship suggests that economic growth leads to an increase in women's employment. This asymmetric structure indicates that the employment expansion triggered by growth is concentrated in labor-intensive, low-wage sectors, and the employment generated in these areas remains limited in terms of productivity. Similarly, the results from the FMOLS test show that women's employment is effective in reducing income inequality in the agriculture and service sectors, but this effect is quite limited in the industrial sector. Overall, employment growth is seen as an important and functional policy tool in reducing societal inequalities. These findings highlight that women's employment should be supported not only quantitatively but also through qualitative transformation. In this regard, mechanisms that increase women's access to registered and productive forms of employment in these sectors must be strengthened. Especially considering the prevalence of low productivity and informal work in agriculture, involving women in collective production and marketing structures through cooperatives will contribute to both their economic empowerment and inclusion within social protection schemes.

However, the Women's Cooperatives Workshop Report (Ankara Development Agency, 2024) revealed that women's cooperatives face structural challenges in areas such as production capacity, access to marketing channels, financial sustainability, and governance. This situation demonstrates that cooperative-based women's employment can only be effectively implemented through supportive institutional and technical infrastructures. Therefore, consistent with the findings of the workshop report, policy tools such as needs-based training programs that enhance women's professional skills and guide them into social service-based employment areas, e-commerce and foreign trade consulting, machinery and equipment support to strengthen production infrastructure, and the expansion of social procurement mechanisms should be prioritized. Many women's cooperatives face various challenges in project development, ensuring financial sustainability, and accessing marketing channels. In this regard, strengthening women's capacity in cooperative processes through training and technical support in areas such as institutional capacity, project writing, and financial management will be beneficial, especially in rural areas, in increasing productivity and institutional resilience. Additionally, the expansion of agricultural skills development programs, the provision of practical training through farmer field schools, and the involvement of experienced female farmers as trainers will facilitate rural women's access to knowledge and enable more active participation in production processes. Furthermore, the development and accessibility of women-friendly mechanization technologies (e.g., mini grain processing machines, ergonomic carrying equipment) will make significant contributions to both reducing labor burdens and enhancing production efficiency. These holistic and gender-sensitive approaches are expected to allow for a more active, registered, and sustainable participation of women in agricultural production in Türkiye.

To strengthen women's entrepreneurship and enhance its contribution to economic development in Türkiye across the service, agriculture, and industrial sectors, the establishment of specialized financial support mechanisms (e.g., ‘Entrepreneurial Mother’ funds) aimed at balancing early parenting responsibilities with entrepreneurial activities could help reduce barriers to women's business start-up and expansion. Additionally, the establishment of sectoral accelerator programs and venture capital funds to encourage female entrepreneurship in the high-tech sector could provide opportunities for innovative and value-added ventures to emerge. Furthermore, the development of structural regulations and incentive mechanisms for large-scale institutions to include more women entrepreneurs in their supply chains, as well as the creation of an accessible and up-to-date information platform encompassing all female entrepreneur support programs, could enhance the effectiveness of the entrepreneurship ecosystem. Implementing these policy recommendations has the potential to foster the sustainable development of female entrepreneurship in Türkiye and increase its contribution to economic growth.

The findings of this study indicate that women's employment in the service sector has a significant impact on improving income distribution. However, to expand this potential to broader segments, structural adjustments are required to facilitate women's access to sustainable and productive employment in the service sector. In this context, expanding flexible working models and remote working opportunities can be effective in increasing women's participation in the labour force. Supporting digital infrastructure investments that facilitate women's teleworking, particularly in sectors such as information technologies, digital marketing, and education, along with expanding e-government-based digital work platforms and online professional development programs, can contribute to enhancing women's spatially independent productivity. Additionally, employers offering flexible and remote working opportunities should be supported through measures such as gradual premium reductions, social security incentives, and tax advantages based on performance criteria that consider the continuity and quality of women's employment. Incentive policies developed in this direction will help promote the widespread adoption of women-friendly employment models in the private sector. Although flexible working arrangements and some policies encouraging women's employment exist in Türkiye, a comprehensive and gradual incentive system combining all the aforementioned elements has not yet been widely implemented. A state-sponsored ‘Women-Friendly Workplace Certificate’ could be introduced, with gradual incentives (such as tax reductions, SSI employer premium support, and point advantages in public tenders) provided to enterprises receiving this certificate, based on indicators such as the female employment rate, the level of flexible working practices, and the duration of women's employment. These certificates are typically targeted at companies in specific sectors or of particular sizes and do not constitute a broad incentive system covering all employers. Moreover, the participation of employers in such programs is usually voluntary, leading to limited uptake. Therefore, it is crucial to develop a gradual and sustainable incentive system based on performance criteria that encourages flexible working and women's employment. This system would motivate employers to adopt women-friendly policies and could significantly increase women's participation in the labor force.

Lastly, while various awareness campaigns have been carried out in Türkiye regarding gender equality and women's employment, the majority of these initiatives tend to be short-term, general in scope, and implemented in a fragmented manner by different institutions and actors, without a comprehensive strategy. However, a need exists for specialized and thematic

communication campaigns focused on areas that directly impact women's employment, such as flexible working. These campaigns should underscore the mutual benefits of flexible work models for women, all employees, and employers; messages aimed at mitigating employers' biases regarding this issue should also be integrated. Additionally, the integration of content promoting the equitable sharing of household responsibilities among men into these campaigns and the development of sustainable collaborations with media organizations to systematically and effectively disseminate these messages across all societal segments could enhance awareness. Comprehensive measures, such as institutionalizing women-friendly flexible working systems, expanding care services, increasing sectoral skills development programs, and strengthening incentive mechanisms to facilitate women's access to productive employment, can play a crucial role in increasing women's employment. The policies and practices developed in this context will not only promote women's participation in the labor force but also foster the creation of an inclusive economic structure that supports gender equality. Should these reforms be implemented, Türkiye will be able to achieve its development goals, prioritizing both economic efficiency and social justice, in a faster and more sustainable manner.

This study aims to make an original contribution to the literature by examining the relationship between women's employment, economic growth, and income distribution in the Turkish economy at a sectoral level using annual data from the period 1991-2023. In the literature, the macroeconomic outcomes of women's employment are typically assessed through overall employment levels; however, this study conducts an in-depth analysis by considering the unique structural dynamics of each sector. Furthermore, the combined application of Fourier-based econometric methods (FADL, RALS-FADL, and Fourier Toda-Yamamoto) presents a modeling approach sensitive to structural breaks and nonlinear relationships. A long-term analytical framework encompassing transformation phases such as the pandemic and the global financial crisis deepens the sectoral impacts in a temporal context. Taken together, no study in the literature simultaneously analyzes the relationship between women's employment, economic growth, and income distribution while using Fourier-based methods. In this regard, the study distinctly differentiates itself from existing research both methodologically and theoretically.

The Fourier-based methods employed in this study offer notable advantages in modeling the effects of structural breaks; however, they may have limitations, particularly in capturing abrupt and high-frequency shifts (Christopoulos and Leon-Ledesma, 2010). This acknowledged limitation in the interpretability of Fourier-based methods for policymakers has been considered in the evaluation of the results, with potential effects arising from the nature of the method duly taken into account. On the other hand, while the study is grounded in a robust methodological and substantive foundation, certain areas require further exploration. First, the employment data used in the analysis exclude informal employment, which may lead to an underestimation of the true scale of women's employment, particularly in the agriculture and service sectors. Therefore, integrating data sources that account for informal labor could enhance the accuracy of future analyses and provide a more comprehensive picture of the actual extent of women's employment. Second, spatial variations (e.g., urban-rural, regional distributions) have not been incorporated into the study, though the regional distribution of women's employment shows significant structural heterogeneity. Thus, analyzing women's employment not only at the sectoral level but also at the regional level could provide a clearer understanding of spatial inequalities. Future research based on micro-level data that takes into account the sectoral and gender-based structure of informal employment could yield a more accurate representation of women's employment. In

conclusion, while this study has provided significant insights by thoroughly examining the relationship between women’s employment, economic growth, and income distribution at the sectoral level, it suggests that future research, by addressing the existing limitations and utilizing broader datasets and methodological approaches, will contribute substantially to the body of knowledge in this field.

Declaration of Research and Publication Ethics

This study, which does not require ethics committee approval and/or legal/specific permission, complies with research and publication ethics.

Researcher's Contribution Rate Statement

The authors declare that they have contributed equally to the article.

Declaration of Researcher's Conflict of Interest

There are no potential conflicts of interest in this study.

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PERFORMANCE ANOMALIES AND DETERMINANTS OF EQUITY FUNDS: EVIDENCE FROM TÜRKİYE*

Hisse Senedi Fonların Performans Anomalileri ve Belirleyicileri: Türkiye’den Kanıtlar

Aykan COŞKUN** 

Abstract

This study aims to contribute to the literature by examining whether the returns of equity funds represent a new source of anomaly within the framework of the Efficient Markets Hypothesis. Equity funds traded under the equity umbrella on the Turkish Electronic Fund Trading Platform have been among the highest-performing funds over the past five years. The analysis was conducted using data from 48 equity funds over the period from February 4, 2019 to January 31, 2024. In this study, the situation where equity funds outperform the BIST 100 index is defined as an "anomaly". The dependent variable is the anomaly status, while the independent variables include the number of investors in the fund, the fund’s duration of activity, fund risk, total fund value, expense ratio, and the number of shares in circulation. The findings suggest that equity funds with a higher number of investors tend to have a lower likelihood of outperforming the market. Conversely, longer activity duration, larger total fund value, and higher expense ratios are positively associated with the likelihood of exceeding market returns. However, these results should be interpreted as associations rather than causal effects due to the observational nature of the study.

Keywords:

Equity Funds,
Efficient Markets
Hypothesis,
Logistic Regression
Analysis

JEL Codes:

G02, G10, G15

Öz

Bu çalışma, hisse senedi fonlarının getirilerinin Etkin Piyasalar Hipotezi çerçevesinde yeni bir anomali kaynağı olup olmadığını inceleyerek literatüre katkıda bulunmayı amaçlamaktadır. Türkiye Elektronik Fon Alım Satım Platformu’nda, hisse senedi şemsiyesi altında işlem gören fonlar, son beş yıl içinde en yüksek performans gösteren fonlar arasında yer almıştır. Analiz, 4 Şubat 2019 ile 31 Ocak 2024 tarihleri arasındaki dönemde 48 hisse senedi fonuna ait veriler kullanılarak gerçekleştirilmiştir. Bu çalışmada, hisse senedi fonlarının BIST 100 endeksinin getirisini aşma durumu “anomali” olarak tanımlanmıştır. Bağımlı değişken anomali durumu iken, bağımsız değişkenler fondaki yatırımcı sayısı, faaliyet süresi, fon riski, toplam fon değeri, gider oranı ve tedavüldeki pay sayısını içermektedir. Bulgular, yatırımcı sayısı yüksek olan fonların piyasayı yenme olasılığının daha düşük olduğunu ortaya koymaktadır. Öte yandan, daha uzun faaliyet süresine, daha yüksek toplam değere ve daha yüksek gider oranına sahip fonlar, piyasayı yenme olasılığıyla pozitif ilişki göstermektedir. Ancak çalışmanın gözlemsel doğası gereği, bu sonuçlar nedensel etkiler değil, yalnızca ilişkisel bulgular olarak yorumlanmalıdır.

Anahtar

Kelimeler:

Hisse Senedi
Fonlar, Etkin
Piyasalar Hipotezi,
Lojistik Regresyon
Analizi

JEL Kodları:

G02, G10, G15

* This study is derived from the paper titled "A New Proposal for Testing Market Efficiency: Analyzing Equity-Heavy Fund Returns Using Logistic Regression", which was presented at the 11th International Congress on Accounting and Finance Research hosted by Bartın University.

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1. Introduction

Mutual funds are important financial instruments that allow individual and institutional investors to evaluate their savings in different asset classes (Aksoy and Tanrıöven, 2014; Münyas, 2015). In Türkiye, mutual funds operate under umbrella funds (Coşkun, 2021: 12). An umbrella fund is an investment vehicle that includes all sub-funds whose participation units are issued under a single internal statute. Among these, equity funds (EFs) stand out by offering high return potential through allocating a significant portion of their portfolios to equities. EFs are defined as umbrella funds that continuously invest at least 80% of their total value in the shares of domestic and/or foreign issuers (Capital Markets Board of Türkiye, 2024). In recent years, interest in EFs has increased in Türkiye, and these funds have begun to play an important role in meeting investors' portfolio diversification and professional management needs. As of July 2024, a total of 99 EFs were listed on the Turkish Electronic Fund Trading Platform (TEFAS), and the total size of these funds has reached approximately USD 6 billion. As illustrated in Figure 1, EFs traded under the stock umbrella category on TEFAS have delivered the highest returns over the past five years, underscoring their growing prominence in Türkiye's capital markets.

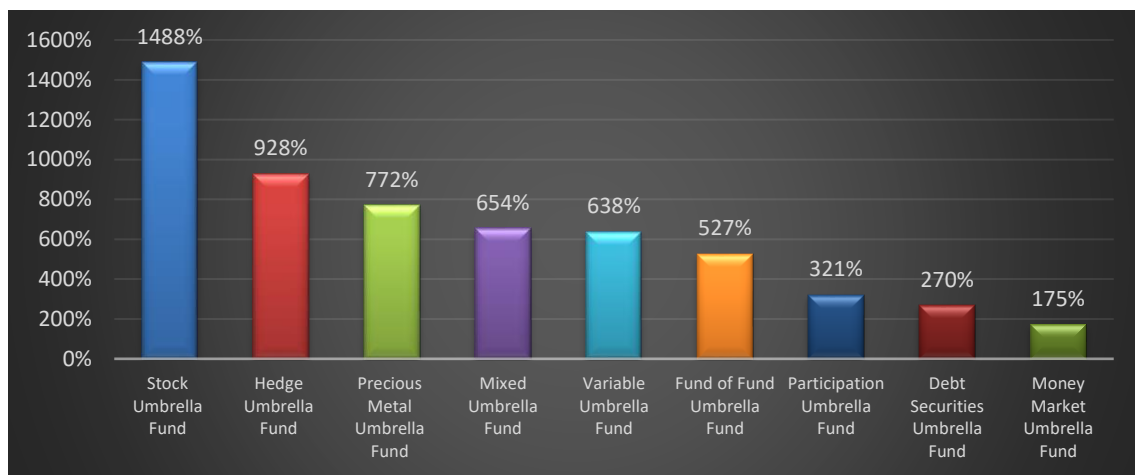


Figure 1. Cumulative Average Returns of Funds Traded on TEFAS from February 2019 to January 2024

The Efficient Markets Hypothesis (EMH) suggests that market prices reflect all available information, making it difficult to earn abnormal returns (Coşkun and Aypek, 2024). While this study evaluates anomalies through the lens of excess returns over the benchmark index (BIST 100), it also acknowledges that the term “anomaly” in the financial literature encompasses a broader set of concepts. These include risk-adjusted anomalies—such as Jensen’s Alpha and the Sharpe Ratio (Jensen, 1968; Sharpe, 1966)—calendar anomalies (e.g., day-of-the-week and January effects) (French, 1980; Lakonishok and Smidt, 1988), and behavioral anomalies arising from investor irrationality (De Bondt and Thaler, 1985). Incorporating this broader conceptual framework, the present study focuses on performance-based anomalies and investigates whether EFs traded on TEFAS consistently generate abnormal returns. Such findings would present a challenge to the notion of market efficiency. Furthermore, the study explores whether these high-performing funds, despite their strong performance over the past five years, conform to

EMH principles and whether their structural characteristics influence their return behavior. This research thereby contributes to the literature by evaluating whether EFs represent a new source of market anomaly.

Mutual funds can be managed under two main strategies: active and passive management. Actively managed funds aim to outperform the market by selecting assets through various analytical techniques (Bogle, 2007), whereas passively managed funds seek to replicate the performance of a particular index with minimal tracking error (Elton et al., 1996). In this context, EFs traded on TEFAS are generally considered passively managed funds, as their primary goal is to mirror a selected benchmark index as closely as possible rather than to generate alpha (Sharpe, 1991). For such funds, performance deviations from the index—whether positive or negative—are considered tracking error rather than indicators of managerial skill (Amenc and Le Sourd, 2003). Therefore, any evidence of excess returns among EFs must be interpreted within the context of their passive investment strategy.

Previous studies on market efficiency have generally focused on weak-form efficiency and examined calendar anomalies (Karan and Uygur, 2001; Kiymaz and Berument, 2003; Zilca, 2017; Karcioğlu, and Özer 2017). This study offers a novel perspective by analyzing the performance of EFs and investigating whether they constitute a new source of anomalies. In particular, the returns of EFs belonging to portfolio management companies and banks will be examined comparatively. In addition, BIST-KYD Government Domestic Debt Securities (GDS) All Index will be used as the risk-free return rate, and the effect of the characteristic features of EFs on excess returns will be evaluated by logistic regression analysis.

This study presents an empirical analysis using EF data obtained from the TEFAS database. The main reason for choosing logistic regression analysis is that the dependent variable is a binary (presence/absence) variable and this method is suitable for this type of data. The basic hypothesis of the study is that EFs behave in line with the market efficiency hypothesis; in other words, they do not generate excess returns. However, the possibility that some EFs may achieve excess returns if they have certain characteristic features has also been taken into consideration.

One of the main limitations of the study is the restrictions on data access. Since hedge funds do not have a daily reporting requirement, EFs belonging to these funds could not be included in the analysis. In addition, the analysis was limited to EFs traded only on the TEFAS platform, and funds on other platforms were excluded. In future studies, these results can be validated using different markets, alternative time periods, and broader datasets. In addition, more complex relationships can be examined using more advanced methods such as machine learning.

The results of this study may have important implications for investors, portfolio managers and regulators. In particular, a better understanding of the factors affecting the performance of EFs may help investors make more informed decisions.

The rest of the study is structured as follows: In the second section, the literature review on market efficiency and mutual funds is presented and the theoretical framework of the study is established. In the third section, the data set and methodology used are explained in detail. In the fourth section, the results of the empirical analysis are presented and interpreted. In the fifth

section, the main findings of the study are summarized, theoretical and practical implications are discussed, limitations are stated, and suggestions for future research are presented.

2. Summary of Literature

The literature on market efficiency and mutual funds has extensively examined the presence of anomalies and the determinants of fund performance across diverse market contexts. Among the most widely studied market irregularities is the day of the week effect, which posits that stock returns vary systematically across weekdays, thereby challenging the assumptions of the EMH. In the context of Borsa Istanbul, several studies have consistently documented abnormal returns toward the end of the trading week. Karan and Uygur (2001), analyzing data from 1991 to 1998, found that positive returns were more pronounced on Thursdays and Fridays, particularly among large-cap firms. Tunçel (2007), confirmed this pattern during the post-2001 crisis recovery period (2002–2005), reporting the highest returns on Fridays and the lowest on Mondays and Tuesdays. Atakan (2008), using ARCH-GARCH models to examine this phenomenon over a longer period (1987–2008), attributed higher Friday returns to firms’ tendency to announce positive news during the week and negative developments near the weekend. These findings point to behavioral patterns among market participants that deviate from the notion of fully rational pricing.

Comparative evidence from other emerging markets presents a more nuanced picture regarding the persistence of such anomalies. Raza et al. (2015), in their analysis of the Pakistan Stock Exchange between 1997 and 2014, observed that while the day of the week effect was present in some periods, it tended to diminish over time, indicating increasing market efficiency. Similarly, Arı and Yüksel (2017), employing GARCH and EGARCH models to the BIST100 Index (2003–2016), argued that improvements in individual financial literacy and technological access to information have led to more rational investor behavior, thereby weakening the anomaly. However, Güneş (2021), found that while the BIST100 Index no longer displayed significant weekday effects between 2011 and 2020, the KAT30 Index still exhibited negative returns on Mondays and Wednesdays, suggesting that these anomalies may persist in specific market segments.

Alongside these studies on anomalies, another strand of literature has focused on mutual fund performance as a lens to assess market efficiency and manager skill. Carhart (1997), developed a four-factor model incorporating momentum as an extension of the Fama-French three-factor model and showed that much of the persistence in mutual fund returns could be explained by factor exposures rather than superior manager skill. This model became a standard for evaluating mutual fund performance by controlling for known risk factors, including momentum, which has itself been interpreted as a market anomaly. However, despite the model's wide usage, Carhart (1997) also noted that R^2 values were generally low, implying that a significant portion of mutual fund returns remained unexplained by the model's factors. This limitation has led to the identification of fund-specific characteristics, behavioral biases, or market frictions that are not captured by traditional risk factors. Similar results in subsequent studies have reinforced the notion that fund performance is only partially attributable to systematic risks, pointing to the importance of exploring additional explanatory variables. Carhart et al. (2002), revealed that mutual fund prices tended to inflate at quarter and yearend, indicating potential window dressing practices by managers. Kaminsky et al. (2004), analyzed

Latin American funds between 1993 and 1999, finding that managers engaged in momentum strategies—buying recent winners and selling losers—especially during periods of heightened volatility. These behaviors suggest strategic timing rather than purely passive investing, raising questions about the actual efficiency of fund operations.

Subsequent studies have explored how fund characteristics influence performance. Varamini and Kalash (2008), found that mutual funds with larger capitalizations tended to yield lower returns over the 1994–2007 period, a finding that challenges the assumption that larger funds benefit from economies of scale. In the Polish context, Białkowski and Otten (2011), found that domestic funds outperformed international counterparts from 2000 to 2008, likely due to superior local information. Babalos et al. (2012), employed Data Envelopment Analysis on Greek funds and found that large funds underperformed and suffered periodic productivity losses between 2003 and 2009. In Turkey, Korkmaz and Uygurturk (2014), assessed fund performance between 2006 and 2009 using multiple risk-adjusted return measures and observed that returns across funds were relatively homogeneous, and fund managers exhibited weak market timing skills.

More recent studies have incorporated environmental and thematic perspectives into fund performance analysis. Wagner and Margaritis (2017), found that domestic Chinese funds delivered superior returns compared to foreign funds between 1992 and 2012, again underlining the advantages of local expertise. Umar et al. (2022), showed that carbon-intensive funds in China generated abnormal returns, while Ji et al. (2021), categorized funds in BRICS countries by their carbon neutrality, discovering that environmentally focused funds outperformed others. During the COVID-19 crisis, Mirza et al. (2022), demonstrated that Islamic EFs offered greater resilience compared to conventional funds, acting as safe havens during peak uncertainty. These results highlight how specific fund mandates, such as ethical, environmental, or religious criteria, can influence risk-return profiles, sometimes contradicting traditional efficiency theories.

In the Turkish mutual fund context, Çömlekçi et al. (2024), examined the performance persistence of equity-heavy funds listed on the TEFAS platform between 2010 and 2023. Their results indicate significant return continuity over three- to five-year periods, challenging the efficient market assumption that past performance is not indicative of future results. This finding suggests that in the Turkish market, at least some degree of performance predictability remains, possibly due to structural or behavioral factors not yet fully arbitrated away.

In summary, the reviewed literature indicates that while certain market anomalies—such as the day of the week effect—tend to weaken over time with increasing market maturity, they are not entirely absent. Similarly, the performance of mutual funds is influenced by a combination of manager skill, market structure, fund size, and thematic orientation. Despite the breadth of research, a comprehensive analysis combining these themes, particularly in the context of Turkish EFs, remains limited. This study aims to bridge that gap by offering an integrated assessment of fund performance anomalies and their determinants in an emerging market setting.

3. Data Set and Method

3.1. Data Set

EF participation share prices, number of shares in circulation, number of people in the fund and total fund values were obtained from the TEFAS database; portfolio management fees and activity periods were obtained from the current prospectuses on the Public Disclosure Platform; BIST100 Index and BIST-KYD GDS All Index data were obtained from the Borsa Istanbul database.

3.2. Universe and Sample

Since data from a maximum of 5 years ago can be downloaded from the TEFAS database, this study analyzed a total of 2.880 monthly observations covering 60 months for 48 EFs belonging to 28 banks and 20 portfolio management companies that consistently reported daily data between February 4, 2019, and January 31, 2024.

3.3. Data Analysis

Excel and STATA/IC 15.0 were used in the analyses. Initially, the data structure was evaluated for suitability for panel logistic regression analysis. To determine the presence of random effects, the Breusch-Pagan Lagrangian Multiplier (LM) test was applied. The LM test results are presented in Table 1.

Table 1. Breusch-Pagan LM Test for Random Effects

Component	Variance	Std. Dev.
Presence/Absence of Anomaly	0.2280302	0.4775251
e (id, t error)	0.2228356	0.4720546
u (id effect)	0.0005738	0.0239535
Test: Var(u) = 0		
chibar2(01) = 0.24		
Prob> chibar2 = 0.3135		

As shown in Table 1, the test statistics (chibar2(01) = 0.24, $p = 0.3135$) indicate that the variance of the unobserved individual-specific effect (u) is not significantly different from zero ($p > 0.05$). Specifically, the estimated variance component for the panel-level effects was very small (0.0005738), with a standard deviation of only 0.0239535. This suggests minimal heterogeneity across the EFs that is not captured by the independent variables in the model. Consequently, a pooled logistic regression approach was deemed more appropriate, as a panel model would not provide efficiency gains or account for unobserved heterogeneity. Odds ratios were calculated, and robust standard errors were used to correct for heteroskedasticity. A significance threshold of $p < 0.05$ was applied.

3.4. EF Performance Calculation

Participation shares from the TEFAS database were used to calculate EF returns, while index closing prices from Borsa Istanbul were used to calculate market returns.

$$R_i = (R_t - R_{t-1}) / R_{t-1} \quad (1)$$

In Equation (1), R_i denotes the monthly return of the fund, R_t is the participation share price on the last business day of the month, and R_{t-1} is the participation share price on the first business day of the month.

$$R_m = (R_{m,t} - R_{m,t-1}) / R_{m,t-1} \quad (2)$$

In Equation (2), represents the monthly return of the BIST100 Index, where $R_{m,t}$ is the index closing price on the last business day of the month and $R_{m,t-1}$ is the closing on the first business day of the month.

Figure 2 illustrates the average return performance of the BIST100 Index, EFs operated by portfolio management companies, EFs operated by banks, and all EFs combined for the period between February 4, 2019, and January 31, 2024.

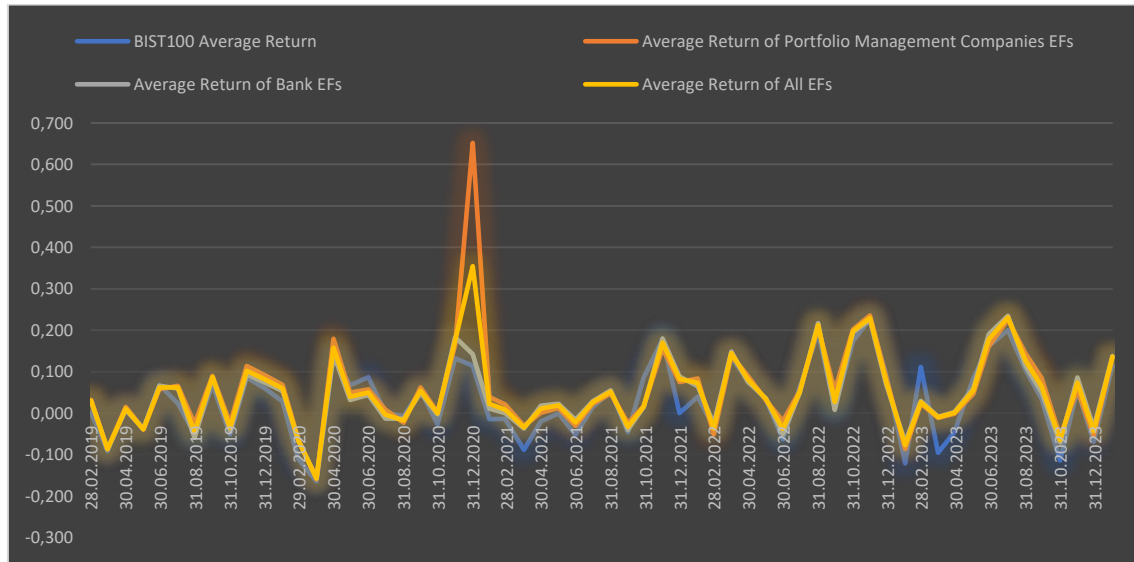


Figure 2. Average Return of BIST100 Index and EFs

As shown in Figure 2, the return trends of all groups were generally parallel over the observed period. However, a sharp increase in the average returns of EFs managed by portfolio management companies is evident toward the end of 2020. This pattern may suggest that these funds were more responsive to prevailing market conditions or that the active management strategies employed by portfolio management companies were particularly effective during that period.

Correlation analysis was conducted to determine the suitability of BIST100 Index as a performance benchmark for EF returns. The results of the correlation analysis are presented in Table 2.

Table 2. Correlation Matrix of BIST100 Index and EF Returns

Variable/Probability	BIST 100 Return	Bank EFs Return	Portfolio Management Companies EFs Return	All EFs Return
BIST 100 Return	1.000000			
Bank EFs Return	0.941653 0.0000	1.000000 -----		
Portfolio Management Company EFs Return	0.758294 0.0000	0.805295 0.0000	1.000000 -----	
All EFs Return	0.896415 0.0000	0.951986 0.0000	0.948133 0.0000	1.000000 -----

As shown in Table 2, the BIST100 Index return is strongly correlated with all EF categories: approximately 0.94 with bank EFs, 0.76 with portfolio management company EFs, and 0.90 with all EFs combined. These results indicate that the BIST100 Index is a suitable benchmark for evaluating EF returns.

Based on this, and in line with previous studies such as Korkmaz and Uygurturk (2014), Ji et al. (2021), and Mirza et al. (2022), Jensen's Alpha and the M^2 ratio were calculated using the market return, allowing fund performances to be assessed in relation to systematic risk.

Jensen's Alpha, proposed by Jensen (1968), is calculated based on the Capital Asset Pricing Model (CAPM) as follows:

$$R_{it} - R_{ft} = \alpha_i + \beta_i (R_{mt} - R_{ft}) + \varepsilon_{it} \quad (3)$$

In Equation (3), R_i represents the return of the EF, R_f is the risk-free return (represented by the BIST-KYD GDS All Index), α_i is the fund's alpha coefficient, β_i is the beta coefficient, R_m is the return of BIST100 Index and ε_{it} is the error term.

The M^2 ratio, developed by Modigliani and Modigliani (1997), is calculated by adjusting the Sharpe ratio to the market's risk level as follows:

$$M^2 = R_f + \frac{R_i - R_f}{\sigma_i} \times \sigma_m \quad (4)$$

In Equation (4), R_f denotes the average return of the BIST-KYD GDS All Index, R_i is the average return of the EF, σ_i is the standard deviation of EF return, σ_m is the standard deviation of BIST100 Index return.

Descriptive statistics of the performance indicators (M^2 and Jensen's Alpha) for bank EFs and portfolio management company EFs, reported annually, are presented in Table 3. According to Table 3, bank EFs generally exhibit positive average values for M^2 across all years. However, their average Jensen's Alpha was slightly negative in 2019 (−0.0003), indicating underperformance relative to the market. In contrast, EFs operated by portfolio management companies displayed positive average values for both M^2 and Jensen's Alpha in each year, suggesting better risk-adjusted and market-relative performance.

Table 3. Descriptive Statistics of Performance Rates of EFs by Year

		M²		Jensen's Alpha	
Years		Bank EFs	Portfolio Management Company EFs	Bank EFs	Portfolio Management Company EFs
2019	Min	0.0087	0.0142	-0.0155	-0.0100
	Max	0.0527	0.0528	0.0194	0.0194
	Mean	0.0232	0.0277	-0.0003	0.0045
	SD	0.0103	0.0099	0.0104	0.0096
2020	Min	0.0131	0.0205	0.0079	0.0119
	Max	0.0562	0.0564	0.8810	0.8751
	Mean	0.0339	0.0377	0.0582	0.0777
	SD	0.0113	0.0111	0.1588	0.1936
2021	Min	-0.0042	0.0146	0.0031	0.0202
	Max	0.0484	0.0483	0.0523	0.0408
	Mean	0.0305	0.0301	0.0333	0.0326
	SD	0.0107	0.0076	0.0094	0.0060
2022	Min	0.0604	0.0604	0.0203	0.02034
	Max	0.1037	0.1037	0.1237	0.1236
	Mean	0.0855	0.0876	0.0509	0.0544
	SD	0.0106	0.0109	0.0195	0.0223
2023	Min	0.0225	0.0225	0.0422	0.0513
	Max	0.0751	0.0751	0.0870	0.0870
	Mean	0.0513	0.0495	0.0640	0.0632
	SD	0.0142	0.0155	0.0106	0.0098

In this part of the study, it was examined whether the performance differences observed in Table 3 are statistically significant. For this purpose, the average annual performance values of each EF over the five-year period were used. A t-test was conducted to determine whether there is a statistically significant difference in performance between bank EFs and portfolio management company EFs. Descriptive group statistics for M² and Jensen's Alpha are presented in Table 4.

Table 4. Statistics of Performance Rates by Groups

Metric	Fund Type	N	Mean	SD	SE Mean
M ²	Bank EFs	140	0.0449	0.0251	0.0021
	Portfolio Management Company EFs	100	0.0465	0.0246	0.0025
Jensen's Alpha	Bank EFs	140	0.0412	0.0747	0.0062
	Portfolio Management Company EFs	100	0.0465	0.0893	0.0091

Following the group statistics, an independent samples t-test was conducted to compare the performance of EFs operated by portfolio management companies and banks. The results are presented in Table 5. As illustrated in Table 5, the comparison of the M² measure ($F = 0.064$, $p = 0.801$; $t(238) = -0.504$, $p = 0.615$) and Jensen's Alpha ($F = 0.076$, $p = 0.782$; $t(238) = -0.491$, $p = 0.624$), assuming equal variances, reveals no statistically significant differences between EFs managed by portfolio management companies and those managed by banks. Moreover, the 95% confidence intervals for both mean differences include zero, indicating that any observed differences in performance are statistically negligible.

Table 5. Comparison of EF Performance Between Portfolio Management Companies and Banks

Metric Equal Variances		F	p	t	df	Sig. (2-tailed)	Mean Difference	SE Difference	95% Confidence Interval of the Difference	
									Lower	Upper
M ²	Assumed	0.064	0.801	-0.504	238	0.615	-0.0016	0.0032	-0.0081	0.0048
Jensen's Alpha	Assumed	0.076	0.782	-0.491	238	0.624	-0.0052	0.01066	-0.0262	0.0157

3.5. Variables Used in the Study

All variables used in the analysis were constructed on a monthly basis. Detailed descriptions are provided in Table 6. As shown in Table 6, several independent variables—specifically, the Number of People in the Fund (NPF), Activity Period (AP), and Total Fund Value (TFV)—were transformed using the natural logarithm. This transformation was performed to (i) correct for positive skewness, (ii) stabilize variance and mitigate heteroskedasticity, (iii) reduce the impact of extreme values by compressing their scale, and (iv) facilitate the economic interpretation of coefficients as elasticities (i.e., a 1% change in the predictor implies an approximate percentage change in the odds of observing an anomaly).

Table 6. Variables Used in the Study

Variable	Abbreviation	Description of the Variable
Presence of Anomaly	PA	It is coded as 0 = not present, 1 = present
Number of People in the Fund	NPF	Natural logarithm of the number of investors in the fund
Net Return of the Fund	NRF	Subtracting fund expenses from fund returns
Fund Risk	FR	Standard deviation of weekly fund returns within each month
Activity Period	AP	Natural logarithm of the number of months the fund has been active
Total Fund Value	TFV	Natural logarithm of the fund's total asset value
Expense Ratio	ER	Total fund expenses divided by total fund value
Number of Shares in Circulation	NSC	Natural logarithm of the number of shares in circulation

3.6. Research Model and Hypotheses

In this study, within the framework of the EMH, it was investigated whether the net returns of EFs deviated from the return of the BIST100 Index and whether such deviations indicated the presence of an anomaly. To this end, the dependent variable—Presence of Anomaly (PA)—was defined as follows: when an EF's net return was lower than the BIST100 Index return, it was coded as 0 (no anomaly); when the net return exceeded the BIST100 Index return, indicating excess return, it was coded as 1 (anomaly). Based on this definition, the following hypotheses were formulated to test whether specific fund characteristics are associated with the likelihood of achieving excess returns:

H_{1.1}: There is a statistically significant relationship between the number of investors in the EF and the likelihood of generating excess return.

H_{1.2}: There is a statistically significant relationship between the risk level of the EF and the likelihood of generating excess return.

H_{1,3}: There is a statistically significant relationship between the number of months the EF has been active and the likelihood of generating excess return.

H_{1,4}: There is a statistically significant relationship between the total asset value of the EF and the likelihood of generating excess return.

H_{1,5}: There is a statistically significant relationship between the expense ratio of the EF and the likelihood of generating excess return.

H_{1,6}: There is a statistically significant relationship between the number of shares in circulation of the EF and the likelihood of generating excess return.

The research model was specified as follows:

$$PA = \beta_0 + \beta_1 NPFit + \beta_2 FRit + \beta_3 APit + \beta_4 TFVit + \beta_5 ERit + \beta_6 NSCit + \varepsilon_{it} \quad (5)$$

3.7. Multiple Logistic Regression Analysis and Its Application

Logistic regression analysis is widely used in the social sciences, particularly when the dependent variable is binary—such as success/failure or presence/absence. Therefore, it was deemed an appropriate method for this study. The odds ratio in logistic regression is defined as the ratio of the probability of an event occurring to the probability of it not occurring.

Let the independent variable vector be defined as $x = (x_1, x_2, \dots, x_p)$ where p is the number of predictors. The multiple logistic regression model is expressed as follows:

$$\pi(x) = \frac{e^{(\beta_0 + \beta_1 x_1 + \dots + \beta_p x_p)}}{1 + e^{(\beta_0 + \beta_1 x_1 + \dots + \beta_p x_p)}} = \frac{1}{1 + e^{-(\beta_0 + \beta_1 x_1 + \dots + \beta_p x_p)}} \quad (6)$$

The logistic regression model can also be expressed in terms of odds as follows:

$$\frac{\pi(x)}{1 - \pi(x)} = e^{\beta_0 + \beta_1 x_1 + \dots + \beta_p x_p} \quad (7)$$

Taking the natural logarithm of the odds results in the logit transformation:

$$\text{logit } \pi(x) = \ln\left(\frac{\pi(x)}{1 - \pi(x)}\right) \quad (8)$$

This transformation converts the model into a linear form:

$$g(x) = \ln\left(\frac{\pi(x)}{1 - \pi(x)}\right) = \beta_0 + \beta_1 x_1 + \dots + \beta_p x_p \quad (9)$$

4. Findings

The monthly average return of the EFs in the sample is 6.59%, its standard deviation is 0.9328499, its monthly minimum return is -22.22%, and its monthly maximum return is 1.050.16%. Other descriptive statistics are shown in Table 7.

Table 7. Descriptive Statistics

Variable	N	Mean	SD	Min	Max
BIST100 Monthly Return	2.880	3.09%	0.0876068	-16.46%	22.76%
Fund Risk	2.880	0.0316338	0.0824274	-0.05243	4.318956
Activity Period	2.880	80.79132	19.93912	21 month	121 month
Total Fund Value	2.880	₺366 million	₺901 million	₺317,346	₺11.1 billion
Number of People in the Fund	2.880	3.287.85	5.734.522	2	73.611
EF Monthly Return	2.880	6.59%	0.9328499	-22.22%	1.050.16%
Expense Ratio	2.880	0.0020859	0.000533	0.0004167	0.0029583
Number of Shares in Circulation	2.880	844.84 million	1.86 billion	524.348	14.64 billion

As shown in Table 7, the descriptive statistics reveal considerable variation across EFs, particularly in fund size, number of investors, and monthly returns. The wide range in EF returns and total fund value indicates high heterogeneity among the EFs, which supports the application of logistic regression analysis to examine the determinants of market outperformance.

In this part of the study, the significance of the logistic regression models was assessed using the Omnibus Test of Model Coefficients, and the results are presented in Table 8. According to the test results, the chi-square value was 47.012 (df = 6, $p < 0.01$) for all EFs and 45.619 (df = 6, $p < 0.01$) for bank EFs, indicating that the models are statistically significant for these groups. However, for portfolio management company EFs, the chi-square value was 6.118 (df = 6, $p = 0.410$), suggesting that the model is not statistically significant for this subgroup.

Table 8. Omnibus Tests of Model Coefficients

Fund Group	Chi-square	df	p
All EFs	47.012	6	0.000***
Bank EFs	45.619	6	0.000***
Portfolio Management Company EFs	6.118	6	0.410

Note: ***, ** and * symbols refer to 1%, 5% and 10%.

As shown in Table 8, the models for all EFs and bank EFs are statistically significant, meaning that the independent variables collectively help explain the likelihood of anomaly occurrence in these groups. In contrast, the model for portfolio management company EFs is not significant, indicating that the included predictors do not sufficiently account for anomaly presence in that subgroup.

The model summary, in which the dependent variable is explained by the independent variables, is presented in Table 9. The -2 Log Likelihood Value showing the significance of unexplained variance in the dependent variable was found to be 3.686.34 in all EFs. According to Cox&Snell R Square statistics, 1.6% of the dependent variable and 2.2% according to Nagelkerke R Square statistics were explained by the independent variables. The -2 Log likelihood value was found to be 2.172.28 in bank EFs. According to Cox&Snell R Square statistics, 2.7% of the dependent variable and 3.7% according to Nagelkerke R Square statistics were explained by the independent variables. The -2 Log likelihood value was found to be 1.498.37 in portfolio management company EFs. According to Cox&Snell R Square statistics, 05% of the dependent variable and 07% according to Nagelkerke R Square statistics were explained by the independent variables.

Table 9. Model Summary

Fund Group	-2 Log Likelihood	Cox & Snell R²	Nagelkerke R²
All EFs	3.686.34	0.016	0.022
Bank EFs	2.172.28	0.027	0.037
Portfolio Management Company EFs	1.498.37	0.005	0.007

As presented in Table 9, the pseudo R² values derived from the logistic regression models—specifically the Cox & Snell and Nagelkerke statistics—are relatively low across all fund groups. This suggests that the independent variables explain a limited portion of the variation in the presence of excess return. However, this is not uncommon in financial models, where dependent variables such as excess returns are influenced by a wide range of observable and unobservable factors. As noted by Menard (2000) and Hosmer et al. (2013), even models with low pseudo R² values can provide meaningful insights, particularly when individual predictors are statistically significant. Therefore, although the models explain only a small portion of the variation in the presence of excess returns, the statistically significant effects of certain fund characteristics suggest relevant and potentially actionable relationships that warrant further investigation.

It is recommended to work with at least 400 observations to apply the Hosmer–Lemeshow test for assessing model goodness of fit (Alpar, 2017:621). Since this study includes 2.880 observations for all EFs, 1.680 for bank EFs, and 1.200 for portfolio management company EFs, the use of the Hosmer–Lemeshow test is considered appropriate.

The results of the Hosmer–Lemeshow test, applied to evaluate how well the logistic regression models fit the data, are presented in Table 10. The significance values were found to be 0.134 for all EFs, 0.447 for bank EFs, and 0.373 for portfolio management company EFs. As all p-values exceed 0.05, it can be concluded that the models provide a good fit to the data for each group.

Table 10. Hosmer–Lemeshow Goodness-of-Fit Test

Fund Group	Chi-square	p
All EFs	12.414	0.134
Bank EFs	7.865	0.447
Portfolio Management Company EFs	8.651	0.373

Note: ***, ** and * symbols refer to 1%, 5% and 10%.

As presented in Table 10, the Hosmer–Lemeshow test results indicate that the logistic regression models fit the data well for all fund groups, as evidenced by p-values exceeding the 0.05 significance level. This suggests no significant difference between observed and predicted values, supporting the adequacy of the model fit.

In multivariate linear regression analyses, multicollinearity among independent variables can pose significant challenges, potentially distorting the estimated coefficients and compromising the reliability of the model (Gamgam and Altunkaynak, 2017: 227). Various methods are used to detect multicollinearity, one of which is the Variance Inflation Factor (VIF) (Zor and Cořkun, 2021: 338). A VIF value less than 5 is generally considered acceptable, indicating that multicollinearity is not a concern (Alpar, 2017: 508). Table 11 presents the VIF

values for the independent variables across all EFs, bank EFs, and portfolio management company EFs.

Table 11. VIF Test Results

Fund Group	Variable	VIF	1/VIF
All EFs	NPF	3.06	0.326968
	FR	1	0.998572
	AP	1.79	0.558247
	TFV	3.06	0.326968
	ER	1.17	0.853898
	NSC	1.35	0.743346
Bank EFs	NPF	2.18	0.458874
	FR	1.04	0.965505
	AP	2.76	0.3623
	TFV	3.29	0.304321
	ER	1.42	0.706234
	NSC	1.44	0.693298
Portfolio Management Company EFs	NPF	3.18	0.31424
	FR	1	0.999198
	AP	1.7	0.589426
	TFV	3.42	0.292217
	ER	1.08	0.928287
	NSC	1.39	0.718313

As shown in Table 11, all VIF values for the independent variables are below the commonly accepted threshold of 5, indicating that multicollinearity is not a concern in the models. This suggests that the independent variables included in the regression analyses do not exhibit strong linear relationships with one another, thus supporting the reliability of the regression coefficients.

In this part of the study, multiple logistic regression analysis was conducted, and the significance levels of the variables are presented in Table 12. In all EFs, a negative and statistically significant relationship was found between the number of people in the fund and excess return (Odds Ratio: 0.651, z : -5.79, $p < 0.01$). Positive and statistically significant relationships were found between the activity period of the fund (Odds Ratio: 2.424, z : 2.01, $p < 0.05$), total value of the fund (Odds Ratio: 1.294, z : 3.07, $p < 0.01$), and expense ratio (Odds Ratio: 4.35E+96, z : 2.77, $p < 0.01$) with excess return.

In bank EFs, negative and statistically significant relationships were observed between the number of fund participants and excess return (Odds Ratio: 0.582, z : -4.74, $p < 0.01$), and between the number of shares in circulation and excess return (Odds Ratio: 0.867, z : -2.41, $p < 0.05$). In this fund group, positive and statistically significant relationships were observed between activity period (Odds Ratio: 13.375, z : 3.59, $p < 0.01$) and expense ratio (Odds Ratio: 1.20E+114, z : 2.62, $p < 0.01$) with excess return.

Table 12. Logistic Regression Analysis Results

Fund Group	Variable	Odds Ratio	Robust SE	z	p	[95% Conf.Interval]	
All EFs (N: 2.880)	NPF	0.6511577	0.048211	-5.79	0.000***	0.563202	0.752849
	FR	1.015585	0.339447	0.05	0.963	0.527488	1.95533
	AP	2.423565	1.065002	2.01	0.044**	1.02425	5.734602
	TFV	1.29409	0.108843	3.07	0.002***	1.097417	1.52601
	ER	4.35E+96	3.50E+98	2.77	0.006***	1.98E+28	9.60E+164
	NSC	0.9378253	0.037299	-1.61	0.107	0.867497	1.013855
	_cons	0.1716467	0.117	-2.59	0.010	0.045126	0.6528907
Bank EFs (N: 1.680)	NPF	0.5821692	0.0664962	-4.74	0.000***	0.4653971	0.7282404
	FR	0.0793971	0.1963629	-1.02	0.306	0.0006232	10.1152
	AP	13.3753	9.660133	3.59	0.000***	3.247393	55.08997
	TFV	1.148961	0.137221	1.16	0.245	0.9091718	1.451994
	ER	1.20E+114	1.20E+116	2.62	0.009***	4.20E+28	3.50E+199
	NSC	0.8675066	0.0510589	-2.41	0.016**	0.7729894	0.9735809
	_cons	0.0487715	0.0417981	-3.52	0.000	0.0090922	0.2616144
Portfolio Management Company EFs (N: 1.200)	NPF	0.8160694	0.1217059	-1.36	0.173	0.6092306	1.093132
	FR	1.194631	0.3586755	0.59	0.554	0.6632383	2.151782
	AP	0.5698986	0.3897157	-0.82	0.411	0.1491824	2.177096
	TFV	1.243395	0.1756694	1.54	0.123	0.942648	1.640093
	ER	6.10E+105	1.10E+108	1.33	0.183	1.72E-50	2.10E+261
	NSC	0.9560433	0.0589697	-0.73	0.466	0.8471779	1.078898
	_cons	1.590544	2.170882	0.34	0.734	0.1095894	23.08463

Note: ***, ** and * symbols refer to 1%, 5% and 10%.

According to the findings in Table 12, the following comments can be made for all EFs and bank.

Number of People in the Fund (NPF): The NPF coefficient is negative and statistically significant for all EFs and banks. This indicates that the probability of anomalies decreases as the number of people in the fund increases. In other words, funds with more investors are less likely to achieve excessive returns.

Fund Risk (FR): The FR is not statistically significant for any fund group. This indicates that fund risk does not have a significant effect on excessive returns.

Activity Period (AP): The AP coefficient is positive and statistically significant for all EFs and banks. This indicates that the probability of anomalies increases as the duration of the fund increases. In other words, funds that have been in operation for a longer period are more likely to achieve excessive returns.

Total Fund Value (TFV): The TFV coefficient is positive and statistically significant for all EFs. This indicates that the probability of anomalies increases as the total value of the fund increases. In other words, larger funds are more likely to achieve excessive returns.

Expense Ratio (ER): The coefficient for ER is positive and statistically significant for all EFs and banks. This indicates that the probability of anomalies increases as the expense ratio increases. In other words, funds with higher expenses are more likely to generate excess returns.

Number of Shares in Circulation (NSC): The coefficient for NSC is negative and statistically significant for bank EFs. This indicates that the probability of anomalies decreases as the number of shares outstanding increases. In other words, funds with more shares outstanding are less likely to generate excess returns.

5. Conclusion

This study examined whether the returns of EFs in Türkiye represent a potential anomaly within the framework of the EMH. Using logistic regression analysis, the relationship between various EF characteristics and excess returns was empirically investigated. To account for heterogeneity, the analysis categorized EFs based on their ownership structure as either bank-owned or portfolio management company-operated.

A negative and statistically significant relationship was found between the number of people in the fund and excess returns for all EFs and bank-owned EFs. This finding indicates that funds with more investors are less likely to be associated with excess returns. However, no such relationship was observed between the number of people and excess returns for portfolio management companies-owned EFs. A positive and statistically significant relationship was found between the duration of activity and excess returns for all EFs and bank EFs. This association suggests that longer-established funds may be linked with a higher probability of excess returns. Again, no relationship was found between the duration of activity and excess returns for portfolio management companies-owned EFs.

For all EFs, a positive and statistically significant relationship was found between the total fund value and excess return. This may imply that larger funds are associated with better performance, possibly reflecting advantages such as economies of scale, although causality cannot be inferred. However, this relationship was not found for bank-owned EFs and portfolio management company EFs. For all EFs and bank EFs, a positive and statistically significant relationship was found between the expense ratio and excess return. This association may reflect that funds with higher expense ratios are more likely to adopt active management strategies and incur additional costs, which may be linked with higher returns in certain cases. For bank EFs, a negative and statistically significant relationship was found between the number of shares in circulation and excess return. This may indicate that as these funds grow in popularity, their likelihood of being associated with excess returns decreases. No significant relationship was found between EF risk and excess return.

The findings of this study provide important insights into the market efficiency of EFs in Türkiye. The negative correlation between the number of investors and excess returns is consistent with Białkowski and Otten (2011), who argued that greater investor participation—due to higher liquidity constraints and herding behavior—may reduce fund performance. Similarly, the positive relationship between operational duration and excess returns aligns with Kaminsky et al. (2004), who found that longer-established funds benefit from experience and greater stability in their investment strategies.

The positive association between the total fund value and excess returns suggests that larger funds can benefit from economies of scale and have access to more favorable investment opportunities, which is consistent with the findings of Wagner and Margaritis (2017). The significant positive relationship between the expense ratio and excess returns is consistent with Carhart (1997), who argues that actively managed funds may generate superior returns despite incurring higher costs. At this point, it is important to distinguish between active and passive fund management strategies. Most EFs traded on the TEFAS platform are managed passively. These funds aim to mirror the performance of a benchmark index rather than outperform it. Therefore, returns close to the benchmark are expected, and any deviation from the benchmark—whether positive or negative—is considered a tracking error rather than a

reflection of fund manager skill. In this context, the absence of consistent excess returns in many EFs aligns with the core principles of passive management. On the other hand, funds with higher expense ratios may employ more active strategies and thus take on additional risk and transaction costs, which could help explain the observed associations. This distinction is essential for properly interpreting performance differences among funds and assessing market efficiency.

Overall, these results contribute to the ongoing debate on market efficiency by highlighting how the structural characteristics of investment funds influence excess returns in Türkiye's stock-intensive fund market. While certain funds appear to deviate from the predictions of the EMH, such deviations should be interpreted as statistical associations rather than definitive causal relationships. Given the observational nature of the data, the relationships identified in this study should be interpreted strictly as correlations rather than causal effects.

This study suggests that the weak form of the EMH is not always valid for investment funds in Türkiye. In particular, it has been found that factors such as the number of people, duration of activity, total value, and expense ratio of the fund have a statistically significant association with excess returns. These findings offer important practical implications for investors, fund managers, and regulators. Investors should consider the ownership structure, operational history, fund size, and expense ratio when choosing a fund. Notably, funds with a longer track record, greater total value, and higher expense ratios tend to be associated with superior performance, though no causal inference can be made. Fund managers should take into account the number of investors, operational duration, fund size, and cost structure to enhance performance. In particular, employing experienced managers and increasing the fund's scale may be strategies worth exploring, even though this study does not establish causality. Regulators should regularly monitor the performance of investment funds to ensure transparency and investor protection. In addition, regulations could be introduced to enhance the clarity and accessibility of information on expense ratios and other costs.

The dataset is limited to EFs traded on the TEFAS platform. Funds and hedge funds on other platforms are excluded. The analysis is restricted to data from the period [Specified Period], and the robustness of the findings can be assessed using longer-term datasets. Logistic regression analysis was employed in this study; however, the results can be further validated using alternative econometric approaches and market efficiency tests (e.g., event study, GARCH models). For future research, the performance of EFs across different markets and time periods can be explored. Additionally, more sophisticated relationships could be investigated using advanced techniques such as machine learning. Research could also incorporate dimensions of behavioral finance.

Declaration of Research and Publication Ethics

This study which does not require ethics committee approval and/or legal/specific permission complies with the research and publication ethics.

Researcher's Contribution Rate Statement

I am a single author of this paper. My contribution is 100%.

Declaration of Researcher's Conflict of Interest

There is no potential conflicts of interest in this study.

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DOES GVC PARTICIPATION ENHANCE ECONOMIC PERFORMANCE? EVIDENCE FROM THE TURKISH MANUFACTURING SECTOR*

Küresel Değer Zincirine Katılım Ekonomik Performansı Artırır mı? Türkiye İmalat Sanayinden Bulgular

Ali BENLİ** & Özgür TONUS***

Abstract

This study investigates the potential economic gains for the Turkish economy from increased participation in Global Value Chains (GVCs). Participation in GVCs enables more specialized production processes, enhancing economic efficiency and leading to increased exports, value added, and employment. This study uses the CS-ARDL method through a triple regression model to estimate the effects of forward and backward GVC participation on exports, the influence of increases in exports on the share of domestic value-added in exports, and the effects of export-driven domestic value-added on employment. The research employs OECD's Trade in Value Added (TiVA) data covering the period 1995-2020 and 17 manufacturing sub-sectors of Türkiye. Findings indicate that both forward and backward participation in GVCs positively influence export performance. Increases in exports decrease the share of domestic value-added while increasing the share of foreign value-added in exports, suggesting high foreign input dependency in Türkiye's exports. Although the share of domestic value-added in exports decreases, its overall size still increases. Rises in domestic value-added also increase employment. The research shows that policies aimed at Türkiye's deeper integration into GVCs can support exports and employment.

Keywords:

Global Value Chains, Production Fragmentation, Trade in Value-Added, CS-ARDL

JEL Codes:

F12, F13, F14

Öz

Bu çalışma Türkiye ekonomisinin küresel değer zincirlerine (KDZ) katılımını artırması yoluyla elde edebileceği ekonomik kazanımları arařtırmaktadır. KDZ'ne katılım, üretime ilişkin görevlerde ileri uzmanlaşma sağlamaktadır. Bu ekonomik verimliliği artırmakta ve böylece ihracat, katma değer ve istihdam artışına yol açmaktadır. Bu çalışmada Türkiye'nin KDZ'ne ileri ve geri yönlü katılımının ihracata, ihracat artışlarının yurt içi katma değer in ihracattaki payına ve ihracata bağlı yurt içi katma değer in istihdama etkileri üçlü bir regresyon modeli üzerinden CS-ARDL yöntemi ile tahmin edilmiştir. Arařtırmada Türkiye ekonomisi için 1995-2020 dönemini ve 17 imalat sanayi alt sektörünü kapsayan OECD'nin Katma Değer Ticareti verileri kullanılmıştır. Bulgulara göre KDZ'ne hem ileri hem de geri yönlü katılım ihracat performansını olumlu etkilemektedir. İhracattaki artışlar ihracattaki yurtiçi katma değer in payını azaltmakta ve yabancı katma değer in payını artırmaktadır. Bu bulgu Türkiye'nin ihracatta yabancı girdi bağımlılığının yüksek olduğuna işaret etmektedir. Yurtiçi katma değer in ihracattaki payı azalsa da büyüklüğü yine de artmaktadır. Yurt içi katma değerdeki artışlar da istihdamı olumlu etkilemektedir. Arařtırma Türkiye'de KDZ'ne katılımı artırmaya yönelik politikaların ihracatı ve istihdamı destekleyebileceğini göstermektedir.

Anahtar

Kelimeler:

Küresel Değer Zincirleri, Üretim Parçalanması, Katma Değer Ticareti, CS-ARDL

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F12, F13, F14

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1. Introduction

Global value chains (GVCs) refer to the worldwide division of production, where the different stages and roles involved in manufacturing are distributed across different countries. The international division of production has been facilitated by the liberalization of trade and investments, reductions in shipping costs, advancements in information technologies, and innovations in logistics. The expansion of GVCs since the 1990s has played a key role in accelerating the growth of global trade volume. Approximately 43% of global merchandise trade in 2020 occurred within GVCs (World Bank, 2024).

GVCs consist of highly complex production and trade relationships. In today's global economy, trade is not just about the exchange of final goods; trade in services, intermediate goods, and specific production tasks is also growing rapidly. In some advanced manufacturing sectors, final products and their associated services are not produced in a single location or simultaneously. In GVCs, various components of a product, including its service content, are produced in different locations in the world, resulting in the final product through a sequence of stages. The phenomenon of allocating production stages to different regions across the world is known as global production fragmentation. As with the production of final goods, firms may also hold comparative advantages in specific stages of the production process. The key determinant of the international fragmentation of production is the varying levels of comparative advantage that firms hold at different stages of production. Comparative advantages in production stages stem from advanced specialization levels in the respective stages. Such comparative advantage can also stem from critical natural resources that a country holds.

Consequently, the most specialized producers in those stages globally are assigned to critical production stages in GVCs. This lowers production costs while improving the quality of the final product. Strong international trade in intermediate goods and services is a result of this kind of production structure. Over the past three decades, the volume of international trade has grown at a never-before-seen rate as a result of this shift in production and trade. New methods were required because the nature of these intricate production patterns could not be adequately explained by traditional methods and tools of trade theory. There are important theories try to explain how GVCs appear. They are Baldwin's Unbundling Economies, Trade in Tasks, and the Production Fragmentation Theory.

The process of globalization has accelerated the fragmentation of production on a global scale, leading to the emergence and expansion of GVCs. This transformation has significantly changed countries' strategies for economic integration. Developed countries, benefiting from technological advantages and capital accumulation, have secured positions in the high value-added segments of the chain. In contrast, developing countries have sought entry into GVCs through their low-cost labor and production capacities. This has led to increasing competition between developed and developing countries for deeper integration into GVCs. While developing countries strive to move up to higher value-added stages, developed countries seek to maintain their existing advantages in these segments. Such competition affects not only trade and production structures, but also in efforts to attract investment, facilitate technology transfer, and generate employment.

Expanding GVCs benefits all nations economically. By accelerating economic growth, GVCs reduce poverty and increase incomes. The World Bank (2020) found that 1% GVC

participation increases per capita income by over 1%. The source of these economic gains primarily lies in productivity increases driven by the international fragmentation of production. For developing countries, being effective in GVCs and generating income is not solely dependent on engaging in high value-added activities within GVCs. Significant income can also be generated from GVCs by specializing in the lower value-added stages of the value chain. The crucial aspect is to integrate into GVCs at stages where a high level of comparative advantage is attained. The key is to integrate into GVCs at stages where a high level of comparative advantage is held. Countries with a comparative advantage in critical tasks and high productivity can become strong global suppliers in those activities. Thus, developing countries can increase their export revenues by benefiting from GVCs.

Due to the effects mentioned above, industrialization and trade specialization based on GVCs could present a significant opportunity for Türkiye's economy to achieve rapid growth, increase its share in global trade, and consequently boost employment. Today, approximately 42% of Türkiye's exports occur within GVCs. Türkiye has the potential to increase its share in GVCs due to certain characteristics and is a strong candidate to become a key supplier within GVCs. First, Türkiye's geopolitical position provides a significant advantage. Geographically, Türkiye is located at the intersection of Europe, the Middle East, and Africa, which together constitute a substantial global market. Moreover, Türkiye holds a strategic advantage due to its proximity to the European mainland and its Customs Union with the EU.

This study investigates the hypothesis that increased participation in GVCs will lead to exports, employment and domestic value-added in Türkiye. The literature contains numerous case studies examining the value chains of specific products. Case studies are limited analyses and do not provide information about the economy's position within GVCs. In GVC research, country-level studies are also frequently encountered. In this study, a more comprehensive approach has been adopted. Sector-level studies are quite limited. The hypothesis proposed in this study has been investigated within the scope of Türkiye's manufacturing sectors. Additionally, this study examines trade volumes using value-added trade data instead of gross trade data, providing a clearer understanding of the value Türkiye generates in international trade. Analyzing GVC effects at the sectoral level and focusing on value-added in trade enhances the originality of the study and it is believed to make a contribution to the literature.

2. Theoretical Backgrounds

Classical trade theory is built on three key assumptions: (i) constant returns to scale in production, (ii) firms operating within economies are homogeneous in terms of productivity, and (iii) economies focus on producing and exporting only the final goods in which they hold a comparative advantage. Advances in trade theory have emerged as these assumptions were progressively re-examined. First, Helpman and Krugman (1985) laid the foundation for the New Trade Theory by challenging constant returns to scale assumption and introducing the concept of increasing returns to scale in production. Second, studies led by Melitz (2003) revisited the assumption that all firms operating within the same industry are homogeneous in terms of productivity and technology. Unlike classical theory, the Melitz Model acknowledges that firms within the same industry can differ in their productivity levels, technological capabilities, and ability to compete in global markets.

According to the third assumption, global trade involves only final goods, which are consumed in the importing country and are not subject to re-export. However, this assumption no longer fully reflects the current structure of international trade. Today, trade in raw materials and intermediate goods accounts for approximately 43% of total merchandise trade (World Bank, 2024). Moreover, these inputs often cross borders multiple times. While the volume of global trade is rapidly increasing, its composition and direction are also changing. Trade theory continues to evolve in response to these practical changes. At the same time, each new approach is built upon traditional foundations. The principles of comparative advantage and specialization in production, introduced by Adam Smith and David Ricardo, remain valid. However, new explanations are being developed to better understand the causes and consequences of these concepts.

Recent studies in trade theory particularly focus on the increasing share of intermediates and raw materials in global trade. These approaches, which form the basis of the GVC paradigm, are also referred to as the New-New-New Trade Theory (Inomata, 2017). According to the GVC approach, significant advancements in transportation, information, and communication technologies enable the “slicing” of production processes into various stages (Krugman, 1995). These production stages include product design, component manufacturing, sourcing, assembly, and distribution. These stages are allocated across regions based on countries' comparative advantage characteristics. Accordingly, in reality, not only final goods move across borders as predicted by classical theory, but also intermediate goods, production stages, and consequently, value-added are transferred as well.

GVCs and deep specialization, which are based on the reconsideration of the third assumption of classical theory, were initially examined within the framework of Balassa's Revealed Comparative Advantage (RCA). Subsequently, the theoretical framework expanded with various concepts such as the production fragmentation (Jones and Kierzkowski, 1990), offshoring (Arndt, 1997), vertical specialization (Hummels et al., 2001), outsourcing (Grossman and Helpman, 2005), vertical specialization networks in GVCs (Feenstra and Hanson, 2001), Baldwin's (2006) unbundling economies, and trade in tasks (Grossman and Rossi-Hansberg, 2008). The following section will discuss the theoretical approaches explaining the formation of GVCs.

GVC paradigm emerged as a result of efforts to understand the nature of the globalization of production and trade. Gereffi (1994) first introduced “global value chain”. Gereffi and Fernandez-Stark (2016) define a value chain as producers and workers' activities from product design to consumption. These include R&D, design, production, marketing, distribution, and after-sales services. The World Bank (2020) defines a value chain as a series of industrial stages that incrementally add value. A GVC has at least two stages in different countries.

2.1. Production Fragmentation

The fragmentation of production is one of the most significant impacts of globalization on production processes. This fragmentation is driven by various structural and economic factors. First, firms are relocating labor-intensive stages of production to developing countries to reduce production costs. Moreover, advancements in communication and transportation technologies have made it both technically feasible and economically advantageous to spread production

activities across multiple countries. At the same time, countries and firms aim to secure a position within GVCs by specializing in specific stages of production. Another factor accelerating this process is the ability of multinational corporations to establish global production networks. Altogether, these dynamics have led to the emergence of an increasingly fragmented and decentralized global production system.

Towards the end of the twentieth century, there was a significant decrease in the proportion of inter-industry trade within overall trade, whereas the proportion of intra-industry trade saw a substantial rise. The significant rise in intra-industry trade is largely attributed to the growth in intermediate goods trade (Ando, 2006). During the same period, it was observed that producers in developed countries segmented their production processes and relocated different stages of their production chains to various regions or countries. This phenomenon was first described by Jones and Kierzkowski (1990) as the “international fragmentation of production.” Krugman (1995) referred to this phenomenon as “slicing up the value chain,” while Feenstra and Hanson (1995) described it as “offshoring”, Feenstra (1998) termed it “disintegration of production”, Arndt (1998) called it “intra-product specialization” and Hummels et al. (2001) identified it as “vertical specialization”. The necessary conditions for global production fragmentation are as follows: (i) The production of a good must occur in two or more sequential stages, (ii) Value must be added during production in two or more countries, and (iii) At a minimum one country must incorporate imported inputs into its manufacturing operation and export a portion of the resulting output (Hummels et al., 2001).

When international trade is evaluated solely based on final goods, it becomes difficult to explain intra-industry trade solely through Ricardian productivity differences or Heckscher-Ohlin factor endowment-based comparative advantage (Jones and Kierzkowski, 2001). However, if separate stages of production are treated as distinct products, applying H-O and Ricardian productivity theories to individual stages of production provides reasonable explanations for intra-industry trade. From this perspective, differences in countries' relative factor endowments can lead to the international fragmentation of production. Labor-intensive stages of production may take place in labor-abundant, low-wage countries, while capital-intensive stages are more likely to be conducted in capital-abundant countries. Thus, the emergence of intra-industry trade can be explained through Production Fragmentation Theory.

The international fragmentation of production allows industries to achieve a higher level of specialization. A country may specialize in the production of a specific final product. However, it does not necessarily have to hold a comparative advantage in every stage of its production process. The country may face comparative disadvantages in certain stages of the product's value chain. In such cases, it can either outsource these stages to countries with a cost advantage or procure them from those countries. Consequently, the production process can be geographically distributed according to countries' comparative advantages at different stages. Antràs (2020a) refers to the phenomenon where firms or industries achieve a high degree of specialization in specific tasks or production stages, resulting from production fragmentation as “hyper-specialization.” Such specialization significantly reduces unit production costs, thereby enhancing comparative advantage and competitiveness in individual production stages. Moreover, since the 1990s, advancements in the services sector (Jones and Kierzkowski, 1990) and innovations in communication and information technologies (Acemoglu and Autor, 2011) have further accelerated the production fragmentation process.

Fragmenting production involves certain costs. Since production occurs in different locations and is carried out by various firms, it requires stringent coordination. Production coordination leads to additional costs in transportation, communication, and insurance. There is a trade-off between the costs incurred to coordinate production units located at distant points and the cost advantages provided by fragmenting production. Fragmenting production becomes economically viable when it sufficiently reduces unit costs to justify the associated coordination expenses. If coordination is required at an international level, these costs tend to be even higher. In summary, the decision to fragment production is made by evaluating the benefits against the incurred costs (Jones and Kierzkowski, 1990).

2.2. Baldwin's Unbundling Economies

Baldwin's concept of unbundling offers a distinct perspective on the phenomenon of international fragmentation of production. The unbundling concept underlines the declining need for economic activities to be carried out at the same site and simultaneously, due to cuts in transportation, communication, or face-to-face interaction expenses (Baldwin, 2016). Historically, Baldwin claims, global production has gone through three major phases; he credits changes between these phases to decreases in three major cost drivers. These are the expenses related to goods trade: transportation expenses, communication expenses required for coordinating among several sites, and the expenses connected with personal interaction, which entail physically gathering individuals.

The development of new transportation technologies and the associated logistical improvements have reduced the costs of goods trade, leading to the first unbundling. Advances in information and communication technologies, on the other hand, have reduced communication costs, which has led to the second unbundling, or the geographic spread of manufacturing operations. Currently, the costs associated with face-to-face interaction, which involve bringing people together to generate knowledge and innovation, are decreasing, facilitating the ongoing process of the third unbundling.

2.3. Trade in Tasks

Trade in tasks is another approach to explaining the fragmentation of production. In this approach, the concept of a task is defined as discrete jobs or processes within the production sequence of a product or service. Trade in tasks refers to firms purchasing certain activities in the production process from other firms. Previously, trade in tasks was limited to activities outside firms' core activities, such as human resources management, sales, and marketing. However, recent technological advancements have enabled the fragmentation of even core activities into distinct tasks across firms (Contractor et al., 2010). The trade in tasks approach was initially proposed by Grossman and Rossi-Hansberg (2008). They defined trade not merely as an exchange of goods, but as a process where value is added to the goods at different locations. Trade in tasks approach fundamentally offers those different stages of production require different labor qualifications. Grossman and Rossi-Hansberg (2008) developed a comprehensive theoretical model to analyze the effects of offshoring tasks on the relative demand for skilled and unskilled labor, and the subsequent impacts on wages and employment. The model suggests that firms can segment their production processes into specific tasks and

allocate these tasks to different regions based on comparative advantage, labor costs, and other factors. Trade in tasks also supports exports and economic growth through productivity increases (Baldwin and Robert-Nicoud, 2014). Overall trade in tasks facilitates countries' specialization in specific tasks, optimizes global production, and promotes the development of intermediate goods trade, thereby serving as one of the driving forces behind the evolution of GVCs (Gereffi et al., 2005; Baldwin and Venables, 2013).

Trade in tasks can also have some negative effects. It increases countries' dependency on each other, making them more sensitive to global shocks (Antràs, 2020b). The trade in tasks approach also implies that trading tasks will alter income distribution through its impact on labor markets. Trade in tasks raises the relative demand for skill-intensive tasks in advanced economies, while it results in greater demand for low-skilled tasks in developing economies. This situation can lead to unemployment in production factors experiencing demand decline and cause a deterioration in income distribution in the economy. The most negatively affected group is generally the unskilled labor force (Feenstra and Hanson, 1999; Hummels et al., 2018).

3. GVC Participation of Türkiye

Participation in GVCs is typically analyzed through two key components: forward and backward participation ratios. Backward participation refers to the share of foreign value added embedded in a country's gross exports, while forward participation captures the share of domestic value added that is embodied in other countries' exports through intermediate goods (OECD, 2023). These indicators are based on the decomposition method proposed by Koopman et al. (2014), and the data used in this study are sourced from the OECD's Trade in Value Added (TiVA) database. Participation data is directly provided as calculated ratios by the OECD. As such, they enable a comparative assessment of countries' positions within GVCs. These indicators provide insight into the extent to which national production processes are integrated into global networks and the degree of dependence on foreign inputs.

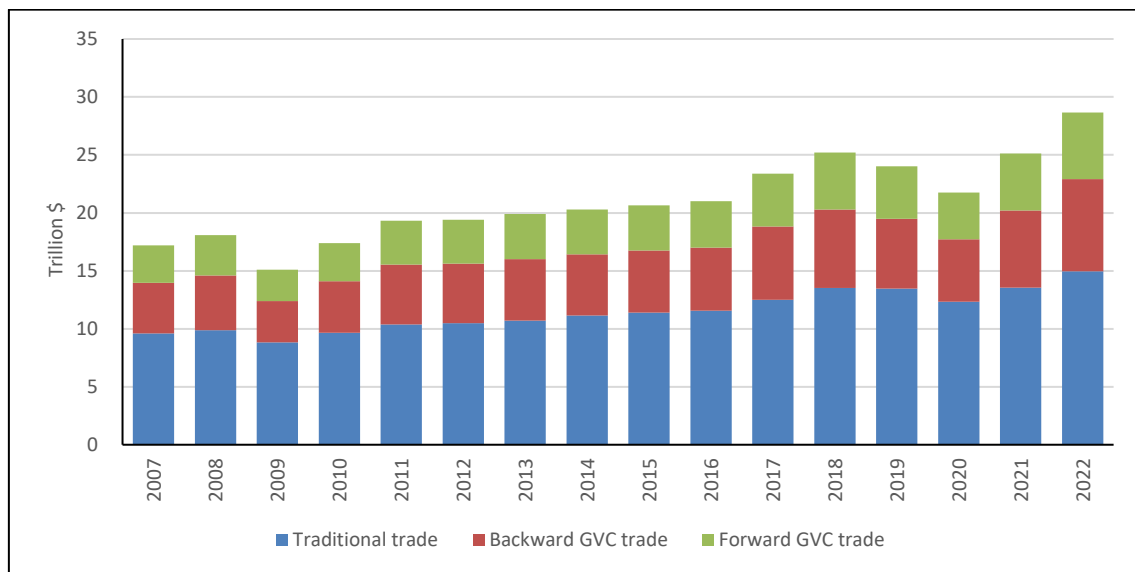


Figure 1. Composition of World Exports (in Trillion \$)

Source: Asian Development Bank, MRIO Database

The size and share of GVCs in world trade are fast growing as production gets more globalized and trade restrictions fall. Global export volume rose from \$17.2 trillion in 2007 to \$28.7 trillion in 2022 (Figure 1). GVC trade in exports has also grown rapidly. Backward GVC trade rose from \$4.3 trillion in 2007 to \$8 trillion in 2022. Forward GVC trade also rose from \$3.2 trillion to \$5.7 trillion (ADB, 2024). The shares of these amounts within total exports serve as indicators of GVC participation. Forward and backward GVC participation indicators reveal the flow of intermediate goods among countries that are involved in GVCs (UNCTAD, 2013). In 2022, the backward GVC participation rate was approximately 27.9% (\$8T / \$28.7T), while the forward participation rate was around 19.9% (\$5.7T / \$28.7T). Combined, they indicate a total GVC participation rate of nearly 47.8% of global exports.

Türkiye's The Twelfth Development Plan (2024-2028) of Türkiye emphasizes the transformation into a technology-intensive, high-value-added, export-oriented production structure that meets global standards (Presidency of Strategy and Budget, 2023). To achieve the targeted production structure, it is crucial for Türkiye to monitor its participation in GVCs and design its production and foreign trade policies based on this information. Currently, GVCs account for approximately 40% of Türkiye's exports.

Figure 2 presents the basic GVC participation indicators for 25 economies with significant shares in the global economy for the year 2020. The countries are ranked based on their total GVC participation rates. According to this, the countries with the highest GVC integration are Belgium (55.5%), the Netherlands (54.7%), and Malaysia (54.3%). Türkiye's backward participation in 2020 is 21.6%, forward participation is 17.1%, and total participation is 38.7%. The countries with the highest backward participation are Mexico (35%) and Malaysia (33.8%). Those with the highest forward participation are Russia (35.2%), the USA (27%), and Japan (26.4%).

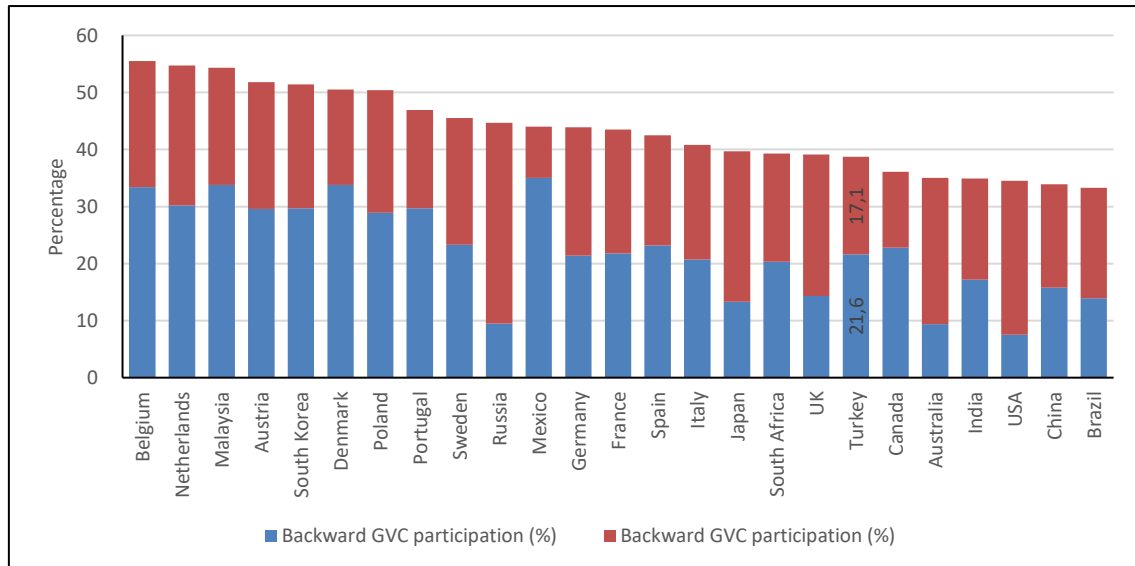


Figure 2. GVC Participation of Selected Countries, 2020
Source: OECD, TiVA

Türkiye's manufacturing exports amounted to approximately \$120 billion in 2020 (Figure 3). The growth in manufacturing exports has been particularly notable since the year 2000. In recent years, backward participation stands at 28%, forward participation at 14%, and total GVC participation at around 42%. Accordingly, about 58% of Türkiye's exports fall under traditional foreign trade, while 42% are within the scope of GVCs. During this period, the proportion of GVCs in Türkiye's total exports has risen, while the share of traditional trade in exports has declined.

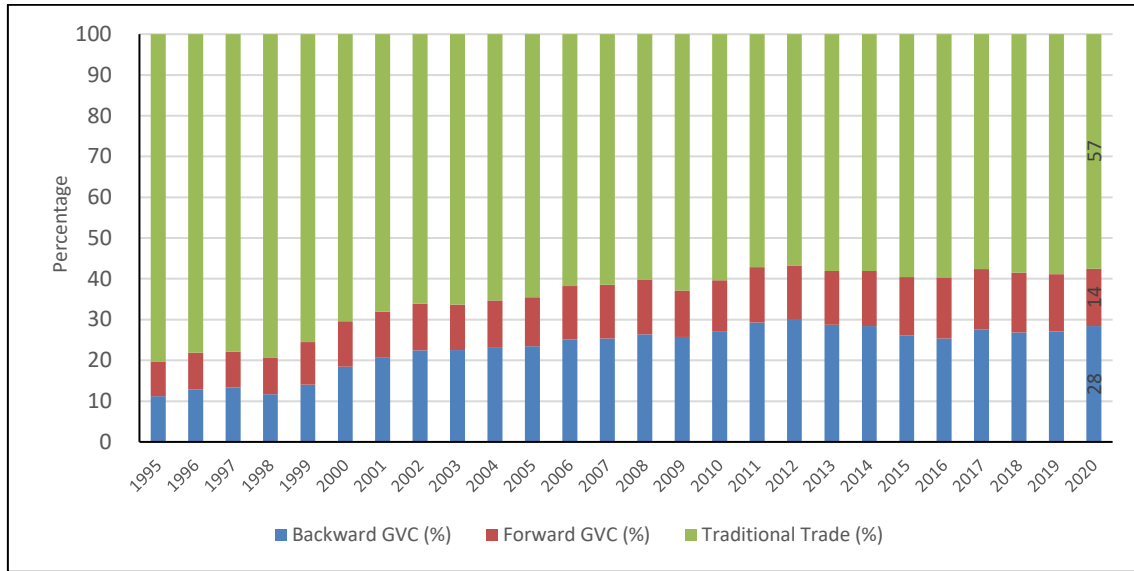


Figure 3. GVC Participation of Türkiye's Manufacturing Industry (% of Total Exports)
Source: OECD, TiVA

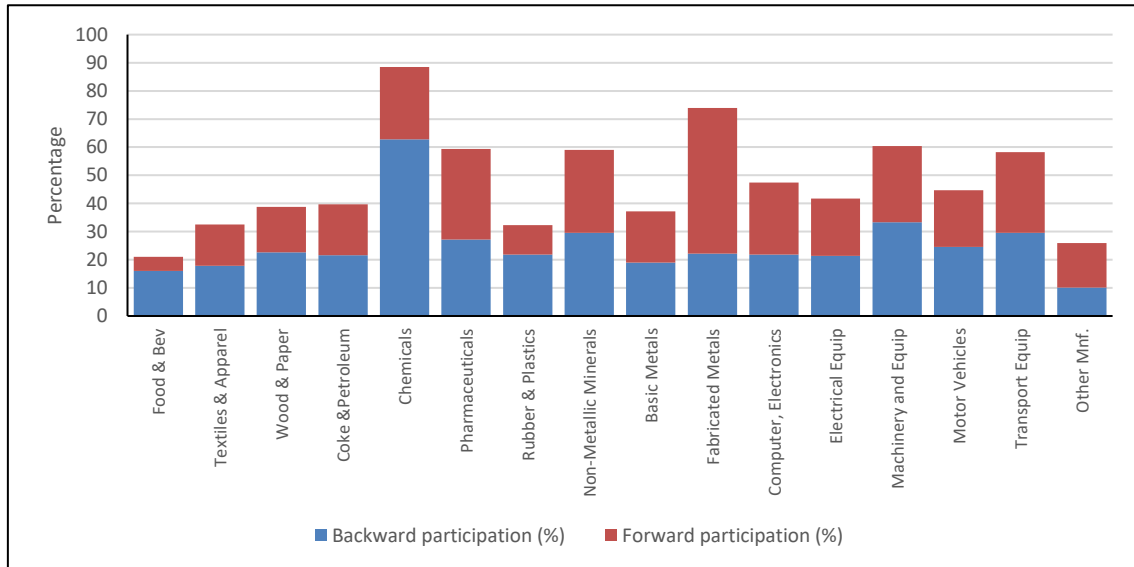


Figure 4. GVC Participation of Türkiye's Manufacturing Industry Sub-Sectors, 2018
Source: University of International Business and Economics, UIBE GVC Laboratory

Figure 4 displays forward and backward GVC participation for the sub-sectors of the Turkish manufacturing industry in 2018. The most recent data available for sub-sector GVC participation is from the year 2018. The sector with the highest total GVC participation in both 1995 and 2018 is the Coke and Petroleum industry. Despite Türkiye not being rich in fossil fuel resources, there is a significant dependency on the importation of these products for the production and exportation of the manufacturing industry. Therefore, the GVC participation level of this sector is notably high. In 1995, the sector with the lowest total GVC participation was the pharmaceutical industry, while in 2018, it was the food, beverage, and tobacco industries.

In 2018, the sector with the highest forward GVC participation was Basic Metals, accounting for 51%. In this sector, Türkiye exports significant industrial inputs for GVCs such as iron and steel. Conversely, the sector with the lowest forward participation was Food, Beverage, and Tobacco, at only 5%. This indicates that Türkiye is not a major food supplier in GVCs, with its food exports primarily involving traditional trade methods. The sector with the highest backward GVC participation in Türkiye was Coke and Petroleum, at 63%, which clearly reflects the country's dependency on imported energy. The sector with the lowest backward participation was Other Transport Equipment, at 10%, which includes ships, boats, locomotives, motorcycles, and military vehicles.

4. Effects of Türkiye's Involvement in GVCs on Exports, Value Added, and Employment

In this study, the effects of the increase in the GVC participation of Türkiye's manufacturing subsectors on Türkiye's exports (X), domestic value added in exports (DVA), and employment levels (EMP) were examined using a triple regression model. In general, an increase in a country's GVC participation is expected to increase its total exports, the absolute size of DVA and employment in exporting and export-supporting sectors.

4.1. Literature Review

Participation in GVCs has significant effects on a country's economy, particularly in the manufacturing sector. Participation can contribute to GDP growth by increasing DVA in exports (Taguchi, 2014). In countries where productivity is relatively low, GVC participation can particularly help boost productivity in the manufacturing sector (Pahl and Timmer, 2020). However, the impact of GVCs on employment is more complex. For instance, Ma et al. (2019) reports positive effects on both employment levels and composition, whereas Kummritz (2015) finds no statistically significant impact. According to Kummritz et al. (2017), GVC participation helps all income levels, but middle- and high-income countries gain the most.

A country's export performance is affected in many ways by GVC involvement. According to Ndubuisi and Owusu (2021) and Nguyen and Park (2021), involvement in GVCs enhances the diversity and quality of exports. According to Pahl and Timmer (2020) and Urata and Baek (2021) the increase in production is the main driver of GVCs' contribution to export growth. GVC participation reduces costs, improves quality, and encourages product and market diversification, which reduces export uncertainty, according to Wang et al. (2022).

Studies in the literature generally find a positive link between backward GVC participation and exports. According to Nguyen and Park (2021), backward participation is especially successful in increasing export diversification. Likewise, Fauceglia et al. (2018) and Taguchi and Thet (2021) argue that backward GVC integration improves a country's logistics performance, so promoting export expansion.

The impact of forward GVC participation on export performance is also positive. Betai and Chanda (2020) argue that forward participation enhances export complexity, thereby contributing positively to export performance. However, Nguyen and Park (2021) emphasize that while forward GVC participation plays a role in improving export diversification, its impact is not as strong as that of backward participation. Considering both types of integration, Urata and Baek (2021) find that forward and backward participation alike contribute to productivity gains and help countries advance their manufacturing processes and technological capacity.

The literature generally suggests that greater GVC participation raises DVA, but the impact varies in degree across nations with varying income levels. According to Kummritz (2015), high-income nations' importation of inputs or intermediate products from lower-wage nations reduces their manufacturing costs, therefore boosting production. To the degree of their creative abilities, lower and middle-income nations can gain from the technology developments and externalities GVCs offer. According to Kowalski et al. (2015), policy-related variables like FDI openness have a greater impact in developed countries, but structural factors like logistics, infrastructure, and institutional quality are more important in facilitating GVC integration in developing nations. In the same way, Taglioni and Winkler (2016) note that while many African nations lag behind because of poor infrastructure and institutional capacity, developing nations in Southeast Asia have effectively made the shift from low-cost assembly hubs to producers of knowledge-intensive goods.

Kummritz (2016) and Park and Park (2020) have found that forward participation is more effective at creating DVA compared to backward participation. Solaz (2018) has stated that the impact of GVC participation on value added varies across different sectors. According to Taguchi (2014), GVC integration is a dynamic process. As GVC participation increases, the manufacturing industry is transformed and shifts to more value-added production. In the process of GVC integration, the share of DVA in exports initially decreases, but as a country progresses to more advanced stages of GVCs and domestic production capacities improve, the value-added increases again.

GVCs are causing a redistribution of production roles both within countries and across borders (Grossman and Rossi-Hansberg, 2008; World Bank, 2013). Therefore, participation in GVCs can lead to short-term unemployment in some sectors or professions. GVC trade can also enhance the quality of the national workforce through demand effects, educational effects, and labor turnover effects (Taglioni and Winkler, 2016). The studies by Farole et al. (2018) and Hollweg (2019) show that the effects of GVC participation on employment vary depending on the type of GVC involvement. Forward GVC participation, associated with an increase in the export of raw materials and intermediate goods, is expected to increase the magnitude of DVA in exports and have a positive impact on employment. However, understanding the effects of backward GVC participation on value addition and employment is more complex. With backward participation, the proportion of foreign value added (FVA) in total exports is expected to rise, while the share of DVA is expected to decrease. Nevertheless, within GVCs, the critical

determinant of domestic employment levels is the absolute size of DVA, not its share in exports. Due to the country's production being oriented toward global markets within the GVC, scale and productivity effects emerge in production. Therefore, although backward GVC participation may reduce the share of DVA in total exports, it positively influences the absolute size of DVA. Indeed, Mohamedou (2019) found that manufacturing industry employment in Türkiye is positively affected by participation in GVCs.

Constantinescu et al. (2019) have demonstrated that GVC participation has a significant and strong positive impact on domestic productivity. Consequently, GVC participation can help create more employment opportunities in participating countries (Grossman and Rossi-Hansberg, 2008; World Bank, 2020). The positive productivity effect resulting from GVC participation may also put upward pressure on domestic wages (Grossman and Rossi-Hansberg, 2008; Wright, 2014).

The studies examining the impact of GVC participation on wages can be summarized as follows. Ndubuisi and Owusu (2021) suggest that GVC participation and upward specialization may lead to wage increases in developed countries; however, the effect is more complex in developing countries. In developing countries, GVC participation generally tends to increase wages, whereas upward specialization puts downward pressure on wages. This leads to two contradictory consequences. Upward specialization is the term used to describe a country's or company's emphasis on the early phases of the manufacturing process, including primary processing operations or raw material extraction. While Paweenawat (2022) underlines the skill premium in GVC-oriented industries, Lu et al. (2019) stresses the significance of labor productivity.

Shepherd (2013) suggested that GVC participation may increase the relative wages of skilled workers, which could, in turn, worsen wage inequality. By contrast, Gonzalez et al. (2015) suggested GVC participation could reduce wage disparity, especially for low-skilled workers. GVC participation and wage remain controversial.

4.1.1. Empirical Research on the Integration of Türkiye into GVCs

Academic research on Türkiye's integration into GVCs is limited. These studies provide important insights into Türkiye's production structure, trade patterns, and position within GVCs. Ziemann and Guérard (2016) argue that Türkiye's GVC participation is below its potential. Türkiye's share of foreign value added in exports (backward participation) has increased over time, the share of domestic value added in other countries' exports (forward participation) is low. Limited integration into GVCs is attributed to structural weaknesses such as institutional inefficiencies, low R&D intensity, and inadequate human capital.

Studies examining the technological dimension of GVC participation highlight similar concerns. Gündoğdu and Saracoğlu (2016) find that Türkiye's integration has progressed particularly in medium-high and high-tech sectors, but partnerships with countries like China remain concentrated in low-tech industries, hindering upward movement in GVCs. Similarly, Altun et al. (2023) show that GVC engagement with developed countries significantly boosts high-tech exports, whereas such links with lower-income countries show no meaningful effect.

At the firm and sectoral level, Kılıçaslan et al. (2021) find that participation in GVCs improves productivity, especially for SMEs in final producer positions. Yanıkkaya et al. (2024)

show that backward linkages have a positive impact on total factor productivity but a limited effect on sectoral value added. Additionally, tariff-related trade barriers are found to negatively affect sectoral performance.

From a macroeconomic perspective, Shuabiu et al. (2021) find that maintaining a competitive exchange rate facilitates deeper integration into GVCs, thereby enhancing trade competitiveness and supporting economic growth. Altun et al. (2025), concentrating on the COVID-19 era, contend that global vaccine shortages and mobility restrictions considerably decreased Türkiye's GVC participation, particularly in high-tech industries. The research emphasizes the significance of supply chain diversification and enhancements in information and communication technology and logistics infrastructure to foster resilience against such disruptions. Yanikkaya et al. (2022) study the impact of complex GVCs participation on productivity and output growth. The "learning by trading" hypothesis is supported by their findings that forward and backward linkages improve economic performance. Türkiye's participation in GVCs has increased, but the literature suggests structural reforms, improved technological competencies, and more strategic trade policies are needed to advance.

4.2. Hypotheses, Model Specification and Data

The following section describes the empirical research that tested the hypothesis that increased participation in GVCs in Türkiye increases employment, exports, and domestic value added. The study uses a panel dataset from 1995 to 2020 to examine how deeper integration into GVCs affects exports, DVA, and employment in 17 manufacturing subsectors.

As a sector's involvement in GVCs increases, its exports (x_j) are expected to increase. With the expansion of the sector's exports, the domestic value-added (DVA) in those exports will likely go up as well. Nevertheless, if export production necessitates a substantial inflow of intermediate goods imports, the absolute value of Domestic Value Added (DVA) may rise, while its proportion of total exports could diminish. Finally, an increase in DVA volume may contribute to higher export-related employment due to scale and productivity effects. To test these hypotheses, a triple regression model has been designed following the econometric approach of Veeramani and Dhir (2022).

$$\ln x_{jt} = \alpha_0 + \alpha_1 GVCb_{jt} + \alpha_2 GVCf_{jt} + \alpha_3 \ln rpr_{jt} + \alpha_4 \ln gdem_{jt} + \varepsilon_{jt} \quad \text{Model 1}$$

$$dva\_sh = \beta_0 + \beta_1 \ln x_{jt} + \beta_2 \ln rpriv_{jt} + \beta_3 \ln domact_{jt} + \mu_{jt} \quad \text{Model 2}$$

$$\ln emp_{jt} = \theta_0 + \theta_1 \ln dva_{jt} + \theta_2 \ln r_{jt} + \theta_3 \ln w_{jt} + \sigma_{jt} \quad \text{Model 3}$$

The notations j , t and $\ln$ represent the sector, year, and natural logarithm, respectively. The endogenous dependent variables in the system are as follows: (i) The value of Türkiye's exports from sector j to the rest of the world in US dollars (x_{jt}). (ii) Domestic value-added share of Türkiye's gross exports from sector j (dva_sh_{jt}). (iii) The direct plus indirect employment associated with Türkiye's exports from sector j (emp_{jt}). The key coefficients that the research focuses on are α_1 , α_2 , β_1 and θ_1 .

The variable GVC_b in Model (1) represents the indicator of backward GVC participation. It refers to the share of foreign value-added within the total value of exports from j sector. The coefficient of this variable, α_1 , is expected to be estimated with a positive sign. This is due to

the expectation that increased backward GVC participation will result in a rise in total exports, quantified in US dollars. The variable GVC_f represents the indicator of forward GVC participation. Forward participation involves DVA produced in Türkiye being exported to third countries. It is measured as the share of DVA going to third countries in total exports. It is anticipated that the coefficient alpha will be estimated to have a positive sign, indicating that an increase in forward GVC participation is predicted to positively affect the measured outcome.

In Model (2), the sign of the coefficient β_1 associated with the total export variable (lnx) could be either positive or negative. If increases in exports require significant imports of intermediate goods or inputs, the share of DVA in exports (dva_sh) may decrease, and the share of FVA (fva_sh) could increase. It is important to remember that it should not be forgotten that even if the share of DVA in exports decreases, the quantity of DVA can still increase. In Model (3), the hypothesis that a rise in domestic value-added within exports ($lndva$) will increase total employment ($lnemp$) is being tested.

The models also include control variables. The selection of control variables is based on their theoretical relevance and empirical use in sector-level studies of trade, value-added, and employment (Veeramani and Dhir, 2022). Model 1 is an estimation of an export function. A country's or sector's export performance is primarily determined by relative prices and external demand conditions; hence, control variables are selected to reflect these fundamental drivers. In this context, $rprio$ represents the relative prices in the relevant sector, and $lngdem$ represents the level of global demand. The $rprio$ variable is obtained by dividing Türkiye's sectoral output level by the output level of the same sector in the US. US prices are considered a proxy for global prices. Increases in this ratio indicate a deterioration in Türkiye's price competitiveness in the relevant sector. $lngdem$ represents the total global imports in a sector (in US dollars), weighted according to the proportion of each country in Türkiye's exports. In Model 2, the effect of export expansion on domestic value-added is analyzed. Relative value-added prices are included to control for cost competitiveness (Bems and Johnson, 2015), while the domestic activity variable captures potential substitution or complementarity between domestic sales and exports. The variable $relpriv$ is a relative price variable calculated in terms of value added. It is derived by dividing the amount of value added produced in a manufacturing sub-industry in Türkiye by the value added produced in the same sector in the USA. Since the dependent variable is expressed in terms of value added, calculating relative prices in terms of value added is more meaningful. Increases in this ratio indicate a decrease in Türkiye's price competitiveness. The variable $lndomact$ represents domestic activity. It is the difference between the gross value added produced by sector j and the domestic value added in the exports of the relevant sector. The coefficient of the variable indicates whether production for the domestic market complements or substitutes production for export. When capacity constraints are present, if an increase in domestic sales requires a decrease in exports, a substitution effect is at play, and a negative coefficient is obtained. On the other hand, if there are increasing returns to scale, or if production for the domestic market can facilitate penetration into global markets, a complementary effect exists. Therefore, the sign of the coefficient for the $lndomact$ variable depends on which effect is strong.

Model 3 is an estimation of an employment function. According to economic theory, wage levels and labor productivity are considered key determinants of sectoral employment; therefore, control variables are selected to capture these influences. In Model 3, the labor-output

ratio (*lor*) is used to account for the effect of labor intensity on employment generation within a sector. The inverse of this variable represents labor productivity. *lnwg* variable is a proxy that represents the nominal wage level. It is calculated by dividing the total labor payments in the relevant sector by the sector's total employment (Veeramani and Dhir, 2022).

The value-added trade data used in this study are drawn from the OECD's TiVA database, released in 2023. This dataset provides a long panel structure covering the period from 1995 to 2020, enabling robust country-sector level analysis for instance C10T12 Food & Beverages. In TiVA, sectors are defined based on the ISIC Rev.4 classification, and certain sectors are aggregated by grouping activities with similar production processes, input structures, and trade characteristics. Within this framework, the manufacturing sector is reported under 17 aggregated sub-sectors (Table 1). All 17 manufacturing sub-sectors have been included in the analysis, and there are no missing observations for Türkiye in the dataset. For a detailed overview of the variables, including descriptive statistics and their correlation structure, please refer to Appendix.

Table 1. Manufacturing Industry Sub-Sector Codes and Names

ISIC Rev4	Sector Abbreviations
C10T12	Food, Beverages & Tobacco
C13T15	Textiles & Apparel
C16T18	Wood & Paper
C19	Coke & Petroleum
C20	Chemicals
C21	Pharmaceuticals
C22	Rubber & Plastics
C23	Non-Metallic Minerals
C24	Basic Metals
C25	Fabricated Metals
C26	Computer, Electronics
C27	Electrical Equipment
C28	Machinery and Equipment
C29	Motor Vehicles
C30	Transport Equipment
C31T33	Other Man., repair and inst. of mach. and eq.

Source: OECD, TiVA

4.3. Preliminary Tests

The data used in the analysis are structured as panel data. According to the panel data analysis procedure, the time period (T) is compared with the number of cross-section units (N). In this study, since T is greater than N, traditional models such as fixed effects and random effects cannot be used (Zoundi, 2017). To determine the appropriate analytical method, the following steps are taken: First, cross-sectional dependence is assessed in the residuals, and slope homogeneity is examined. Second, unit root tests are conducted to determine whether the series is stationary. Third, cointegration tests are performed to establish the existence of a long-term relationship among the series. Finally, an appropriate estimator is selected to analyze both the long-term and short-term dynamics.

4.3.1. Cross-Sectional Dependency and Slope Homogeneity Tests

Externalities or unobserved common effects between cross-sections cause cross-sectional dependence (CSD). CSD test helps to decide whether first- or second-generation unit root and co-integration test is used. CSD in residuals was investigated using the Breusch and Pagan (1980) LM test, the Pesaran (2004) scaled LM test, the Pesaran (2004) CD test, and the Baltagi et al. (2012) bias-corrected scaled LM test. According to the findings presented in Table 2, the null hypothesis, which states that there is no CSD in all series, has been statistically significantly rejected, indicating that cross-sectional dependence (CSD) exists among the series.

Table 2. CSD Test Results

Variable	Breusch-Pagan LM	Pesaran Scaled LM	Bias-corrected Scaled LM	Pesaran CD
lnx	3192.16***	185.31***	184.97***	56.34***
dva_sh	2065.17***	116.97***	116.63***	44.64***
lnemp	2361.60***	134.95***	134.61***	28.85***
GVC_b	1667.91***	99.92***	99.57***	39.11***
GVC_f	1532.84***	91.20***	90.85***	30.03***
lngdem	3209.72***	186.37***	186.03***	56.50***
relprio	2440.67***	139.74***	139.40***	35.84***
ln dva	2924.65***	169.09***	168.75***	52.38***
relpriv	2035.01***	115.14***	114.80***	32.63***
lndomact	1952.83***	110.16***	109.82***	39.02***
lor	2532.80***	145.33***	144.99***	47.45***
lnwg	2197.54***	125.00***	124.66***	39.29***

Note: *** denotes statistical significance level of 1%.

The slope homogeneity in the model has been tested using the delta tests by Pesaran and Yamagata (2008) and Blomquist and Westerlund (2013). According to the findings presented in Table 3, the null hypothesis stating that the slope coefficients have a homogeneous structure has been statistically significantly rejected, leading to the conclusion that the slope coefficients in the panel exhibit a heterogeneous structure.

Table 3. Slope Homogeneity Test Results

	Pesaran, Yamagata (2008)		Blomquist, Westerlund (2013)	
	Delta	Adj. Delta	Delta	Adj. Delta
Model 1	16.245***	18.758***	10.355***	11.957***
Model 2	21.783***	23.681***	15.187***	16.510***
Model 3	21.947***	24.421***	12.499***	13.907***

Note: *** denotes statistical significance level of 1%.

4.3.2. Second-Generation Unit Root Tests

Due to the presence of cross-sectional dependence (CSD) in the residuals, second-generation unit root tests that account for CSD, specifically the Pesaran (2007) CIPS and CADF tests, have been conducted. According to the findings presented in Table 4, it has been concluded that all series, except for lngdem and GVC_b, are integrated of order one.

Table 4. Second-Generation Unit Root Test Results

Variables	Pesaran (2007) CIPS				Pesaran (2007) CADF			
	Level		First Difference		Level		First Difference	
	Constant	Constant & Trend	Intercept	Constant & Trend	Intercept	Constant & Trend	Intercept	Constant & Trend
lnx	-1.302	-1.821	-4.497***	-4.865***	-1.447	-1.800	-4.554***	-4.968***
dva_sh	-1.448	-1.856	-5.030***	-4.989***	-1.452	-1.916	-5.025***	-4.921***
lndva	-1.762	-1.998	-4.965***	-5.223***	-1.726	-1.981	-4.916***	-5.160***
lnemp	-1.534	-2.009	-4.353***	-4.654***	-1.534	-2.009	-4.495***	-4.827***
GVC_b	-2.212**	-2.388	-4.424***	-4.510***	-2.212**	-2.388	-4.424***	-4.510***
GVC_f	-2.157*	-2.555	-4.399***	-4.517***	-2.055	-2.555	-4.399***	-4.399***
lngdem	-2.733***	-3.243***	-5.539***	-5.596***	-2.624***	-3.133***	-5.539***	-5.596***
relprio	-1.940	-2.364	-4.487***	-4.659***	-1.843	-2.261	-4.487***	-4.591***
relpriv	-2.038	-2.795**	-4.905***	-5.080***	-2.055*	-2.800**	-5.018***	-5.118***
lndomact	-1.976	-2.530	-5.295***	-5.353***	-2.050	-2.530	-5.295***	-5.353***
lor	-1.511	-2.486	-4.930***	-4.990***	-1.651	-2.509	-4.930***	-4.990***
lnwg	-1.809	-2.846**	-4.443***	-4.615***	-1.764	-2.664*	-4.305***	-4.485***

Note: ***, **, and * denote statistical significance levels of 1%, 5%, and 10%, respectively.

4.3.3. Second-Generation Co-Integration Test

According to the results presented in Table 2, after detecting CSD in residuals, the use of second-generation cointegration tests is considered appropriate. Due to its ability to account for both CSD and slope heterogeneity, the Westerlund (2008) Durbin-Hausman (DH) Panel Cointegration Test was conducted. Another advantage of the Westerlund (2008) DH test is that it can be applied regardless of whether the explanatory variables are integrated. Considering that the explanatory variable lngdem is stationary at the level, the Westerlund (2008) DH test is expected to provide consistent and unbiased results. According to the findings presented in Table 5, the null hypothesis stating that there is no cointegration among the series has been statistically significantly rejected in all models based on both the DH panel and DH group statistics. This finding indicates the presence of cointegration relationships among the series.

Table 5. Westerlund (2008) Cointegration Test

	Durbin-H Group	Durbin-H Panel
Model 1	2.122**	2.144**
Model 2	3.995***	7.967***
Model 3	2.013**	1.675**

Note: *** and ** denote statistical significance levels of 1%, 5%, respectively.

As a result of the conducted tests, CSD and slope heterogeneity were identified in the dataset. Additionally, it was determined that one of the explanatory variables is stationary. Additionally, it has been confirmed that there is a cointegration relationship, indicating a long-term relationship in all models to be estimated. However, there is concern that there may endogeneity problem in the estimates. Considering all these factors, the use of the Cross-sectionally Augmented Autoregressive Distributed Lag (CS-ARDL) estimator is considered both compatible with the objectives of the study and effective in overcoming some potential econometric issues. The CS-ARDL estimator accounts for heterogeneity and endogeneity, and can also operate with series at different levels of stationarity. For these reasons, it allows for the execution of consistent and unbiased estimates.

4.3.4. CS-ARDL: Methodology and Results

CS-ARDL is designed to address both short-term dynamics and long-term relationships. It can be considered the ARDL variant of the “Dynamic Common Correlation Estimator.” (Carvelli, 2023). The Dynamic Common Correlated Effects (DCCE) method was initially developed by Pesaran (2006) and later expanded by Chudik and Pesaran (2015). Subsequently, Chudik et al. (2016) developed the CS-ARDL model, which incorporates the cross-sectional averages of variables into the analysis. The CS-ARDL model can be expressed in the form of a regression equation that depends on both the current and lagged values of dependent and independent variables. Cross-sectional averages are also included in the regression to account for cross-sectional dependence. The general form of the model is as follows:

$$y_{it} = \alpha_i + \sum_{j=1}^p \lambda_{ij} y_{i,t-j} + \sum_{j=0}^q \beta_{ij} X_{i,t-j} + \sum_{j=0}^q \gamma_{ij} \bar{X}_{t-j} + \varepsilon_{it} \quad (1)$$

Here; y_{it} : The value of the dependent variable at time t in cross-section i , α_i : Cross-section specific intercept, λ_{ij} : Coefficients for lagged values of the dependent variable, $X_{i,t-j}$: Values of the independent variables at time $t-j$ in cross-section i , $\bar{X}_{t-j}$: Cross-sectional averages of the independent variables, β_{ij}, γ_{ij} : Short and long-term coefficients of the independent variables, ε_{it} : Error term.

The CS-ARDL model can capture short-term dynamics through the short-term coefficients β_{ij} and γ_{ij} . Long-term relationships are typically expressed as the sum or ratio of these coefficients. Cross-sectional averages ($\bar{X}_{t-j}$) also help capture the impact of external factors. The error correction form of the CS-ARDL model illustrates how imbalances between short-term dynamics and long-term relationships are adjusted. The error correction form of the CS-ARDL model is as follows:

$$\Delta y_{it} = \alpha_i + \sum_{j=1}^{p-1} \lambda_{ij} \Delta y_{i,t-j} + \sum_{j=0}^q \beta_{ij} \Delta X_{i,t-j} + \theta ECT_{i,t-1} + \varepsilon_{it} \quad (2)$$

The symbol Δ denotes the first-difference operator (for example, $\Delta y_{it} = y_{it} - y_{i,t-1}$). $ECT_{i,t-1}$, is the error correction term, representing the value of the long-term disequilibrium from the previous period. This term indicates deviations from the long-term relationship. θ , is the coefficient of the error correction term. It represents the speed at which short-term imbalances adjust back to the long-term equilibrium. This coefficient is expected to be negative, indicating that deviations from the long-term equilibrium are expected to decrease over time.

The CS-ARDL model offers significant advantages. The first benefit is that it estimates short-term and long-term dynamics simultaneously. Second, it can predict stationary variables at different levels. Third, the model takes into account cross-sectional dependence by considering global shock patterns and economy-to-economy interactions. The model also accounts for heterogeneity, which can cause panel cross-section parameter differences. By considering independent variable endogeneity, the CS-ARDL model manages bidirectional causality. Finally, the CS-ARDL model addresses cross-sectional dependence, heterogeneity, and endogeneity. It makes the results more consistent and unbiased.

Table 6 shows the coefficients of Model 1, which examines the hypothesis regarding the relationship between GVC participation indicators and export volume. According to the long-term coefficients, both forward (GVC_f) and backward (GVC_b) participation in GVCs have a statistically significant positive impact on export performance (lnx). This finding supports the studies by Koopman et al. (2014), Taglioni and Winkler (2016) and, Ndubuisi and Owusu (2021). The impact of forward GVC participation on exports is stronger compared to backward participation. This finding indicates that integration into GVCs through domestically produced specific inputs is likely to generate higher export revenues. The sign of the $lngdem$ variable, which represents global demand conditions, is positive and statistically meaningful. This finding implies that Türkiye's export performance is sensitive to global demand conditions. The coefficient of the relative price variable ($relprio$) is insignificant. This finding suggests that Türkiye's export performance is not sensitive to changes in relative prices. The error correction term (ECT) has a negative coefficient (-0.710), and it is statistically significant. This finding indicates that short-term deviations are rapidly corrected, restoring equilibrium. From an economic perspective, it suggests that export mechanisms function efficiently and that sectors are resilient to shocks.

Table 6. Relationship between GVC Participation and Exports (Model 1)

Dependent Variable: Δlnx	Coefficient	Standard Error	Probability
Short run			
$\Delta lnx(-1)$	0.290***	0.050	0.000
ΔGVC_b	0.195	0.467	0.677
ΔGVC_f	4.630***	1.368	0.001
$\Delta GVC\_b(-1)$	-0.044	0.467	0.925
$\Delta GVC\_b(-2)$	1.617***	0.320	0.000
$\Delta GVC\_f(-1)$	-1.186	1.026	0.248
$\Delta relprio$	0.126***	0.046	0.006
$\Delta relprio(-1)$	-0.007	0.032	0.813
$\Delta relprio(-2)$	0.004	0.017	0.806
$\Delta lngdem$	0.514***	0.071	0.000
Long run			
GVC_b	2.788**	1.101	0.011
GVC_f	4.683***	1.700	0.006
$lngdem$	0.735***	0.107	0.000
$relprio$	0.120	0.089	0.174
ECT	-0.710***	0.050	0.000
Number of obs.	336		
R^2 (MG)	0.58		
Number of groups	17		

Note: ***, **, and * denote statistical significance levels of 1%, 5%, and 10%, respectively.

Table 7 shows the estimated coefficients of Model 2, which investigates the impact of export growth on the share of domestic value added (dva_sh) in exports. According to the long-term coefficients, increases in exports result in a decrease in the share of domestic value added (dva_sh) in exports. This also implies that increases in exports lead to a rise in the share of FVA in exports. This indicates that greater exports in Türkiye's manufacturing industry require more foreign inputs and intermediate goods, consistent with empirical results observed in developing countries. This finding is similar to the studies by Antràs and Chor (2013) and Koopman et al. (2014).

Table 7. Relationship between Exports and the Share of DVA (Model 2)

Dependent Variable: Δdva_sh	Coefficient	Standard Error	Probability
Short run			
$\Delta dva\_sh(-1)$	0.150***	0.031	0.000
$\Delta \ln x$	-5.239***	1.111	0.000
$\Delta \ln domact$	-0.022	1.187	0.985
$\Delta \ln domact(-1)$	3.256***	0.879	0.000
$\Delta relpriv$	0.817	0.675	0.226
$\Delta relpriv(-1)$	-1.354*	0.766	0.077
Long run			
$\ln x$	-6.248***	1.384	0.000
$\ln domact$	3.964**	1.571	0.012
$relpriv$	-0.561	1.091	0.607
ECT	-0.850	0.031	0.000
Number of obs.	391		
R ² (MG)	0.75		
Number of groups	17		

Note: ***, **, and * denote statistical significance levels of 1%, 5%, and 10%, respectively.

The sign of *relpriv*, the relative price variable calculated in terms of value added, is insignificant. This implies that the share of domestic value added in exports is insensitive to changes in relative prices. The coefficient of *ln domact* is positive and statistically significant. This finding suggests that accelerations in domestic activity led to an increase in the share of domestic value added. The positive coefficient also indicates that domestic sales and exports are complementary rather than substitutes. In other words, production for the domestic market is accompanied by an increase in production for exports.

Table 8 presents the coefficients of Model 3, which examines the hypothesis regarding the relationship between employment and domestic value added in exports. According to the long-term results, the coefficient of *ln dva* has been found to be positive and statistically significant. Although increases in exports decrease the share of DVA within total exports, the total size of DVA still increases. This finding, as also identified by Mohamedou (2019), shows that increases in export-driven domestic value-added (DVA) positively affect employment in the Turkish manufacturing sector.

The labor-output ratio, denoted by *lor*, has a positive and significant sign. This finding indicates that an increase in the labor intensity of the sector generates more employment. Considering that Türkiye is a labor-intensive country and that labor intensity is typically high in manufacturing industry production, it is reasonable to estimate a positive coefficient. The inverse of the labor-output ratio also represents labor productivity. Accordingly, increases in labor productivity reduce employment. In economic theory, the relationship between labor productivity and employment is generally considered negative. If a company or economy has high labor productivity, it can produce more with fewer workers. In this case, increased efficiency can directly lead to a need for fewer employees. Finally, the variable *lnw* represents the nominal wage level and its coefficient is significantly negative, consistent with economic theory.

Table 8. Relationship between DVA and Employment (Model 3)

Dependent Variable: $\Delta \ln emp$	Coefficient	Standard Error	Probability
Short run			
$\Delta \ln emp(-1)$	0.037	0.030	0.218
$\Delta \ln emp(-2)$	0.044*	0.027	0.095
$\Delta \ln dva$	0.088***	0.023	0.000
$\Delta \ln dva(-1)$	0.018	0.023	0.443
$\Delta \ln dva(-2)$	0.057***	0.010	0.000
$\Delta \ln or$	0.156**	0.063	0.014
$\Delta \ln wg$	-0.200***	0.038	0.000
$\Delta \ln wg(-1)$	0.012**	0.012	0.339
Long run			
$\ln dva$	0.184***	0.035	0.000
$\ln or$	0.172**	0.079	0.029
$\ln wg$	-0.222***	0.052	0.000
ECT	-0.918***	0.045	0.000
Number of obs.	391		
R ² (MG)	0.71		
Number of groups	17		

Note: ***, **, and * denote statistical significance levels of 1%, 5%, and 10%, respectively.

4.3.5. Robustness Test

Table 9 presents the results from FMOLS, DOLS, and 3SLS estimations conducted for robustness checks. FMOLS and DOLS are frequently used for robustness checks of CS-ARDL estimates (Kuo et al., 2022; Deka et al., 2023; Uddin et al., 2023). In this study, 3SLS is preferred over 2SLS in this study due to control for both endogeneity and cross-equation error correlations. The 3SLS method estimates the three equations simultaneously, thereby addressing both endogeneity and cross-equation error correlations in a unified framework (Yap and Allen, 2011; Silpachai, 2023).

Table 9. Robustness Tests: FMOLS, DOLS and 3SLS

Variable	3SLS			FMOLS			DOLS		
	Coef.	Std. Error	Prob.	Coef.	Std. Error	Prob.	Coef.	Std. Error	Prob.
Dependent Variable: $\ln x$									
GVC_b	1.837	0.430	0.000	1.604	0.304	0.000	3.042	0.818	0.000
GVC_f	3.902	0.543	0.000	4.362	0.503	0.000	5.153	1.655	0.002
relprio	0.027	0.002	0.000	0.159	0.018	0.000	0.120	0.041	0.004
$\ln gdem$	0.636	0.046	0.000	0.699	0.046	0.000	0.518	0.014	0.000
Dependent Variable: dva_sh									
$\ln x$	-7.040	0.457	0.000	-5.798	0.544	0.000	-6.039	0.621	0.000
$\ln domact$	0.238	0.032	0.000	2.023	0.639	0.017	2.077	0.866	0.017
relpriv	6.282	0.580	0.000	-0.029	0.038	0.452	-0.040	0.035	0.255
Dependent Variable: $\ln emp$									
$\ln dva$	0.666	0.014	0.000	0.145	0.031	0.000	0.519	0.087	0.000
$\ln or$	0.661	0.033	0.000	0.071	0.046	0.128	0.170	0.114	0.136
$\ln wg$	-0.318	0.040	0.000	-0.134	0.036	0.000	-0.182	0.075	0.017

The empirical model comprises three equations estimated simultaneously, with exports ($\ln x$), domestic value-added share (dva_sh), and employment ($\ln emp$) treated as endogenous

due to simultaneity and potential reverse causality. Since these sectoral outcomes are shaped within a common economic environment and subject to shared macroeconomic shocks, their interdependence and correlated error terms must be taken into account. Each equation includes theoretically informed exogenous regressors—such as *GVC_b*, *GVC_f*, relative prices, global demand, wages, and productivity—which also function as instruments for the endogenous variables. Unlike 2SLS, 3SLS jointly estimates the system while exploiting its covariance structure, thereby producing more efficient and reliable estimates. This makes 3SLS particularly well-suited for capturing the complex interactions underlying sectoral dynamics in the context of GVC participation. The results of the robustness checks are generally consistent with the CS-ARDL outcomes. Specifically, the focal variables *GVC_b*, *GVC_f*, *lndva*, and *lnx* coefficients are complied with the CS-ARDL findings in the robustness checks.

In the robustness tests, contrary to the CS-ARDL estimates, the coefficient for *relprio*, which represents relative prices, is estimated to be positive and significant. In Model 2, the estimation for *lndomact* is consistent with the CS-ARDL findings. The relative price variable, *relpriv*, calculated based on added value and the labor-output ratio, *lor*, are significantly positive in the 3SLS estimations, but insignificant in the FMOLS and DOLS estimations. Finally, the coefficient for the proxy variable representing nominal wages, *lnwg*, is negatively significant in all checks and consistent with the CS-ARDL estimates.

In conclusion, the findings from the CS-ARDL estimates are generally consistent with those obtained from robustness checks. While the signs of the variables focused on in the research are directly consistent with CS-ARDL estimations, a few control variables' coefficients differ. Based on this information, it can be concluded that the estimated coefficients are robust.

5. Discussion

The findings of this study are generally consistent with the existing literature, although they show limited divergence at certain points. Results show that both forward and backward GVC participation have a statistically significant and positive impact on Türkiye's exports. This finding aligns closely with the expanding literature emphasizing how GVC integration can enhance trade performance in developing economies. In this regard, the current findings are consistent with the key studies which emphasize the role of backward participation in improving export diversification and quality (Veeramani and Dhir, 2022; Nguyen and Park (2021); Ndubuisi and Owusu, 2021). Similarly, Betai and Chanda (2020) argue that forward participation enhances export sophistication and contributes to the growth of export volumes. Research focused on Türkiye offers parallel results. For instance, Altun et al. (2023) highlight that GVC integration with developed countries supports high-tech exports, while Ziemann and Guérard (2016) observe that increasing backward participation has strengthened Türkiye's export capacity over time. However, some studies contend that the impact of forward participation is weaker than that of backward participation (Nguyen and Park, 2021). These discrepancies may stem from differences in model specifications, country samples, or measurement approaches to GVC participation.

The results also show that backward GVC participation increases domestic value added by stimulating exports. This supports the argument that GVCs expand production scales and promote DVA through trade channels, as suggested by Taguchi (2014), Urata and Baek (2021),

and Pahl and Timmer (2020). A particularly noteworthy finding of this study is that while the share of DVA in exports tends to decline with increased exports, the absolute level of DVA still rises. This indicates a high dependency on imported inputs in Türkiye's export sectors. Similar patterns have been noted in the literature. For example, Kummritz (2015) and Taglioni and Winkler (2016) argue that backward integration can lead to a higher share of foreign value added (FVA), thereby reducing the relative share of DVA, even as the total amount of DVA increases due to rising export volumes.

Findings of the study indicate that GVC participation supports domestic employment by influencing exports and DVA. This result is consistent with the findings of Farole et al. (2018) and Hollweg (2019), who emphasize the role of demand-side and scale-related mechanisms in creating jobs through GVC integration. In the context of Türkiye, Mohamedou (2019) provides evidence of a positive link between GVC participation and employment in the manufacturing sector. However, Yanıkkaya et al. (2024) argue that while GVC integration enhances total factor productivity, its impact on sectoral employment remains limited. In this regard, the present study contributes to the literature by highlighting the indirect and compound channels through which GVCs can influence employment in developing economies.

6. Conclusion

This study empirically tests the hypotheses that Türkiye's increased participation in GVCs will enhance export revenues, that an increase in exports will raise the share of DVA in exports, and that an increase in DVA will boost employment. These hypotheses have been estimated using the CS-ARDL method on a panel data set covering the period 1995-2020 and 17 manufacturing sub-sectors of the Turkish economy.

The findings of this study are consistent with those of other key studies. According to the results, increases in forward and backward participation in GVCs both positively impact Türkiye's exports. Increases in exports reduce the share of DVA in exports and increase the share of FVA. This indicates that the production of export goods is highly dependent on foreign inputs. This finding is consistent with research conducted on developing countries which generally require more foreign inputs to increase their production. As the share of domestic value added in exports increases, its impact on export-based employment is positive. Conversely, increases in labour productivity have been observed to negatively affect employment. Additionally, the impact of nominal wage levels on employment has been identified as negative. In summary, GVC participation positively affects exports, value-added, and employment in the Turkish manufacturing industry through the scale and efficiency effects it generates.

The findings suggest that Türkiye's export policy should focus on GVCs. Greater integration into GVCs presents a significant opportunity for the Turkish economy to increase its export revenues. Türkiye should design its industrial and trade policies with a GVC-focused approach to capitalize on this opportunity. Firstly, Türkiye should identify the industrial sectors and specific production tasks where it has a comparative advantage. Secondly, the key products or tasks demanded by GVCs should be identified. Priority sectors can be determined by matching GVC demands with the sectors in which Türkiye holds a comparative advantage. By providing the necessary incentives to priority sectors, production growth and higher levels of

specialization in these sectors can be achieved. Greater specialization leads to higher productivity. Productivity increases lead to cost reductions, thereby enhancing Türkiye's competitiveness in global markets. Increases in exports can support Türkiye's economic growth and employment. Thirdly, steps can be taken to remove trade barriers in strategic markets identified for GVC participation. This would reduce trade costs and enhance export potential. For instance, the possibility of expanding the scope of the Customs Union between Türkiye and the EU can be reconsidered. While GVC participation improves export performance and employment through scale and efficiency effects, it also shapes the structural transformation of the domestic economy. As a developing country, for Türkiye, integration into GVCs can serve as a catalyst for industrial upgrading, technological learning, and international collaboration. However, these benefits are contingent on the Türkiye's capacity to move toward higher value-added segments within GVCs and to retain sufficient domestic value in its exports.

Despite the economic gains, increased backward integration into GVCs also raises concerns regarding dependency on foreign inputs. As observed in the findings rising exports have coincided with a decline in the share of domestic value added, highlighting Türkiye's reliance on imported intermediates. This dependency can increase vulnerability to external shocks, such as global supply chain disruptions, energy price volatility, or geopolitical tensions. Therefore, Türkiye's GVC strategy should be balanced with policies to strengthen domestic input production and supply chain resilience.

Recent global developments—such as the COVID-19 pandemic, rising geopolitical fragmentation, and shifts in global trade architecture—have prompted countries to reassess their positions in GVCs. Concepts like reshoring, nearshoring, and friendshoring are becoming increasingly prominent, especially in Europe and North America. Türkiye, with its geographic proximity to EU markets and its established manufacturing base, is well-positioned to benefit from these shifts. To secure a competitive and resilient role within reconfigured value chains, policymakers should actively align Türkiye's trade and industrial strategies with these evolving global dynamics.

In conclusion, this study has reconfirmed the positive effects of GVC participation on exports, value added, and employment using a unique dataset. Türkiye should increase its integration into strategic areas of GVCs to benefit from the potential gains. The methods for determining the sectors and tasks where Türkiye has an advantage in GVCs, the products and tasks needed by GVCs, and how the identified sectors can be incentivized, are potential topics for future GVC research.

Declaration of Research and Publication Ethics

This study, which does not require ethics committee approval and/or legal/specific permission, complies with the research and publication ethics.

Researcher's Contribution Rate Statement

The authors declare that they have contributed equally to the article.

Declaration of Researcher's Conflict of Interest

There are no potential conflicts of interest in this study.

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APPENDIX

Table A1. Descriptive Statistics of Variables

	lnx	dva_sh	lnemp	GVC_b	GVC_f	lngdem
Mean	7.55	74.76	4.92	0.22	0.16	11.33
Median	7.55	76.55	5.07	0.22	0.15	11.40
Maximum	10.14	93.80	7.26	0.63	0.52	13.44
Minimum	3.92	14.50	1.65	0.02	0.02	9.04
Std. Dev.	1.28	11.16	1.22	0.11	0.08	0.97
Skewness	-0.19	-1.58	-0.56	1.23	1.22	-0.25
Kurtosis	2.52	7.57	3.07	5.87	6.01	2.38
Jarque-Bera	6.95	569.17	22.90	227.96	239.91	11.81
Probability	0.03	0.00	0.00	0.00	0.00	0.00
Sum	3338	33043	2174	86	62	5006
Sum Sq. Dev.	728	54946	655	4	3	414
Observations	442	442	442	384	384	442
	relprio	lndva	relpriv	lndomact	lor	lnwg
Mean	9.85	7.72	9.03	7.25	2.41	9.13
Median	4.98	7.64	4.40	7.16	2.46	9.23
Maximum	123.29	9.89	116.59	9.92	4.48	11.06
Minimum	0.27	5.18	0.43	3.81	-1.04	6.56
Std. Dev.	18.75	0.96	17.69	1.27	1.02	0.85
Skewness	4.73	-0.09	4.57	-0.06	-0.97	-0.61
Kurtosis	26.04	2.70	24.42	2.41	4.79	3.35
Jarque-Bera	11423	2.28	9989	6.75	129	30
Probability	0.00	0.32	0.00	0.03	0.00	0.00
Sum	4354	3411	3991	3203	1065	4036
Sum Sq. Dev.	155085	403	137976	706	458	321
Observations	442	442	442	442	442	442

Table A2. Correlation matrix of the variables for Model 1

Model 1	lnx	GVC_b	GVC_f	relprio	lngdem
lnx	1.000	0.237	0.399	0.519	0.666
GVC_b	0.237	1.000	0.455	-0.088	0.330
GVC_f	0.399	0.455	1.000	0.000	0.354
relprio	0.519	-0.088	0.000	1.000	0.259
lngdem	0.666	0.330	0.354	0.259	1.000

Table A3. Correlation matrix of the variables for Model 2

Model 2	dva_sh	lnx	relpriv	lndomact
dva_sh	1.000	-0.229	0.161	0.259
lnx	-0.229	1.000	0.514	0.525
relpriv	0.161	0.514	1.000	0.415
lndomact	0.259	0.525	0.415	1.000

Table A4. Correlation matrix of the variables for Model 3

Model 3	lnemp	lndva	lor	lnwg
lnemp	1.000	0.625	0.607	-0.586
lndva	0.625	1.000	-0.154	0.130
lor	0.607	-0.154	1.000	-0.843
lnwg	-0.586	0.130	-0.843	1.000

ASSESSING CORPORATE SUSTAINABILITY IN TURKISH BANKS: WASPAS AND ARAS APPROACHES IN THE COVID-19 AND THE POST-COVID-19 ERA*

COVID-19 ve Sonrası Dönemde Türk Bankalarında Kurumsal Sürdürülebilirliğin Değerlendirilmesi: WASPAS ve ARAS Yaklaşımları

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Abstract

As sustainability becomes an ever-larger structural imperative, particularly in emerging markets, banking's contribution to sustainable development is becoming more important. Sustainability performance of banks during the COVID-19 pandemic year (2020) and recovery period (2022) is analyzed by an innovative approach based on seven large-sized Turkish banks. Data based on 75 criteria and 7 dimensions consistent with international standards (GRI, UNGC, UNEP FI) were collected from banks' sustainability reports through content analysis. The data are analyzed by applying three goal-programming objective methods (MEREC, CILOS, CCSD) and two CRM (Compromise Ranking Methods) methods (WASPAS and ARAS). The outcome shows that commercial banks perform better than state-owned banks. The primary explanations for this are commercial banks' effective governance frameworks, improved transparency, and investor pressures. Banks gave priority to measures such as SME support and employee health for resilience in the pandemic period, and to measures such as green finance, transformation, and innovation for the recovery period. The poor performance of state-owned banks during these periods indicates that policy-specific interventions are urgently needed. This article fills an important gap in sustainability literature for emerging markets and offers a handy benchmark for policymakers, investors, and banking institutions regarding systemic distortions and long-term strategic overhaul.

Öz

Sürdürülebilirlik, özellikle gelişmekte olan piyasalarda gittikçe yapısal bir zorunluluğa dönüşürken bankacılık sektörünün sürdürülebilir kalkınmadaki rolü giderek daha kritik hale gelmektedir. Bu çalışmada, Türkiye’de aktif büyüklüğü açısından en yüksek yedi banka kullanılarak COVID-19 krizi yılı (2020) ve takip eden toparlanma dönemi (2022) için bankaların sürdürülebilirlik performansı yenilikçi bir yöntemle değerlendirilmiştir. Uluslararası standartlarla (GRI, UNGC, UNEP FI) uyumlu 75 kriter ve 7 boyutu içeren veriler bankaların sürdürülebilirlik raporlarından içerik analizi yoluyla elde edilmiştir. Elde edilen veriler üç objektif ağırlıklandırma yöntemi (MEREC, CILOS, CCSD) ile birlikte iki ÇKKV tekniği (WASPAS ve ARAS) kullanarak analiz edilmiştir. Bulgular, ticari bankaların kamu bankalarına kıyasla daha yüksek performans gösterdiğini ortaya koymaktadır. Ticari bankaların güçlü yönetim yapıları, daha yüksek şeffaflık düzeyi ve ticari bankalarda yatırımcı baskısının daha fazla olması bunun başlıca nedenleri olarak gösterilebilir. Pandemi döneminde bankaların çalışan sağlığı ve KOBİ desteği gibi kısa vadeli direnç önlemlerine öncelik verdiğini, toparlanma sürecinde ise yeşil finansman, dijital dönüşüm ve inovasyon gibi uzun vadeli stratejilere odaklandığı söylenebilir. Kamu bankalarının her iki dönemde de görece düşük performans sergilemesi, bu konuda belli başlı politika müdahaleleri gerekliliğini ortaya koymaktadır. Bu çalışmada, gelişmekte olan piyasalardaki sürdürülebilirlik çalışmalarındaki önemli bir boşluğu doldurmakta olup politika yapıcılar, yatırımcılar ile finansal kurumlar için sistemik bozulmalar ve uzun vadeli stratejik dönüşüm süreci açısından pratik bir kıyaslama aracı sunmaktadır.

Keywords:

Corporate Sustainability, Banking Sector, WASPAS, ARAS.

Jel Codes:

A10, Q50, D70.

Anahtar

Kelimeler:

Kurumsal Sürdürülebilirlik, Bankacılık Sektörü, WASPAS, ARAS.

JEL Kodları:

A10, Q50, D70

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1. Introduction

Life's sustainability upon our planet is an essential priority, given that human existence is intrinsically connected to natural ecological balances. The balance, though, is progressively threatened by such global issues as climate change, environmental degradation, and social inequality. For example, military expenses globally exceeded \$2 trillion in 2022, while an estimated 828 million humans endured hunger (SIPRI, 2022). These contrasting figures demonstrate how imperative it is to adopt sustainable practices of development that combine economic, environmental, and social aspects to address the welfare of current and future human populations.

Sustainability has emerged as an absolute necessity for businesses and financial institutions globally. Following an upsurge of consciousness of environmental, social, and governance or ESG factors, companies now engage extensively in voluntary disclosure of their sustainability initiatives (Davis and Searcy, 2010). Of these, the banking sector has a singular role to play owing to its dual role of a capital intermediary and a systemic-change inducer (Beck et al., 2000; Decker, 2004). Banks are distinct from other businesses, which tend to react to pressures from outside, by proactively incorporating sustainability into their activities, directing capital towards green assets and minimizing long-term risks.

As facilitators of sustainable development, not only are banks driving responsible investment, but economic resilience is also promoted through new and innovative funding mechanisms. This has been deepened by increasing demand for sustainable finance and reputational risk concerns linked to their Environmental, Social, and Governance (ESG) performance (Decker, 2004). Nowhere is this seen more heavily than in emerging markets such as Turkey, where banking has become a regional leader for sustainability uptake. The Turkish Banks Association (TBA) launched, in 2022, a landmark “Sustainability Strategic Plan,” harmonizing a nation's goals with the UN Sustainable Development Goals (SDGs). Turkish banking has also led the uptake of international reporting frameworks, such as the Global Reporting Initiative (GRI), the United Nations Global Compact (UNGC), and the Carbon Disclosure Project (CDP).

Notwithstanding these advances, significant knowledge gaps exist in the literature. Much existing research has concentrated primarily upon developed economies to the extent that emerging markets' sustainability dynamics, especially their banking sectors, are not very well understood. Furthermore, although the COVID-19 pandemic caused unprecedented shocks, scholars have not extensively reviewed how banks evolved from managing crises to long-term sustainability measures upon recovery.

This article fills key knowledge gaps through three core innovations. First, it offers a contextual contribution by presenting the first comprehensive assessment of sustainability performance in Turkey's banking sector during and after the COVID-19 pandemic, treating 2022 as a distinct transitional year. Methodologically, the study integrates internationally recognized frameworks—UNGC, UNEP FI, and GRI—with two advanced Multi-Criteria Decision-Making (MCDM) methods, WASPAS and ARAS. This combination yields a robust, transparent model based on 75 criteria across seven sustainability dimensions. On a practical level, the findings serve as a benchmarking tool for both banks and policymakers, enabling them to align emerging market practices with global standards while addressing domestic socio-economic priorities.

Structurally, the paper is organized as follows. Section 2 presents the conceptual framework, followed by a review of the relevant literature in Section 3. Section 4 details the data and methodology used in the study. Sections 5 and 6 focus on the application of the ARAS and WASPAS methods and the subsequent sensitivity analysis. Finally, Section 7 discusses the policy implications, and Section 8 concludes the paper with a summary of key findings.

2. Conceptual Framework

The idea of sustainability took center stage globally when the Brundtland Report (WCED, 1987) formulated sustainable development as “meeting present needs without compromising the ability of future generations to meet their own needs.” This original vision was enacted through the Triple Bottom Line (TBL) approach (Elkington, 1997), which brings together economic, ecological, and social factors. Early discussion treated these pillars separately, but newer scholarship highlights their interconnections: ecological degradation, like climatic variations, fuels social injustice, which further destabilizes economies (Eccles et al., 2020). Sustainability today is therefore conceived of not merely as an outcome but also as a process of dynamic balance to be sought after.

Corporate sustainability evolved out of these pressures, compelling companies to balance profitability and planetary and social well-being (Dyllick and Hockerts, 2002). Banks, unlike manufacturing companies, leave little direct environmental footprint, but their lending choice creates widespread systemic impacts. Banks heavily influence sustainable outcomes across sectors through such a “multiplier effect” (Aras et al., 2018). This makes them key facilitators of the United Nations SDGs, especially when lending practices are aligned with global sustainability goals (UNEP FI).

To provide transparent and consistent reporting on sustainability performance, a number of global frameworks have been created. The GRI offers general-purpose measures of ESG factors. The Sustainability Accounting Standards Board (SASB) deals with sector-specific and financially material measures, and the Integrated Reporting Framework (IR) brings together finance and non-finance reporting to evaluate long-term value creation. To address fragmentation, the International Sustainability Standards Board (ISSB) has been formed to consolidate these practices into a global benchmark. The United Nations Environment Programme Finance Initiative (UNEP FI), meanwhile, has brought forward Principles for Responsible Banking (2019), which mandates bankers to ensure their plans are SDG and Paris Agreement-aligned.

Turkey's banking sector has been increasingly integrating sustainability through a dual-track approach. On the internal side, banks have implemented ESG risk scoring models and embedded sustainability considerations into their governance structures, guided by strategic sectoral planning. On the external front, there has been a noticeable rise in the use of green finance instruments, including the issuance of green bonds and the alignment of loan portfolios with SDGs, particularly in areas such as renewable energy and energy efficiency. These developments reflect a growing alignment with international sustainability standards and a proactive effort to localize global frameworks within the Turkish financial ecosystem.

The COVID-19 pandemic served as a structural watershed moment for the banking sector. It revealed critical vulnerabilities in social inclusion, such as unequal access to digital

services and economic resilience, particularly for small and medium-sized enterprises (SMEs). In response, Turkish banks shifted their focus toward promoting decent work and economic growth, increasing lending for working capital, and accelerating digital transformation. This shift was evident in a sharp rise in mobile banking usage, highlighting how quickly institutions adapted to changing needs. The period underscored the urgency of updating sustainability priorities within the TBL model to better address real-time systemic shocks.

The present research fills an essential gap in the literature by connecting the pandemic's crisis (2020) and recovery/transition (2022) periods and developing a new analytical framework to reflect how banking institutions rebalanced their sustainability agendas throughout these periods. Using a content analysis of integrated reports combined with MCDM methods, our research presents an empirical examination of how Turkish banking institutions responded to changing global frameworks and existing local conditions through their sustainability policies.

To guide this analysis, the central research question posed is: How did Turkish banks perform in terms of sustainability during the pandemic and recovery periods (2020 and 2022), and what institutional or structural factors explain the observed differences across bank types (commercial vs. state-owned)?

3. Literature Review

Considering the paucity of MCDM-based applications within the banking sustainability literature, this study synthesizes existing works that have integrated MCDM with econometric and statistical approaches to identify key methodological limitations addressed in the present analysis. Notably, most prior studies have focused on developed economies, relied on single-criterion assessment models, and were conducted before the COVID-19 pandemic and the subsequent post-crisis recovery phase—conditions that limit their applicability to emerging markets such as Turkey during periods of systemic disruption and recovery.

Applications of MCDMs in Banking Sustainability methods have been of specific benefit when dealing with intricate trade-offs between ESG factors in banking. Aras et al. (2016) employed entropy-weighted TOPSIS to order Turkish banks based on 49 indicators, ranking Ziraat Bank as the top sustainability performer. Analysis depth, though, was limited by available indicators. Rebai et al. (2016), by contrast, combined AHP and TOPSIS for French banks and concluded that expert weightings have a significant effect upon sustainability rankings—a conclusion which underpins our entropy-CRITIC hybrid weightings. The Polish banking sector has been assessed by Korzeb and Samaniego-Medina (2019), who concluded that domestic institutions perform better than foreign institutions due to their stronger national policies for sustainability, an observation that resonates with post-2020 regulatory policy plans presented by TBA. A common disadvantage to these exercises, though, has been reliance upon a single MCDM method, opening to potential methodological bias. Dual utilization of WASPAS and ARAS by our exercise corrects for that.

Outside of MCDM, econometrics emphasizes the systemic function of policy and institutional quality in determining sustainable banking. Weber (2016) proved that China's green credit policies resulted in a 12% enhancement of ESG performance, stressing the regulatory lever—a relatively untapped area of Turkey. Yip et al. (2018) compared green banking across 20 countries and identified a 9% decrease in emissions, but their 1995–2015 dataset omits post-

Paris Agreement scenario developments. Úbeda et al. (2022) attributed 63% of the sustainability performance difference among 46 countries to institutional drivers such as control of corruption and rule of law, which could equally count for enhanced banking sustainability improvements under recent governance reforms and ISSB alignment.

Turkey-specific evidence indicates an increasing commitment to sustainability frameworks but a lack of consideration for the COVID-19 period. Aras and Mutlu (2022) used ARAS to order public banks' ESG performance, but their dataset for 2018–2019 does not reflect responses during the period of crises. Jan et al. (2023) demonstrated that green banking adds to profitability within emerging markets but did not include Turkey during the pivotal 2020–2022 period. This temporal blind spot constrains the applicability of current models to the post-pandemic Turkish setting.

Three critical limitations dominate the current literature. First, Methodological Narrowness: Too much dependency upon individual tools (TOPSIS, regression). We combine WASPAS and ARAS approaches using three different weight sets (MEREC, CILOS, CCSD), thus obtaining solid, unbiased results. Second, Developed-Country Bias: Bibliometrics indicate that research on sustainable finance is heavily focused within developed nations, especially the United Kingdom, China, America, Switzerland, and Japan, and emerging markets are substantially underrepresented in existing literature (Kashi and Shah, 2023). The current study helps balance out such bias by examining Turkey, an important emerging economy that has changing ESG frameworks. Third, Temporal Blindness: The majority of analyses employ pre-2020 datasets, excluding how the pandemic has affected sustainability strategy. Comparing 2020 (crisis year) and 2022 (recovery year), we outline how Turkish banks adjusted their sustainability agendas by reprioritizing among TBL aims of economic sustainability, social responsibility, and stewardship of the environment.

Theoretically, the contribution of this research lies in bringing UNEP FI's sustainability standards together within a quantitative MCDM framework, closing the gap between qualitative ESG disclosure and evidence-backed decision-making. From a policy-making perspective, our 75-criterion model is synchronized with the ISSB's 2023 global baseline, which provides a benchmark tool to enable regulators to fairly compare and contrast the sustainability performance of Turkish banks with EU counterparts.

In recent years, numerous studies have been conducted to evaluate ESG performance in the banking sector using MCDM methods. For instance, Karki et al. (2025) integrated the R-SWARA method to determine the weights of ESG sub-factors and the CoCoSo method to rank ESG performance, identifying governance as the most decisive dimension (Karki et al., 2025). Similarly, Yu et al. (2024) employed an interval type-2 fuzzy AHP and CoCoSo hybrid model to assess ESG sustainability performance in the corporate context (Yu et al., 2024). While these studies typically focus on a single sector, time frame, or corporate setting, the present study contributes to the literature by analyzing the ESG performance of the Turkish banking sector in two critical years—2020 (pandemic) and 2022 (recovery)—and by applying a comparative approach through the integrated use of WASPAS and ARAS methods, supported by multiple objective weighting techniques. This provides both methodological and contextual novelty to the field.

4. Data and Methodology

The sustainability performance of listed banks in Turkey is assessed in this study. There are seven commercial banks listed and publishing regular sustainability reports, namely Akbank, Garanti Bank, Halkbank, İşbank, Yapı Kredi, Vakıfbank, and Ziraat Bank. The years 2020 and 2022 are considered for examination to analyze how the COVID-19 pandemic and recovery period affected sustainability performance across Turkish banks. This period allows a comparative examination of sustainability strategies by banks before and after the pandemic's peak.

Table 1. Criteria and Codes

No	Dimension Analyzed	Code
1	Strategic Analysis	C1
2	Corporate profile	C2
3	Economic	C3
4	Environmental	C4
5	Social	C5
6	Product responsibility	C6
7	Administrative	C7

Note: The ESG criteria presented in Table 1 have been structured based on the GRI standards (notably series 200, 300, and 400) and the UNEP FI Principles for Responsible Banking. Each indicator was selected in alignment with these frameworks and adapted to the context of the banking sector.

To ensure a comprehensive assessment, sustainability criteria were structured across seven key dimensions, as presented in Table 1. Data were extracted from the integrated reports published by the selected banks, following an in-depth content analysis approach.

4.1. Justification for the Content Analysis Method

Content analysis is a systematic, replicable method for transforming qualitative textual data into quantifiable metrics, allowing objective comparison of corporate sustainability disclosures (Krippendorff, 2018). This study employs computer-assisted content analysis using NVivo Pro 11.0, following best practices in ESG research (Hussain et al., 2018). By integrating standardized global frameworks and automation tools, the methodology ensures both reliability and cross-bank comparability.

This method was selected over alternatives because it offers standardization, transparency, and reproducibility—three qualities essential for robust sustainability assessment. In terms of standardization, all criteria were drawn from internationally accepted frameworks such as GRI, UNGC, and UNEP FI, ensuring consistency across banks. For example, the GRI-based metric “Scope 1 GHG emissions (tonnes CO₂e),” coded as E.3.7, was extracted in the same format from each bank’s report. Transparency was achieved through the development of a detailed codebook (see Supplementary File 1), which lists all 75 sub-criteria, their source frameworks, and specific extraction rules, such as mapping “Anti-corruption training %” to UNGC Principle 10. To ensure reproducibility, NVivo’s automated Boolean search function (e.g., “carbon footprint” AND “reduction”) was used to minimize researcher bias, and all raw data, coding protocols, and keyword logs were archived in an open-access repository. Intercoder

reliability was verified with Krippendorff's alpha ($\alpha = 0.81$), exceeding the commonly accepted threshold for qualitative content analysis.

4.2. Data Sample and Content Analysis Procedure

Integrated reports were collected from Turkey's top seven banks, which collectively account for the vast majority of the sector's total assets. Two strategic years were analyzed: 2020, reflecting the immediate impact of COVID-19 (e.g., employee protection, SME relief), and 2022, representing recovery strategies (e.g., green bonds, digital inclusion). Banks were selected based on consistent report availability and adherence to international standards. The data extraction process followed four structured steps to ensure methodological rigor and accuracy:

Step 1 focused on framework alignment, where 75 sub-criteria were mapped to seven sustainability dimensions, as detailed in Table 1. For instance, the criterion "Energy consumption (GJ)" falls under the Environmental dimension, aligned with GRI 305, and is coded as E.2.5.

Step 2 involved text mining, using NVivo's Boolean search operators (e.g., "carbon" NEAR "target") to identify relevant disclosures within the sustainability reports. Manual screening was employed to eliminate false positives, such as irrelevant mentions like "carbon copy."

Step 3 entailed quantitative conversion of the extracted indicators, which varied in measurement level: binary (e.g., 0 = no disclosure, 1 = disclosure), ordinal (e.g., policy implementation stages), and interval/ratio (e.g., GJ of energy use). Binary coding was applied when only the presence or absence of information was assessed. Continuous variables were retained and normalized via min-max scaling to ensure comparability across banks and ESG categories.

Step 4 ensured validation, with 20% of the coded data independently reviewed by a second coder. The resulting discrepancy rate was only 2.1%, indicating high inter-coder reliability and consistency in data interpretation.

4.3. Multi-Criteria Decision-Making (MCDM) Methods

To measure sustainability performance and rank banks, this study uses MCDM methods, which are widely recognized for their ability to handle complex decision-making problems involving multiple criteria (Figueira et al., 2005). Specifically, the study applied two complementary approaches, Weighted Aggregated Sum Product Assessment (WASPAS) and Additive Ratio Assessment (ARAS), both of which are suitable for evaluating performance across multiple sustainability dimensions.

The justification for method selection is threefold. First, these methods are well-suited for sustainability evaluations, as they enable robust comparisons across diverse criteria, making them ideal for assessing bank performance. Second, they enhance decision-making accuracy by integrating weighted scores with performance assessments, resulting in more consistent and objective rankings. Third, their reliability has been validated in previous studies, where

WASPAS and ARAS have been successfully applied to sustainability-related evaluations (Zavadskas et al., 2012; Stanujkic et al., 2015). The integration of MCDM methods with content analysis ensures a structured, data-driven, and objective evaluation of sustainability performance in the Turkish banking sector.

To ensure data accuracy and reliability, several measures were implemented throughout the research process. First, an independent content analysis review was conducted, where two researchers analyzed the reports separately and resolved any discrepancies through discussion and consensus. Second, cross-validation with international standards was performed, as the extracted data were checked against GRI, UNEP FI, and UNGC frameworks to ensure consistency with globally accepted sustainability criteria. Third, methodological consistency was maintained, with identical content analysis and MCDM procedures applied uniformly across all seven banks, thereby preserving objectivity and comparability of results.

4.3.1. Weighting Methods

This section presents the weighting approaches MEREC, CILOS, and CCSD, from which weight levels of sustainability criteria for assessing sustainability performance of Turkish banks have been calculated. These approaches ensure objective weight calculations and maintain an unbiased process of assessment.

4.3.1.1. MEREC Method

The MEREC (Method based on Removal Effects of Criteria) is a very new objective weight determination method developed by Keshavarz-Ghorabae et al. (2021). Unlike other traditional weight methods, MEREC quantifies criterion weights by assessing their displacement effect on the overall performance of alternatives.

The key advantages of MEREC lie in its ability to enhance objectivity and ranking reliability in multi-criteria evaluations. It minimizes subjectivity by employing an objective, removal-based approach that reduces dependence on expert judgment. Additionally, it improves ranking stability by systematically assessing the influence of each criterion on overall performance, thereby ensuring more robust and consistent results. Unlike traditional methods that rely on equal weighting or expert opinion, MEREC effectively addresses these limitations by eliminating potential sources of bias in the weighting process.

Calculation Steps of MEREC (Keshavarz-Ghorabae et al., 2021; Goswami et al., 2022; Ünlü et al., 2022):

Step 1: Construct the decision matrix. It is assumed that there is a decision matrix that should be greater than zero $x_{ij} \geq 0$, as in Equation (1).

$$X = \begin{matrix} & \begin{matrix} w_1 & w_2 & \dots & w_n \\ C_1 & C_2 & \dots & C_n \end{matrix} \\ \begin{matrix} A_1 \\ A_2 \\ \vdots \\ A_m \end{matrix} & \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \dots & x_{mn} \end{bmatrix} \end{matrix} \quad (1)$$

Step 2: Normalize the decision matrix and convert all values into the minimization type. If B^S represents the set of beneficial criteria and C^S represents the set of cost-increasing criteria, Equation (2) below can be used for normalization.

$$n_{ij}^x = \begin{cases} \frac{\min_k x_{kj}}{x_{ij}} & j \in B^S \\ \frac{x_{ij}}{\max_k x_{kj}} & j \in C^S \end{cases} \quad \text{if} \quad (2)$$

Step 3: The third step involves calculating the performance of the alternatives (S_i) using a logarithmic measure with the help of Equation (3).

$$S_i = \ln \left(1 + (1/m \sum_j |\ln(n_{ij}^x)|) \right) \quad (3)$$

Step 4: The fourth step consists of calculating the performance of the alternatives by sequentially removing each criterion.

The performance related to the removal of the j^{th} criterion for the i^{th} alternative can be represented as follows, and the values can be calculated using Equation (4) below:

$$S'_{ij} = \ln \left(1 + (1/m \sum_{k, k \neq j} |\ln(n_{ik}^x)|) \right) \quad (4)$$

Step 5: The removal effect of the j^{th} criterion is obtained by calculating the total absolute deviations of the values obtained from steps 3 and 4 of the method. This is referred to as the removal effect of the j^{th} criterion. The values are calculated using Equation (5) below.

$$\varepsilon_j = \sum_i |S'_{ij} - S_i| \quad (5)$$

Step 6: The objective weights of the criteria are determined using the removal effects (ε_j) from the previous step. If the objective weight of the j^{th} criterion is to be calculated, Equation (6) can be used.

$$w_j^o = \frac{\varepsilon_j}{\sum_k \varepsilon_k} \quad (6)$$

By applying MEREC, this study objectively determines the weights of sustainability criteria, ensuring that the ranking process reflects real-world data rather than subjective inputs.

4.3.1.2. CILOS Method

The CILOS (Criterion Impact Loss Score) method is an objective weighting technique based on the concept of impact loss when a specific criterion is selected as the best (Mirkin, 1974; Čereřka et al., 2016; Zavadskas and Podvezko, 2016).

The key advantages of CILOS stem from its ability to refine the weighting process in multi-criteria decision-making. It effectively solves a major weakness of the Entropy method by ensuring that similar values across alternatives do not artificially reduce the importance of a criterion. Moreover, it differentiates highly correlated criteria by adjusting weights to account for interdependencies, thereby maintaining balance in the evaluation. This approach also ensures meaningful weight assignment by preventing the undervaluation of critical indicators, particularly in datasets where the values are relatively homogeneous.

The method can only be applied to maximizing criteria; therefore, minimizing criteria need to be transformed into maximizing criteria. Various transformations are applied for this purpose:

$$\bar{r}_{ij} = \frac{\min_i r_{ij}}{r_{ij}} \quad (7)$$

The new matrix, which has transformed minimum values and the same maximum values, is denoted $X = \|x_{ij}\|$, and by grouping rows that contain the maximum value of each criterion in every column, the new square matrix $R = \|r_{kl}\|$ is obtained. The R matrix contains the highest values of all criteria on its diagonal.

A square matrix $A = \|a_{ij}\|$ is formed from the k_j rows of the X matrix. X_{ki} corresponds to the maximum values of the i^{th} criterion. Subsequently, the matrix of relative losses $P = \|p_{ij}\|$ is constructed:

$$p_{ij} = \frac{x_j a_{ij}}{x_j} \quad (8)$$

The p_{ij} elements of the P matrix indicate the loss of the j^{th} alternative with respect to the i^{th} criterion when the i^{th} criterion is selected as the best. Subsequently, the weights $q = (q_1, q_2, \dots, q_m)$ are calculated by solving the following linear equation: $F \cdot q = 0$,

Here, the matrix F is as follows (Zavadskas and Podvezko, 2016):

$$F = \begin{pmatrix} -\sum_{i=1}^m p_{i1} & p_{12} & \dots & p_{1m} \\ \vdots & \ddots & & \vdots \\ p_{m1} & p_{m2} & \dots & -\sum_{i=1}^m p_{im} \end{pmatrix} \quad (9)$$

By addressing the entropy method's limitations, CILOS ensures that important sustainability criteria retain their weight, even when alternative values are close to each other. This makes CILOS particularly useful for evaluating banking sustainability performance, where some criteria may exhibit similar numerical ranges but remain critical for decision-making.

4.3.1.4. CCSD Method

The CCSD (Criteria Correlation and Standard Deviation) method, developed by Wang and Luo (2010), determines the importance of each criterion by integrating two key statistical elements: the within-criteria standard deviation, which captures variability within individual criteria, and inter-criteria correlation, which adjusts for potential redundancy across different criteria. The key advantages of CCSD lie in its ability to improve weighting precision by combining statistical variability with correlation-based adjustments. It accounts for interdependencies among criteria, ensuring that highly correlated indicators do not exert disproportionate influence on the final rankings. Additionally, CCSD balances weight distribution effectively, preventing the overemphasis of specific variables and thereby supporting a more equitable and accurate evaluation framework.

CCSD is calculated as follows (Wang and Luo, 2010: 2-3):

In CCSD, the decision matrix $X = \|X_{ij}\|_{(n \times m)}$, which evaluates alternatives $A_1, \dots, A_n$ across features $O_1, \dots, O_m$, is first normalized according to whether the features are benefit or

cost criteria. The normalized decision matrix $Z = \|Z_{ij}\|_{(n \times m)}$ is obtained by applying Equations 7 and 8, respectively. In Equations 7 and 8, X_j^{min} and X_j^{max} represent the minimum and maximum values in the respective criterion.

$$\text{If } j \text{ is a benefit criterion, } Z_{ij} = \frac{X_{ij} - X_j^{min}}{X_j^{max} - X_j^{min}} \quad (10)$$

$$\text{If } j \text{ is a cost criterion, } Z_{ij} = \frac{X_j^{max} - X_{ij}}{X_j^{max} - X_j^{min}} \quad (11)$$

Subsequently, the criterion O_j is removed from the model to observe its effect on evaluating the alternatives. The evaluation of the alternatives without O_j is performed using the following equation. Here, w_k represents the criterion weights that are yet to be determined.

$$d_{ij} = \sum_{k=1, k \neq j}^m Z_{ik} \cdot w_k \quad (i = 1, \dots, n) \quad (12)$$

The correlation between criterion O_j and the evaluation d_{ij} calculated without criteria is calculated as in Equation 9.

$$R_j = \frac{\sum_{i=1}^n (Z_{ij} - \bar{Z}_j)(d_{ij} - \bar{d}_j)}{\sqrt{\sum_{i=1}^n (Z_{ij} - \bar{Z}_j)^2 \sum_{i=1}^n (d_{ij} - \bar{d}_j)^2}}, \quad (j = 1, \dots, m) \quad (13)$$

The values of $\bar{Z}_j$ and $\bar{d}_j$ in Equation 9 are calculated as in Equations (10) and (11) below:

$$\bar{Z}_j = \frac{1}{n} \sum_{i=1}^n Z_{ij} \quad (j = 1, \dots, m) \quad (14)$$

$$\bar{d}_j = \frac{1}{n} \sum_{i=1}^n d_{ij} \quad (j = 1, \dots, m) \quad (15)$$

The larger the obtained R_j value, the less impact criterion O_j has on the alternative ranking, and the change caused by its inclusion or exclusion in the evaluation is minimal. Therefore, calculating criterion weights with CCSD involves solving a nonlinear model with as many equations as there are criteria, as shown in Equation (12):

$$\begin{aligned} \text{Min}_j &= \sum_{j=1}^m \left(w_j - \frac{\sigma_j \sqrt{1 - R_j}}{\sum_{k=1}^m \sigma_k \sqrt{1 - R_k}} \right)^2 \\ \text{Constraints: } &\sum_{j=1}^m w_j = 1 \quad w_j \geq 0, \quad (j = 1, \dots, m) \end{aligned} \quad (16)$$

CCSD ensures that highly correlated criteria do not receive excessive weighting, leading to a balanced distribution of importance across all sustainability dimensions.

The combination of MEREC, CILOS, and CCSD allows for a comprehensive, data-driven approach to weighting sustainability criteria. Each method offers unique advantages, ensuring that the evaluation remains robust and unbiased:

Table 2. Justification and Analytical Contribution of the Applied Weighting Methods

Method	Key Feature	Why It Was Selected
MEREC	Measures removal effect of criteria	Captures the impact of each criterion on overall performance
CILOS	Addresses entropy limitations	Ensures significant criteria retain their importance
CCSD	Accounts for correlation and variability	Balances redundancy and weight distribution

4.3.2. ARAS Method

Multi-criteria decision-making (MCDM) issues occur when several alternatives need to be ranked and compared from different criteria. Comparison among alternatives stands out as the foremost characteristic of such issues (Aouam et al., 2003). The ARAS and WASPAS approaches were chosen for assessing the sustainability performance of Turkish banks in this case. They are chosen due to their suitability to address intricate decision-making situations and deliver sound, fact-based findings.

The ARAS method, developed by Zavadskas and Turskis (2010), is an MCDM approach that not only determines the performance level of each alternative but also expresses the ratio of each alternative to the ideal alternative. This proportional rating feature distinguishes ARAS from other MCDM methods.

The key advantages of ARAS lie in its clarity, usability, and adaptability in multi-criteria decision-making. It employs a proportional rating system, which allows for a transparent comparison of alternatives relative to an ideal solution. The method is known for its simplicity and transparency, making it easy to implement and interpret in practical settings. Furthermore, ARAS demonstrates strong flexibility, as it can effectively accommodate both benefit-oriented and cost-oriented criteria within the same evaluation framework.

The method follows four main steps (Zavadskas and Turskis, 2010):

Step 1 involves constructing the decision matrix, where, unlike classical approaches, the ARAS method also incorporates the best values for each criterion directly into the matrix to facilitate comparison with an ideal solution.

$$X = \begin{bmatrix} x_{01} & \dots & x_{0j} & \dots & x_{0n} \\ x_{i1} & \dots & x_{ij} & \dots & x_{in} \\ x_{m1} & \dots & x_{mj} & \dots & x_{mn} \end{bmatrix}_{m \times n} \quad i = 1, 2, 3, \dots, m \quad j = 1, 2, 3, \dots, n \quad (17)$$

where X denotes the decision matrix, m alternatives, and n criteria.

In the decision matrix X , X_{ij} represents the performance value of alternative i in criterion j , and X_{0j} represents the optimal value of criterion j . If the optimal value of criterion j is not known in advance, it can be calculated using the following formula, depending on whether the criterion represents a benefit or a cost:

$$\begin{aligned} X_{ij} &= \max X_{ij} \\ X_{0j} &= \min X_{0j} \end{aligned} \quad (18)$$

Step 2 involves normalization of the decision matrix, where the original matrix X is transformed into a normalized matrix to enable comparability across different criteria scales.

$$\bar{X} = \begin{bmatrix} \bar{x}_{01} & \dots & \bar{x}_{0j} & \dots & \bar{x}_{0n} \\ \bar{x}_{i1} & \dots & \bar{x}_{ij} & \dots & \bar{x}_{in} \\ \bar{x}_{m1} & \dots & \bar{x}_{mj} & \dots & \bar{x}_{mn} \end{bmatrix}_{m \times n} \quad i=1,2,3,\dots,m \quad j=1,2,3,\dots,n \quad (19)$$

Step 3 involves constructing the normalized weighted decision matrix, where the normalized matrix is adjusted by applying the corresponding criteria weights. Using the previously calculated weights w_j , the weighted values of each criterion are derived through the following equation.

$$\hat{X}_{ij} = \bar{X}_{ij} \cdot w_j \quad 0 < w_j < 1 \quad (20)$$

Step 4: Calculation of Optimality Function

$$S_i = \sum_{j=1}^n \hat{X}_{ij} \quad i=0,1,2,3,\dots,m \quad (21)$$

The highest value of S_i represents the highest level, and the lowest value represents the lowest level. Finally, the decision alternatives are ranked according to their utility levels. The ranking is performed by calculating the K_i value representing the utility level of the alternative. When determining the utility level of an alternative, the optimality function value of the alternative (S_i) and the highest optimality function value (S_o) are taken into account. The K_i value is calculated using the following equation.

$$K_i = \frac{S_i}{S_o} \quad i=0,1,2,3,\dots,m \quad (22)$$

4.3.3. WASPAS Method

The WASPAS method, developed by Zavadskas et al. (2012), combines the Weighted Sum Model (WSM) and the Weighted Product Model (WPM) to achieve a high level of consistency in decision-making. This hybrid approach enhances the accuracy and reliability of the evaluation process.

The key advantages of WASPAS stem from its hybrid structure and adaptability in multi-criteria decision-making. It combines the strengths of both the WSM and the WPM, thereby enhancing decision-making accuracy through balanced aggregation. The method also offers strong flexibility, as it allows for the adjustment of the weighting parameter λ to reflect the preferences of decision-makers. Additionally, WASPAS ensures robustness, delivering consistent and reliable rankings even in complex evaluation scenarios with multiple interrelated criteria.

Six steps to be followed to implement the WASPAS method are as follows (Zavadskas et al., 2012):

Step 1 begins with constructing the decision matrix, which organizes the performance scores of each alternative across all evaluation criteria, serving as the foundational structure for the WASPAS method.

$$X = [X_{ij}]_{m \times n} = \begin{bmatrix} X_{11} & X_{12} & X_{1n} \\ X_{21} & X_{22} & X_{2n} \\ X_{m1} & X_{m2} & X_{mn} \end{bmatrix}$$

$$i=1,2,3,\dots,m \quad j=1,2,3,\dots,n \quad (23)$$

x_{ij} ($x_{ij} \geq 0$), which indicates the success level of the i^{th} alternative in the j^{th} criterion.

Step 2 involves normalizing the decision matrix, where calculations are performed using specific formulas based on whether each criterion represents a benefit or a cost, ensuring that all values are scaled comparably across alternatives. For benefit-type criteria, normalization is done by dividing each alternative's value by the maximum value for that criterion, so that higher values indicate better performance.

$$n_{ij} = \frac{x_{ij}}{\max_i x_{ij}} \quad i=1,2,3,\dots,m \quad j=1,2,3,\dots,n \quad (24)$$

For cost:

$$n_{ij} = \frac{\min_i x_{ij}}{x_{ij}} \quad i=1,2,3,\dots,m \quad j=1,2,3,\dots,n \quad (25)$$

In the WSM, the total relative importance of each alternative is denoted by Q_i (1) as presented in Equation (1). This value is obtained by aggregating the weighted performance scores of the alternative across all evaluation criteria using the following formula.

$$n_{ij} = \frac{\min_i x_{ij}}{x_{ij}} \quad (26)$$

In the formula, w_j denotes the weight of the j^{th} criterion.

Step 4 involves calculating the second relative importance value using the WPM, in which the relative importance of each alternative is denoted by (2). This value is calculated by multiplying the normalized performance scores of the criteria, each raised to the power of their corresponding weights, as shown in the following formula.

Step 4 involves calculating the second relative importance value using the WPM, where the relative importance of each alternative is represented by the symbol $Q_i^{(2)}$. This value is determined using the following formula, which applies a multiplicative aggregation of the normalized criteria values, each raised to the power of their respective weights.

$$Q_i^{(2)} = \prod_{j=1}^n n_{ij}^{w_j} \quad (27)$$

Step 5 involves calculating the total relative importance of alternatives based on the method results, where the final Q_i value is obtained by combining the results from the WSM and the WPM, as expressed by the following formula.

$$Q_i = \lambda Q_i^{(1)} + (1 - \lambda) Q_i^{(2)} \quad (28)$$

The symbol Q_i represents the total relative importance of the i^{th} alternative, while λ is a parameter in this method, taking a value between 0 and 1. The value of λ can vary according to the decision maker's preferences. When λ equals 0, the system transitions to the WPM, and when λ equals 1, it transitions to the WSM.

Step 6 involves identifying the ideal alternative, which is determined as the one with the highest Q_i value. This alternative represents the most favorable option based on the combined evaluation results.

5. Application of ARAS and WASPAS Methods

To evaluate the identified criteria, their relative weights must first be determined. The calculated criteria weights used in the sustainability performance ranking are presented in Table 3. The criteria values of the alternatives are shown in Table 4.

Table 3. Criteria Weights 2020 (MEREK-CILOS-CCSD)

	C1	C2	C3	C4	C5	C6	C7
MEREK	0.2606	0.1067	0.1031	0.1213	0.0941	0.1180	0.1962
CILOS	0.0790	0.0695	0.0885	0.2216	0.2097	0.2604	0.0712
CCSD	0.1186	0.2196	0.1997	0.0880	0.1039	0.1043	0.1658

Table 4. Criteria Values of Alternatives (2020)

Alternatives - Criteria	C1	C2	C3	C4	C5	C6	C7
Akbank	8	14	41	292	456	62	43
Garanti Bank	9	24	26	265	680	74	176
Halkbank	2	8	10	125	246	49	28
İşbank	14	10	31	255	716	61	56
VakıfBank	7	12	32	234	723	63	370
Yapı Kredi Bank	16	33	13	314	612	75	184
Ziraat Bank	1	27	12	88	281	25	151

After normalizing the decision matrix according to the ARAS method, the weighted normalized decision matrix was obtained by multiplying it by the criteria weights shown in Table 5. Then, the steps of the method were followed, and the findings in Table 5 below were obtained.

Table 5. Sustainability Performance Ranking for ARAS Method (2020)

Bank/Code	MEREK			CILOS			CCSD		
	S_i	K_i	Rank	S_i	K_i	Rank	S_i	K_i	Rank
Akbank	0.1342	0.5113	5	0.1501	0.6789	5	0.1423	0.5529	5
Garanti Bank	0.1707	0.6503	3	0.1747	0.7905	2	0.1731	0.6725	3
Halkbank	0.0575	0.2192	7	0.0772	0.3490	7	0.0610	0.2369	7
İşbank	0.1580	0.6020	4	0.1606	0.7266	4	0.1429	0.5552	4
VakıfBank	0.1886	0.7184	2	0.1734	0.7846	3	0.1841	0.7156	2
Yapı Kredi Bank	0.2060	0.7847	1	0.1866	0.8442	1	0.1897	0.7373	1
Ziraat Bank	0.0851	0.3242	6	0.0773	0.3498	6	0.1069	0.4156	6

Based upon the ARAS method, Yapı Kredi Bank and Garanti Bank are best-performing private banks during COVID-19, VakıfBank has good public banking sustainability performance, while Ziraat Bank and Halkbank, the remaining public banks, perform poorly. The calculated weight of ranking criteria for post-COVID-19 sustainability performance is given in Table 6. The criteria values of the alternatives are shown in Table 7

Table 6. Criteria Weights 2022 (MEREC-CILOS-CCSD)

	C1	C2	C3	C4	C5	C6	C7
MEREC	0.3363	0.0546	0.0732	0.1680	0.1165	0.1927	0.0587
CILOS	0.0606	0.0822	0.0568	0.1402	0.1105	0.3704	0.1793
CCSD	0.1668	0.1700	0.1438	0.0548	0.1046	0.1501	0.2099

Table 7. Criteria Values of Alternatives (2022)

Alternatives and Criteria	C1	C2	C3	C4	C5	C6	C7
Akbank	27	59	14	321	689	89	285
Garanti Bank	16	45	19	287	764	66	323
Halkbank	1	39	15	204	827	68	159
İşbank	13	101	53	390	1145	84	217
VakıfBank	7	44	24	209	869	68	333
Yapı Kredi Bank	25	81	25	295	894	40	254
Ziraat Bank	4	54	12	72	336	15	177

The results of sustainability performance according to the ARAS method for the post-COVID-19 period are given in Table 8. The ARAS method determined that Akbank, İşbank, and Yapı Kredi Bank had the best performance in the post-COVID-19 period, while public banks had the worst performance.

Table 8. ARAS Sustainability Performance Ranking (2022)

Bank/Code	MEREC			CILOS			CCSD		
	S _i	K _i	Rank	S _i	K _i	Rank	S _i	K _i	Rank
Akbank	0.2059	0.8346	1	0.1790	0.8124	2	0.1728	0.7175	2
Garanti Bank	0.1559	0.6320	4	0.1537	0.6979	3	0.1488	0.6178	4
Halkbank	0.0880	0.3565	6	0.1210	0.5493	6	0.0956	0.3968	6
İşbank	0.1899	0.7699	2	0.1950	0.8850	1	0.2000	0.8307	1
VakıfBank	0.1216	0.4928	5	0.1481	0.6724	4	0.1382	0.5737	5
Yapı Kredi Bank	0.1853	0.7513	3	0.1425	0.6467	5	0.1701	0.7062	3
Ziraat Bank	0.0534	0.2165	7	0.0608	0.2759	7	0.0746	0.3098	7

Similar to the ARAS method, the steps were applied sequentially in the WASPAS method. WASPAS method sustainability performance results calculated for the COVID-19 period using the criteria weights presented in Table 2 are reported in Table 9. According to the WASPAS method, it was found that the banks with the best performance in the COVID-19 period were the same as the ARAS method, while the banks with the worst performance were two public banks.

Table 9. WASPAS Sustainability Performance Ranking (2020)

Bank/Code	MEREC		CILOS		CCSD	
	Q _i	Rank	Q _i	Rank	Q _i	Rank
Akbank	0.5173	5	0.6849	5	0.5504	5
Garanti Bank	0.6787	3	0.8164	2	0.6971	2
Halkbank	0.2280	7	0.3560	6	0.2449	7
İşbank	0.5989	4	0.7344	4	0.5541	4
VakıfBank	0.6900	2	0.7793	3	0.6859	3
Yapı Kredi Bank	0.7895	1	0.8508	1	0.7301	1
Ziraat Bank	0.2828	6	0.3285	7	0.3744	6

Using the criteria weights in Table 5 for the post-COVID-19 period, the results in the Table 10 are obtained for the WASPAS method. The findings of both the WASPAS and ARAS methods are consistently reflecting the excellent sustainability performance of private banks like Yapı Kredi Bank, Garanti Bank, and Akbank. Public banks like Ziraat Bank and Halkbank ranked lower consistently across periods, by contrast. The findings reflect how critical it is to embed sustainability practices within banking processes, especially after COVID-19, when resilience and flexibility are essential.

Tablo 10. WASPAS Sustainability Performance Ranking (2022)

Bank/Code	MEREC		CILOS		CCSD	
	Q _i	Sıra	Q _i	Sıra	Q _i	Sıra
Akbank	0.8176	1	0.8115	2	0.7131	2
Garanti Bank	0.6433	4	0.7079	3	0.6342	4
Halkbank	0.3129	6	0.5321	6	0.3729	6
İřbank	0.7743	2	0.8763	1	0.8171	1
VakıfBank	0.5013	5	0.6802	4	0.5868	5
Yapı Kredi Bank	0.7259	3	0.6326	5	0.6978	3
Ziraat Bank	0.8176	7	0.8115	2	0.7131	7

6. Sensitivity Analysis

Sensitivity analysis is a review tool used to assess how dependent the results of optimization problems are on changes in the criteria weights. Sensitivity analyses are frequently employed techniques to examine how criteria variations affect decision-making model outcomes (Demir et al., 2024). In this study, sensitivity analysis was conducted to observe how rankings change with variations in criteria weights. Criteria weights were calculated using five different methods (MEREC, CILOS, CCSD, Equal Weighting, and Entropy), and these results were used to examine five distinct scenarios.

A two-year study was conducted, covering the years 2020 and 2022. The five scenarios used in the sensitivity analysis were determined using five different weighting methods. The aim is to measure how changes in criteria weights affect the ranking of the method. The Spearman rank correlation coefficient was used to assess the sensitivity of the ranking results across different scenarios.

Table 11. ARAS Method Sustainable Banking Performance Ranking (2020)

	Akbank	Garanti	Halk	Is	Vakıfbank	Yapıkredi	Ziraat
Sc0	5	3	7	4	2	1	6
Sc1	5	2	7	4	3	1	6
Sc2	5	3	7	4	2	1	6
Sc3	5	3	7	4	2	1	6
Sc4	5	3	7	4	2	1	6

Table 11 indicates that the rankings are quite close in different weighting scenarios. The situation in the rankings can be seen visually in the table below. In order to measure whether there are significant changes in the rankings, Spearman rank correlation is calculated, and the results are presented in Table 12. Table 12 shows minimal differences in the sustainability performance rankings that emerged in different weighting scenarios. The lowest correlation in

the rankings is 0.9642. In other words, even if the weights are different, there is no significant change in sustainability performance.

Table 12. ARAS Method Correlation Table (2020)

	Sc0	Sc1	Sc2	Sc3	Sc4
Sc0	1.0000	0.9642	1.0000	1.0000	1.0000
Sc1		1.0000	0.9642	1.0000	1.0000
Sc2			1.0000	1.0000	1.0000
Sc3				1.0000	1.0000
Sc4					1.0000

The sustainability performance rankings of banks obtained according to the WASPAS method are given in Table 13 for five scenarios.

Table 13. Performance Ranking of Banks for WASPAS Method in 2020

	Akbank	Garanti	Halk	Isbank	Vakıfbank	Yapı kredi	iraat
Sc0	5	3	7	4	2	1	6
Sc1	5	2	6	4	3	1	7
Sc2	5	2	7	4	3	1	6
Sc3	5	2	7	4	3	1	6
Sc4	5	2	7	4	3	1	6

As seen in Table 13, the rankings are pretty close to each other in different weighting scenarios. Spearman rank correlation test results are presented in Table 14.

Table 14. WASPAS Method Correlation Table for 2020

	Sc0	Sc1	Sc2	Sc3	Sc4
Sc0	1.0000	0.9285	0.9642	0.9642	0.9642
Sc1		1.0000	0.9642	0.9642	0.9642
Sc2			1.0000	1.0000	1.0000
Sc3				1.0000	1.0000
Sc4					1.0000

Table 14 reports that tiny differences were found in the sustainable performance rankings that emerged in different weighting scenarios. The lowest correlation in the rankings is 0.9285. It can be said that the sustainable performance results of banks using the WASPAS method are consistent. A sensitivity analysis for the year 2022 was conducted to assess the robustness of the ARAS method results. The performance ranking of banks under five different weighting scenarios is presented in Table 15.

Table 15. ARAS Method Sustainable Banking Performance Ranking in 2022

	Akbank	Garanti	Halk	Isbank	Vakıfbank	Yapı kredi	Ziraat
Sc0	1	4	6	2	5	3	7
Sc1	2	3	6	1	4	5	7
Sc2	2	4	6	1	5	3	7
Sc3	2	4	6	1	5	3	7
Sc4	2	4	6	1	5	3	7

As seen in Table 15, the rankings are pretty close to each other in different weighting scenarios. Spearman rank correlation results are given in the Table 16. Table 16 indicates that minor differences were found in the performance rankings that emerged in different weighting scenarios. According to these results, it can be suggested that the performance results of the banks using the ARAS method are consistent.

Table 16. ARAS Method Correlation Table (2022)

	Sc0	Sc1	Sc2	Sc3	Sc4
Sc0	1.0000	0.8571	0.9643	0.9643	0.9643
Sc1		1.0000	0.8929	0.8929	0.8929
Sc2			1.0000	1.0000	1.0000
Sc3				1.0000	1.0000
Sc4					1.0000

The performance ranking of banks based on the WASPAS method is shown in Table 17 for five scenarios.

Table 17. WASPAS Method Performance Ranking of Banks (2022)

	Akbank	Garanti	Halk	Isbank	Vakıfbank	Yapı kredi	Ziraat
Sc0	1	4	6	2	5	3	7
Sc1	2	3	6	1	4	5	7
Sc2	2	4	6	1	5	3	7
Sc3	2	4	6	1	5	3	7
Sc4	2	4	6	1	5	3	7

As shown in Table 18, the rankings in different weighting scenarios are similar. The Spearman rank correlation coefficients are displayed in the table below. As seen in Table 18, there are only minor differences in performance results across different weighting scenarios. The lowest correlation observed in the rankings is 0.86, indicating no significant change in sustainability performance despite weight variations.

Table 18. WASPAS Method Correlation Table for (2022)

	Sc0	Sc1	Sc2	Sc3	Sc4
Sc0	1.0000	0.8600	0.9600	0.9600	0.9600
Sc1		1.0000	0.8900	0.8900	0.8900
Sc2			1.0000	1.0000	1.0000
Sc3				1.0000	1.0000
Sc4					1.0000

7. Policy Implications

The implications of this study reinforce the changing role of banks as drivers of sustainable development, especially post-COVID-19 pandemic. Since banking institutions shift from managing crises to strategic recovery, incorporating sustainability into long-term planning is not an ancillary requirement but an intrinsic part of institutional resilience and value generation. This section presents policy implications for five groups of stakeholders, considering particularly Turkey's post-pandemic economy.

The relative underperformance of public banks when compared to commercial peers indicates an urgent necessity for targeted approaches to ESG. Public banks need to set up their own internal ESG task forces, implement sustainability performance measures based on frameworks like UNEP FI and GRI, and include sustainability into cornerstone lending criteria. Institutional training programs to build up ESG proficiency and rewarding sustainable project lending are further avenues through which a closing of the gap could be achieved. These measures are consistent with best practices from state-backed institutions in China and the European Union (Úbeda et al., 2022; Weber, 2016).

Turkey’s banking regulator, the Banking Regulation and Supervision Agency (BRSA) need to step up their ESG oversight by requiring sustainability disclosure under ISSB and EU Taxonomy standards. The imposition of ESG-linked capital requirements and climate stress tests would add systemic resilience. Furthermore, green tax incentives, renewable energy financing subsidies, and government-backed sustainability bonds can spur the transformation of the sector.

Global investors are increasingly interested in ESG-aligned portfolios. Turkish banks thus need to enhance comparability and transparency through alignment with UN Principles for Responsible Banking, Equator Principles, and TCFD guidelines. This transition could be further reinforced by ESG rating agencies by comparing Turkish banks with global peers. A national platform for ESG scoring could further aid investors and accountability through transparency towards public accountability. Non-governmental organizations have an important watchdog and advocacy function. NGOs within Turkey need to increase sustainability tracking, create public scorecards, and engage with banks and their financial education initiatives focusing on environment risk and social inclusion. Multi-stakeholder platforms tend to generate trust, policy discussion, and collaborative ESG innovation.

The 2020–2022 period demonstrated that ESG priorities are not static but shift in response to macroeconomic crises. During this time, banks placed increased emphasis on digital access, support for small and medium-sized enterprises (SMEs), and the protection of individuals. This was particularly evident in Turkey, where mobile banking usage experienced a significant rise and recovery-related lending activity reached record levels. Policymakers must institutionalize these achievements through permanent mechanisms of ESG frameworks and disaster-resistant financial planning.

Consequently, the banking industry of Turkey is at a strategic juncture. Public banks, regulators, investors, and civil society need to take coordinated action to embed sustainability throughout the sector. Embedding ESG measures into financial policy, coordinating with global frameworks, and enhancing transparency and stakeholder engagement can help Turkey become a regional champion of sustainable finance.

8. Conclusion

This research provides a new, multi-method assessment of sustainability performance for Turkey’s banking industry through an examination of integrated reports from both the year of COVID-19 (2020) and recovery (2022). Using 75 ESG factors from GRI, UNGC, and UNEP FI guidelines, the research applied a hybrid approach fusing WASPAS and ARAS, two prominent MCDM methods, and three objective weight models (MERECE, CILOS, CCSD). The findings

indicate that commercial banks outperformed public banks across all years consistently, noting key differences in institutional capacity and integration of ESG. Whereas private banks changed from prioritizing employee health and liquidity protection during 2020 to strategic green bond and digital inclusion investments by 2022, public banks fell behind due to governance inefficiencies, regulatory lag, and partial disclosure transparency.

The findings of this study align with previous research emphasizing the importance of governance and disclosure in ESG performance evaluations. For example, Karki et al. (2025) identified governance as the most influential ESG pillar in ranking sustainable banks, while Yu et al. (2024) demonstrated the effectiveness of MCDM models in capturing variations in ESG performance. In line with these studies, the present research found that state-owned banks exhibited weaker ESG performance compared to private banks in both the pandemic (2020) and post-pandemic (2022) periods. However, these findings differ from the earlier results of Aras et al. (2018) who reported relatively stronger sustainability alignment among public banks, possibly reflecting changes in institutional priorities and reporting practices over time.

These findings are consistent with the understanding that regulatory frameworks, management stability, and institutional incentives are key drivers of strong sustainability performance. Methodologically, the reliability of ranking results—validated through sensitivity analysis across five scenarios and three aggregation models—demonstrates the robustness of the hybrid MCDM framework adopted in this study. From a policy perspective, public banks should consider realigning executive incentives to prioritize ESG objectives and implementing real-time sustainability dashboards. Regulators, in turn, could mandate Scope 3 emissions disclosure and provide capital adequacy relief for SDG-linked lending instruments to promote responsible banking practices.

As a limitation, the study focuses on a two-year window (2020 and 2022), intentionally selected to capture the immediate effects of the COVID-19 crisis and early recovery. While this design enables a focused comparison, future research could benefit from including a broader timeline—extending to pre-pandemic and more recent years—to better assess ESG strategy evolution over time. Additionally, the study's scope is limited to the banking sector, suggesting opportunities for comparative studies across sectors or regions, particularly within and beyond the BRICS economies. Ultimately, this research contributes to the expanding literature on sustainable finance by showing how an integrated, transparent ESG evaluation framework can guide both financial institutions and policymakers in advancing sustainability strategies in emerging market economies.

Declaration of Research and Publication Ethics

This study which does not require ethics committee approval and/or legal/specific permission complies with the research and publication ethics.

Researcher's Contribution Rate

Statement the authors declare that they have contributed equally to the article.

Declaration of Researcher's Conflict of Interest

There is no potential conflicts of interest in this study.

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BİR MAKİNE ÖĞRENİMİ UYGULAMASI: G7 ÜLKELERİNDE FİNANSAL KRİZ TAHMİNLEME

A Machine Learning Approach: Financial Crisis Forecasting in G7 Countries

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Öz

Bu çalışma, sistemik bankacılık krizlerini tahmin etmede makine öğrenmesi yöntemlerinin etkinliğini, özellikle karmaşık ve doğrusal olmayan örüntüleri yakalama yeteneğiyle öne çıkan XGBoost algoritmasını kullanarak arařtırmaktadır. 1870-2020 dönemi için G7 ülkelerine ait finansal ve makroekonomik veriler kullanılarak sistemik bankacılık kriz tahmininde XGBoost tabanlı bir model geliştirilmiştir. Ayrıca, modelin 'kara kutu' doğasını aşarak karar alma süreçlerini derinlemesine anlamlandırmak amacıyla SHAP (SHapley Additive exPlanations) yöntemleri uygulanarak model sonuçları arasındaki nedensel ilişkiler analiz edilmiş, böylece tahmin edici değişkenler ile kriz riski arasındaki nedensel ilişkiler şeffaf bir şekilde analiz edilmiştir. Bulgular, XGBoost'un yüksek tahmin performansı sergileyerek uygulayıcılar ve politika yapıcılar için kriz riskini değerlendirmede yeni olanaklar sunduğunu göstermektedir. Ek olarak SHAP değerleri, tahmin edici değişkenler ile kriz riski arasındaki karmaşık ilişkileri ortaya çıkararak makine öğrenimi modellerinin şeffaflığını ve hesap verebilirliğini önemli ölçüde artırmaktadır. Bu yaklaşım, finansal krizlerin temel ekonomik itici güçlerini belirleme konusunda sağlam ve güvenilir bir analitik altyapı sunarak finansal kriz tahmininde makine öğrenmesi yöntemlerinin potansiyelini vurgulamaktadır.

Anahtar Kelimeler:

Finansal Krizler,
Makine Öğrenimi,
XGBoost,
SHAP Değeri,
Tahminleme

JEL Kodları:

C53, E44, G01, N10

Abstract

This study investigates the effectiveness of machine learning methods in predicting systemic banking crises, particularly using the XGBoost algorithm, which stands out for its ability to capture complex and non-linear patterns. A XGBoost-based model was developed to predict systemic banking crises using financial and macroeconomic data from G7 countries for the period 1870-2020. Additionally, SHAP (SHapley Additive exPlanations) methods were applied to analyze the causal relationships between model results, thereby overcoming the model's "black box" nature and providing a deeper understanding of decision-making processes. This allowed for a transparent analysis of the causal relationships between predictive variables and crisis risk. The findings demonstrate that XGBoost exhibits high predictive performance, offering new opportunities for practitioners and policymakers in assessing crisis risk. Additionally, SHAP values significantly enhance the transparency and accountability of machine learning models by revealing the complex relationships between predictive variables and crisis risk. This approach provides a robust and reliable analytical framework for identifying the fundamental economic drivers of financial crises, highlighting the potential of machine learning methods in financial crisis prediction.

Keywords:

Financial Crises,
Machine Learning,
XGBoost,
SHAP Value,
Forecasting.

JEL Codes:

C53, E44, G01, N10

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1. Giriş

Finansal krizler, ekonomi ve sosyal sistemler üzerinde önemli maliyetlere neden olmaktadır (Hoggarth vd., 2002; Laeven ve Valencia, 2018). Bu bağlamda, finansal krizlere işaret eden uyarı sinyallerinin zamanında tespiti politika yapıcılar açısından kritik bir öneme sahiptir. Erken teşhis konjonktür karşıtı makro ihtiyati politikaların etkin bir şekilde uygulanmasına olanak tanımakta ve böylece artan riskler karşısında finansal krizlerin ortaya çıkma olasılığı ve etkileri azaltılabilmektedir (Giese vd., 2013; Akinci ve Olmstead-Rumsey, 2018). Bununla birlikte güvenilir bir erken uyarı gösterge seti oluşturmak çeşitli zorluklar içermektedir. İlk olarak geçmişte gözlemlenen finansal krizlerin sayısının sınırlı olması, sağlam ekonometrik modelleme çalışmalarını güçleştirmektedir. İkinci olarak kriz sinyalleri genellikle müdahale için elverişli zaman dilimi aşıldıktan sonra belirginleşmektedir. Üçüncü olarak karmaşık erken uyarı modellerini makro ihtiyati otoritelerin zamanında müdahalesine rehberlik edecek, basit ve şeffaf göstergelere indirgemek zor olabilmektedir. Son olarak ekonomik ve finansal sistemler doğası gereği öngörülemezliğe ve belirsizliğe tabidir. Bu durum, Covid-19 salgınının ekonomik etkilerinde gözlemlendiği gibi bazı olayların önceden tahmin edilmesinin neredeyse imkânsız olduğu anlamına gelmektedir (Aikman vd., 2021). Ancak, altta yatan kırılma noktalarının tespit edilmesi, bu tür olağanüstü durumlarda dahi faydalı olabilmektedir.

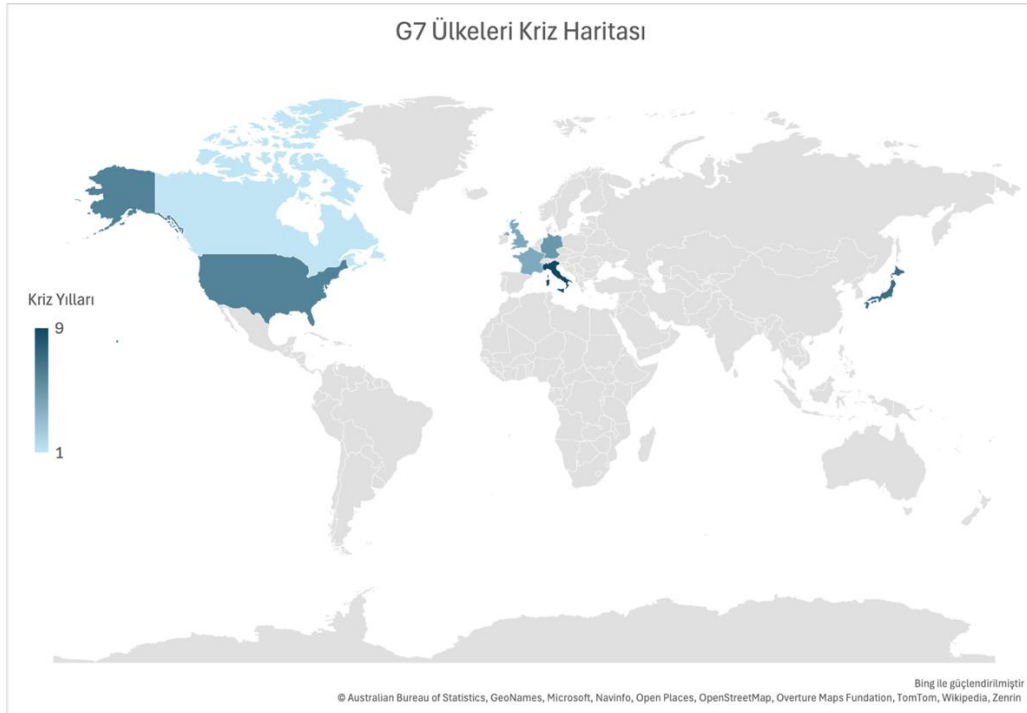
Finansal krizler ekonomik faaliyetler üzerinde büyük zararlı etkilere sahiptir ve bu nedenle geniş bir araştırmanın odak noktası olmuştur. Küresel finansal sistemin işleyişi ve istikrarı açısından G7 ülkeleri (Almanya, Amerika Birleşik Devletleri, Birleşik Krallık, İtalya, Fransa, Japonya, Kanada) kritik bir öneme sahiptir. Dünya GSYİH’sinin yaklaşık %43’ünü oluşturan bu ileri ekonomiler, sahip oldukları büyük merkez bankaları, ihraç ettikleri başlıca rezerv para birimleri ve küresel sermaye akımlarını yönlendirme kapasiteleriyle uluslararası finansal mimarinin şekillenmesinde belirleyici bir rol oynamaktadırlar (World Bank, 2023). Sonuç olarak, G7 ekonomilerinde yaşanan makroekonomik dalgalanmalar, küresel sermaye hareketleri ve finansal istikrar üzerinde doğrudan ve sistemik etkiler yaratma potansiyeline sahiptir. Ayrıca, bu ülkeler bankacılık sektörü açısından dünya çapında sistemik öneme sahip bankalara ev sahipliği yapmakta ve Basel düzenlemeleri gibi küresel finansal istikrar çerçevelerinin oluşturulmasına öncülük etmektedir.

Bu çalışma, 1870-2020 yılları arasında G7 ülkeleri için makro finansal veriler kullanarak finansal kriz tahmini için erken uyarı modelleri geliştirmeyi amaçlamaktadır. Aynı zamanda makine öğrenimi tekniklerinin finansal kriz tahmininde nasıl etkili bir şekilde kullanılabileceğini ve hangi makroekonomik göstergelerin bu tahminlerde kritik rol oynadığını göstermektedir. Bu çalışmanın önemli katkılarından biri tahmin modelinin güvenilirliğini ekonometri uzmanlarına ve politika yapıcılara gösterebilmek amacıyla makine öğrenimi modelinin yorumlanmasından elde edilen nedensel ilişkiler SHAP (SHapley Additive exPlanations) metodolojisi aracılığıyla analiz edilmesidir. Lundberg ve Lee (2017) tarafından geliştirilen SHAP, açıklanabilir yapay zekâ (XAI) yaklaşımlarından biri olup her bir özelliğin tahmin edilen sonuç üzerindeki mutlak etki düzeyini ve aynı zamanda bu etkinin yönünü (olumlu veya olumsuz) ölçebilen güçlü bir makine öğrenimi yorumlama tekniği olarak kullanılmaktadır.

Çalışmada kullanılan SHAP analizi finansal piyasalar için sistemik bankacılık krizi altında yatan nedenleri belirlemek için etkili bir yöntem sunmaktadır. En ilgili unsurların belirlenmesi, paydaşların finansal krizlerle ilişkili riskleri daha iyi tahmin etmelerini ve en aza

indirmelerini saęlamaktadır. Çeřitli ÷lkelerden elde edilen deneyimlerin bir araya getirilmesi finans ve bankacılık dñzenlemelerinde hem kñresel eęilimleri hem de yerel gerekleri dikkate alan kapsamlı bir yaklařıma duyulan ihtiyaı vurgulamaktadır.

řekil 1’de G7 ÷lkelerinde yařanan finansal kriz yoęunluęu haritası oluřturulmuřtur. Önerilen yöntem, řekil 2’de gösterildięi gibi altı ařamadan oluřan sistematik bir veri analizi ve modelleme sürecidir. Bu süreç řu adımları içermektedir: veri toplama, veri ön iřleme, sınıf dengesizlięi giderme, model oluřturma, performans deęerlendirme ve Açıklanabilir YZ (XAI) ile sonuların yorumlanması. Bu adımlar, veri analizi sürecinin güvenilir ve anlaşılır sonular üretmesini hedeflemektedir.



řekil 1. G7 ÷lkelerinde Yařanan Finansal Kriz Yoęunluęu.



řekil 2. Yöntem Akışı

Çalıřmanın ikinci bölümünde, kapsamlı bir literatür taraması sunulmuř, üçñcñ bölümünde metodolojiye yer verilerek uygulanan makine öğrenme modeli ve Shapley deęeri çerçevesi özetlenmiřtir. Dñrdñcñ bölümde veri seti ile tahmin edici deęiřkenlere iliřkin detaylı bilgi verilmiřtir. Bu bölümde ayrıca Shapley deęerleri aracılıęıyla tahmin edicileri göreli önem düzeyleri ortaya koyulmuřtur. Son olarak beřinci bölümde, çalıřmanın temel bulguları özetlenerek ekonomik yorumuna yer verilmiřtir.

Mevcut literatürde, G7 ÷lkelerinde sistemik bankacılık krizlerinin makine öğrenimi tabanlı tahminine odaklanan çalıřmaların yetersizlięi göze çarpmaktadır. Bu çalıřma,

literatürdeki bu eksikliği gidermek üzere, gelişmiş ekonometrik analizler ve makine öğrenimi tekniklerinin (özellikle XGBoost algoritmasının) entegrasyonu ile zaman serisi verilerinin daha etkin bir şekilde değerlendirilmesini hedeflemektedir. Çalışmanın özgün katkıları arasında, dengesiz veri kümeleri için uygun veri ön işleme yöntemlerinin uygulanması, model doğrulama süreçleriyle XGBoost modelinin etkinliğinin titizlikle değerlendirilmesi ve SHAP analizleri aracılığıyla finansal krizlerin tahmininde rol oynayan faktörlerin kapsamlı bir şekilde incelenmesi yer almaktadır. Bu sayede, finansal krizlerin erken uyarısı için daha sağlam ve yorumlanabilir bir modelleme çerçevesi sunulmaktadır.

2. Literatür Taraması

Finansal krizlerin köklü bir geçmişe sahip olmasına karşın ülkeler arası panel veri setlerine dayalı erken uyarı modelleri 1990'lı yılların sonlarına doğru Kaminsky ve Reinhart (1999), Berg ve Pattillo (1999) gibi öncü çalışmalarla literatürde nispeten yeni bir uygulama alanı olarak ortaya çıkmıştır. Bu öncü makaleler, finansal krizlerin tarihlerine ilişkin veri setleri derleyerek hangi makro-finance büyüklüklerin bu olayları öngörmeye etkili olduğunu araştırmıştır. Söz konusu dönemde erken uyarı sistemlerinde yaygın olarak kullanılan iki temel yöntem sinyal yöntemi ve logit modeli olmuştur. Sinyal yöntemi, bir zaman serisini (örneğin, yıllık kredi büyümesi veya başka bir risk ölçüsü) analiz ederek önceden belirlenen bir eşiği aşan değerleri bir uyarı sinyali olarak kabul etmiştir. Logit modeli ise kriz durumunu (veya kriz öncesi dönemi temsil eden bir kukla değişkenini) doğrudan bir dizi makro-finance değişken aracılığıyla açıklamayı hedeflemiştir. Bu ilk çalışmaların ardından finansal krizlerde öne çıkan makroekonomik ve finansal göstergelerin belirlenmesine yönelik çok sayıda çalışma literatüre kazandırılmıştır.

2008 Küresel Finans Krizi'nin ardından erken uyarı sistemlerine olan ilginin yeniden artmış olduğu Reinhart ve Rogoff (2011), Schularick ve Taylor (2012), Laeven ve Valencia (2012), Babecký vd. (2014) çalışmalarıyla birlikte görülmektedir. Bu alanda kullanılan veri setleri önemli ölçüde genişletilmiştir. Elde edilen sonuçlar ülke ve veri setine göre farklılık göstermekle birlikte 2008 sonrası yapılan araştırmalar, özellikle özel sektör kredileri ve kredilerin gayri safi yurt içi hasılaya (GSYH) oranının, bankacılık krizlerinin güçlü belirleyicileri olduğunu gösteren önemli bulgular sunmuştur. Örneğin, Jordà, Schularick ve Taylor (2017) ve Tölö (2020) 1870-2016 yılları arasında finansal krizi “bir ülkenin bankacılık sektörünün banka iflasları yaşadığı, temerrüt oranlarında keskin artışların yaşandığı, kamu müdahalesi, iflas veya finansal kurumların zorunlu birleşmesiyle sonuçlanan büyük sermaye kayıplarının eşlik ettiği olaylar” olarak tanımlayan veri setini kullanmıştır.

Son dönemdeki literatür kriz tahmininde logit modellerin ötesine geçerek makine öğrenimi yöntemlerine yönelmiştir. Bu kapsamda, karar ağaçları ve yapay sinir ağları da dahil olmak üzere çeşitli makine öğrenimi algoritmaları araştırılmıştır. Bazı çalışmalar makine öğrenimi yöntemlerinin geleneksel ekonometrik modellere kıyasla daha iyi performans gösterdiğini ortaya koymuş olsa da logit modellere kıyasla makine öğrenimi yöntemlerinin etkinliği konusundaki tartışmalar hala devam etmektedir. Bu tartışmaların temelinde makine öğrenimi yöntemlerinin kriz öncesi gelişmeler için doğrusal olmayan kuralları belirleme potansiyeli yatmaktadır. Ancak mevcut literatürde tahmin süreçlerinde zaman serisi bilgilerinin tam olarak kullanılmadığı görülmektedir.

Geçmiřte finansal krizlerin tahmini için yaygın olarak kullanılan modellerin aksine Dabrowski vd. (2016) tarafından yapılan bir çalışmada makine öğrenimi modellerinin geleneksel logit modellerine ve sinyal çıkarma yöntemlerine kıyasla daha üstün bir performans sergilediđi gösterilmiřtir. Vařićek vd. (2017) finansal krizleri öngöreceğ göstermeleri belirlemek için 25 OECD ülkesinden elde edilen veriler üzerinde Bayesian Model Ortalaması uygulamıř ve dođrusal modellerin finansal dinamikleri yakalayamadıđı ve finansal stresi tahmin edemediđini vurgulamıřtır.

Makine öğrenmesi yöntemleriyle finansal krizleri tahmin etmek için Alessi ve Detken (2018), tarafından yürütölen bir arařtırmada, Avrupa Birliđi (AB) bankacılık krizleri veri seti kullanarak sistemik riski tespit etmek amacıyla rastgele orman algoritmasına dayalı bir erken uyarı sistemi geliřtirilmiřtir. Bu sistemde, makroekonomik göstergeler risk tahmininde kullanılacak temel deđişkenler olarak belirlenmiřtir. Çalışmanın sonuçları, rastgele orman modelinin kayda deđer bir tahmin performansı sergilediđini ve makroekonomik verilerden yararlanarak erken uyarı sistemlerinin oluřturulması konusunda gelecek vaat ettiđini ortaya koymuřtur. Bu bulgular, rastgele orman gibi makine öğrenimi tekniklerinin finansal istikrarın izlenmesi ve risk yönetimi alanlarında önemli katkılar sađlayabileceđini göstermektedir. Chatzis vd. (2018), Rastgele Orman, sınıflandırma ađaçları, Destek Vektör Makineleri (DVM), XGBoost ve İleri Beslemeli Sinir Ađları'nın (FFNN) performansını ampirik olarak karřılařtırmıřlar ve en iyi sonucu XGBoost yönteminin verdiđi sonucuna ulařmıřlardır.

Tran vd. (2022) tarafından gerçekeřtirilen yakın tarihli bir arařtırma, Vietnam borsasında 2010-2021 yılları arasında iřlem gören řirketlere ait bir veri seti üzerinde karmařık makine öğrenimi modellerinin tahmin sonuçlarını yorumlamak için Shapley deđerlerinden yararlanmıřtır. Bu çalışmanın bulguları, aşırı gradyan güçlendirme (Extreme Gradient Boosting) ve rastgele orman (Random Forest) modellerinin diđer makine öğrenimi modellerine kıyasla daha yüksek performans gösterdiđini ortaya koymuřtur. Çalışmanın dikkat çekici bir yönü ise yazarların Shapley deđerlerini kullanarak her bir özelliđin tahmin sonuçları üzerindeki etkisini detaylı bir řekilde analiz etmesi ve bu sayede teorik çerçevede öngörölmeyen iliřkiler hakkında ek bilgiler sunmalarındır. Bu yaklařım, makine öğrenimi modellerinin karar verme süreçlerini daha řeffaf hale getirerek ilgili alanlardaki arařtırmacılar ve uygulayıcılar için deđerli içgörüler sađlamaktadır. Liu vd. (2022), daha etkili tahmin göstergelerini belirlemek ve makine öğrenimi modellerinin nedensel iliřkilerini analiz etmek amacıyla Shapley deđerli ayrıştırma ve Shapley regresyon yöntemlerini kullanmıřlardır. Chen vd. (2024) logit modeli ve diđer derin öğrenme modellerini karřılařtırarak erken uyarı sisteminin yorumlanabilirliđi için Shapley deđer ayrışımı hesaplamıřtır. Çalışmanın ampirik sonuçları TCN'nin diđer modellerden daha iyi performans gösterdiđini ve hisse senedi fiyatı ve reel GSYİH büyümesinin kriz tahmininde en büyük katkıya sahip olduđunu göstermektedir.

Bu çalışma, finansal krizler bađlamında geliřmiř ekonometrik ve makine öğrenimi teknikleri aracılıđıyla G7 ölkelerinde sistemik bankacılık krizlerini tahmin ederek literatöre önemli bir katkı sađlamaktadır. Öncelikle, dengesiz veri kümeleri için uygun olan yöntemler kullanılarak veri ön işleme aşaması detaylı bir řekilde tamamlanmıřtır. İkinci olarak söz konusu problemi ele almak için ilgili bir makine öğrenimi tekniđi olan XGBoost yöntemi kapsamlı bir řekilde incelenmiřtir. Daha sonra bu modelleme tekniđinin etkinliđini deđerlendirmek amacıyla model dođrulama süreçleri uygulanmıř ve performans ölçütleri kullanarak modelin başarıımı deđerlendirilmiřtir. Son olarak SHAP analizleriyle finansal kriz tahmin görevini yerine getirmek

için kullanılabilir ve büyük finansal piyasaların tüm yelpazesini kapsayan genişletilmiş bir açıklayıcı değişkenler kümesinin kapsamlı bir incelemesi sunulmuştur.

3. Metodoloji

3.1. Aşırı Gradyan Artırma (Extreme Gradient Boosting – XGBOOST)

Chen ve Guestrin (2016) tarafından geliştirilen XGBoost (Extreme Gradient Boosting), Friedman (2001) tarafından önerilen boosting algoritmasını temel alan bir yaklaşımdır. Bu algoritma, model karmaşıklığını düşürmek, aşırı öğrenmeyi engellemek ve öğrenme sürecini hızlandırmak için amaç fonksiyonunda düzenleme (normalizasyon) tekniklerini kullanır. Bu özellik, modelin karmaşıklığını denetim altında tutarak daha iyi bir genelleme performansı sergilemesine katkı sağlamaktadır. Ayrıca XGBoost, karar ağaçlarının verimli bir şekilde bir araya getirilmesiyle oluşturulan bir topluluk modelidir ve bu sayede tek başına kullanılan yöntemlere kıyasla daha yüksek tahmin performansı sunar. Bu özellikleriyle XGBoost, makine öğrenimi uygulamalarında yaygın olarak tercih edilen bir algoritma haline gelmiştir.

Minimize edilecek optimizasyon fonksiyonu Denklem (1)'deki gibidir. Burada $L^{(t)}$ ile ifade edilen bir kayıp fonksiyonudur. $\Omega(\phi_t)$ ise modelin karmaşıklığını tanımlayan bir düzenleme terimidir. Amaç, $L^{(t)}$ fonksiyonunu minimize edecek ϕ_t değerini tespit etmektir. Bu optimizasyon süreci modelin hem eğitim verilerine iyi uyum sağlamasını hem de aşırı öğrenme (overfitting) riskini azaltarak genelleme yeteneğinin artırılmasını hedeflemektedir. Sınıflandırma görevlerinde XGBoost, önceki modellerin hatalarını tahmin eden yeni modelleri yinelemeli olarak inşa ederek ve bu modelleri birleştirerek nihai tahmine ulaşır. XGBoost'un amaç fonksiyonu, bir kayıp fonksiyonu ve bir düzenleme teriminden oluşur. Kayıp fonksiyonu tahmin edilen ve gerçek değerler arasındaki farkı ölçerken, düzenleme terimi aşırı öğrenmeyi engellemektedir.

$$L^{(t)} = \sum_{k=1}^n l(y_k, \hat{y}_k^{(t-1)} + \phi_t(x_k)) + \Omega(\phi_t) \quad (1)$$

XGBoost algoritmasının hesaplama hızı ve bellek kullanımındaki optimizasyon, bu tekniği özellikle büyük veri kümeleri için elverişli kılmaktadır (Mitchell ve Frank, 2017). Ayrıca XGBoost, aşırı öğrenme riskini önemli ölçüde azaltan hem L1 (Lasso) hem de L2 (Ridge) düzenleme algoritmalarını bünyesinde barındırmaktadır (Osman vd., 2024). Algoritmanın dikkate değer bir diğer özelliği ise eksik verileri dahili olarak işleyebilmesi ve bu sayede kapsamlı veri ön işleme ihtiyacını azaltmasıdır (Dhaliwal vd., 2018).

Çok sayıda avantaj sunmasına rağmen XGBoost bazı zorlukları da beraberinde getirmektedir. Özellikle çok sayıda ağaç ve özellik ile çalışıldığında ortaya çıkan modeller karmaşık bir yapıya sahip olabilmekte ve yorumlanması güçleşebilmektedir (Meng vd., 2020). XGBoost'ta hiperparametrelerin ayarlanması, özenli bir çalışma gerektiren ve zaman alıcı bir süreç olabilir (Qin vd., 2021). Son olarak XGBoost modelleri, özellikle küçük veri kümelerinde aşırı öğrenmeye yatkın olup bu durum sağlam bir düzenleme gerektirmektedir (Aksoy ve Genc, 2023). Bu nedenle modelimizde SMOTE tekniği uygulanmıştır.

3.2. SHAP Analizi

Bu alıřma, iřbirliki oyun teorisinin temel kavramlarından olan Shapley deęerlerini (Shapley, 1953) kullanarak makine ęrenimi modellerindeki ngrclerin katkılarını deęerlendirmeyi amalamaktadır. Shapley deęerleri, her bir ngrcnn model ıktısına yaptığı katkıyı nicelendirmek iin kullanılmaktadır. Lundberg ve Lee (2017) tarafından geliřtirilen SHAP (SHapley Additive exPlanations) kavramı ise her bir zellilięin tahminlere olan katkısını hesaplayarak makine ęrenimi modellerinin yaptığı tahminleri daha anlařılır kılmayı hedeflemektedir. Bu sayede karmařık modellerin karar alma sreleri řeffařlařır.

4. Uygulama

4.1. Veriler

G7 lkeleri iin kullanılan veriler Jrda-Schularick-Taylor makro tarih veri tabanından alınmıřtır (Jord vd., 2017). Veri seti, sistemik finansal krizleri “bir lkenin bankacılık sektrnn, kamu mdahalesi, iflas veya finansal kurumların zorunlu birleřmesi ile sonulanan byk sermaye kayıplarının eřlik ettięi temerrt oranlarında keskin artıřlar yařadığı olaylar” olarak sınıflandırmaktadır (Schularick ve Taylor, 2012). alıřmada finansal piyasadaki kriz durumu 0 ve 1 deęerlerine sahip ikili (binary) bir deęiřken olarak tanımlanmıřtır. Bu yaklařım, ikili hedefli makine ęrenimi yntemlerinin kullanılmasını mmkn kılmakta ve hedef deęiřkenin daha kolay tahmin edilmesini saęlamaktadır. alıřmada kriz durumunun baęımlı deęiřken olarak ele alınması yalnızca ařırı uyum olasılıęını azaltmakla kalmayıp aynı zamanda piyasadaki kriz durumunun daha net bir řekilde temsil edilmesine olanak tanımaktadır. Sonu olarak bu yaklařım makine ęrenimi modellerinin tahmin doęruluęunu artırmaya katkı saęlamaktadır.

Sistemik kriz, bir bankanın yařadığı sorunların dięer bankaları da etkileyerek tm finansal sistemi tehdit ettięi bir durumdur. Dřk sermaye yeterlilięi, yksek faiz oranları ve yksek enflasyon gibi faktrler sistemik riski artırabilir. Sistematik bankacılık krizlerini tahmin etmek iin kullanılan gstergeler arasında kredi ile ilgili gstergeler, makroekonomik gstergeler; GSYH ve piyasa ile ilgili gstergeler (faiz oranları) bulunmaktadır (Nazareth ve Ramana Reddy, 2023). Makroekonomik ortamı ve ekonomik faaliyetleri yansıtmak amacıyla GSYH byme oranı ve enflasyon oranı olmak zere iki standart konjonktr gstergesi kullanılmıřtır. ılımlı GSYH bymesi ekonomik istikrarı yansıtırken hızlı veya dřk GSYH bymesi kırılganlığın endiře verici bir iřareti olabilir (Kauko, 2014). Ařırı ısınmıř ekonomiler, sermaye akıřları yoluyla sınır tesine aktarılabilen dıřsal risklere karřı daha savunmasızdır (Jord vd., 2011). Dięer yandan, yavař veya olumsuz ekonomik geliřmeler reel ekonomik zayıflıklara iřaret ederek potansiyel olarak krizlere yol aabilir. Benzer řekilde yksek enflasyon makro-finance istikrarsızlıklara iřaret edebilirken, ok dřk enflasyon veya deflasyon da tketicilerin harcamalarını kısıtladığı ve hatta resesyona neden olabileceęi iin endiře verici bir durumdur.

Gemiřte yařanan ok sayıda kriz ve 2007/2008 kresel finans krizi ncesinde birok sanayi lkesinde byk cari aıkların grlmesi, cari iřlemler dengesizliğinin makro-finance kırılganlığın potansiyel bir kaynağı olduęunu ve bu nedenle dzenleyicilerin ilgi odağı olması gerektięini ortaya koymaktadır (Obstfeld, 2012). Bu nedenle, sistemik kriz tahminlemesi gstergelerinde cari hesap/GSYH oranı bir gsterge olarak yer almaktadır.

1980'lerde Japonya'da, 1990'larda İskandinav ülkelerinde ve 2000'lerde ABD'de görülen kredi kaynaklı varlık fiyatı balonları, önemli kredi krizlerine yol açmıştır (Brunnermeier ve Oehmke, 2013). Bu nedenle, kredi gelişmelerini analiz etmek amacıyla finans dışı özel sektöre sağlanan toplam kredinin GSYH içindeki payı kullanılmıştır.

Tablo 1. Kriz Tahminlemesinde Kullanılan Değişkenler ve Açıklamaları

crisis	Sistemik finansal krizler (Dummy: 0-1 göstergesi)
rgdp_gr	Reel GSYİH büyüme oranı (2005=100)
inv_gdp	Yatırımın GSYİH'ye oranı
cpi_rate	Tüketici fiyatlarındaki yüzdesel değişim (1990=100)
broadmoney	Geniş para arzı büyüme oranı (nominal, yerel para birimi)
rate	Uzun dönem vadeli faiz oranı (nominal, yıllık yüzde)
xrusd	USD döviz kuru (yerel para birimi/USD)
ltd	Bankalar, kredilerin mevduata oranı (%)
lev	Bankalar, sermaye oranı (yüzde)
cur/gdp	Cari işlemler hesabı (nominal, yerel para) / Gerçek kişi başı GSYİH (endeks, 2005=100)
loans/gdp	Finansal olmayan özel sektöre verilen toplam krediler / Gerçek kişi başı GSYİH (endeks, 2005=100)

Bu çalışmada finansal krizlerin makine öğrenmesi yöntemleriyle tahminlenmesi kapsamında aşağıda Tablo 1'de yer alan değişkenler kullanılmıştır. Tablo, makroekonomi ve finans literatüründe kriz tahminindeki etkinlikleri ve sundukları anlamlı sonuçlar ile kabul görmüş 11 makroekonomik ve finansal değişkenden oluşmaktadır. Model parametrelerini optimize etmek ve genelleme yeteneğini değerlendirmek amacıyla sırasıyla eğitim veri seti (X) ve test veri seti (y) kullanılmış, veri setinin %80'i eğitim ve %20'si test için ayrılmıştır.

4.2. Model Değerlendirme

LazyPredict parametre optimizasyonu gerektirmeksizin, birkaç satır kod aracılığıyla çeşitli modellerin kolaylıkla denenmesine imkân vermektedir (Shankarpandala, 2024). Bu çalışmada, LazyPredict kütüphanesi aracılığıyla LazyClassifier kullanılarak veri analizinde yaygın olarak tercih edilen 26 farklı sınıflandırıcı modelinin performansları karşılaştırılmış ve elde edilen sonuçlar neticesinde, en yüksek genel doğruluk(accuracy) oranına sahip XGBoost modeli Tablo 2'de sunulan tahmin sonuçlarıyla detaylandırılmıştır.

Tablo 2. G7 Ülkeleri için LazyPredict XGBoostClassifier Tahmin Sonuçları

	Doğruluk Oranı	F1 Skoru	İşlem Süresi
ABD	0.9032	0.8879	0.0585
Almanya	0.9677	0.9519	0.0704
İngiltere	0.9677	0.9519	0.0545
Fransa	1.0000	1.0000	0.0586
İtalya	1.0000	1.0000	0.0588
Japonya	0.9677	0.9519	0.0722
Kanada	1.0000	1.0000	0.0527

4.3. Model Tanımı ve XGBoost Sonuçları

Çalışmada öncelikle dengesiz veri setlerindeki azınlık sınıfını güçlendirmek ve sınıflandırıcı performansını artırmak amacıyla Resampling teknikleri arasında en sık kullanılan

yöntem olan SMOTE (Synthetic Minority Over-sampling Technique) yöntemi kullanılmıştır. SMOTE, azınlık sınıfına ait sentetik örnekler oluşturarak veri setindeki sınıf dengesizliğini azaltır ve sınıflandırıcıların azınlık sınıfını daha iyi öğrenmesini sağlar (Chawla vd., 2002; He vd., 2024). Sonrasında ise finansal krizlerin potansiyel göstergelerini tespit etmek amacıyla aşırı gradyan artırma (XGBoost) tekniğinden yararlanılmıştır. Uygulanan metodolojide, G7 ülkelerinde meydana gelen bankacılık krizlerinin potansiyel tahmin değişkenlerinin belirlenmesinden önce XGBoost algoritmasının model tanılama yeteneği ve tahmin doğruluk düzeyi ayrıntılı olarak analiz edilmiştir. Elde edilen bulgular, modelin güvenilirliğini ve öngörü kapasitesini değerlendirme imkânı sunmaktadır.

Model karmaşıklığı, özellik örnekleme ve öğrenme oranı gibi çeşitli ayarlama parametrelerine ilişkin yaklaşımlar ülkeler arasında farklılık göstermektedir. Bu farklılıklar her ülkenin kendine özgü ekonomik koşulları ve veri setlerinin nitelikleriyle ilişkilendirilmektedir. Bu tespitlerin analizi, model performansını optimize etmek ve güvenilir makroekonomik tahminler üretmek açısından büyük önem arz etmektedir. Tablo 3'te G7 ülkelerinden elde edilen sonuçlar ışığında, finansal krizleri en yüksek model performansı ile tahminleyen optimal parametre değerleri belirtilmiştir. Bu parametreler, her ülkenin kendi veri yapısına ve dinamiklerine göre modelin en iyi genelleme yeteneğine sahip olmasını sağlamak üzere optimize edilmiştir. Farklı ülkeler için farklı optimal parametrelerin bulunması, XGBoost gibi algoritmaların esnekliğini ve veri odaklılığını göstermektedir.

Tablo 3. Model İyileştirme (Tuning) Sonrası En İyi Parametreler

Parametreler / Ülke	ABD	Almanya	İngiltere	Fransa	İtalya	Japonya	Kanada
max_depth	3	3	3	3	7	5	3
subsample	0.7	0.8	1	0.8	1	0.8	1
n_estimators	100	300	100	75	75	300	50
learning_rate	0.20	0.30	0.05	0.20	0.10	0.20	0.05
gamma	0.1	0.0	0.0	0.2	0.0	0.2	0.0
colsample_bytree	0.8	0.8	0.7	0.7	0.7	0.9	0.7
min_child_weight	1	1	3	1	1	1	1

G7 ülkeleri için XGBoost model tuning sonuçlarına göre, ABD, Almanya, İngiltere, Fransa ve Kanada için genellikle sığ ağaçlar (max_depth=3) tercih edilmiştir. ABD ve Fransa orta düzeyde öğrenme oranı (0.20) ile çalışırken, Almanya daha agresif (0.30), İngiltere ve Kanada ise muhafazakâr (0.05) oranlar kullanmıştır. Ağaç sayısı ülkeler arasında değişmekle birlikte, Japonya (3000) ve Fransa-İtalya (750) yüksek değerlerle öne çıkmaktadır. İtalya farklı olarak derin ağaçlar (max_depth=7), Japonya ise orta derinlikte ağaçlar (max_depth=5) kullanmıştır. Gamma regülerizasyonu Fransa (0.2), Japonya (0.2) ve ABD (0.1) için uygulanırken, diğer ülkelerde kullanılmamıştır. Özellik ve örneklem oranları genelde %70–%100 aralığında kalmış, modeller ülkelere göre farklı öğrenme stratejileri yansıtmıştır. Bu sonuçlar, her ülkenin veri setindeki ilişkilerin ve yapısının farklı olduğunu ve en iyi model performansına ulaşmak için farklı hiperparametre ayarlamaları gerektiğini göstermektedir. Örneğin, İtalya için daha derin ağaçların gerekmesi, Japonya için ise çok sayıda ağaçla daha detaylı bir öğrenmenin optimum olması gibi farklılıklar dikkat çekicidir. Öğrenme oranları ve regülerizasyon parametrelerindeki çeşitlilik de her modelin aşırı öğrenmeden kaçınmak için farklı stratejiler benimsediğini ortaya koymaktadır.

5. Ampirik Bulgular

5.1. XGBoost Performans Sonuçları

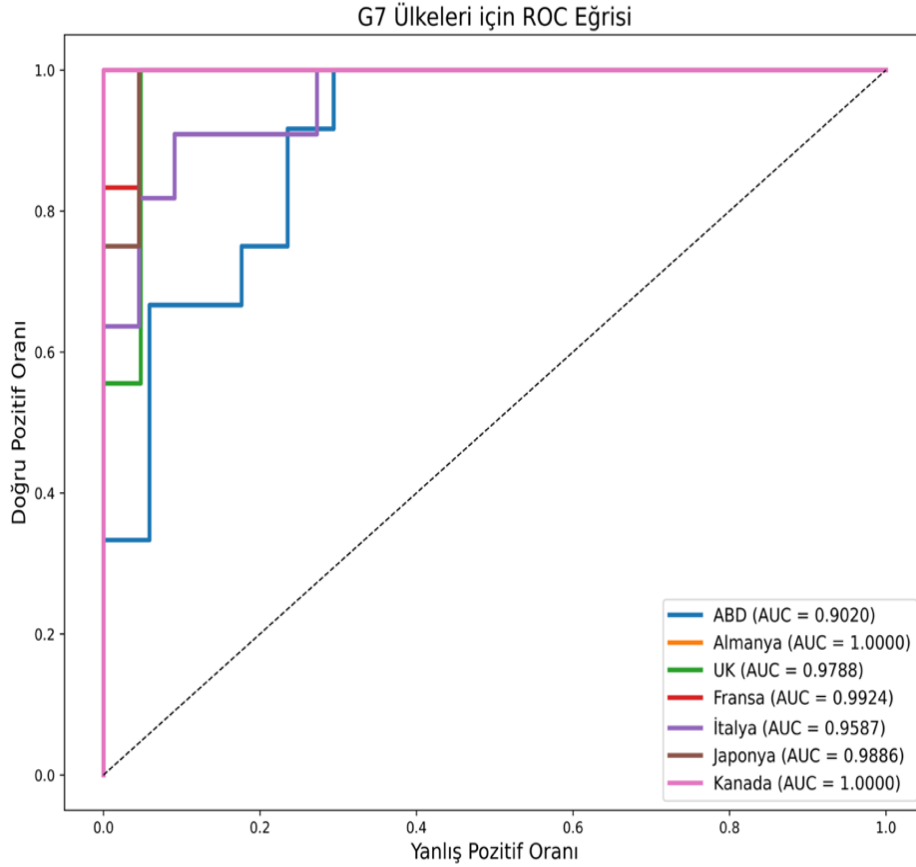
Tablo 4'te sunulan performans değerlendirme metrikleri, G7 ülkelerinde XGBoost yöntemiyle geliştirilen modellerin farklı senaryolardaki tahmin yeteneklerini ve güvenilirliğini analiz etmek amacıyla kullanılan temel istatistiksel göstergeleri kapsamlı bir şekilde özetlemektedir. Bu metrikler, modelin genel sınıflandırma başarısını, pozitif ve negatif vakaları doğru tespit etme yeteneğini ve tahminlerinin istatistiksel güvenilirliğini ortaya koymaktadır.

Tanı kriterleri ülkeler arasında aşırı gradyan artırma modellerinin performansında kayda değer farklılıklar olduğunu göstermektedir. Özellikle Kanada ve Almanya modelleri, tüm değerlendirme metriklerinde sürekli olarak üstün bir performans sergileyerek güçlü tahmin potansiyellerine işaret etmektedir. Model, Japonya ve İtalya için ise çok yüksek ve dengeli bir performans sergilemiştir. Fransa'da doğruluk yüksek olmakla birlikte duyarlılık orta düzeydedir. Buna karşılık İngiltere için özellikle duyarlılık oranlarındaki düşüklükler, modelin performansının ülkelere göre değiştiğini ve bazı ülkelerde ek optimizasyonların gerekebileceğini işaret etmektedir. Bununla birlikte ABD modelinde doğruluk diğerlerine göre daha düşük ve tahmin belirsizliği daha yüksektir. Tüm ülkelerde özgüllük değerlerinin genel olarak yüksek olması (≥ 0.941), modelin negatif örnekleri tanımlamada tutarlı bir şekilde başarılı olduğunu göstermektedir. Duyarlılık metrikleri ise ülkeler arasında daha belirgin farklılıklar sergilemektedir. Bu tür farklılıklar güvenilir ve doğru tahminler elde etmek amacıyla uygulamalı makroekonomi çalışmalarında bağlama özgü model ayarlaması ve doğrulamanın kritik önemini vurgulamaktadır. Bu araştırma, G7 ülkeleri için geliştirilen modellerin performansını kapsamlı bir şekilde analiz etmekte ve her bir ülkeye özgü etkinlik düzeylerindeki farklılıkları (güçlü ve zayıf yönleri) ortaya koymaktadır. Bu ampirik bulgular temel alınarak, modellerin gelecekteki tahmin doğruluğunu ve güvenilirliğini artırmaya yönelik potansiyel iyileştirme stratejileri önerilmektedir.

Tablo 4. XGBoost Sınıflandırıcının Tahmin Performans Sonuçları

Metrik	ABD	Almanya	İngiltere	Fransa	İtalya	Japonya	Kanada
Doğruluk	0.828	1	0.867	0.929	0.909	0.933	1
95% Güven Aralığı	(0.690, 0.965)	(1.000, 1.000)	(0.745, 0.988)	(0.833, 1.024)	(0.811, 1.007)	(0.844, 1.023)	(1.000, 1.000)
Duyarlılık	0.667	1	0.556	0.667	0.818	0.875	1
Özgüllük	0.941	1	1	1	0.955	0.955	1

Bununla birlikte Şekil 3'te G7 ülkeleri için sunulan XGBoost ROC eğrisi (Receiver Operating Characteristic Curve) ve AUC değerleri, modelin genel olarak yüksek bir performans sergilediğini göstermektedir; AUC değerlerinin büyük çoğunluğunun 0.90'ın üzerinde olması, sınıflandırıcının ayırım gücünün kayda değer düzeyde olduğunu desteklemektedir. ABD için elde edilen AUC değerinin (0.9020) diğer ülkelere kıyasla daha düşük olması, modelin bu ülke için daha az başarılı olduğunu göstermemekle birlikte verilerde daha fazla varyans veya sınıflandırma zorluğu olabileceğine işaret etmektedir. Elde edilen sonuçlar, XGBoost algoritmasının G7 ülkelerine yönelik sınıflandırma görevlerinde etkili bir modelleme aracı olduğunu ortaya koymaktadır.



Şekil 3. G7 Ülkeleri için XGBoost ROC Eğrisi ve AUC Değerleri

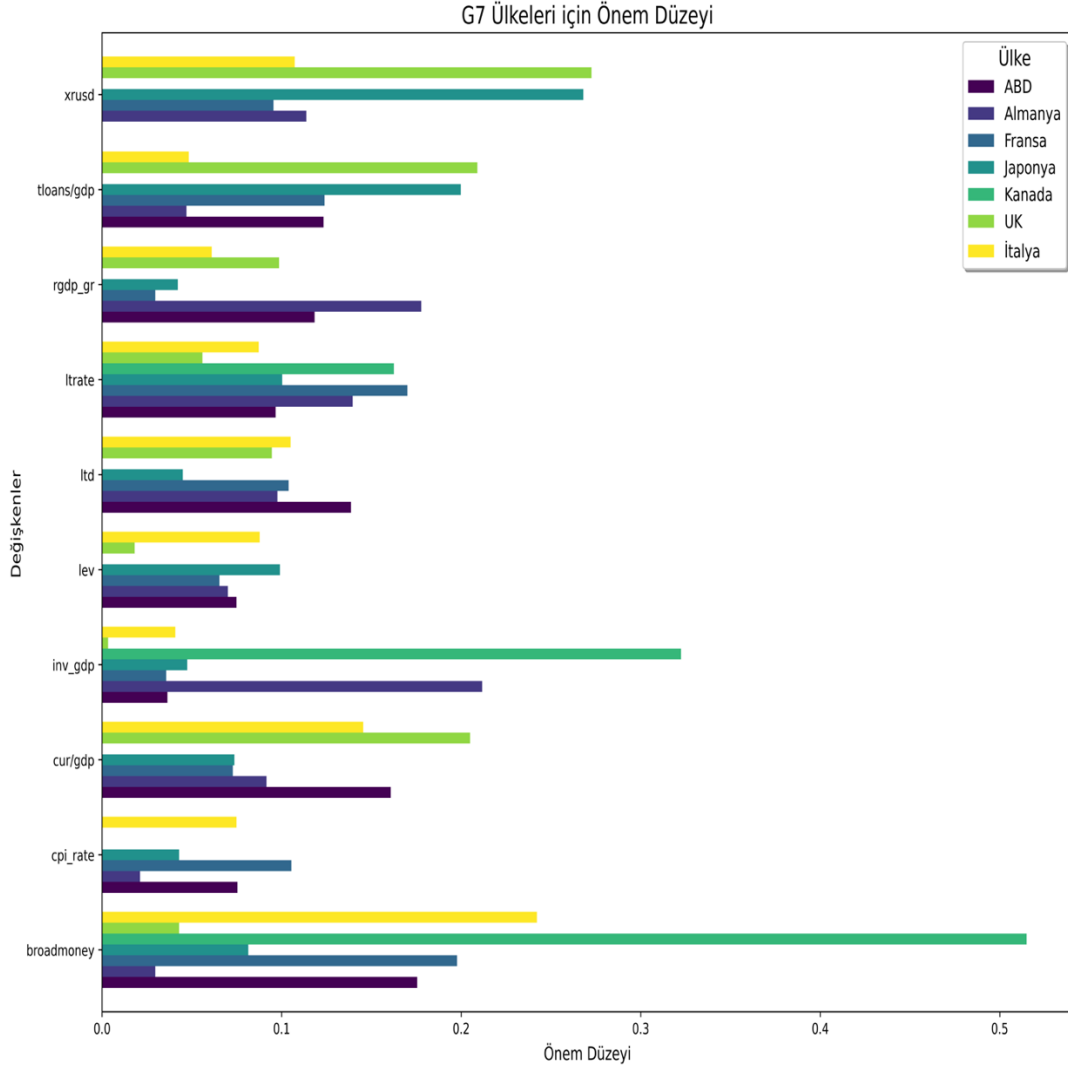
5.2. Değişkenlerin Önem Düzeyleri

Şekil 4'te sunulan G7 ülkelerine ait sistemik finansal kriz dönemlerini tahminleyen XGBoost modellerindeki değişken önem düzeyleri, kriz öngörüsü için hangi göstergelerin daha belirleyici bir rol oynadığını ortaya koymaktadır. Tablo 5'te ise değişken önem düzeyleri detaylı bir şekilde sunulmaktadır. Her değişkenin, modelin tahmin başarısına ne ölçüde katkıda bulunduğunu temsil eden önem düzeyleri, ülkeler bazında farklılık göstermektedir.

Kredilerin mevduata oranı (ltd), bankacılık sisteminin likidite durumu ve kredi verme kapasitesi hakkında bilgi sunmaktadır. İtalya, Fransa ve ABD'de bu değişkenin önemi, bankacılık sektörünün krizlere karşı duyarlılığını artırılabilir. Bu ülkelerde bankaların likidite düzenlemelerinin (örneğin, Basel III kuralları) sıkılaştırılması ve kredilerin sürdürülebilirliğinin sağlanması gerekmektedir. Bankalar için sermaye yeterlilik rasyosunun (lev) ABD, İtalya ve Japonya için önemli olması, bankacılık sektöründeki yapısal kırılganlıklara işaret edebilir. Bu doğrultuda bankaların sermaye yeterlilik oranlarının artırılması ve risk yönetimi standartlarının güçlendirilmesi önem taşımaktadır.

İtalya, ABD ve İngiltere için cari açığın GSYİH'ya oranının kriz tahmininde yüksek bir önem skoruna sahip olması, bu ülkelerde tarihsel olarak büyük ve/veya süregelen cari açıkların (veya bu açıkların finansman biçimindeki değişimlerin) finansal kriz riskini artıran önemli bir faktör olduğunu düşündürmektedir. Cari açığın yönetimi, genellikle uzun vadeli ve kapsamlı makroekonomik politika ayarlamaları gerektirir. Tek bir "kontrol" mekanizması olmamakla

birlikte, kullanılabilecek temel politika araçları maliye politikası aracılığıyla ulusal tasarrufları artırmak/iç talebi kısmak ve para politikasıyla iç talep ile kur dinamiklerini etkilemektir. Uzun vadeli çözüm için ise rekabet gücünü ve verimliliği artıracak yapısal reformlar ile ulusal tasarrufları teşvik edecek politikalar uygulamak esastır.



Şekil 4. G7 Ülkeleri İçin Potansiyel Kriz Tahmincileri

Almanya ve Kanada gibi ülkelerde ise yatırımların GSYİH'ye oranı ve reel GSYİH büyüme oranı gibi faktörler ön plana çıkmaktadır. Bu durum, ekonomik büyüme ve yatırım dinamiklerinin finansal istikrar üzerindeki etkisinin ülke ekonomisinin yapısal özelliklerine göre değişebileceğini göstermektedir. Bu bulgu, Levine (2005) tarafından vurgulanan finansal gelişim ve ekonomik büyüme arasındaki ilişkiyi destekler niteliktedir. Ancak yüksek büyüme oranlarının finansal riskleri her zaman azaltmadığı, özellikle spekülasyonlara dayalı büyümenin kriz olasılığını artırabileceği de unutulmamalıdır (Kindleberger, 2000). Bunlara karşın tüketici fiyatlarındaki yüzdesel değişim ve büyüme oranı, kriz dönemi tahminlerinde en az öneme sahip değişkenler olarak değerlendirilmektedir.

Tablo 5. G7 Ülkelerine Ait Değişken Önem Düzeyleri

	ABD	Almanya	UK	Fransa	İtalya	Japonya	Kanada
broadmoney	0.17550	0.02965	0.04290	0.19775	0.24217	0.08140	0.51496
cur/gdp	0.16080	0.09158	0.20494	0.07281	0.14547	0.07369	0.00000
ltd	0.13862	0.09764	0.09462	0.10391	0.10497	0.04502	0.00000
loans/gdp	0.12340	0.04701	0.20900	0.12391	0.04826	0.19983	0.00000
rgdp_gr	0.11834	0.17778	0.09864	0.02963	0.06110	0.04221	0.00000
rate	0.09665	0.13956	0.05589	0.17006	0.08726	0.10036	0.16255
cpi_rate	0.07540	0.02116	0.00000	0.10544	0.07488	0.04289	0.00000
lev	0.07487	0.07013	0.01816	0.06532	0.08780	0.09909	0.00000
inv_gdp	0.03642	0.21172	0.00329	0.03573	0.04081	0.04746	0.32249
xrusd		0.11375	0.27258	0.09545	0.10729	0.26805	0.00000

XGBoost sınıflandırıcısı ile gerçekleştirilen sistemik finansal kriz tahminleme çalışmalarının özellik önem derecelendirmesi sonuçları, G7 ülkelerinin ekonomik yapıları ve finansal sistemleri arasındaki farklılıkları ortaya koymaktadır. Elde edilen bulgular, ekonomik literatürdeki makine öğrenimi tabanlı finansal kriz tahmin çalışmalarıyla paralellikler göstermekte, ancak aynı zamanda bazı farklılıklar da barındırmaktadır. Bu sonuçlar, politika yapıcılarının makro ihtiyati politikaları tasarlarırken ve uygularken ülke özelindeki risk faktörlerini dikkate almaları gerektiğini vurgulamaktadır. Özellikle, para politikası, maliye politikası ve düzenleyici çerçeveler her ülkenin ekonomik ve finansal yapısına uygun olarak tasarlanmalıdır. Ayrıca küresel ekonomik şokların etkileri de ülke özelindeki risk faktörleri ile etkileşime girerek kriz olasılığını artırabileceği için, uluslararası iş birliği ve koordinasyon mekanizmaları da güçlendirilmelidir. Sonuç olarak sistemik finansal krizlerin önlenmesi ve yönetilmesi, ülke özelindeki risk faktörlerinin ve küresel ekonomik dinamiklerin dikkate alındığı kapsamlı ve koordineli politika yaklaşımlarını gerektirmektedir.

Sonuç olarak bu analiz G7 ülkelerinin farklı ekonomik dinamiklere sahip olduğunu ve her ülkenin krizleri önlemek için kendine özgü politikalar geliştirmesi gerektiğini ortaya koymaktadır. Bu nedenle, politika yapıcılarının ülkeye özgü kırılganlıkları ve risk faktörlerini dikkate alarak proaktif ve uyarlanabilir bir yaklaşım benimsemeleri finansal istikrarın sağlanması açısından elzemdir.

5.3. SHAP Değerleri

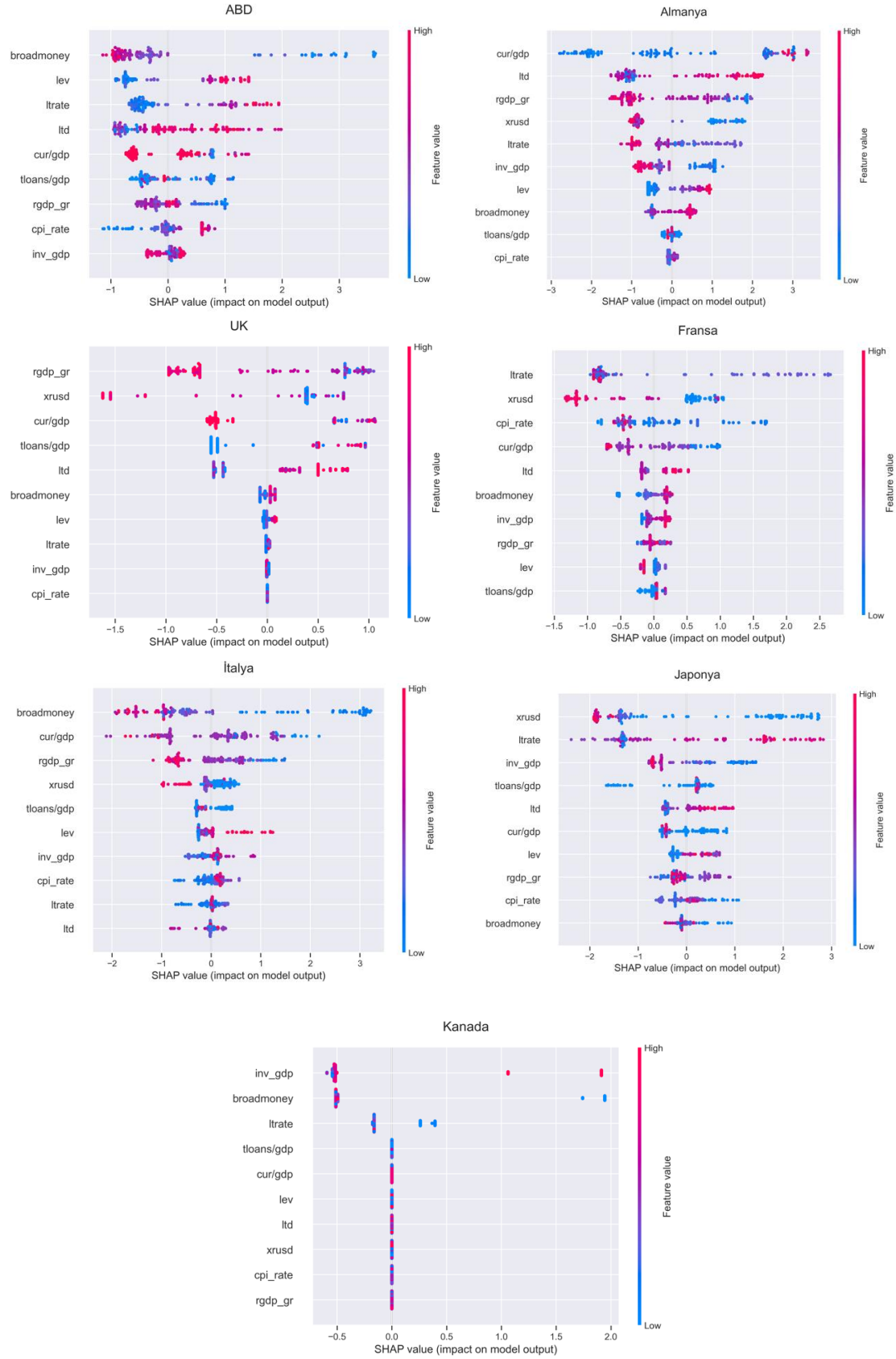
Şekil 5'te G7 ülkeleri için oluşturulan SHAP değerleri için özet grafikler, finansal krizleri etkileyen temel faktörler hakkında ayrıntılı bir analiz sunarak modelin tahminlerini etkileyen değişkenlerin önemini ve yönünü detaylı bir şekilde görselleştirmektedir. Bulgular, çoğu ülkede uzun vadeli faiz oranları, para arzındaki genişleme oranı ve cari işlemler dengesinin GSYİH içindeki payının önemli belirleyiciler olduğunu ortaya koymaktadır. Söz konusu oranlardaki artışlar, modelin tahminlerini daha yüksek sistemik finansal kriz olasılıklarına doğru yönlendirme eğilimindedir.

G7 ülkelerindeki sistemik finansal risklerin analizi, finansal sistemlerin istikrarını ve kırılganlığını yansıtan çeşitli ekonomik göstergeleri içermektedir. Kritik değişkenlerden biri olan para arzı, likiditenin korunması ve ekonomik istikrarın desteklenmesi için gerekli olmakla birlikte para arzının aşırı büyümesi halinde bir risk faktörü haline de gelebilir. Bankalarda kredilerin mevduata oranı (ltd) ve yine bankaların sermaye oranı (lev) bankacılık krizlerini

etkileyen diğer önemli faktörlerdendir. Bu özelliklerle ilişkili yüksek SHAP değerleri, potansiyel krizlerin tespit edilmesindeki önemini vurgulamaktadır. Politika yapıcılar, finansal piyasalarda sistemik kriz habercisi olarak bu oranları aktif bir şekilde izlemelidir. Bu sonuçlar, (Bluwstein vd., 2023) çalışmalarıyla uyumlu şekilde söz konusu faktörlerin bir ülkeyi finansal krizlere karşı daha savunmasız hale getirdiğini vurgulamaktadır.

Grafik incelendiğinde ABD için geniş para arzının kontrol altında tutulması, bankacılık sektöründeki kredi/mevduat oranının sürdürülebilir seviyelerde tutulması ve uzun vadeli faiz oranlarının aşırı yükselmesini önleyecek para politikalarının uygulanması, finansal istikrarı korumak için kritik öneme sahiptir. Almanya için ihracatın teşvik edilmesi ve pozitif cari işlemler dengesinin sürdürülmesi, bankacılık sektöründeki borç seviyelerinin yakından izlenmesi ve ekonomik büyümeyi desteklemek için yatırımların artırılması, ülke ekonomisinin dayanıklılığını artırabilir. İngiltere’de ekonomik büyümeyi teşvik eden politikaların geliştirilmesi, dış ticaret açıklarının azaltılması ve bankaların kredi/mevduat oranlarının yakından takip edilmesi, İngiltere ekonomisinin kırılganlıklarını azaltmaya yardımcı olacaktır. Fransa’da enflasyonu kontrol altına almak için para politikalarının dikkatlice yönetilmesi, uzun vadeli faiz oranlarını düşük tutmak için piyasa istikrarının artırılması ve cari açığı azaltmak için üretim ve ihracatın desteklenmesi, finansal istikrarı destekleyecektir. İtalya’da para arzının dengeli bir şekilde artırılarak likiditenin desteklenmesi, altyapı yatırımlarının artırılması ve cari işlemler dengesini geliştirmek için rekabet gücünü artırıcı adımların atılması, ülke ekonomisinin toparlanmasına katkıda bulunacaktır. Japonya’da döviz kuru istikrarını sağlamak için para politikalarının güçlendirilmesi, uzun vadeli faiz oranlarını kontrol altında tutarak borçlanma maliyetlerinin azaltılması ve yatırımları teşvik eden mali politikaların uygulanması, Japon ekonomisinin dış şoklara karşı direncini artıracaktır. Kanada için ise yatırımları artırarak ekonomik büyümenin desteklenmesi, likiditeyi artıracak ancak finansal riskleri sınırlayacak para politikalarının uygulanması ve faiz oranlarını düşük tutarak ekonomik istikrarın korunması, Kanada ekonomisinin sürdürülebilir büyümesini sağlayacağı belirtilebilir.

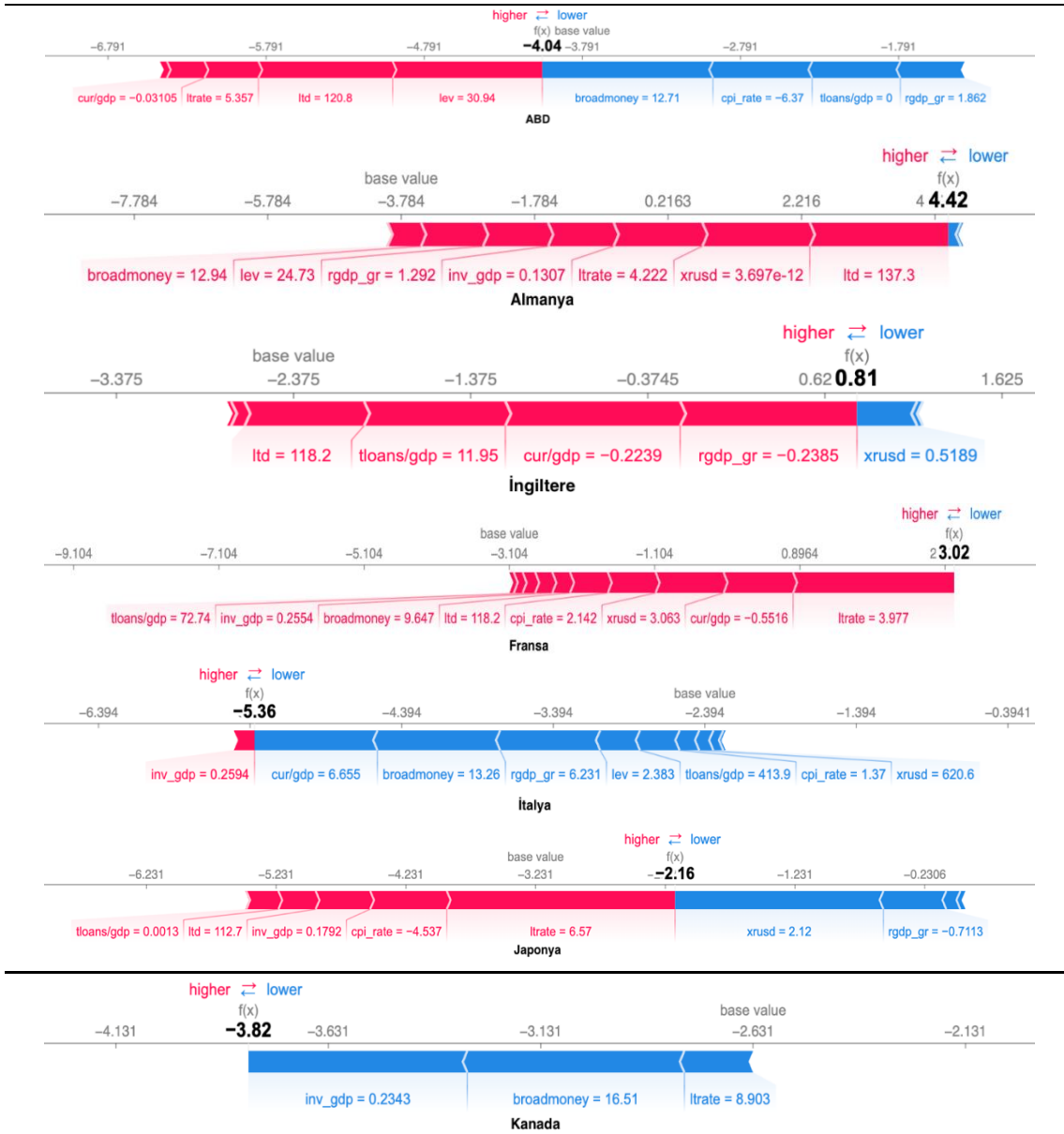
Para politikalarının önerilen şekilde dikkatlice yönetilmesi veya güçlendirilmesi, her ülkenin özel hedeflerine uygun araçların kullanılmasını içerir. Fransa’da enflasyon kontrolü için Avrupa Merkez Bankası’nın enflasyon beklentilerini çıpalamak ve politika adımlarının etkinliğini artırmak için %2’lik enflasyon hedefine bağlılığını ve gelecekteki politika niyetlerini net ve tutarlı bir şekilde piyasalara iletmesi ve bilanço politikalarını veri odaklı yönetmesi gerekirken, İtalya için likidite desteğinin enflasyon hedefiyle dengelenmesi ve muhtemelen hedefe yönelik araçların kullanılması önemlidir. Japonya’da kur istikrarını desteklemek amacıyla BoJ’un politika çerçevesini netleştirmesi ve uluslararası koordinasyonu gözetmesi, Kanada’da ise BoC’nin likidite sağlarken finansal riskleri sınırlamak için hedefli mekanizmalar uygulaması ve düzenleyici kurumlarla koordinasyonu kritik rol oynamaktadır. Bu yaklaşımlar, merkez bankalarının standart araçlarını spesifik ulusal ihtiyaçlara ve risklere göre uyarlamasını gerektirir.



Şekil 5. SHAP Analizi Sonuçları

Ülkeler arasındaki özellik farklılığı, farklı ekonomik koşulları, bankacılık ve finans piyasaları koşullarını yansıtmaktadır. Örneğin, aktif para politikalarına sahip ülkeler faiz oranlarından daha güçlü bir etki görürken, esnek kredi piyasalarına sahip olanlar kredi büyüme oranlarından daha fazla etkilenebilir. Bu bulgular, sistemik finansal krizlere yol açan durumları değiştirmek için hedeflenen politika eylemlerinin önemini vurgulamaktadır.

Şekil 6’da yer alan SHAP Force plot (Kuvvet grafiği) sonuçları, XGBoost modeli kullanılarak gerçekleştirilen sistemik finansal kriz tahminleme analizinde, belirli makroekonomik ve finansal değişkenlerin kriz olasılığı üzerindeki etkilerinin daha net bir şekilde anlaşılmasını sağlamaktadır.



Şekil 6. SHAP Kuvvet Grafiği Sonuçları

Grafikte baz deęer (base value) modelin sistemik finansal kriz olasılıęı tahmininin bařlangıç noktasıdır. Nihai tahmin $f(x)$ ise özelliklerin pozitif ve negatif katkıları toplanarak baz deęerinden hareketle hesaplanır. Kırmızı deęere sahip olan deęiřkenler tahmini artırarak (kriz olasılıęını artırma yönünde) etki ederken mavi deęere sahip olan deęiřkenler tahmini azaltarak (kriz olasılıęını düşürme yönünde) etki etmektedir.

ABD ekonomisi için XGBoost modeli ile yapılan sistemik finansal kriz tahminleme analizinde, bazı makroekonomik ve finansal deęiřkenlerin kriz olasılıęı üzerindeki etkileri belirginleřmektedir. Cari iřlemler açığıнын GSYİH'ye oranının düşüklüęü, uzun dönem faiz oranlarındaki artış, kredilerin mevduata oranının yükseklięi ve bankacılık kesimindeki sermaye oranının yükseklięi kriz olasılıęını artıran faktörler olarak öne çıkmaktadır. Bu durum, cari dengesizliklerin, yüksek borçlanma maliyetlerinin, aşırı kredi genişlemesinin ve bankaların sermaye yapılarındaki deęiřimlerin finansal kırılganlıęı tetikleyebileceęine iřaret etmektedir. Öte yandan düşük enflasyon ve reel GSYİH büyümesi kriz olasılıęını azaltan faktörler olarak tespit edilmiřtir. Bu durum, likidite bolluęunun, fiyat istikrarının ve güçlü ekonomik büyümenin finansal sistemi destekleyerek sistemik riskleri azaltabileceęini göstermektedir. Finansal olmayan özel sektöre verilen kredilerin GSYİH'ye oranı ise model için anlamlı bir katkı sağlamamaktadır.

Almanya ve İngiltere için kredi piyasası ve bankacılık sektörü dinamiklerinin kriz olasılıęı üzerinde baskın bir etkiye sahip olduęu görölmektedir. Kredilerin mevduata oranındaki yüksek seviyeler ve bankaların sermaye oranındaki artış, sistemik riskin en önemli göstergeleri olarak öne çıkmaktadır. Bu durum, aşırı kredi genişlemesinin ve bankacılık sektöründeki potansiyel kırılganlıkların finansal istikrarı tehdit edebileceęine iřaret etmektedir. Bu analiz, Almanya'da politika yapıcıların özellikle bankacılık sektörünü yakından izlemesi ve kredi piyasasının sürdürülebilirlięini sağlamak için makro ihtiyati tedbirler alması gerektięini vurgulamaktadır. İngiltere'de USD döviz kurunun kriz olasılıęını azaltıcı etkisi ise döviz kurunun istikrarının ekonomik güveni destekleyebileceęine iřaret etmektedir.

Fransa ekonomisi için XGBoost sınıflandırıcısı ile yapılan sistemik finansal kriz tahminleme analizinde, özel sektör borçlanmasının yükseklięi ve bankacılık sektöründeki bazı göstergelerin kriz olasılıęı üzerinde önemli bir etkiye sahip olduęu görölmektedir. Grafik üzerinde negatif katkı saęlayan faktörlerin bulunmaması ise Fransa ekonomisinin krizlere karřı daha az dirençli olabileceęine iřaret etmektedir.

Model İtalya'nın ekonomik istikrarını destekleyen çeřitli faktörlere ağırlık vermektedir. Cari iřlemler hesabının GSYİH'ye oranının yükseklięi ve devamındaki deęiřkenler kriz olasılıęını azaltan en önemli faktörler olarak öne çıkmaktadır. Japonya ekonomisinde ise bankacılık sektöründeki likidite risklerinin kriz olasılıęı üzerindeki etkileri öne çıkmaktadır. Döviz kurunun ve büyüme oranının kriz olasılıęını azaltması ise Japonya'da ekonomik büyümenin istikrarı destekledięini göstermektedir.

Kanada ekonomisi için XGBoost sınıflandırıcısı ile yapılan sistemik finansal kriz tahminleme analizinde, ülkenin genel olarak düşük bir kriz riski taşıdıęı görölmektedir. Model, analizde kullanılan tüm deęiřkenlerin kriz olasılıęını azaltıcı yönde etki ettięini göstermektedir. Yatırımın GSYİH'ye oranı (inv_gdp), geniş para arzındaki büyüme (broadmoney) ve uzun dönem vadeli faiz oranları (rate) kriz olasılıęını azaltan faktörler olarak öne çıkmaktadır. Bu durum, Kanada ekonomisinin yatırım, likidite ve faiz oranları açısından istikrarlı bir durumda olduęunu ve bu faktörlerin finansal istikrarı destekledięini göstermektedir.

Analiz, Kanada'da politika yapımcıların ekonomik istikrarı korumaya, yatırımları teşvik etmeye, likiditeyi desteklemeye ve faiz oranlarını istikrarlı bir seviyede tutmaya odaklanması gerektiğini vurgulamaktadır. Genel olarak Kanada ekonomisinin mevcut durumu dikkate alındığında, sistemik finansal kriz olasılığı düşük seviyelerde seyretmektedir ve mevcut politikaların finansal istikrarı desteklemeye devam ettiği söylenebilir.

G7 ülkelerinin ekonomik istikrarını güçlendirmek ve ortak riskleri azaltmak için kapsamlı bir politika seti uygulanması gerekmektedir. Finansal sistemin direnci için bankaların sermaye yeterliliğinin artırılması ve kredi/mevduat oranlarının sürdürülebilir düzeylerde tutulması kritik öneme sahiptir. Para politikası, fiyat istikrarını hedefleyerek ve ekonomik büyümeyi destekleyici faiz oranları aracılığıyla makroekonomik dengeyi sağlamalıdır. Özel sektör yatırımlarını teşvik eden mali teşvikler ve büyüme odaklı reformlar reel büyüme oranlarını yükseltmelidir. Dış ticaret açıklarını azaltmaya yönelik politikalar ve ihracatın artırılması yoluyla cari açığın kontrol altına alınması, dış finansman ihtiyacını düşürerek ekonomik kırılganlığı azaltacaktır. Bu bütüncül strateji, G7 ülkelerinin küresel ekonomik liderliğini sürdürmesine ve refahını artırmasına olanak tanıyacaktır.

6. Sonuç

Finansal sistemlerin kırılganlığının tespiti, finansal krizlerin sosyoekonomik sonuçları göz önüne alındığında büyük önem arz etmektedir. Çünkü kırılgan bir sistem, dış şokları geniş çaplı bir krize dönüştürebilme potansiyeline sahiptir. Bu bağlamda, finansal krizlerin erken dönemde belirlenmesi, politika yapımcıların proaktif önlemler alarak olumsuz etkileri minimize etmesine olanak tanırken, erken uyarı sistemlerinin geliştirilmesi veri sınırlamaları, gecikmeli sinyaller ve model karmaşıklığı gibi zorlukları da beraberinde getirmektedir.

Bu çalışmada G7 ülkeleri için XGBoost sınıflandırıcısı ile yapılan sistemik finansal kriz tahminleme analizlerinin SHAP özet grafiklerine dayalı ekonomik politika önerileri, ülkelerin özgün risk profillerini ve ortak eğilimlerini dikkate alan stratejik bir çerçeve sunmaktadır. Çalışmanın bulguları, G7 ülkelerinin kriz dönemlerinin etkilerini en aza indirmek amacıyla etkili para ve maliye politikası araçları geliştirmesi gerektiğini göstermektedir. Bu bağlamda, ABD Merkez Bankası (FED) ve diğer düzenleyici kurumlar, finansal şoklara karşı hızlı ve etkin bir şekilde yanıt verebilmelidir. G7 ülkelerinde makro ihtiyati politikalarla sorumlu ulusal ve uluslararası otoriteler, ilgili ülkeler için makro ihtiyati politika duruşunu belirlerken muhakemelerini kullanmalıdır. Bu süreçte, bu çalışmada önerilen XGBoost yöntemi ve SHAP değerleri gibi araçlar çeşitli amaçlara hizmet edebilir. Geçmişte sistemik bankacılık krizlerine yol açan risklerin ortaya çıkması durumunda, makro ihtiyati politika araçlarının neden devreye sokulmadığını yalnızca muhakemeye dayanarak açıklamak zorlaşabilir. Dolayısıyla, bu tür analitik modellerin güçlü performansı, politika yapımcıların bu tür durumlarda kararlarının gerekçesini daha sağlam temellere dayandırmalarını sağlamaktadır. Ayrıca XGBoost yönteminin sezgisel yapısı ve kolay görselleştirilmesi, politika tartışmaları için bir başlangıç noktası olarak analitik bir yaklaşımın benimsenmesini teşvik edebilir. Son olarak bu yöntemin bir diğer avantajı, belirli bir kriz olasılığı ile ilişkilendirilen özelliklere bağlı olarak kırılganlığın niteliğinin de belirlenebilmesidir. Bu, belirli bir politika aracının diğerine göre daha uygun olduğu yönünde önerilerde bulunulmasına olanak tanıyacaktır.

Gelecekteki arařtırmalar, sistemik bankacılık krizlerinin lkeler arasındaki finansal ve ekonomik aktrler zerindeki yayılma etkilerini hem finansal hem de ticari baėlantıları dikkate alarak detaylı bir řekilde inceleyebilir. Sistemik bankacılık krizlerinin temel nedenlerinin ve uluslararası politika btnlėnn sz konusu krizlerin kresel istikrar zerindeki etkilerini azaltmadaki rolnn arařtırılması da alana nemli katkılar saėlayacaktır. Sonu olarak, makro ihtiyati politikaların tasarımı ve uygulanması, lke zelindeki risk faktrlerinin ve kresel ekonomik dinamiklerin dikkate alındıėı btncl bir yaklařımla gerekleřtirilmelidir. Makine ėrenimi modellerinin sunduėu ngr yeteneėi, politika yapıcılarının erken uyarı sistemlerini geliřtirmelerine ve proaktif nlemler almalarına yardımcı olabilir.

Arařtırma ve Yayın Etiėi Beyanı

Etik kurul izni ve/veya yasal/zel izin alınmasına gerek olmayan bu alıřmada arařtırma ve yayın etiėine uyulmuřtur.

Arařtırmacıların Katkı Oranı Beyanı

Yazarlar makaleye eřit oranda katkı saėlamıř olduklarını beyan eder.

Arařtırmacıların ıkar atıřması Beyanı

Bu alıřmada herhangi bir potansiyel ıkar atıřması bulunmamaktadır.

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A MACHINE LEARNING APPROACH: FINANCIAL CRISIS FORECASTING IN G7 COUNTRIES

EXTENDED SUMMARY

The Purpose of the Study

The objective of this study is to empirically evaluate the efficacy of an XGBoost-based modelling approach in predicting systemic banking crises. This investigation utilizes financial and macroeconomic data from G7 countries from the period 1870 to 2020. The study aims to elucidate the causal relationships between crisis risk and forecasting variables through SHAP (SHapley Additive exPlanations) analyses. The findings of this study will provide policy recommendations to enhance financial stability.

Literature Review

The extant literature contains a paucity of studies that focus on the machine learning-based forecasting of systemic banking crises in G7 countries. The present study aims to address this gap in the literature by integrating advanced econometric analyses and machine learning techniques (in particular, the XGBoost algorithm) to evaluate time series data more effectively. The study's distinguishing features include the employment of suitable data preprocessing methodologies for imbalanced datasets, the rigorous evaluation of the efficacy of the XGBoost model through model validation processes, and a comprehensive examination of the factors involved in the prediction of financial crises through SHAP analyses. This provides a more robust and interpretable modelling framework for the early warning of financial crises.

Existing literature demonstrates the potential of machine learning methods for financial crisis prediction, offering advancements in financial stability monitoring and risk management. For example, Alessi and Detken (2018) found the random forest algorithm yielded promising results. Chatzis et al. (2018) reported that XGBoost outperformed alternative methods. More recently, researchers have focused on model interpretability. Tran et al. (2022) used Shapley values to interpret the predictive outputs of XGBoost and random forest models, increasing the transparency of the models' decision-making processes. Similarly, Liu et al. (2022) and Chen et al. (2024) employed Shapley values to identify impactful prediction indicators and analyze causal relationships within their models.

Methodology

This study utilizes XGBoost and SHAP values. XGBoost (Extreme Gradient Boosting), developed by Chen and Guestrin (2016), is an approach based on the boosting algorithm proposed by Friedman (2001). XGBoost is an ensemble model created by efficiently combining decision trees and thus offers higher prediction performance compared to stand-alone methods. These features have contributed to the widespread adoption of XGBoost as a preferred algorithm in machine learning applications. Additionally, XGBoost employs Shapley values

(Shapley, 1953), a fundamental concept in cooperative game theory, to evaluate the contributions of predictors in machine learning models.

Findings

The performance of extreme gradient boosting models varies significantly between countries, as indicated by the substantial differences in the diagnostic criteria. Specifically, the Canadian and German models demonstrate consistent superiority across all evaluation metrics, signifying their notable predictive capability. Conversely, the UK model exhibits comparatively low sensitivity ratios, suggesting that its performance is contingent on the specific context of each country and that additional optimizations may be necessary in certain instances. These observations underscore the paramount importance of adapting models to the unique characteristics of each country in applied macroeconomic studies, ensuring the reliability and precision of forecasts. In conclusion, this analysis reveals that G7 countries have different economic dynamics, and each country needs to develop its own policies to prevent crises. Therefore, it is essential for policymakers to adopt a proactive and adaptive approach by taking into account country-specific vulnerabilities and risk factors to ensure financial stability.

Conclusion and Policy Implications

In this study, economic policy recommendations are derived from SHAP summary graphs of systemic financial crisis forecasting analyses with the XGBoost classifier for G7 countries. This provides a strategic framework that takes into account the unique risk profiles and common trends of the countries. The findings of the study suggest that G7 countries should develop effective monetary and fiscal policy tools to minimize the effects of crisis periods. In this context, the Federal Reserve and other regulatory agencies should be able to respond quickly and effectively to financial shocks. The judicious application of macroprudential policies by national and international authorities in G7 countries is critical in determining the appropriate policy stance for their respective nations. In this process, the XGBoost method and SHAP values proposed in this paper can serve various purposes. Finally, an additional advantage of this method is that the nature of vulnerability can also be determined depending on the characteristics associated with the probability of a particular crisis. This capacity to discern between policy instruments, based on their relative appropriateness in different contexts, positions this method as a valuable tool for decision-making processes within macroprudential frameworks.

SPOT VE FUTURE PİYASALARI ARASINDAKİ OYNAKLIK YAYILIMLARI VE YAYILIMLARIN KALICILIĞININ ANALİZİ

Volatility Spillovers between Spot and Futures Markets and the Analysis of Their Persistence

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Öz

Anahtar Kelimeler:
Hisse
Senedi
Piyasaları,
Varyansta
Nedensellik,
Kalıcılık

JEL Kodları:
F3, C58,
G11

Future piyasalar ve dayanak varlığa ait spot piyasalar birbiriyle yakından ilişkilidir. Bu ilişkiler fiyatlar ve getiriler bazında veya risk geçişleri olarak gözlemlenmektedir. Yatırımcılar için önemli risk kaynaklarından biri piyasalar arasındaki oynaklık yayılımlarıdır. Piyasalar arasındaki oynaklık yayılımlarının belirlenmesi, piyasaların geleceğe ilişkin oynaklık tahmininde önemli bir rol oynamaktadır. Piyasalar arasındaki bilgi aktarımı, piyasalarda meydana gelen oynaklık şokları ve ani fiyat değişimleri, artan entegrasyon gibi pek çok farklı faktöre bağlı olarak ortaya çıkan oynaklık yayılımları karşılıklı veya bir piyasadaki diğerine doğru gerçekleşebilmektedir. Öte yandan, bu yayılımlar geçici olabilmekte veya kalıcılık sergileyebilmektedir. Bu bağlamda çalışmanın amacı, 4 Ocak 2000-25 Mart 2025 tarihleri arasında 27 gelişmiş ve gelişmekte olan ülkede spot ve future hisse senedi piyasaları arasındaki oynaklık yayılımlarının varlığının sınanması, yayılımların yönünün ve kalıcılık yapısının belirlenmesidir. Belirlenen amaç doğrultusunda çalışmada Hafner ve Herwartz (2006) varyansta nedensellik testi ve Li ve Enders (2018) Fourier fonksiyonları ile genişletilmiş varyansta nedensellik testi uygulanmıştır. Sonuçlar, ele alınan ülkelerin hemen hepsinde spot ve future piyasalar arasında oynaklık yayılımları bulunduğunu ve 21 ülkede bu yayılımların karşılıklı olduğunu ortaya koymuştur. Ayrıca oynaklık yayılımlarının çoğunun kalıcı nitelikte olduğu tespit edilmiştir.

Abstract

Keywords:
Stock
Markets,
Causality in
Variance,
Persistency

JEL Codes:
F3, C58,
G11

Futures markets and spot markets of the underlying assets are closely interrelated. These relationships are observed on the basis of prices and returns, or in terms of risk transmissions. One of the important risk sources for investors is volatility spillovers between markets. Determining volatility spillovers between markets plays an important role in estimating the future volatility of the markets. Volatility spillovers, which occur due to many different factors such as information transfer between markets, volatility shocks, sudden price changes in the markets, and increased integration, can occur mutually or from one market to another. On the other hand, these spillovers may be temporary or permanent. In this context, the aim of the study is to test the existence of volatility spillovers between spot and futures stock markets in 27 developed and developing countries and to determine the direction and persistence structure of the spillovers for the period from January 4, 2000, to March 25, 2025. In line with the determined purpose, the Hafner and Herwartz (2006) causality-in-variance test and the causality-in-variance test extended with Fourier functions were applied in the study. The results show that there are volatility spillovers between spot and futures markets in almost all of the countries considered, and these spillovers are bidirectional for 21 countries. Also, it was determined that most of the volatility spillovers are persistent in nature.

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1. Giriş

Spot ve future piyasalar, finansal piyasaların işleyişinde yatırımcı davranışlarını, fiyatlama süreçlerini ve risk aktarım mekanizmalarını şekillendirmektedir. Spot piyasalar, finansal varlıkların anlık olarak işlem gördüğü ve mevcut bilginin doğrudan fiyatlara yansıdığı piyasalardır. Future piyasalar ise yatırımcıların geleceğe ilişkin beklentilerini ve risk algılarını yansıttıkları, aynı zamanda riskten korunma ve spekülasyon amaçlı işlemlerin yürütüldüğü piyasalardır. Diğer bir ifadeyle, future piyasalar gelecekteki fiyat beklentilerini yansıtırken, spot piyasalar mevcut arz ve talebi yansıtmaktadır (Williams, 1986). Bu iki piyasa arasındaki etkileşim hem fiyat keşfi sürecinin yönünü hem de piyasa beklentilerini etkileyerek yatırım kararlarını doğrudan etkilemektedir. Özellikle bir piyasadan diğerine veya karşılıklı olarak gerçekleşen oynaklık yayılımları yatırımcıların karar alırken dikkate almaları gereken önemli faktörlerden biridir. Spot ve future piyasalar arasında gerçekleşen oynaklık yayılımlarını ortaya çıkaran temel dinamikler bilgi aktarımı ve oynaklık şoklarıdır. Öte yandan, bu piyasalarda meydana gelen ani fiyat değişimleri, karşılıklı olarak yatırım kararlarını etkileyerek oynaklık yayılımlarına yol açabilmektedir. Dolayısıyla, spot ve future piyasalar arasında oynaklık geçişkenliği, finansal bilgi akışının yönü, yatırımcı davranışlarının senkronizasyonu ve sistemik risklerin yayılma potansiyeli açısından detaylı bir şekilde analiz edilmelidir.

Finansal oynaklık, belirli bir dönemde bir finansal varlığın değerinde meydana gelen değişkenliğin ölçüsüdür ve hem yatırımcıların karar alma süreçlerini hem de politika yapıcıların piyasa istikrarını sağlamaya yönelik kararlarını belirleyen temel faktörlerden biridir. Küresel ve bölgesel krizler, piyasalarda artan belirsizlikler ve ani sermaye hareketleri, finansal varlık fiyatlarının giderek daha oynak bir yapı sergilemesine neden olmaktadır (Funke ve Goldstein, 1996). Bununla birlikte, piyasalar arasında artan entegrasyona bağlı olarak oynaklık yayılımları da hızlı bir şekilde gerçekleşmektedir. Oynaklık yayılımı, bir piyasadaki geçmiş dönemdeki oynaklığın, diğer bir piyasanın mevcut oynaklığı üzerinde etkisi olarak tanımlanmaktadır (McAleer ve da Veiga, 2008). Oynaklık yayılımları hem uluslararası piyasalar arasında hem de spot ve future piyasalar gibi aynı ülke içinde yer alan farklı tür piyasalar arasında gerçekleşebilmektedir. Öte yandan, yayılımlar yalnızca gelişmekte olan ülkelerde değil aynı zamanda gelişmiş ülkelerin piyasaları arasında da gözlemlenmektedir. Bu nedenle, yatırımcı stratejileri ve sistemik riskin tespiti ve yönetimi açısından finansal gelişmişlik düzeyinden bağımsız olarak her bir ülkede oynaklık yayılım dinamiklerinin detaylı bir şekilde incelenmesi gerekmektedir. Özellikle oynaklık yayılımının hangi piyasada başladığı ve hangi piyasaya doğru yöneldiği, yayılımların kalıcı mı yoksa geçici mi olduğu gibi soruların yanıtlanması, yatırımcılara ve politika yapıcılara birçok alanda önemli bilgiler sunmaktadır.

2000’li yıllardan itibaren finansal piyasalar arasındaki entegrasyonunun artması, teknolojik gelişmelerin hızlanması ve yatırımcı profillerinin değişmesi gibi birçok faktöre bağlı olarak küresel finansal sistemde önemli değişimler gerçekleşmiştir. Özellikle 2008 Küresel Krizi, Avrupa Borç krizi, COVID-19 Pandemisi ve ardından yaşanan yüksek enflasyon-faiz dalgalanmaları gibi şoklar hem finansal varlıklar üzerinde ani etkilere hem de piyasaların işleyişinde kalıcı değişikliklere neden olmuştur. Bu süreç, future piyasaların hem bilgi taşıyıcı hem de oynaklık yayıcı bir yapıya dönüşerek daha kritik roller üstlenmesine neden olmuştur (Kang ve Lee, 2019; Hou ve Li, 2020). Tüm bu gelişmeler, future piyasaların davranışsal ve yapısal özelliklerinin zamanla değiştiğini göstermektedir. Bu nedenle, spot ve future piyasalar arasındaki oynaklık yayılımlarının analizinde sabit parametrelili geleneksel yöntemler yerine,

yapısal deęiřimleri ve doęrusal olmayan yapıyı dikkate alan yöntemlerin kullanılması daha uygun hale gelmiřtir.

Spot ve future hisse senedi piyasaları arasındaki iliřkileri arařtıran alıřmalarda, ele alınan dönem ve uygulanan yöntemlere baęlı olarak farklı sonuçlar elde edilmiř ve genellikle yayılımların kalıcılık yapısı dikkate alınmamıřtır (Sim ve Zurbreugg, 1999; Antoniou vd., 2003; Zhong vd., 2004; Zhang ve Jaffry, 2015; Hou ve Li, 2020; Kılı, 2022; Sundararajan ve Balasubramanian, 2025). alıřmaların bir bölümü piyasalar arasındaki oynaklık iliřkilerinin asimetrik boyutuna odaklanmıřtır (Tse, 1999; Mallikarjunappa ve Afsal, 2010; Tokat ve Tokat, 2010; Yang vd., 2012; Siddiqui ve Roy, 2020; Truong vd., 2021; Kara vd., 2022; Yaęcılar, 2022). Dięer bir bölümde ise kısa bir tarih aralıęında yüksek frekanslı veriler kullanılarak piyasalar arasındaki yayılımların kısa vadeli dinamikleri arařtırılmıřtır (Chan vd., 1991; Fan ve Du, 2017; Gannon, 2005; Gkillas vd., 2021; Kang vd., 2013; Min ve Najand, 1999; Pati ve Rajib, 2011; Wu vd., 2005; Zhang ve Jaffry, 2015). Ancak, spot ve future piyasaları baz alarak portföy çeřitlendirmesi yapan yatırımcılar aısından sadece bu piyasalar arasındaki oynaklık yayılımlarının varlıęının ve yönünün belirlenmesi yeterli deęildir. Yatırımcıların risklerini etkin bir řekilde yönetebilmesi için oynaklık yayılımlarının kalıcılık yapısını da dikkate alması gerekmektedir. Ayrıca, ilgili literatürde yer alan alıřmaların çoęunda tek bir ülkenin spot ve future piyasaları arasındaki iliřkiler incelenmiř, sınırlı alıřmada ise birden fazla ülkenin kendi piyasaları arasındaki veya farklı ülkelerin spot ve future piyasaları arasındaki etkileřim ele alınmıřtır (Sim ve Zurbreugg, 1999; Antoniou vd., 2003; Antonakakis vd., 2016; Siddiqui ve Roy, 2020). Finansal piyasalarda yatırımcıların karar alma süreçleri, ülke içi piyasalar arasındaki iliřkilere oldukça duyarlıdır ve piyasalar arasındaki yayılımların yapısı da ülkeye özęü dinamikler çerçevesinde řekillenmektedir. Dięer yandan, her ülkenin finansal gelişmiřlik seviyesi, piyasa derinlięi, likidite düzeyi vb. unsurlara baęlı olarak farklılık göstermektedir. Dolayısıyla, birbirlerinden farklı dinamiklere sahip ülkelerin kendi spot ve future hisse senedi piyasaları arasında gerekleşen oynaklık yayılımlarının analiz edilmesi ile her bir ülke özelinde finansal bilginin aktarımı hızı, fiyat keřfi süreçlerinin yönü ve řokların etkileri hakkında ayrıntılı bir deęerlendirme yapılabilecektir. Bu bağlamda alıřmada, geniş bir veri seti çerçevesinde, spot ve future hisse senedi piyasaları arasındaki oynaklık yayılımlarının detaylı olarak belirlenmesi amaçlanmıřtır. Bu amaç doęrultusunda 27 gelişmiř ve gelişmekte olan ülkenin her birinde, spot ve future piyasalar arasındaki oynaklık yayılımları Hafner ve Herwartz (2006) varyansta nedensellik testi ve Li ve Enders (2018) Fourier fonksiyonları ile genişletilmiř varyansta nedensellik testi ile analiz edilmiřtir.

Oynaklık yayılımlarının yapısal deęiřimleri dikkate alan Fourier fonksiyonları ile genişletilmiř varyansta nedensellik testleri ile analiz edilmesi, spot ve future piyasalar arasındaki yayılımlarının varlıęı ve yönünün yanı sıra kalıcılık yapısının da belirlenmesine imkan tanıyarak literatüre katkı saęlamaktadır. alıřmanın bir dięer katkısı, literatürdeki alıřmalardan farklı olarak, yayılımların 25 yıllık bir döneme ait geniş bir veri seti ile incelenmesidir. Belirtilen amaç kapsamında, alıřma ile ařaęıdaki arařtırma sorularına cevap aranmıřtır;

Hangi ülkelerde spot ve future getiriler arasında oynaklık yayılımları bulunmaktadır?

Yapısal deęiřimlerin dikkate alınması durumunda oynaklık yayılımları deęiřim göstermekte midir?

Oynaklık yayılımlarının kalıcılık yapısı ne řekildedir?

Çalışma ile spot ve future piyasaları baz alarak portföy çeşitlendirmesi yapan yatırımcılara, daha etkin risk yönetim stratejileri geliştirebilmeleri açısından detaylı çıktıların sunulması planlanmaktadır.

2. Literatür

Finansal piyasalarda yatırım kararlarını etkileyen en kritik unsurlardan biri, farklı finansal varlıklar arasındaki oynaklık etkileşimlerinin belirlenebilmesidir. Özellikle spot ve future piyasalar arasındaki oynaklık yayılımları hem fiyat keşfi süreci hem de etkin riskten korunma stratejileri açısından yatırım kararlarını doğrudan şekillendirebilmektedir. Bu nedenle, bu iki piyasa arasındaki oynaklık yayılımlarının yönü, şiddeti ve süresi sıklıkla araştırılan konular arasında yer almaktadır. Literatürde birçok farklı spot ve vadeli piyasa arasındaki ilişki incelenmiştir. Magkonis ve Tsouknidis (2017) ve Apostolakis vd. (2024) petrol, Sehgal vd. (2021) ve Saini ve Sharma (2024) altın, Sakthivel vd. (2017) döviz kurları, RL ve Mishra (2020) tarımsal emtia, Apostolakis (2024) ise Bitcoin’e ilişkin spot ve future piyasalar arasındaki oynaklık ilişkilerini ele almışlardır. Bununla birlikte, çalışmanın bu bölümünde, belirlenen amaç doğrultusunda spot ve future hisse senedi piyasaları arasındaki ilişkileri araştıran çalışmalara detaylı olarak yer verilmiştir.

Spot ve future hisse senedi piyasaları arasındaki oynaklık yayılımlarını analiz eden çalışmaların birçoğunda karşılıklı ilişkiler tespit edilmiştir (Chan vd., 1991; Sim ve Zurbreugg, 1999; Min ve Najand, 1999; Tse, 1999; Wu vd., 2005; Tokat ve Tokat, 2010; Pati ve Rajib, 2011; Yang vd. 2012; Kang vd., 2013; Zhang ve Jaffry, 2015; Siddiqui ve Roy, 2020; Kara vd. 2022; Sundararajan ve Balasubramanian, 2025). Chan vd. (1991) çalışmalarında, 1 Ağustos 1984-31 Aralık 1989 tarihleri arasında ABD’de spot ve future hisse senedi endeksleri arasındaki getiri ve oynaklığı araştırmışlardır. Çalışmada uygulanan iki değişkenli genelleştirilmiş otoregresif koşullu değişen varyans (GARCH) modeli ve etki tepki analizi ile spot ve future endeks getirilerinin oynaklıkları arasında karşılıklı güçlü bir bağımlılık tespit etmişlerdir. Sim ve Zurbreugg (1999) çalışmalarında, Avustralya ve Japonya piyasalarını baz alarak spot ve future piyasaları arasındaki ilişkileri, yerel ve yabancı spot vadeli hisse senedi endeks piyasalarını içerecek şekilde genişleterek incelemişlerdir. 24 Temmuz 1997-24 Ekim 1997 dönemi kapsayan çalışmada uygulanan EC-ARCH modeli ile ülkeler arasında çift yönlü oynaklık yayılımları olduğu sonucuna ulaşılmıştır. Min ve Najand (1999) çalışmalarında, 3 Mayıs 1996-16 Ekim 1996 tarihleri arasında, Güney Kore’de spot ve future hisse senedi endeksleri arasındaki öncül-ardıl ilişkiyi dinamik eşzamanlı denklem modelleri ile analiz etmişlerdir. On dakikalık yüksek frekanstaki verilerin kullanıldığı çalışma sonucunda, spot ve future piyasalar arasında karşılıklı bir ilişki olduğu ortaya konmuştur. Benzer şekilde Kang vd. (2013) çalışmalarında Güney Kore’de yüksek frekanslı verileri baz alarak spot ve future hisse senedi endeksleri arasındaki oynaklık yayılımları araştırmış ve GARCH-BEKK modeli ile karşılıklı ilişki tespit etmişlerdir. Çalışma ile yeni bilginin Güney Kore spot ve future piyasalarında eş zamanlı olarak yansıdığı vurgulanmıştır. Yang vd. (2012) ve Zhang ve Jaffry (2015) ise çalışmalarında Çin’de spot ve future hisse senedi piyasaları arasındaki oynaklık ilişkilerini incelemişlerdir. Her iki çalışmada yüksek frekanslı veriler kullanılmış ve Çin’de spot ve future piyasalar arasında karşılıklı oynaklık ilişkileri belirlenmiştir. Tse (2009) çalışmasında, ABD’de spot ve future piyasalar arasında fiyat keşif sürecini ve oynaklık yayılımlarını araştırmıştır. Kasım 1997-Nisan 1998 dönemi kapsayan çalışmada uygulanan iki değişkenli

EGARCH modeli ve Hasbrouck (1995) eşbütünleşme testi ile piyasalar arasında çift yönlü bilgi akışı tespit edilmiştir. Ayrıca, her iki piyasada asimetrik oynaklık etkileri saptanmış ve kötü haberlerin oynaklık üzerinde iyi haberlere göre daha büyük bir etkiye sahip olduğu ortaya konmuştur.

Wu vd. (2005) çalışmalarında, ABD ve İngiltere piyasalarını baz alarak, yüksek frekanslı veriler ile future piyasalar arasındaki kısa dönemli bilgi aktarımını incelemiştir. Çalışmada uygulanan iki değişkenli GARCH modeli ile future piyasalar arasında çift yönlü oynaklık yayılımları tespit edilmiştir. Tokat ve Tokat (2010) çalışmalarında, Şubat 2005-Haziran 2009 tarihleri arasında Türkiye’de spot ve future döviz ve hisse senedi piyasaları arasındaki oynaklık yayılımlarını araştırmıştır. Çalışmada uygulanan BEKK–GARCH modeli ile incelenen tüm piyasalar arasındaki yayılımların karşılıklı olduğu belirlenmiş, ayrıca spot ve future hisse senedi piyasaları arasındaki ilişkinin asimetrik yapıda olduğu ortaya konmuştur. Benzer şekilde Kara vd. (2022) çalışmalarında Türkiye spot ve future hisse senedi piyasaları oynaklık değişimleri arasında karşılıklı bir nedensellik ilişkisi tespit etmişlerdir. Ayrıca çalışmada uygulanan GJR-GARCH ve DCC-GARCH modelleri ile incelenen piyasalarda negatif şoklara, pozitif şoklara göre daha yüksek tepki verildiği sonucuna ulaşılmıştır. Pati ve Rajib (2011) çalışmalarında, Hindistan’da spot ve future hisse senedi endeksleri arasındaki getiri ve oynaklığı farklı ekonometrik teknikler ile analiz etmişlerdir. 1 Mart 2007-31 Ocak 2008 dönemini ele alan çalışmada uygulanan Johansen–Juselius eşbütünleşme ve nedensellik testleri ile future piyasadaki spot piyasaya doğru tek yönlü bir nedensellik tespit edilmiş ve future fiyatların spot fiyatlara öncülük ettiği, dolayısıyla future piyasanın fiyat keşfine büyük ölçüde katkıda bulunduğu sonucuna ulaşılmıştır. Bununla birlikte BEKK–GARCH modeli ile spot ve vadeli piyasalar arasında çift yönlü oynaklık yayılımları da saptanmıştır. Siddiqui ve Roy (2020) çalışmalarında, 16 Mayıs 2010-31 Mayıs 2019 tarihleri arasında farklı ülkelerin spot ve future piyasaları arasındaki ilişkileri araştırmışlardır. Çalışmada Hindistan, Çin ve ABD’de piyasalar arasındaki ilişkiler dalgacık tabanlı BEKK-GARCH modeli ile analiz edilmiş ve üç ülkede de piyasalar arasında çift yönlü bilgi yayılımı olduğu sonucuna ulaşılmıştır. Sundararajan ve Balasubramanian (2025) ise çalışmalarında, yüksek frekanslı veriler kullanarak 02 Eylül 2019-12 Eylül 2022 tarihleri arasında Hindistan ve Singapur’da eş zamanlı olarak işlem gören çift kote spot ve future finansal varlıklar arasındaki fiyat keşif mekanizmasını ve oynaklık yayılımlarını araştırmışlardır. Çalışmada uygulanan nedensellik testleri ile future piyasanın fiyat keşfinde spot işlemlere öncülük ettiği belirlenmiş, BEKK–GARCH modeli sonucunda da karşılıklı oynaklık yayılımları ortaya konmuştur.

Spot ve future piyasalar arasındaki yapıyı araştıran çalışmaların bir kısmında ise tek yönlü ve karışık ilişkiler belirlenmiştir (Koutmos ve Tucker, 1996; Antoniou vd., 2003; Zhong vd., 2004; Gannon, 2005; Fan ve Du, 2017; Hou ve Li, 2020; Gkillas vd. 2021; Gürbüz ve Şahbaz, 2022; Kılıç, 2022). Fan ve Du (2017) çalışmalarında yüksek frekanslı veriler ile Çin’de spot ve future hisse senedi endeksleri arasındaki ilişkileri ve future işlemlerin 2015 borsa çöküşündeki payını araştırmışlardır. 16 Nisan 2015-1 Eylül 2015 dönemini kapsayan çalışmada uygulanan DCC-GARCH modeli ile future piyasanın spot piyasa üzerinde tek yönlü yayılma etkisine sahip olduğu saptanmış ve yayılma etkisinin önemli ölçüde asimetrik olup, piyasaların yükseldiği dönemde nispeten ılımlı ve yavaş, piyasaların düştüğü dönemde ise şiddetli ve hızlı olduğu belirtilmiştir. Ayrıca future piyasa işlemlerinin, 2015 Çin borsasının çöküşünde düşüşü hızlandırdığını ve şiddetlendirdiği ortaya konmuştur. Benzer şekilde Hou ve Li (2020) çalışmalarında 2015 yılındaki piyasa çöküşü sırasında Çin’de spot ve future piyasalar arasındaki

oynaklık yayılımlarını DCC-GARCH modeli ile analiz etmişlerdir. Çalışma ile future piyasadan spot piyasaya yayılım tespit edilmiş, ayrıca ve aşağı yönlü riskin aktarımının future piyasa öncülüğünde çift taraflı olduğu sonucuna ulaşılmıştır. Gürbüz ve Şahbaz (2022) ve Kılıç (2022) ise çalışmalarında Türkiye’de spot ve future piyasalar arasındaki ilişkileri incelemişlerdir. Gürbüz ve Şahbaz çalışmalarında, 5 Mayıs 2007-27 Eylül 2017 tarihleri arasında BİST30 spot ve future sözleşmelerini baz alarak future piyasa işlemlerinin hisse senedi endeksleri üzerinde oynaklık yayılma etkisine sahip olup olmadığını araştırmışlardır. Çalışmada uygulanan dalgacık yöntemi ve çok değişkenli GARCH modelleri ile future piyasadan spot piyasaya oynaklık yayılımları ortaya konmuştur. Kılıç çalışmasında, 29.06.2012-28.07.202 tarihleri arasında spot ve future piyasalar arasında getiri ve oynaklık ilişkilerini VAR-EGARCH modeli ile analiz etmiştir. Çalışmada future BİST30 ve spot BİST30, BİST100 ile farklı sektör endeksleri arasındaki ilişkiler incelenmiş ve çoğunlukla tek yönlü oynaklık yayılımları tespit edilmiştir. Antoniou vd. (2003) çalışmalarında, Almanya, Fransa ve İngiltere’de spot ve future hisse senedi piyasaları arasındaki ilişkiyi uluslararası bir bağlamda araştırmışlardır. Aralık 1990-Aralık 1998 dönemini kapsayan çalışmada uygulanan VAR-EGARCH modeli sonucunda, incelenen ülkeler arasında future piyasalarda spot piyasalara göre daha fazla entegrasyon olduğu belirlenmiş ve hem ülke içinde hem de ülkeler arasında çok yönlü öncül-ardıl ilişkiler ve oynaklık ilişkileri saptanmıştır. Zhong vd. (2004) çalışmalarında, 15 Nisan 1999-24 Temmuz 2002 tarihleri arasında Meksika’da spot ve future hisse senedi piyasaları arasındaki ilişkileri EGARCH modeli ile analiz etmişlerdir. Çalışma ile future piyasanın faydalı bir fiyat keşif aracı olduğu saptanmış, diğer yandan spot piyasa için de istikrarsızlık kaynağı olduğu belirtilmiştir. Gannon (2005) çalışmasında, Hong Kong spot ve future piyasaları arasındaki ilişkiyi yapısal sistem yaklaşımı ile analiz etmiş ve future piyasa oynaklığından spot piyasa oynaklığına tek yönlü aktarım belirlemiştir. Koutmos ve Tucker (1996) çalışmalarında, ABD’de spot ve future hisse senedi getirilerinin ortak dağılımını iki değişkenli EGARCH modeli ile analiz etmiş ve her iki piyasadaki kısa vadeli dinamiklerin benzer olduğunu belirlemiştir. Gkillas vd. (2021) ise çalışmalarında, Avrupa Merkez Bankası haberlerinin ABD spot ve future piyasaları arasındaki oynaklık yayılım mekanizması üzerindeki eşzamanlılık etkisini incelemişlerdir. 1 Ağustos 2008-31 Aralık 2015 dönemini kapsayan çalışmada uygulanan yanlışlığı düzeltilmiş vektör otoregresif model ile Avrupa Merkez Bankası haberlerinin dolaylı etkisinin spot ve future piyasaları arasındaki ilişkilere olan etkilerinin farklılaştığı tespit edilmiştir.

Literatürde spot ve future piyasalar arasındaki kompleks ve dinamik ilişkileri analiz etmek üzere eşbütünleşme ve nedensellik testleri, çok değişkenli GARCH modelleri (VAR-GARCH, BEKK-GARCH, DCC-GARCH) dalgacık analizi gibi çeşitli yöntemler sıklıkla kullanılmaktadır. Söz konusu yöntemleri kullanan çalışmalarda, farklı ülkeler için spot ve future piyasalar arasındaki ilişkilerin sadece varlığı değil aynı zamanda ilişkilerin yönü, gücü, dinamikleri ve bilginin piyasalar arasında nasıl iletildiği de ortaya konmuştur. Bununla birlikte çalışmaların bir kısmında, spot ve future piyasalar arasındaki oynaklık ilişkilerinin asimetrik yapısı ele alınmıştır. Örneğin Tse (1999) ABD’de, Tokat ve Tokat (2010) ve Kara vd. (2022) Türkiye’de, Yang vd. (2012) Çin’de, Siddiqui ve Roy (2020) ise ABD, Çin ve Hindistan’da spot ve future piyasalar arasında karşılıklı oynaklık yayılımları ve asimetrik etkiler tespit etmişlerdir. Mallikarjunappa ve Afsal (2010) çalışmalarında, Hindistan’da 12 bireysel hisse senedinin yüksek frekanslı fiyat verilerini kullanarak spot ve vadeli işlem piyasaları arasındaki öncül-ardıl ilişkiyi araştırmışlardır. Çalışmada uygulanan VECM ve EGARCH modelleri ile spot ve future piyasaları arasında eşzamanlı ve karşılıklı öncül-ardıl ilişkisi tespit edilmiştir. Çalışma ile ayrıca

spot piyasa oynaklığındaki bir düşüşün, future piyasa oynaklığında düşüşle yol açtığı şeklindeki asimetrik ilişki yapısı da ortaya konmuştur. Truong vd. (2021) çalışmaları, Vietnam’da spot piyasanın future piyasa oynaklığı üzerindeki etkisini Granger nedensellik testi ve EGARCH modeli ile analiz etmişlerdir. Mart 2015-2 Ocak 2020 dönemini kapsayan çalışma ile future piyasanın spot piyasa oynaklığı üzerinde kaldıraç etkisine sahip olduğu sonucuna ulaşılmıştır. Yağcılar (2022) ise çalışmasında, 5 Ağustos 2013-28 Nisan 2021 tarihleri arasında Türkiye spot ve future piyasaları arasındaki etkileşimi VAR-BEKK-GARCH ve VAR-DCC-GARCH modelleri ile analiz etmiş ve oynaklık yayılımlarının asimetrik yapıda olduğunu tespit etmiştir. Spot ve future piyasalar arasındaki oynaklık yayılımlarını inceleyen çalışmaların bir kısmı ise yayılımların yönünü ve büyüklüğünü belirlemek üzere Diebold ve Yilmaz (2009) yayılım endeksi yaklaşımını kullanmıştır (Antonakakis vd., 2016; Yarovaya vd., 2016; Chen vd., 2021). Antonakakis vd. (2016) çalışmaları, 25 Şubat 2008-14 Mart 2013 tarihleri arasında ABD ve İngiltere’de spot ve future piyasalar arasındaki dinamik karşılıklı bağımlılığı araştırmışlardır. Çalışma ile ABD ve İngiltere arasında karşılıklı oynaklık yayımları belirlenmiştir. Yarovaya vd. (2016), çalışmaları, Asya, Amerika, Avrupa ve Afrika’daki 10 gelişmiş ve 11 gelişmekte olan piyasada spot ve future piyasaları baz alarak bölge içi ve bölgeler arası ilişkileri incelemişlerdir. 3 Ekim 2005-3 Ekim 2014 dönemini kapsayan çalışma ile piyasaların bölgeler arası bulaşıcılıktan ziyade yurtiçi ve bölgeye özgü oynaklık şoklarına karşı daha duyarlı olduğu sonucuna ulaşılmıştır. Chen vd. (2021) ise çalışmaları, Çin ve Hong Kong spot ve future piyasaları arasındaki risk yayılımlarını analiz etmişlerdir. Çalışmada dışsal şokların piyasalar arasındaki risk yayılımlarını önemli ölçüde etkilediğı tespit edilmiştir.

İncelenen çalışmalardan görülebileceğı gibi spot ve future hisse senedi piyasaları arasındaki oynaklık yayılımlarında, uygulanan ekonometrik yöntemler ve ele alınan dönemlere bağılı olarak farklı sonuçlara ulaşılmıştır. Literatürde genellikle belirli ülke ya da bölgeler baz alınmış ve yüksek frekanslı veriler kullanılarak piyasalar arasındaki yayılımların kısa vadeli dinamiklerine ve asimetrik etkilere odaklanılmıştır. Literatürdeki en önemli boşluk, söz konusu ilişkilerin belirlenmesinde piyasalarda yaşanan yapısal değişimlerin dikkate alınmaması ve oynaklık yayılımlarının kalıcılık yapısının belirlenmemesidir. Bu bağlamda, gelişmiş ve gelişmekte olan farklı ülkeleri içeren geniş bir seti kapsamında, spot ve future hisse senedi piyasaları arasındaki oynaklık yayılımlarının kalıcılık yapıları ile birlikte belirlenmesi ile hem literatüre katkı sağlanması hem de yatırımcılara portföy kararlarında kullanabilecekleri bilgilerin sunulması planlanmaktadır.

3. Veri ve Yöntem

Çalışmada, 27 gelişmiş ve gelişmekte olan ülkede (Almanya-DEU, Amerika Birleşik Devletleri (ABD)-USA, Avustralya-AUS, Belçika-BEL, Brezilya-BRA, Çin-CHN, Finlandiya-FIN, Fransa-FRA, Güney Kore-KOR, Hindistan-IND, Hollanda-NLD, Hong Kong-HKG, İngiltere-GBR, İspanya-ESP, İsveç-SWE, İsviçre-CHE, İtalya-ITA, Japonya-JPN, Kanada-CAN, Meksika-MEX, Norveç-NOR, Polonya-POL, Portekiz-PRT, Singapur-SGP, Tayvan-TWN, Türkiye-TUR, Yunanistan-GRC) spot ve future hisse senedi piyasaları arasındaki oynaklık yayılımlarının tespit edilebilmesi amacıyla 4 Ocak 2000-25 Mart 2025 dönemini kapsayan bir veri seti ele alınmış ve haftalık frekansta 27 ülkenin her birine ilişkin spot ve future hisse senedi endeks getirileri kullanılmıştır. Söz konusu tüm veriler, Thomson&Reuters Refinitiv veri tabanından temin edilmiştir.

Oynaklık yayılımlarının yönünün belirlenmesinde en sık kullanılan yöntemlerden biri, Hafner ve Herwartz (2006) (*LM*) tarafından geliştirilen varyansta nedensellik testidir. Hafner ve Herwartz (2006) varyansta nedensellik testinde, *LM* test istatistiğini elde etmek üzere 2 ayrı seri için GARCH(1,1) modeli hesaplanmaktadır. *i* serisi için GARCH(1,1) spesifikasyonu;

$$y_{it} = x'_{it}c_i + \varepsilon_{it} \quad (1)$$

$$\sigma_{it}^2 = \omega_i + \alpha_i \varepsilon_{it-1}^2 + \beta_i \sigma_{it-1}^2 \quad (2)$$

$\omega_i > 0$, $\alpha_i, \beta_i \geq 0$ ve $\alpha_i + \beta_i < 1$ model koşullarını ifade etmektedir. GARCH modeline dayanan varyansta nedensellik testi;

$$\varepsilon_{it} = \xi_{it} \sqrt{\sigma_{it}^2 (1 + z'_{jt} \pi)}, z_{jt} = (\varepsilon_{jt-1}^2, \sigma_{jt-1}^2)' \quad (3)$$

Burada σ_{jt}^2 koşullu varyans, ξ_{it} GARCH modelinin standartlaştırılmış hatalarıdır. Boş hipotez ($H_0: \pi = 0$) varyansta nedenselliğin (oynaklık yayılımının) olmadığını, alternatif hipotez ise ($H_1: \pi \neq 0$) varyansta nedenselliğin olduğunu ifade etmektedir. Hafner ve Herwartz (2006), varyansta nedenselliğin varlığının sınanabilmesi için 4. eşitlikte gösterilen *LM* istatistiğini tanımlamıştır;

$$\lambda_{LM} = \frac{1}{4T} \left(\sum_{t=1}^T (\xi_{it}^2 - 1) z'_{jt} \right) V(\theta_i)^{-1} \left(\sum_{t=1}^T (\xi_{it}^2 - 1) z_{jt} \right) \quad (4)$$

Burada;

$$(\theta_i) = \frac{K}{4T} \left(\sum_{t=1}^T z_{jt} z'_{jt} - \sum_{t=1}^T z_{jt} x'_{it} \left(\sum_{t=1}^T x_{it} x'_{it} \right)^{-1} \sum_{t=1}^T x_{it} z'_{it} \right), K = \frac{1}{T} \sum_{t=1}^T (\xi_{it}^2 - 1)^2 \quad (5)$$

Hafner ve Herwartz (2006) varyansta nedensellik testinde yapısal değişimleri dikkate alınmamaktadır. Ancak oynaklık sürecinde yapısal değişimlerin bulunması halinde, geleneksel GARCH(1,1) model sonuçları hatalı olabilmektedir. Öte yandan, Fourier yaklaşımına dayalı testler dönemsel şokları, ani rejim değişimlerini ve doğrusal olmayan dinamikleri yakalayabilmeleri nedeniyle, yapısal değişimlerin yaşandığı dönemlerin ele alındığı çalışmalarda ön plana çıkmaktadır. Diğer bir ifadeyle, yapısal değişimlerin ihmal edildiği yöntemler ile oynaklık yayılımlarının tam olarak belirlenememe riski, Fourier temelli yöntemlerin önemini daha da artırmaktadır. Li ve Enders (2018), Hafner ve Herwartz (2006) oynaklık yayılım testini, Fourier yaklaşımı ile yapısal kırılmalı oynaklık yayılım testi şeklinde geliştirmiştir. Trigonometrik fonksiyonların eklenmesi ile 1. Eşitlik;

$$\sigma_{it}^2 = \omega_{0i} + \sum_{k=1}^n \omega_{1i,k} \sin\left(\frac{2\pi k_i t}{T}\right) + \sum_{k=1}^n \omega_{2i,k} \cos\left(\frac{2\pi k_i t}{T}\right) + \alpha_i \varepsilon_{it-1}^2 + \beta_i \sigma_{it-1}^2 \quad (6)$$

Burada, *k* belirli bir frekansı ifade etmektedir ve bilgi kriterine bağlı olarak 0 ile 5 arasında bir değer almaktadır. Frekansın (*k*) tam sayı olması oynaklık yayılımının geçici olduğunu, kesirli sayı olması ise kalıcı olduğunu göstermektedir.

4. Analiz Sonuçları

Çalışmada öncelikle her bir ülkenin spot ve future hisse senedi endeks getirilerine ilişkin tanımlayıcı istatistikler hesaplanmış ve sonuçlar Tablo 2’de verilmiştir.

Tablo 1. Tanımlayıcı İstatistikler

	Ortalama	Standart Sapma	Çarpıklık	Basıklık	JB	ADF	PP
AUS_F	0.0001	0.0074	0.001	5.436	287.42***	-35.37***	-35.36***
BEL_F	-0.0001	0.0142	0.222	9.340	2098.6***	-33.77***	-33.97***
BRA_F	0.0003	0.0206	0.015	4.017	53.801***	-34.56***	-34.60***
CAN_F	0.0000	0.0123	-0.545	7.859	1288.7***	-34.96***	-35.02***
CHE_F	-0.0002	0.0137	0.006	7.093	870.63***	-35.76***	-35.97***
CHN_F	0.0001	0.0254	-0.446	6.726	434.83***	-17.08***	-18.77***
DEU_F	-0.0004	0.0181	0.216	6.142	522.77***	-35.82***	-35.86***
ESP_F	-0.0001	0.0249	-0.764	9.049	2022.2***	-23.82***	-28.12***
FIN_F	-0.0005	0.0169	0.006	4.660	140.86***	-34.31***	-34.31***
FRA_F	-0.0004	0.0163	-0.019	5.045	217.45***	-36.46***	-37.04***
GBR_F	0.0001	0.0191	-1.034	11.38	3873.4***	-24.29***	-28.26***
GRC_F	-0.0018	0.0376	-0.575	7.030	912.63***	-26.41***	-26.15***
HKG_F	0.0001	0.0257	-0.347	4.952	222.91***	-28.26***	-28.20***
IND_F	0.0022	0.0252	-0.832	7.171	1029.5***	-25.08***	-25.10***
ITA_F	0.0001	0.0261	-1.251	11.730	3532.9***	-24.75***	-24.55***
JPN_F	0.0005	0.0250	-0.915	9.066	2086.0***	-28.92***	-28.76***
KOR_F	0.0008	0.0265	-0.642	7.063	943.29***	-24.77***	-27.93***
MEX_F	0.0016	0.0236	-0.526	6.354	642.06***	-30.18***	-30.00***
NLD_F	0.0001	0.0236	-1.169	10.18	2963.4***	-27.69***	-27.35***
NOR_F	0.0015	0.0532	7.773	295.8	4467.4***	-9.123***	-44.60***
POL_F	0.0015	0.0248	-1.235	9.549	2321.1***	-23.91***	-23.97***
PRT_F	-0.0004	0.0229	-0.920	7.789	1367.4***	-23.27***	-27.62***
SGP_F	0.0003	0.0203	-0.598	9.880	2483.4***	-26.21***	-26.01***
SWE_F	0.0011	0.0217	-0.924	8.238	1261.1***	-26.41***	-26.30***
TUR_F	0.0033	0.0338	-0.463	4.466	122.98***	-15.65***	-24.90***
TWN_F	0.0010	0.0243	-0.546	6.507	664.20***	-27.75***	-27.84***
USA_F	0.0013	0.0208	-1.331	12.21	3578.9***	-26.00***	-25.98***
AUS_S	0.0003	0.0103	-0.360	5.487	324.72***	-32.22***	-32.22***
BEL_S	0.0001	0.0118	0.183	6.458	628.38***	-29.72***	-29.42***
BRA_S	0.0000	0.0186	0.111	6.133	512.47***	-24.60***	-29.07***
CAN_S	0.0002	0.0113	-0.548	6.782	805.64***	-32.21***	-32.11***
CHE_S	0.0000	0.0115	-0.117	6.197	534.04***	-32.84***	-32.76***
CHN_S	-0.0002	0.0243	-0.607	6.615	430.87***	-19.67***	-19.62***
DEU_S	-0.0003	0.0138	-0.185	4.355	102.45***	-31.77***	-31.78***
ESP_S	0.0002	0.0269	-0.753	7.975	1404.0***	-28.01***	-27.90***
FIN_S	-0.0006	0.0258	-0.457	8.350	1506.2***	-34.63***	-34.66***
FRA_S	-0.0001	0.0141	-0.121	4.334	95.460***	-33.83***	-33.87***
GBR_S	0.0000	0.0232	-1.280	11.68	4257.6***	-28.92***	-28.75***
GRC_S	-0.0019	0.0383	-0.799	6.864	908.25***	-27.87***	-28.04***
HKG_S	0.0003	0.0247	-0.464	4.822	217.17***	-28.54***	-28.43***
IND_S	0.0022	0.0258	-0.823	7.079	987.51***	-25.93***	-25.92***
ITA_S	0.0001	0.0283	-1.175	10.55	2682.1***	-25.11***	-25.11***
JPN_S	0.0000	0.0211	-0.438	6.117	544.72***	-29.86***	-29.72***
KOR_S	0.0006	0.0326	-0.957	8.921	2012.1***	-28.26***	-28.15***
MEX_S	0.0012	0.0275	-1.150	10.66	3325.2***	-28.29***	-28.39***
NLD_S	0.0003	0.0258	-1.024	8.237	1642.9***	-27.36***	-27.31***
NOR_S	0.0007	0.0315	-1.375	10.23	3112.1***	-23.93***	-27.83***
POL_S	0.0006	0.0335	-1.113	8.536	1686.6***	-25.90***	-25.90***

Tablo 1. Devamı

PRT_S	-0.0003	0.0255	-0.985	8.052	1527.5***	-17.29***	-28.55***
SGP_S	0.0005	0.0216	-0.855	10.51	3013.4***	-24.51***	-24.36***
SWE_S	0.0008	0.0298	-0.855	7.554	967.39***	-26.30***	-26.20***
TUR_S	0.0003	0.0416	-0.769	5.567	366.43***	-25.63***	-25.83***
TWN_S	0.0008	0.0256	-0.356	5.192	261.70***	-26.70***	-26.75***
USA_S	0.0013	0.0200	-1.448	11.36	3044.8***	-25.47***	-25.33***

Not: _S ve _F sırasıyla ilgili ülkenin spot ve future hisse senedi endeks getirisini ifade etmektedir. ***, **, * sırasıyla %1, %5 ve %10 anlam düzeyini göstermektedir.

Tanımlayıcı istatistiklere göre spot hisse senedi endeks getirileri açısından ortalama getirilerde ülkeler arasında belirgin farklılıklar bulunmaktadır. Elde edilen sonuçlar, incelenen dönemde en yüksek ortalama getiriyi sağlayan spot endeks getirilerinin sırasıyla Hindistan, ABD, Meksika, İsveç ve Tayvan’da olduğunu göstermektedir. Bu ülkelerdeki yüksek getiriler, uzun vadede güçlü büyüme potansiyeli sunmaları ve yatırımcılar açısından cazip getiriler üretebilmeleri ile ilişkilendirilebilir. Ayrıca bu ülkelerdeki yüksek getiri performansı, yapısal ekonomik dinamizm, sermaye piyasalarının derinliği ve inovasyon odaklı sektör ağırlıkları gibi temel faktörler ile açıklanabilir. Diğer yandan, ortalama getirinin en düşük seviyede gerçekleştiği ülkeler ise Yunanistan, Finlandiya, Portekiz, Almanya ve Çin’dir. Bu ülkelerde getirilerin daha düşük olması, finansal piyasaların göreceli olgunluğu ve sermaye hareketlerinin daha istikrarlı bir çerçevede yönetilmesi ile ilişkili olabilir. Söz konusu farklılıklar, spot piyasa getirilerinin yalnızca ülke makroekonomik göstergeleriyle değil aynı zamanda piyasa beklentileri, yapısal reform kapasitesi ve dışsal şoklara karşı duyarlılıkla da şekillendiğine işaret etmektedir. Tablo 1’den görülebileceği gibi spot hisse senedi piyasalarının risk düzeylerinde ülkeler arası belirgin ayrılmalar bulunmaktadır. Türkiye, Yunanistan, Polonya, Güney Kore ve Norveç gibi ülkelerdeki yüksek standart sapma değerleri, bu piyasalarda getirilerin oldukça dalgalı bir seyir izlediğini ve yatırımcıların daha yüksek riskle karşı karşıya kaldığını göstermektedir. Bu durum, ilgili ekonomilerin dönem boyunca çeşitli içsel ve dışsal şoklara açık yapıları, politik belirsizlikler veya sermaye hareketlerindeki keskin dalgalanmalarla ilişkilendirilebilir. Öte yandan, Avusturya, Kanada, İsviçre, Belçika ve Almanya gibi ülkelerdeki düşük standart sapma değerleri, bu piyasaların daha istikrarlı bir performans sergilediğini ve risk algısının görece daha düşük olduğunu göstermektedir. Bu ülkelerdeki güçlü kurumsal yapılar, finansal piyasaların derinliği ve makroekonomik istikrar, oynaklığın sınırlı düzeylerde kalmasında belirleyici rol oynamıştır. Future hisse senedi endeks getirilerine ilişkin bulgular ise ülkeler arasında ortalama getiriler açısından önemli farklılıklar bulunduğunu ortaya koymaktadır. Türkiye, Hindistan, Meksika, Norveç ve Polonya gibi ülkelerde future piyasalarının yüksek ortalama getiriler sağlamış olması, bu ülkelerdeki türev piyasaların yatırımcılar açısından cazip fırsatlar sunduğuna ve geleceğe dönük piyasa beklentilerinin güçlü olduğuna işaret etmektedir. Bu performans, söz konusu ülkelerdeki ekonomik büyüme potansiyeli, likidite koşulları ve yatırımcı davranışlarındaki spekülasyon eğilimleriyle birlikte değerlendirildiğinde daha iyi anlaşılabilir. Diğer yandan ortalama getirinin en düşük seviyede gerçekleştiği ülkeler ise Yunanistan, Finlandiya, Portekiz, Almanya ve Fransa’dır. Bu durum, ilgili ekonomilerdeki sınırlı büyüme beklentileri, düşük oynaklık veya yatırımcıların riskten kaçınma eğilimleri ile ilişkilendirilebilir. Sonuçlar, future piyasaların sunduğu getirilerin yalnızca ekonomik temellere değil, aynı zamanda piyasa derinliği, likidite yapısı ve beklenti dinamiklerine de duyarlı olduğunu ortaya koymaktadır. Tanımlayıcı istatistikler Norveç, Yunanistan, Türkiye, Güney Kore ve İtalya’da future endeks getiri oynaklıklarının yüksek

olduđunu g stermektedir. Bu durum, gerek ekonomik ve politik belirsizliklerin yoğunluđu gerekse piyasa katılımcılarının risk alma davranıřlarıyla iliřkili olabilir. Buna karřılık, Avusturya, Kanada, İsvi re, Bel ika ve Fransa gibi  lkelerde kaydedilen d ř k oynaklık d zeyleri, geliřmiř finansal altyapı, sađlam reg lasyon  er evesi ve daha rasyonel fiyatlama davranıřlarının bir yansıması olarak deđerlendirilebilir. Spot ve future piyasaların ortalama getiri ve oynaklık deđerleri genel olarak benzemesine rađmen bazı  lkelerde bu iki piyasa arasında belirgin farklılıklar dikkat  ekmektedir.  zellikle T rkiye, Hindistan ve Meksika gibi  lkelerde her iki piyasada da y ksek getiriler g zlemlenirken oynaklık a ısından benzer řekilde y ksek dalgalanmalar dikkat  ekmiřtir.  te yandan, bazı geliřmiř piyasalarda future getiriler spot piyasalara kıyasla daha d ř k ve daha az oynaklıkla seyretmiř, bu da future piyasaların daha kontroll  ve beklentiye dayalı bir yapıya sahip olabileceđini g stermektedir.

Tablo 1’den g r lebileceđi gibi Almanya, Avustralya, Bel ika, Brezilya, Finlandiya, İsvi re ve Norve  future endeksleri ile Bel ika ve Brezilya spot endeksleri dıřında ele alınan t m endeks getirileri negatif  arpıklık deđerlerine sahiptir. Ayrıca ele alınan t m endeks getirilerinin y ksek basıklık deđerline sahip olduđu belirlenmiřtir. Sonu  olarak, Jarque-Bera test istatistikleri de (JB) t m serilerin normal dađılıma sahip olmadıđını g stermektedir. Bununla birlikte  alıřma kapsamında ele alınan endeks getirilerinin durađanlıkları Geniřletilmiř Dickey Fuller (ADF) ve Phillips-Perron (PP) birim k k testleri ile sınanmıřtır. Birim k k testleri sonu larına g re ise ele alınan t m endeks getiri serileri durađandır.  alıřmanın ilerleyen ařamasında  lke bazında her bir spot ve future endeks getirisi arasındaki kořulsuz korelasyonlar hesaplanmıř ve sonu lar Tablo 2’de verilmiřtir.

Tablo 2. Kořulsuz Korelasyon Sonu ları

AUS	0.63***	FRA	0.85***	NLD	0.80***
BEL	0.68***	GBR	0.82***	NOR	0.78***
BRA	0.71***	GRC	0.87***	POL	0.71***
CAN	0.82***	HKG	0.94***	PRT	0.79***
CHE	0.73***	IND	0.93***	SGP	0.78***
CHN	0.88***	ITA	0.83***	SWE	0.80***
DEU	0.82***	JPN	0.77***	TUR	0.93***
ESP	0.85***	KOR	0.92***	TWN	0.95***
FIN	0.76***	MEX	0.83***	USA	0.61***

Not: ***, **, * sırasıyla %1, %5 ve %10 anlam d zeyini g stermektedir.

Tablo 2’den g r lebileceđi gibi, incelenen t m  lkelerde spot ve future hisse senedi endeks getirileri arasında anlamlı ve y ksek d zeyde pozitif iliřkiler bulunmaktadır. Bu bulgu, future piyasaların spot piyasaların ayrılmaz bir uzantısı olduđunu ve fiyatların her iki piyasada b y k  l de benzer dinamikler dođrultusunda řekillendiđini ortaya koymaktadır. Tespit edilen y ksek korelasyon katsayıları, future piyasaların hem riskten korunma aracı olarak hem de etkin bir fiyat keřfi mekanizması olarak iřlev g rd đ n  g stermektedir. Aynı zamanda her iki piyasanın da k resel řoklar, makroekonomik geliřmeler ve  lke bazlı haber akıřlarına benzer řekilde tepki verdiđi anlařılmaktadır. Bununla birlikte, y ksek d zeyli korelasyonlar incelenen  lkelerin finansal geliřmiřliklerinden bađımsız olarak yatırımcı davranıřlarının her iki piyasada  nemli d zeyde senkronize olduđunu ve bilgi akıřının da hızlı bir bi imde fiyatlara yansıdıđını g stermektedir.  alıřmanın ilerleyen ařamasında, varyansta nedensellik testlerinin  n kořulu olarak  alıřma kapsamında incelenen her bir endeks getiri serisinin oynaklıđı GARCH(1,1) ile

modellenmiş ve sonuçlar Ek 1’de verilmiştir. GARCH(1,1) model sonuçlarına göre ele alınan 27 ülkenin her bir spot ve future endeks getiri serisi için model kısıtları sağlanmaktadır. İlerleyen aşamada, çalışmanın temel amacına ulaşmak ve araştırma sorularına cevap vermek üzere, incelenen her bir ülkede spot ve future hisse senedi endeks getirileri arasındaki oynaklık yayılımlarını belirlemek için Hafner ve Herwartz (2006) varyansta nedensellik testleri ve Li ve Enders (2018) Fourier varyansta nedensellik testleri uygulanmış ve sonuçlar Tablo 3’te verilmiştir.

Tablo 3. Hafner ve Herwartz (2006) Varyansta Nedensellik Testi ve Fourier Varyansta Nedensellik Testi Sonuçları

	Spot $\nrightarrow$ Future			Future $\nrightarrow$ Spot		
	λ_{LM}	F_{LM}	k	λ_{LM}	F_{LM}	λ_{LM}
AUS	8.176**	11.90***	0.1	1.647	5.417*	1.0
BEL	2.067	15.09***	1.0	0.847	5.037*	0.1
BRA	0.213	11.70***	0.8	2.410	9.155**	0.1
CAN	2.594	8.806**	0.5	1.630	10.02***	0.5
CHE	2.145	17.00***	1.0	2.082	5.698*	0.1
CHN	8.188**	5.875*	0.1	5.893*	24.49***	0.1
DEU	3.662	17.74***	1.0	1.838	8.421**	0.1
ESP	4.268	1.359	1.0	0.072	7.286**	1.0
FIN	2.656	13.99***	0.1	2.481	10.96***	0.1
FRA	2.083	16.61***	0.1	2.671	11.11***	0.1
GBR	0.093	2.042	0.9	70.52***	5.308*	1.0
GRC	31.78***	4.768*	1.0	4.459	8.502*	1.0
HKG	2.398	5.712*	1.0	4.928*	5.838*	1.0
IND	3.693	6.047**	0.9	4.756*	7.670**	0.5
ITA	13.86***	11.56***	0.1	3.416	7.468**	0.1
JPN	20.52***	9.978***	0.1	3.627	14.77***	0.4
KOR	4.791*	5.489*	0.8	7.931**	12.17***	0.1
MEX	6.679**	9.470***	0.9	9.478***	5.501*	1.0
NLD	0.643	4.089	0.9	0.962	2.675	1.0
NOR	4.512	4.438	1.0	0.505	2.567	1.0
POL	1.431	2.068	1.0	5.656*	7.841**	1.0
PRT	3.095	4.722*	1.0	1.036	6.359**	1.0
SGP	1.804	5.286	0.1	3.516	7.025**	0.7
SWE	2.599	4.343	1.0	0.408	10.57***	1.0
TUR	6.525**	15.26***	1.0	4.855*	12.46***	1.0
TWN	60.24***	6.437**	0.1	3.947	5.892*	0.1
USA	4.450	4.707*	1.0	9.299*	4.700*	1.0

Not: λ_{LM} ve F_{LM} sırasıyla Hafner ve Herwartz (2006) varyansta nedensellik testi ve Fourier varyansta nedensellik testi sonuçlarını göstermekte, k ise optimal frekansı ifade etmektedir. k değerinin tam sayı olması oynaklık yayılımının geçici olduğunu, kesirli sayı olması ise oynaklık yayılımının kalıcı olduğunu anlamına gelmektedir. ***, **, * sırasıyla %1, %5 ve %10 anlam düzeyini göstermektedir.

Tablo 3 incelendiğinde gibi hem Hafner ve Herwartz (2006) varyansta nedensellik testi hem de Li ve Enders (2018) Fourier varyansta nedensellik testi sonuçlarına göre çalışma kapsamında ele alınan birçok ülkede spot ve future getiriler arasında karşılıklı oynaklık yayılımı bulunmaktadır. Diğer bir ifadeyle, spot ve future getiriler arasında genel olarak karşılıklı yayılımlar bulunmaktadır. Bu bulgu, spot ve future getirileri arasındaki oynaklık yayılımlarının ülkelere özgü yapısal ve dinamik farklılıklara bağlı olarak çeşitlilik gösterdiğini de ortaya koymaktadır.

“Hangi lkelerde spot ve future getiriler arasında oynaklık yayılımları bulunmaktadır?”

Hafner ve Herwartz (2006) varyansta nedensellik testi sonularına gre Almanya, Avustralya, Belika, Brezilya, Finlandiya, Fransa, Hollanda, İspanya, İsve, İsvire, Kanada, Norve, Portekiz ve Singapur’da spot ve future hisse senedi endeks getirileri arasında oynaklık yayılımları bulunmamaktadır. Sonular, in, Gney Kore, Meksika ve Trkiye spot ve future endeks getirileri arasında ise karřılıklı yayılım olduėunu gstermektedir. Bununla birlikte Japonya, İtalya, Tayvan ve Yunanistan’ da sadece spot getirilerinden future getirilerine; ABD, İngiltere, Hindistan, Hong Kong ve Polonya’da sadece future getirilerinden spot getirilerine tek ynl oynaklık yayılımları tespit edilmiřtir. zetle, Hafner ve Herwartz (2006) varyansta nedensellik testleri ile zellikle Avrupa lkeleri olmak zere birok lkede spot ve future getiriler arasında oynaklık yayılımı tespit edilmezken, in, Gney Kore, Meksika ve Trkiye gibi geliřmekte olan lkelerde karřılıklı yayılımların bulunduėu saptanmıřtır.

Li ve Enders (2018) Fourier varyansta nedensellik testleri sonularına gre ise Hafner ve Herwartz (2006) varyansta nedensellik testi sonularından farklı olarak Hollanda ve Norve dıřındaki 25 lkede spot ve future getiriler arasında oynaklık yayılımları bulunmaktadır. Tablo 3’ten grlebileceėi gibi ABD, Almanya, Avusturya, Belika, Brezilya, in, Finlandiya, Fransa, Gney Kore Hindistan, Hong Kong, İsve, İsvire, İtalya, Japonya, Kanada, Meksika, Portekiz, Singapur, Trkiye ve Tayvan’da spot ve future endeks getirileri arasında ise karřılıklı yayılım bulunmaktadır. Ayrıca İngiltere, İspanya, İsve ve Polonya’da sadece future getirilerinden spot getirilerine tek ynl oynaklık yayılımları bulunmaktadır.

“Yapısal deėiřimlerin dikkate alınması durumunda oynaklık yayılımları deėiřim gstermekte midir?”

Hafner ve Herwartz (2006) varyansta nedensellik testi ile 27 lkenin 13’nde, Li ve Enders (2018) Fourier varyansta nedensellik testi ile ise 27 lkenin 25’inde spot ve future getiriler arasında oynaklık yayılımı tespit edilmiřtir. Hafner ve Herwartz (2006) varyansta nedensellik testi sonularına gre spot ve future getirileri arasında oynaklık yayılımı bulunmayan Almanya, Avustralya, Belika, Brezilya, Finlandiya, Fransa, İsvire, Kanada, Portekiz ve Singapur’da Fourier varyansta nedensellik testleri ile karřılıklı yayılımların bulunduėu ortaya konmuřtur. Ayrıca Hafner ve Herwartz (2006) varyansta nedensellik test sonularına gre ABD, Hindistan Hong Kong ve Polonya’da sadece future getirilerinden spot getirilere tek ynl yayılımlar bulunurken, Fourier varyansta nedensellik testleri ile bu lkelerde spot ve future getiriler arasındaki yayılımların da karřılıklı olduėu tespit edilmiřtir. Benzer řekilde Hafner ve Herwartz (2006) varyansta nedensellik testleri ile aralarında oynaklık yayılımı bulunmayan İspanya ve İsve’te ise Fourier varyansta nedensellik testleri ile future getirilerinden spot getirilere tek ynl yayılımlar tespit edilmiřtir. Bir diėer farklılık, yapısal deėiřimlerin dikkate alınmaması durumunda Japonya, İtalya, Tayvan ve Yunanistan’da spot getirilerinden future getirilerine, Fourier varyansta nedensellik test sonularına gre ise future getirilerinden spot getirilere tek ynl yayılımların bulunmasıdır. Kısacası, yapısal deėiřimleri dikkate alan Fourier varyansta nedensellik testleri ile neredeyse alıřma kapsamında incelenen tm lkelerin spot ve future getirileri arasında oynaklık yayılımları belirlenmiřtir. 25 lkenin 21’inde ise yayılımların karřılıklı olduėu belirlenmiř, diėer 4 lkede (İngiltere, İspanya, İsve ve Polonya) ise future getirilerden spot getirilere tek ynl yayılımlar olduėu saptanmıřtır. Bu bulgular, spot ve future piyasalar arasında oynaklık yayılımlarının lkeden lkeye farklılık

gösterdiğini ve bu farklılıkların piyasa yapısı ile birlikte aynı zamanda finansal gelişmişlik, piyasa entegrasyonu, düzenleyici politikalar ve yatırımcı profilleriyle de yakından ilişkili olduğunu göstermektedir. Karşılıklı yayılımların tespit edildiği ülkelerin finansal sistemleri genellikle likidite düzeyi yüksek, bilgi akışı hızlı ve türev piyasaları da etkin bir yapıdadır. Bu durum, spot ve future piyasaların entegre bir yapıda çalıştığını, dolayısıyla finansal şokların hızla her iki piyasaya da yayıldığı dinamik yapıyı ifade etmektedir. Tek yönlü yayılımın belirlendiği ülkelerde ise asimetrik bilgi dağılımı, fiyat keşfi sürecinde future piyasanın daha baskın olması ya da yatırımcıların spot piyasaya göre future piyasaya daha duyarlı olması gibi yapısal unsurlar öne çıkmaktadır.

"Oynaklık yayılımlarının kalıcılık yapısı ne şekildedir?"

Tablo 3'ten görülebileceği gibi tespit edilen oynaklık yayılımlarının çoğu kalıcı niteliktedir. Sonuçlar, spot ve future getirileri arasında karşılıklı ilişki tespit edilen Brezilya, Çin, Finlandiya, Fransa, Güney Kore, Hindistan, İtalya, Japonya, Kanada, Singapur ve Tayvan'da yayılımların kalıcı; ABD, Hong Kong, İspanya, İsveç, Polonya, Portekiz, Türkiye ve Yunanistan'da ise geçici nitelikte olduğunu göstermektedir. Avusturalya, İngiltere ve Meksika'da spot getirilerden future getirilere olan yayılımların kalıcı, future getirilerden spot getirilere olan yayılımların geçici olduğu belirlenmiştir. Öte yandan, Almanya, Belçika ve İsviçre'de ise spot getirilerden future getirilere olan yayılımlar geçici, future getirilerden spot getirilere olan yayılımlar ise kalıcı niteliktedir.

Özellikle Hindistan, Japonya, Çin, Kanada ve Singapur gibi ülkelerde gözlemlenen kalıcı karşılıklı yayılımlar, bu ülkelerde spot ve future piyasalar arasındaki bilgi geçişlerinin uzun süreli etkiler doğurduğuna işaret etmektedir. Diğer yandan ABD, İsveç, Türkiye ve İspanya gibi piyasalarda tespit edilen geçici yayılımlar ise şokların daha kısa sürede sönmeye başladığı, dolayısıyla söz konusu piyasalarda yaşanan kısa süreli dalgalanmalara karşı yatırım stratejilerinin daha duyarlı uygulanması gerektiğini göstermektedir. Ayrıca Almanya ve Avustralya gibi belirli ülkelerde yayılım yönüne bağlı olarak kalıcılık yapısının farklılaşması, asimetrik bilgi geçişlerinin ve yatırımcı algısındaki farklılıkların etkili olduğu anlamına gelmektedir. Bu bağlamda, özellikle spot ve future arasındaki yayılım ilişkilerinin kalıcılık yapısının farklı olduğu piyasaları baz alan yatırımcıların daha esnek portföy stratejileri benimsemeleri gerekmektedir.

5. Tartışma ve Sonuç

Çalışmada, spot ve future piyasalar arasındaki oynaklık yayılımlarının varlığının, yönünün ve kalıcılığının belirlenmesi amaçlanmıştır. Bu amaç doğrultusunda 27 gelişmiş ve gelişmekte olan ülkenin her birinde spot ve future piyasalar arasındaki oynaklık yayılımları, Hafner ve Herwartz (2006) varyansta nedensellik testi ve doğrusal olmayan yapılar ile yapısal değişimleri dikkate alan Li ve Enders (2018) Fourier varyansta nedensellik testi ile analiz edilmiştir.

Çalışmada uygulanan analizlerin bulguları, özellikle Fourier varyansta nedensellik testinin sağladığı avantajlar sayesinde, geleneksel yöntemlerin ötesinde neredeyse çalışma kapsamında incelenen tüm ülkelerin spot ve future getirileri arasında oynaklık yayılımlarını ortaya koymuştur. Çalışma ile Chan vd. (1991), Min ve Najand (1999), Sim ve Zurbreugg (1999), Tse (1999), Wu vd. (2005), Tokat ve Tokat (2010), Pati ve Rajib (2011), Yang vd.

(2012), Kang vd. (2013), Zhang ve Jaffry (2015), Siddiqui ve Roy (2020), Kara vd. (2022) ve Sundararajan ve Balasubramanian (2025) alıřmalarının sonuları ile benzer, Antoniou vd. (2003), Zhong vd. (2004), Gannon (2005), Fan ve Du (2017), Hou ve Li (2020), Grbz ve řahbaz (2022) ve Kılı (2002) alıřmalarının sonularından farklı olarak 21 farklı lkede spot ve future getiriler arasında karřılıklı oynaklık yayılımları saptanmıřtır. Bu sonu, piyasa katılımcılarının hem mevcut piyasa fiyatlamalarına hem de geleceėe iliřkin beklentilere aynı anda duyarlı olduėunu gstermektedir. Bu tr karřılıklı oynaklık yayılımları, spot ve future piyasalar arasında gl bilgi geiři olduėunu ve hem spot hem de future piyasaların birbirini karřılıklı olarak etkilediėine iřaret etmektedir. Geliřmekte olan lkelerde tespit edilen karřılıklı yayılımlar, bu piyasalardaki yapısal kırılganlıkların, haber akıřlarına olan duyarlılıėın ve yatırımcı davranıřlarındaki ani tepkilere dayalı olduėunu ortaya koymaktadır. Bu durum, aynı zamanda bu piyasaların řoklara daha aık olduėunu ve bir piyasada meydana gelen oynaklıėın diėer piyasaya hızla yansıdıėını gstermektedir. te yandan, geliřmiř lkelerde de spot ve future getiriler arasında karřılıklı yayılımlarının tespit edilmesi, bu piyasalardaki yksek likidite dzeyi, etkin fiyatlama mekanizmaları ve yatırımcıların profesyonelliėi ile iliřkilendirilebilir. Bu sonu hem spot ve future gibi farklı piyasaların birbirlerine olan entegrasyon dzeyinin yksek olduėunu hem de trev rnlerin spot piyasalardaki fiyatlamalarla entegre biimde alıřtıėını gstermektedir. Bununla birlikte alıřma ile sınırlı dzeyde lkelerde, yalnızca future getirilerden spot getirilere řeklinde tek ynl yayılım iliřkileri de tespit edilmiřtir. Bu sonu, İngiltere, İřpanya, İsve ve Polonya’da future piyasaların nc bilgi tařıdıėı ve yatırımcılar tarafından fiyatlama mekanizmasında referans alındıėı anlamına gelmektedir.

alıřma ile oynaklık yayılımlarının oėunun kalıcı nitelikte olduėu tespit edilmiřtir. Oynaklık yayılımlarının kalıcı olduėu lkelerde, piyasalarda meydana gelen oynaklık řokları zaman iinde snmlenmemekte ve uzun sreli etkiler yaratmaktadır. Bu durum, sz konusu lkelerde gemiř řokların gelecek fiyat davranıřları zerinde belirleyici olduėunu ve yatırımcıların uzun vadeli stratejilerinde bu oynaklık etkilerini dikkate almaları gerektiėini gstermektedir. Hindistan, Japonya, in, Kanada ve Singapur gibi lkelerde gzlemlenen karřılıklı ve kalıcı nitelikteki yayılımlar, bu piyasalarda finansal haberlerin ve řokların uzun vadeli etkiler doėurduėunu ortaya koymaktadır. Diėer yandan ABD, İsve, Trkiye ve İřpanya gibi lkelerde tespit edilen geici yayılımlar, oynaklıėın daha kısa srede snmlandıėını ve bu piyasalarda uygulanan stratejilerde daha ok kısa vadeli belirsizliklere odaklanılması gerekliliėini belirtmektedir.

alıřma sonuları portfy ynetimi aısından nemli ıktılara sahiptir. Oynaklık yayılımlarının yn ve kalıcılıėı, yatırımcıların portfy eřitlendirmesi ve strateji belirleme srelerini doėrudan etkilemektedir. Karřılıklı ve kalıcı yayılımların bulunduėu piyasalarda, spot ve future varlıkların aynı anda elde tutulması durumunda portfy riskinin artması kaınılmazdır. Bu gibi durumlarda yatırımcıların, alternatif finansal varlıkları tercih etmesi ya da pozisyonlarını vadeye gre uyarlayarak riskten korunmaları gerekmektedir. Diėer yandan, tek ynl ve geici yayılımların bulunduėu piyasalarda hedge stratejileri daha etkin bir biimde uygulanabilir. Belirli bir piyasadan kaynaklanan yayılım etkilerinin sınırlı ve kısa sreli olması, yatırımcılar iin daha saėlıklı ve ngrlebilir portfy daėıtım kararlarının alınmasını saėlayabilir. Risk ynetimi aısından ise alıřma sonuları trev rnlerin korunma iřlevlerinin farklı piyasa yapılarında nasıl alıřtıėına dair nemli bilgiler sunmaktadır. zellikle kalıcı yayılımların tespit edildiėi piyasalarda gemiř oynaklık řokları, gelecekteki fiyatlar zerinde uzun vadeli etkiler yaratabilme potansiyeli sahiptir. Bu nedenle sz konusu piyasalarda

yatırımcıların hedge oranlarını sabit tutmak yerine dinamik olarak güncellemeleri gerekmektedir. Geçici yayılımların bulunduğu piyasalarda ise hedge oranlarının daha az sıklıkla güncellenmesi mümkündür. Bununla birlikte, oynaklık yayılım ilişkilerinin yönü ve süresi dikkate alınmaksızın oluşturulan risk yönetimi stratejileri, finansal kriz dönemlerinde yetersiz kalabilir ve portföylerde telafisi güç kayıplara yol açabilir.

Bir diğer önemli sonuç, spot ve future piyasalar arasındaki karşılıklı ve kalıcı yayılım ilişkileri dolayısıyla piyasalarda yaşanabilecek sistemik risklerin domino etkisiyle hızla yayılabilme potansiyelidir. Bu bağlamda, politika yapıcılar ve düzenleyici otoritelerin finansal istikrarı koruyabilmesi için piyasalar arası oynaklık aktarım kanallarını sürekli izlemesi ve erken uyarı sistemleri geliştirilmesi büyük önem taşımaktadır. Özellikle karşılıklı ve kalıcı yayılımların mevcut olduğu ülkelerde, spot ve future piyasalar arasında daha koordineli bir denetim mekanizması geliştirilmesi ve bilgi asimetrisinin azaltılması gerekmektedir. Ayrıca, türev piyasaların düzenleyici çerçevesinin güçlendirilmesi, şeffaflık düzeyinin artırılması ve fiyatlama mekanizmalarının etkinliğinin izlenmesi gibi yapısal önlemler, piyasaların istikrarına doğrudan katkı sağlayabilir. Bununla birlikte, kalıcılık özelliklerine göre farklılaşan yayılım yapılarının, para politikası ve makro politikalar çerçevesinde de dikkate alınması gerekmektedir. Örneğin, kalıcı yayılımların bulunduğu bir piyasada gerçekleşen finansal şokun reel ekonomi üzerindeki etkisi uzun vadeli olabilir. Bu nedenle, para politikası kararlarında yalnızca makroekonomik göstergeler değil, aynı zamanda finansal oynaklığın yönü ve süresi de dikkate alınmalıdır.

Spot ve future hisse senedi piyasaları arasındaki oynaklık yayılımlarının yön ve kalıcılık boyutlarıyla ayrıntılı bir biçimde analiz edildiği çalışmada, ele alınan dönem ve finansal varlıklar bazında sınırlılıklar bulunmaktadır. Gelecek çalışmalarda, çok daha geniş bir dönem baz alınabileceği gibi petrol, altın vb. farklı emtiaların spot ve future piyasaları arasındaki oynaklık yayılımları da sıranabilir. Bununla birlikte, geleneksel ve Fourier varyansta nedensellik testleri yayılımlarının yönü ve kalıcılığı ile ilgili önemli bilgiler sunmakta, ancak oynaklık ilişkilerinde zamana bağlı değişimi göstermemektedir. Bu bağlamda, gelecek çalışmalarda, farklı finansal varlıkların spot ve future piyasaları arasındaki ilişkilerde zamana bağlı değişimleri dikkate alan yöntemlerin uygulanması ile yatırımcılara portföy ve risk yönetimi kararları açısından daha detaylı sunulabilir.

Araştırma ve Yayın Etiği Beyanı

Etik kurul izni ve/veya yasal/özel izin alınmasına gerek olmayan bu çalışmada araştırma ve yayın etiğine uyulmuştur.

Araştırmacıların Katkı Oranı Beyanı

Yazarlar makaleye eşit oranda katkı sağlamış olduklarını beyan eder

Araştırmacıların Çıkar Çatışması Beyanı

Bu çalışmada herhangi bir potansiyel çıkar çatışması bulunmamaktadır.

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EKLER

Ek-1. GARCH (1,1) Model Sonuçları

	w	α	β		w	α	β
AUS_F	<0.01	0.06	0.91	AUS_S	<0.01	0.06	0.89
BEL_F	<0.01	0.14	0.83	BEL_S	<0.01	0.13	0.84
BRA_F	<0.01	0.03	0.95	BRA_S	<0.01	0.11	0.82
CAN_F	<0.01	0.06	0.92	CAN_S	<0.01	0.07	0.92
CHE_F	<0.01	0.13	0.85	CHE_S	<0.01	0.12	0.85
CHN_F	<0.01	0.13	0.83	CHN_S	<0.01	0.11	0.86
DEU_F	<0.01	0.06	0.91	DEU_S	<0.01	0.09	0.88
ESP_F	<0.01	0.18	0.75	ESP_S	<0.01	0.19	0.76
FIN_F	<0.01	0.05	0.95	FIN_S	<0.01	0.01	0.98
FRA_F	<0.01	0.08	0.91	FRA_S	<0.01	0.09	0.89
GBR_F	<0.01	0.20	0.75	GBR_S	<0.01	0.22	0.70
GRC_F	<0.01	0.20	0.77	GRC_S	<0.01	0.14	0.84
HKG_F	<0.01	0.10	0.88	HKG_S	<0.01	0.14	0.82
IND_F	<0.01	0.18	0.79	IND_S	<0.01	0.19	0.78
ITA_F	<0.01	0.23	0.74	ITA_S	<0.01	0.21	0.74
JPN_F	<0.01	0.19	0.69	JPN_S	<0.01	0.22	0.72
KOR_F	<0.01	0.13	0.86	KOR_S	<0.01	0.15	0.81
MEX_F	<0.01	0.16	0.80	MEX_S	<0.01	0.16	0.76
NLD_F	<0.01	0.21	0.74	NLD_S	<0.01	0.22	0.75
NOR_F	<0.01	0.33	0.65	NOR_S	<0.01	0.16	0.79
POL_F	<0.01	0.23	0.72	POL_S	<0.01	0.16	0.77
PRT_F	<0.01	0.16	0.77	PRT_S	<0.01	0.16	0.79
SGP_F	<0.01	0.14	0.83	SGP_S	<0.01	0.23	0.72
SWE_F	<0.01	0.14	0.79	SWE_S	<0.01	0.13	0.84
TUR_F	<0.01	0.11	0.82	TUR_S	<0.01	0.15	0.65
TWN_F	<0.01	0.13	0.85	TWN_S	<0.01	0.12	0.85
USA_F	<0.01	0.29	0.64	USA_S	<0.01	0.30	0.64

Not: ***, **, * sırasıyla %1, %5 ve %10 anlam düzeyini göstermektedir.

VOLATILITY SPILLOVERS BETWEEN SPOT AND FUTURES MARKETS AND THE ANALYSIS OF THEIR PERSISTENCE

EXTENDED SUMMARY

Aim of the Study

This study aims to provide detailed information to investors who diversify their portfolios based on spot and futures markets, in order to develop more effective risk management strategies. Therefore, the study tests the existence of volatility spillovers between spot and future markets and determines the direction and persistence of the existing spillovers. The study covers the data set of spot and future markets of 27 developed and developing countries and uses Hafner and Herwartz's (2006) causality in variance test and Li and Enders's (2018) causality in variance test extended with Fourier functions.

The Literature

Studies investigating the relationship between spot and future stock markets reveal different results depending on the period and the methods employed (Sim and Zurbreugg, 1999; Zhong et al., 2004; Zhang and Jaffry, 2015; Hou and Li, 2020; Kılıç, 2022; Sundararajan and Balasubramanian, 2025). Some of the studies focus on the asymmetry of volatility relationships between markets (Tse, 1999; Mallikarjunappa and Afsal, 2010; Tokat and Tokat, 2010; Truong et al., 2021; Kara et al., 2022; Yağcılar, 2022) while some of the studies focus on short-term dynamics of short-term spillovers between markets and uses high-frequency data over a short period of time (Chan et al., 1991; Fan and Du, 2017; Gannon, 2005; Min and Najand, 1999; Pati and Rajib, 2011; Zhang and Jaffry, 2015). Moreover, most of the studies in the related literature investigates the relationship between spot and future markets of a single country, while limited studies examine the interaction between spot and future markets of multiple countries or between spot and future markets of different countries (Sim and Zurbreugg, 1999; Antoniou et al., 2003; Antonakakis et al., 2016; Siddiqui and Roy, 2020). However, it is not sufficient for investors to determine only the existence and direction of volatility spillovers between the markets. The most important gap in the literature is that structural changes in the markets are not taken into account while investigating the spillovers. The persistence of volatility spillovers is also not comprehensively determined in the previous studies. In this context, this study aims to contribute to the literature and provide investors with information that they can use in their portfolio decisions.

Methodology

In this study, the volatility spillovers between spot and future stock markets for 27 developed and developing countries are analyzed by the Hafner and Herwartz (2006) causality in variance test and causality in variance test extended with Fourier functions, for the period of January 4, 2000, and March 25, 2025. One of the most frequently used methods for determining the direction of volatility spillovers is the test for causality in variance developed by Hafner and Herwartz (2006) (LM). The causality in variance test allows for the identification of the existence and direction of volatility spillovers, but does not take structural changes into account.

Since tests based on the Fourier approach can capture cyclical shocks, abrupt regime shifts, and nonlinear dynamics, they stand out in studies that cover the periods of structural changes. Li and Enders (2018) improved the Hafner and Herwartz (2006) volatility spillover test as the volatility spillover test with structural breaks using the Fourier approach. The study uses both of these tests.

Results

Hafner and Herwartz (2006) causality in variance test and causality in variance test extended with Fourier functions applied in this study reveal that there are volatility spillovers between spot and future markets in almost all of the countries analyzed and that these spillovers are bidirectional in 21 countries. The results indicate bidirectional volatility spillovers between spot and future markets, unlike the studies in the literature indicating unidirectional spillovers between the markets. Another important finding that differentiates the study is that the identified spillovers between the spot and future stock markets are generally permanent, contrary to the studies indicating temporary spillovers in the literature.

Conclusion

The study reveals bidirectional and persistent volatility spillovers between spot and future stock markets. In markets with bidirectional spillovers, holding spot and future assets in the portfolio would inevitably increase the portfolio risk. Moreover, in markets with persistent spillovers, past volatility shocks have the potential to have long-term effects on future prices. Therefore, investors investing in these markets are advised to prefer alternative financial assets or hedge their positions by adjusting their positions according to maturity and dynamically updating their hedge ratios instead of keeping them fixed. It is also crucial for policymakers to continuously monitor volatility transmission channels between the markets and develop early warning systems to maintain financial stability. Especially in countries with bidirectional and persistent spillovers, a more coordinated supervisory mechanism between spot and future markets should be developed, and information asymmetry should be reduced.

SERMAYE YAPISI İLE FİRMA PERFORMANSI ARASINDAKİ NEDENSELLİĞİN İNCELENMESİ

Examining Panel Causality Between Capital Structure and Firm Performance

Metin BORAK* 

Öz

Bu çalışma, 2010-2023 yılları arasında Borsa İstanbul'da imalat sektöründe faaliyet gösteren 109 firmanın sermaye yapıları ile performansları arasındaki ilişkiyi incelemektedir. Çalışmada firma performansını ölçmek için hem muhasebe hem de piyasa tabanlı değişkenler kullanılmıştır. Muhasebe tabanlı değişkenler, aktif ve faaliyet karlılığı oranları iken piyasa tabanlı değişken ise Tobin Q oranıdır. Sermaye yapısını ölçmek için toplam, kısa vadeli ve uzun vadeli kaldıraç oranları kullanılmıştır. Ayrıca sermaye yapısı ve firma performansı arasındaki ilişkiyi etkileyebilecek bazı değişkenler de kontrol değişkenler olarak kullanılmıştır. Sermaye yapısı ile firma performansı arasındaki ilişkinin ortaya konulması için iki aşamalı sistem genelleştirilmiş momentler yöntem ve dinamik ortak ilişkili etkiler tahmincileri kullanılmış ve panel nedensellik testleri uygulanmıştır. Bulgular, sermaye yapısı ile finansal performans (aktif ve faaliyet karlılığı) arasında negatif ve anlamlı, piyasa performansı (Tobin Q) arasında anlamsız bir ilişki olduğunu ortaya koymaktadır. Ayrıca nedensellik bulguları, toplam kaldıraç ile aktif karlılığı ve Tobin Q arasında çift taraflı, faaliyet karlılığı ile tek taraflı bir nedensellik ilişkisi olduğunu göstermektedir.

Anahtar Kelimeler:

Sermaye Yapısı,
Firma Performansı,
Nedensellik,
GMM,
DCCE

JEL Kodları:

C23, G30, G32.

Abstract

This study examines the relationship between capital structure and the performance of 109 companies operating in Borsa Istanbul's manufacturing sector over the period 2010-2023. The study measured company performance using both accounting (return on assets and operating profitability) and market-based (Tobin Q) variables. To measure capital structure, total, short-term, and long-term debt ratios were used. In addition, some variables that may affect the relationship between capital structure and company performance were used as control variables. The results suggest that there is a negative and significant relationship between capital structure and financial performance and an insignificant relationship between capital structure and market performance, using two-stage GMM and DCCE. In addition, the causality results show that there is a bidirectional causality relationship between return on assets and total debt, and between Tobin's Q and total debt.

Keywords:

Capital Structure,
Firm Performance,
Causality,
GMM,
DCCE

JEL Codes:

C23, G30, G32

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1. Giriş

Firmalar, faaliyetlerini ve yükümlülüklerini yerine getirebilmek, rekabet güçlerini koruyabilmek ve en önemlisi paydaşlarını memnun edebilmek için gelecekte nakit akışlarına gereksinim duyar. Gelecekte nakit akışlarının yaratılması, yatırımlar ve bu yatırımları finanse edebilecek sermayeye bağlıdır. Firmalar, sermaye ihtiyaçlarını genellikle iki kaynaktan sağlar. Birincisi öz sermaye, ikincisi ise borçlanmadır. Bu iki finansman kaynağı, firmanın toplam sermayesini; bunların bileşimi ise sermaye yapısını ifade etmektedir. Diğer bir deyişle, bir firmanın sermaye yapısı menkul kıymetlerin bileşiminden oluşmaktadır. Firma yöneticileri, finansman ihtiyaçlarını karşılamak için bu kaynaklar arasında iyi bir seçim yapmalıdır. Çünkü sermaye yapısı kararları; firmanın maliyetini, riskini, değerini, performansını ve hissedarların refahını etkileyebilmektedir. Dolayısıyla firma yöneticileri, sermaye yapısı kararlarının bu etkilerini gözetererek seçim yapmalı ve firma açısından en uygun bileşimi tercih etmelidir (Abor, 2005; Tong ve Green, 2005; Iyoha ve Umoru, 2017).

Finansman kararlarının önemi, bazı soruları da gündeme getirmektedir: (1) Sermaye yapısı ile firma performansı arasında karşılıklı bir etkileşim var mı? (2) Firma performansı, sermaye yapısı kararlarını etkiler mi? (3) Sermaye yapısı ile sermaye maliyeti arasında bir ilişki var mı? (4) Sermaye yapısı içinde borcun oranı diğer bir deyişle kaldıracın artması firma değerini veya performansını etkiler mi? (5) Firmalar için optimum sermaye yapısı var mı? Akademik çevre, sermaye yapısına ilişkin bu tür soruları, çeşitli teorileri ortaya koyarak cevaplamaya çalışmıştır. Modern anlamda bu konuya değinen ilk teori çalışması, Modigliani ve Miller (1958) tarafından yapılmıştır. Modigliani ve Miller (MM), etkin bir piyasada firma değerinin sermaye yapısına bağlı olmadığını, firma yöneticilerinin faaliyetlerini finanse etmek için başvurduğu çeşitli kaynakların sermaye yapısı içindeki oranlarını değiştirerek firma değerini dolayısıyla da firma performansını artıramayacağını ileri sürmektedirler. MM görüşü, bazı varsayımlara dayanmaktadır. Bunlar; iflas ve işlem maliyetlerinin olmaması, verginin olmaması, piyasaların etkin olması, asimetric bilginin olmaması, tüm firmaların aynı risk sınıfında yer alması, temsil maliyetlerinin olmaması gibi varsayımlardır (Ardalan, 2017). Yıllar içinde bu varsayımların gerçekçi olmağı yönünde eleştiriler artmış ve sermaye yapısının firma değeri ile ilişkili olabileceğini savunan farklı teoriler ortaya atılmıştır. Bunlardan birincisi, Kraus ve Litzenberger (1973) tarafından ileri sürülen dengeleme teorisidir. Dengeleme teorisi, optimum bir sermaye yapısının olduğunu, bunun da borçlanmanın sağladığı avantaj (borcun vergi avantajı) ile borç kullanımından kaynaklanan finansal sıkıntı maliyetlerinin dengelendiği noktada oluştuğunu ileri sürmektedir. Dolayısıyla dengeleme teorisi, MM teorisinin aksine borçlanmanın firma değeri üzerinde olumlu bir etkisi olabileceğini ileri sürmektedir. Bu bakımdan dengeleme teorisi, karlı firmaların neden fazla borçlandıklarını açıklamaktadır. İkincisi ise finansal hiyerarşi teorisidir (Myers ve Majluf, 1984). Finansal hiyerarşi teorisi, bilgi asimetrisi, işlem maliyetleri ve sinyal etkisini öne sürerek firmaların faaliyetlerini finanse etmek için ilk olarak içsel sonra dışsal kaynaklara başvurmaları gerektiğini ileri sürmektedir. Dolayısıyla bu teoriye göre karlı firmaların borç oranları daha düşüktür. Ayrıca Jensen ve Meckling (1976), temsil maliyetlerini dikkate alarak sermaye yapısının firma değeri üzerinde etkili olabileceğini ileri sürmüşlerdir.

Konuya ilişkin farklı teorilerin ortaya çıkmasıyla birlikte araştırmacılar da çeşitli araştırmalar yaparak, bu teorilerinin geçerliliklerini inceleyip firmalar açısından fayda sağlayıp sağlamadıklarını incelemişlerdir. Bazı çalışmaların sonuçları, sermaye yapısının firma performansı üzerinde negatif bir etkisi olduğunu göstermektedir (Nguyen ve Nguyen, 2020;

Boshnak, 2023; Ronoowah ve Seetanah, 2023). Dięer alıřmalar ise sermaye yapısının firma performansını zerinde pozitif bir etkisi olduęunu savunmuřtur (Myers ve Majluf, 1984; Margaritis ve Psillaki, 2007; Gill vd., 2011; Detthamrong vd., 2017). Dięer yandan ampirik alıřmalar, sermaye yapısının belirlenmesinde firma performansının nemli bir faktr olduęunu ortaya koymaktadır (Titman ve Wessels, 1988; Rajan ve Zingales, 1995; Frank ve Goyal, 2009; Karadeniz vd., 2009; Chakraborty, 2010; Vo, 2017). Ayrıca sermaye yapısı ile firma performansı arasında ift taraflı bir nedensellik olabileceęi de ileri srlmektedir (Abdullah ve Tursoy, 2021). Trkiye’de ise sermaye yapısı ile firma performansı arasındaki iliřki oęunlukla negatif bulunurken (Bayrakdaroglu vd., 2013; opuroęlu ve Korkmaz, 2018; Kkbay ve Gler, 2020; Ar ve Sakur, 2021; Dolunay ve Gker, 2021; Elmas ve Gzel, 2022; Ersoy, 2022; Konak ve Trkoęlu, 2022; Uyar ve Moalinahmed, 2024) bu iliřkinin pozitif olabileceęini ileri sren alıřmalar da bulunmaktadır (elik, 2024; Dzakın ve zekenci, 2024).

Sermaye yapısı ile firma performansı arasındaki iliřkiyi inceleyen yukarıdaki alıřmaların ampirik sonuları, bu iliřki hakkında hemfikir olunan bir sonucun olmadıęını, alıřmanın yapıldıęı lke, zaman aralıęı ve kullanılan deęiřkenlere gre farklılık gsterebileceęini ortaya koymaktadır. Yapılan bu arařtırmaların daha iyi anlařılması, sermaye yapısı ile firma performansı arasındaki iliřkinin daha da incelenmesi gerektięini gstermektedir. Bu alıřma birok aıdan Trkiye’de gncel literatre katkı saęlamaktadır. Birincisi, alıřmada benzersiz ve gncellenmiř bir veri seti kullanılarak sermaye yapısı ile performans arasındaki iliřki ortaya konulmuřtur. Bor vadesinin, bu iliřkide nemli olacaęı gereęiyle kısa ve uzun vadeli borlanma deęiřkenleri de analizlere dahil edilmiřtir. Ayrıca sz konusu deęiřkenler arasındaki iliřkinin, imalat alt sektrlerinde farklılık gsterip gstermedięine dair kanıtlar da raporlanmıřtır. İkincisi, sermaye yapısı ile firma performansı arasındaki iliřki ortaya konulurken finans literatrnde yaygın ve nemli bir sorun olan baęımsız deęiřkenler ile hata terimleri arasındaki korelasyondan kaynaklanan isellik ve dıřlanmış deęiřkenlerden kaynaklanan problemleri ele almak iin GMM tahmincisi kullanılmıřtır. Bu yntem teknięi, isel aralar kullanarak isellieęi kontrol etmektedir. Ayrıca kesitler arasındaki korelasyonu dikkate alan Chudik ve Pesaran (2015) tarafından nerilen Dynamic Common Correlated Effects (DCCE) yaklařımı ile elde edilen sonuların gvenirlięi artırılmıřtır. ncs, Trkiye’de sermaye yapısı ile firma performansı arasındaki iliřki ve sermaye yapısının belirleyicileri geniř bir řekilde ele alınmıřtır. Ancak sermaye yapısı ile firma performans arasındaki ift ynl iliřkiyi inceleyen alıřmalar sınırlı sayıda kalmıřtır. Sermaye yapısı firma performansını etkilerken firma performansı da sermaye yapısını etkileyebilmektedir. Oysa yapılan arařtırmalarda, sermaye yapısı ile firma performansı arasındaki iliřki oęunlukla tek taraflı incelenmiřtir. Dięer bir deęiřle ya sermaye yapısının firma performansı zerindeki etkisi ya da performansın sermaye yapısı zerindeki etkisi incelenmiřtir. Bu alıřmada her iki durum incelenmiř ve sonuları raporlanmıřtır. Ayrıca bu alıřma, sermaye yapısı ile firma performansı arasındaki nedensellik ynn incelemek iin Dumitrescu ve Hurlin (2012) ve Emirmahmutoglu ve Kse (2011) panel nedensellik yaklařımlarını uygulamaktadır.

Bu alıřmanın amacı, 2010-2023 yılları arasında Borsa İstanbul’da faaliyet gsteren ve imalat sektrnde yer alan firmaların sermaye yapıları ile performansları arasındaki iliřkiyi incelemek ve aralarında karřılıklı bir nedensellik iliřkisi olup olmadıęını arařtırmaktır. İlk olarak iki ařamalı sistem genelleřtirilmiř momentler yntemi (GMM) ve DCCE tahmincileri kullanılmıřtır. Daha sonra iki deęiřken arasındaki nedensellik iliřkisinin ortaya konulması iin Dumitrescu ve Hurlin (2012) ve Emirmahmutoglu ve Kse (2011) panel nedensellik testleri

uygulanmıştır. Elde edilen tahminlere göre sermaye yapısı ile finansal performans (aktif ve faaliyet karlılığı) arasındaki ilişki negatif ve anlamlı iken sermaye yapısı ile piyasa performansı (Tobin Q) arasındaki ilişki anlamsızdır. Ayrıca nedensellik bulguları, toplam kaldıraç ile aktif karlılığı ve Tobin Q arasında çift taraflı bir nedensellik, faaliyet karlılığı ile tek taraflı bir nedensellik ilişkisi olduğunu göstermektedir.

Bu çalışmanın sonraki bölümleri şöyle olacaktır: İkinci bölüm, konuya ilişkin literatür ve çalışmanın hipotezlerini içermektedir. Üçüncü bölüm, çalışmanın modelini ve modelde kullanılan değişkenleri kapsamaktadır. Dördüncü bölüm, çalışmada kullanılan modellerin ve diğer testlerin bulgularını, son olarak beşinci bölüm çalışmanın sonuçlarını göstermektedir.

2. Literatür ve Hipotez

Sermaye yapısı ile firma performansı arasındaki ilişki inceleyen birçok teori bulunmaktadır. Bunlar arasında Modigliani ve Miller'in (1958) ilintisizlik, Kraus ve Litzenberger'in (1973) dengeleme ve Myers ve Majluf'un (1984) finansal hiyerarşi teorileri yer almaktadır. Modigliani ve Miller (1958), finansal kararlar ile firma değeri arasında bir ilişki olmadığını ileri sürmektedirler. Diğer bir deyişle firma değerinin, finansman kaynakları içinde borç-öz sermaye oranından bağımsız olduğunu savunmaktadırlar. Bu öneriyi gerçek dünya ile uyuşmayan bazı katı varsayımlara (iflas, vergi ve bilgi asimetrisinin olmaması gibi) dayandırmaktadırlar. Dengeleme ve finansal hiyerarşi teorileri ise bu katı varsayımların bazılarını gevşeterek sermaye yapısının firma değeri üzerinde etkisi olabileceğini savunmaktadır. Dengeleme teorisine göre borç kullanımı bir noktaya kadar firma değerini artırabilir. Bu teoride borç kullanımı vergi kalkını olarak görülmektedir. Borç, vergi avantajı sağlamaktadır. Diğer bir deyişle borç kullanımından kaynaklanan faiz ödemeleri, vergilendirilebilir karı azaltmaktadır. Bu da borcun katkısı olarak görülmektedir. Finansal hiyerarşi teorisine göre ise firmalar finansman ihtiyaçlarını bir hiyerarşiye göre yapmalıdır. Bu hiyerarşinin en üstünde firmanın faaliyetleri sonucunda elde ettiği ve ortaklarına dağıtmayıp firmada bıraktığı iç kaynak (otofinansman) yer almaktadır. Teoriye göre iç finansmanın yetersiz olması durumunda dış finansmana başvurulmalıdır. Otofinsmandan sonra borç, daha sonra öz sermaye finansmanı tercih edilmelidir. Çünkü sermaye yapısı içinde yüksek düzeyde borç bulunması, piyasa tarafından olumsuz algılanabilir, bu da firma değeri üzerinde olumsuz bir etki yaratabilir. Yıllarca bu teorilerinin genel geçerliliği ve üstünlükleri hakkında tartışmalar yaşanmıştır. Ancak teoriler ile ilgili yapılan çalışmaların sonuçları, evrensel bir teorisinin olmadığı diğer bir deyişle borç-öz sermaye tercihinin ülkeler ve firmalar için farklılık gösterebileceğini ortaya koymaktadır. Örneğin, bazı çalışmaların sonuçları, sermaye yapısının firma performansı üzerinde negatif bir etkiye sahip olduğunu göstermektedir (Zeitun ve Tian, 2007; Salim ve Yadav, 2012; Chang vd., 2014; Le ve Phan, 2017; Nguyen ve Nguyen, 2020; Boshnak, 2023; Ronoowah ve Seetanah, 2023). Diğer çalışmalar ise sermaye yapısının firma performansı üzerinde pozitif bir etkiye sahip olduğunu göstermektedir (Abor, 2005; Margaritis ve Psillaki, 2007; Gill vd., 2011; Detthamrong vd., 2017).

Sermaye yapısının firma performansını etkilemesi gibi firma performansı da sermaye yapısını etkileyebilmektedir. Firma performansının kaldıraç üzerindeki etkisi hem teorik hem de ampirik olarak pozitif ya da negatif olabilmektedir. Finansal hiyerarşi teorisine göre firmalar öncelikle iç finansmanı tercih ederler. Dolayısıyla daha yüksek karlılığa sahip firmaların sinyal ve asimetrik bilgi sorunlarından dolayı ilk tercih tercihleri borç olmayacağı için karlılık ile kaldıraç

arasında negatif bir iliřki beklenmektedir. Birçok alıřma bu neri desteklemektedir (Titman ve Wessels, 1988; Rajan ve Zingales, 1995; Booth vd., 2001; Tong ve Green, 2005; Huang ve Song, 2006; Frank ve Goyal, 2009; Chakraborty, 2010; Vo, 2017). Dięer yandan dengeleme teorisine gre karlı firmalar, vergi tasarrufundan yararlanmak iin dięer kaynaklardan ziyade daha fazla bor alma eęiliminde olabilirler. Ayrıca karlı firmaların iflas maliyetlerinin daha dřük olması da daha fazla bor kullanmalarına neden olabilmektedir. Bu nedenle karlılık ile kaldıra arasında pozitif bir iliřki beklenmektedir (Fama ve French, 2002; Frank ve Goyal, 2009).

Yukarıdaki alıřmaların bulgularına gre sermaye yapısı ile firma performansı arasındaki iliřki; ekonomi, sektr, zaman ve kullanılan ynteme baęlı farklılık gstermektedir. Konuya iliřkin literatrde sermaye yapısını temsilen oęunlukla toplam bor oranı (toplam borcun toplam varlıklara oranı) kullanılmaktadır. Bu oran, bir firmanın finansal gc ve sermaye yapısı hakkında bilgi sunarken firma varlıklarının ne kadarının bor verenler tarafından saęlandığını gstermektedir. Bu oranın dřük olması (toplam borlanmanın toplam varlıkların kk bir kısmını oluřturması) finansal riskin dřklęn gsterirken yksek olması riskli bir finansman yapısını yansıtmaktadır. Oranın yksek olması potansiyel bor verenler veya yatırımcılar iin kt bir sinyal olabilir. Bu, bir yandan bor maliyetinin ykselmesine neden olurken bir yandan da firma performansını olumsuz etkileyebilmektedir. Dięer yandan borcun vergi avantajından dolayı oranın ykseklіęi firma performansına olumlu yansıyabilir. Dolayısıyla sermaye yapısı, firma performansını olumlu veya olumsuz ynde etkileyebilmektedir. Ayrıca gemiř alıřmalar, sermaye yapısı ile firma performansı arasında karřılıklı bir nedensellik olabileceğini ortaya koymaktadır. Bu nedenlerden dolayısıyla alıřmanın hipotezleri ařaęıdaki gibi oluřturulmuřtur:

Hipotez 1: Sermaye yapısı, kontrol deęiřkenlerin varlıęında firma performansını etkilemektedir.

Hipotez 2: Firma performansı, kontrol deęiřkenlerin varlıęında sermaye yapısını etkilemektedir.

Hipotez 3: Sermaye yapısı firma performansının nedenidir.

Hipotez 4: Firma performansı sermaye yapısının nedenidir.

3. Veri ve Yntem

3.1. Veri ve rneklem

Bu alıřma, 2010-2023 yılları arasında Borsa İstanbul'da imalat sektörnde faaliyet gsteren 109 firmanın sermaye yapıları ile performansları arasındaki iliřkiyi incelemektedir. alıřmada firma performansını lmek iin hem muhasebe hem de piyasa tabanlı deęiřkenler kullanılmıřtır. Muhasebe tabanlı deęiřkenler, aktif ve faaliyet karlılıęı oranları iken piyasa tabanlı deęiřken ise Tobin Q oranıdır.

Sermaye yapısını lmek iin ise toplam, kısa vadeli ve uzun vadeli kaldıra oranları kullanılmıřtır. Ayrıca sermaye yapısı ve firma performansı arasındaki iliřkiyi etkileyebilecek bazı deęiřkenler de kontrol deęiřkenler olarak kullanılmıřtır. Bunlar; firma byklę, byme ve varlık yapısı deęiřkenleridir. alıřmada kullanılan tm deęiřkenler, Borsa İstanbul tarafından yetkilendirilen Finnet Elektronik Yayıncılık Data İletiřim Tic. ve San. Ltd. řti. veri tabanından alınmıřtır (Finnet, 2024).

3.2. Değişkenler

Firma performansı, finansal performans (muhasabe tabanlı/muhasabe performansı) veya piyasa performansı şeklinde hesaplanabilmektedir. Finansal performansı temsilen çeşitli göstergeler kullanılmaktadır. Bunlar; aktif karlılığı (ROA), öz sermaye karlılığı (ROE), yatırılan sermayenin getirisi (ROCE), net kâr marjı, faaliyet karlılığı gibi oranlardır (Ronoowah ve Seetanah, 2023; Nguyen vd., 2023; Demiraj vd., 2024). Diğer yandan piyasa performansını temsilen pay getirileri, firmanın piyasa değeri, piyasa değeri/defteri değeri, fiyat kazanç oranı ve Tobin Q gibi oranları kullanılmaktadır (Zeitun ve Tian, 2007; Al-Haddad vd., 2024). Konuya ilişkin yapılan çalışmalarda (Abor, 2005; Fosu, 2013; Mundi, 2024) firma performansını ölçmek için yaygın bir şekilde muhasabe tabanlı göstergeler kullanılmaktadır. Bazı çalışmalarda (Zeitun ve Tian, 2007; Le ve Phan, 2017; Abdullah ve Tursoy, 2021) ise muhasabe tabanlı göstergelerle birlikte piyasa tabanlı göstergeler de kullanılmaktadır. Dolayısıyla bu çalışmada firma performansını ölçmek için hem muhasabe tabanlı hem de piyasa tabanlı göstergeler kullanılmıştır. Firmaların finansal performanslarını ölçmek için ilk olarak yaygın bir şekilde tercih edilen ROA kullanılmıştır. İkinci olarak da faaliyet karlılığı oranı kullanılmıştır. Aktif karlılığı, toplam net karının; faaliyet karlılığı ise faaliyet karının aynı dönemdeki toplam varlıklara bölünmesiyle elde edilmiştir. Firmaların piyasa performansını ölçmek için ise Tobin Q oranı kullanılmıştır. Bu oran, firmanın piyasa değeri ile borçlar toplamının, toplam varlıklara bölünmesiyle hesaplanmaktadır (Zeitun ve Tian, 2007).

Tablo 1. Çalışmada Kullanılan Değişkenler

Değişkenler	Gösterge	Hesaplama
Finansal performans	Aktif karlılığı (ROA)	Net Kar/Toplam Varlıklar
Finansal performans	Faaliyet karlılığı (FTA)	Faaliyet Karı/Toplam Varlıklar
Piyasa performansı	Tobin Q (TQ)	(Piyasa Değeri + Toplam Borçlar)/Toplam Varlıklar
Sermaye yapısı	Toplam kaldıraç (TKAL)	Toplam Borç/Toplam Varlıklar
Sermaye yapısı	Kısa vadeli kaldıraç (KKAL)	Kısa Vadeli Borç/Toplam Varlıklar
Sermaye yapısı	Uzun vadeli kaldıraç (UKAL)	Uzun Vadeli Borç/Toplam Varlıklar
Firma büyüklüğü	Toplam varlıklar (BUY)	Toplam varlıkların doğal logaritması
Firma büyümesi	Satışlardaki büyüme (SBUY)	Satışlar(t) - Satışlar (t-1)/Satışlar (t-1)
Varlık yapısı	Sabit varlık oranı (VY)	Sabit Varlıklar/Toplam Varlıklar

Sermaye yapısı, firmaların finansman ihtiyaçlarını karşılamak için kullandıkları kaynakların çeşitli kombinasyonu şeklinde ifade edilmektedir. Bir firmanın sermaye yapısı, kaldıraç oranı ile ölçülebilmektedir. Kaldıraç oranı, toplam borç/toplam varlıklar, kısa vadeli borç/toplam varlıklar ve uzun vadeli borç/toplam varlıklar şeklinde hesaplanabilmektedir (Fosu, 2013; Işık ve Ersoy, 2021; Le ve Phan, 2017; Ersoy, 2022; Boshnak, 2023; Nguyen vd., 2023; Demiraj vd., 2024). Bu çalışmada sermaye yapısını ölçmek için yaygın olarak kullanılan toplam borç/toplam varlıklar oranı kullanılmıştır. Ayrıca elde edilen bulguları desteklemek amacıyla kısa vadeli ve uzun vadeli borçların, toplam varlıklara oranları da kullanılmıştır. Sermaye yapısının firma performansı üzerindeki etkisi veya firma performansının sermaye yapısı üzerindeki etkisinin doğru bir şekilde ortaya konması için bu ilişkide etkili olabilecek firmaya özgü bazı değişkenlerin de kontrolü gerekmektedir. Bu çalışmada firma büyüklüğü (Işık ve Ersoy, 2021; Lin ve Chang, 2011; Ronoowah ve Seetanah, 2023), firma büyüme fırsatları (Abor, 2005; Abdullah ve Tursoy, 2021; Al-Haddad vd., 2024) ve firmanın varlık yapısı

(Margaritis ve Psillaki, 2007; Bandyopadhyay ve Barua, 2016; Ersoy, 2022; Mundi, 2024) deęiřkenleri kontrol deęiřkenler olarak analizlere dahil edilmiřtir. Analizlerde kullanılan deęiřkenler Tablo 1’de detaylandırılmıřtır.

Tablo 2. Çalışmada Kullanılan Deęiřkenler için Özet İstatistikler

Deęiřkenler	Gözlem	Ortalama	Standart S.	Min. Deęer	Maks. Deęer
Panel A. Firma performansını için tanımlayıcı istatistikler					
ROA	1526	0.050	0.103	-1.986	0.587
FTA	1526	0.072	0.082	-0.880	0.528
TQ	1526	1.73	2.477	0.445	61.577
Panel B. Sermaye yapısı için tanımlayıcı istatistikler					
TKAL	1526	0.509	0.209	0.036	1.044
KKAL	1526	0.367	0.172	0.021	0.979
UKAL	1526	0.143	0.116	0.000	0.635
Panel C. Kontrol deęiřkenler için tanımlayıcı istatistikler					
BUY	1526	20.53	1.887	15.836	26.849
SBUY	1526	0.421	0.909	-0.821	9.957
VY	1526	0.466	0.191	0.009	0.947

Not: ROA, FTA ve TQ firma performansını ölçmek için kullanılmıřtır. ROA, net kar/toplam varlıklar; FTA, faaliyet karı/toplam varlıklar; TQ, (piyasa deęeri+toplam borçlar) / defter deęeri řeklinde hesaplanmıřtır. TKAL, KKAL ve UKAL sırasıyla toplam borç, kısa vadeli borç ve uzun vadeli borçların, toplam varlıklara bölünmesiyle elde edilmiřtir. BUY, firma büyüklüğünü (toplam varlıkların doęal logaritması); SBUY, firma büyümesini (satıřlardaki yıllık deęiřim) ve VY, firma varlık yapısını (duran varlıklar/toplam varlıkları) temsil etmektedir.

Tablo 2, bu çalışmada kullanılan deęiřkenlere ilişkin özet istatistikleri göstermektedir. ROA ve FTA firmanın finansal performansını gösterirken TQ, firmanın piyasa performansını göstermektedir. ROA %5 ortalama ve yaklaşık %10 standart sapmaya sahip iken -%199 ile %59 arasında deęiřmektedir. FTA’nın ortalaması yaklaşık %7 iken standart sapması %8’dir. FTA’nın deęerleri -%88 ile %53 arasında deęiřmektedir. Muhasebe esaslı bu iki deęiřken, imalat firmalarının düşük bir finansal performansa sahip olduklarını göstermektedir. TQ %173 ortalama ve %248 standart sapmaya sahiptir. Piyasa performansını gösteren bu oran, finansal performans deęiřkenleriyle karşılaştırıldığın yüksek bir performans yüzdesi göstermektedir. Bu yüksek oran, firmaların faaliyet performanslarında herhangi bir artış olmadan firmaların hisse senetlerindeki fiyat artışlarının bir sonucu olabilir. TKAL, KKAL ve UKAL deęiřkenleri, firmaların sermaye yapılarını ölçmek için kullanılmıřtır. Toplam borç oranını gösteren TKAL deęiřkeni, yaklaşık %51 ortalama ve yaklaşık %21 standart sapmaya sahip iken KKAL ve UKAL deęiřkenleri sırasıyla yaklaşık %37 ve %14 ortalama sahiptir. Bu deęiřkenlerin standart sapmaları sırasıyla %17 ve %12’dir. Sermaye yapısına ilişkin bu veriler, 2010-2023 yılları arasında Borsa İstanbul’da faaliyet gösteren imalat firmalarının finansman ihtiyaçlarının yaklaşık yarısını borçla karşıladıklarını göstermektedir. Ayrıca bu oranlar, Türkiye’de imalat firmalarının uzun vadeli borçlanmada sıkıntı çektiklerini dolayısıyla faaliyetlerini finanse etmek için kısa vadeli borçlanmaya yöneldiklerini göstermektedir. Bunun çeřitli nedenleri olabileceęi gibi Türkiye’de uzun vadeli borçlanma piyasasının gelişmemiř olması da olabilir. Kontrol deęiřkenlerinden olan firma büyüklüğü 20.53 ortalama ve 1.89 standart sapmaya sahip iken SBUY ve firmanın varlık yapısı (VY) deęiřkenleri sırasıyla yaklaşık %42 ve %47 ortalama ve %91 ve %19 standart sapmaya sahiptir.

3.3. Model

Bir önceki bölümde önerilen hipotezleri ampirik olarak test etmek için teoriye dayalı olarak oluşturulan aşağıdaki regresyon modelleri kullanılmıştır. İlk model (eşitlik (1)), çalışma dönemi boyunca kontrol değişkenlerin varlığında sermaye yapısının firma performansı üzerinde etkisini (Hipotez 1) test etmektedir. İkinci model (eşitlik (2)) ise firma performansının sermaye yapısı üzerinde etkisini (Hipotez 2) test etmektedir. Bu eşitlikler, Arellano ve Bond’un (1991) dinamik GMM tahminci ile tahmin edilmiştir. Bu tahmin tekniği, dinamik modellerde genellikle modelde yer alması gereken ancak modelde olmayan (dışlanmış) değişkenlerden kaynaklanan problem ve bağımsız değişkenler ile hata terimi arasındaki korelasyondan kaynaklanan (içsellik) sorununu dikkate almak için kullanılmaktadır. Çünkü içsellik sorunu, finans alanında önemli ve yaygın bir sorundur (Roberts ve Whited, 2013). Dolayısıyla bu tür problemlerin dikkate alınması gerekmektedir (Fosu, 2013; Le ve Phan, 2017).

$$FP_{i,t} = \beta_0 + \beta_1 SY_{i,t} + \beta_2 BUY_{i,t} + \beta_3 SBUY_{i,t} + \beta_4 VY_{i,t} + \varepsilon_{i,t} \quad (1)$$

$$SY_{i,t} = \beta_0 + \beta_1 FP_{i,t} + \beta_2 BUY_{i,t} + \beta_3 SBUY_{i,t} + \beta_4 VY_{i,t} + \varepsilon_{i,t} \quad (2)$$

Eşitlik (1)’de bağımlı değişken firma performansdır (FP). Firma performansını temsilen 3 farklı değişken (ROA, faaliyet karlılığı (FTA) ve Tobin Q (TQ) oranı) kullanılmıştır. Dolayısıyla her bir firma performans göstergesi için ayrı ayrı modeller uygulanmıştır. Ana bağımsız değişken ise sermaye yapısıdır (SY). Sermaye yapısı için de 3 farklı değişken kullanılmıştır. Bunlar; toplam kaldıraç, kısa vadeli kaldıraç KKAL ve uzun vadeli kaldıraç (UKAL) oranlarıdır. Kontrol değişkenler ise firma büyüklüğü (BUY), büyüme fırsatları SBUY ve firmanın varlık yapısı değişkenleridir. Eşitlik (2)’de bağımlı değişken sermaye yapısı iken temel bağımsız değişken firma performansdır. Mevcut firma performansı (sermaye yapısı kararları), geçmiş performanstan (sermaye yapısı kararları) etkilenebilir. Bu dinamik ilişkiyi dikkate almak için bağımlı değişkenlerin bir gecikmeli değerleri, bağımsız değişken olarak analizlere dahil edilmiştir.

Ayrıca firma performansı ve kaldıraç arasında bir nedensellik olup olmadığını (Hipotez 3 ve 4) test etmek için Dumitrescu ve Hurlin (2012) ve Emirmahmutoglu ve Köse (2011) panel nedensellik testleri uygulanmıştır.

4. Bulgular

4.1. Korelasyon Katsayıları

Tablo 3, firma performansı, sermaye yapısı, firma büyüklüğü, firma büyümesi ve firmanın varlık yapısı için kullanılan değişkenler arasındaki korelasyon katsayılarını göstermektedir. ROA ile FTA arasında korelasyon katsayı 0.63’tür. Bu yüksek korelasyon görmezden gelinebilir. Çünkü ROA, FTA ve TQ değişkenleri farklı modellerin bağımlı değişkenleridir. TKAL, KKAL ve UKAL değişkenleri de farklı modellerin açıklayıcı değişkenleridir. Bu değişkenler de farklı modellerde ayrı ayrı kullanıldığı için aralarındaki yüksek korelasyon katsayıları (0.83 ve 0.57) sorun teşkil etmemektedir.

Tablo 3. Deęiřkenler Arasındaki Korelasyon Katsayıları

Deęiřken	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) ROA	1								
(2) FTA	0.63***	1							
(3) TQ	0.17***	0.15***	1						
(4) TKAL	-0.30***	-0.14***	-0.08***	1					
(5) KKAL	-0.23***	-0.11***	-0.02	0.83***	1				
(6) UKAL	-0.20***	-0.09***	-0.10***	0.57***	0.01	1			
(7) BUY	0.10***	0.17***	-0.07***	0.17***	0.08***	0.18***	1		
(8) SBUY	0.11***	0.14***	0.01	0.01	0.05**	-0.06**	0.27***	1	
(9) VY	-0.23***	-0.29***	-0.11***	-0.18***	-0.38***	0.24***	0.13***	-0.02	1

Not: ***, ** ve * sırasıyla %1, 5% ve %10 anlamlılık düzeylerinde anlamlı katsayıları göstermektedir. ROA, FTA ve TQ firma performansını ölçmek için kullanılmıştır. ROA, net kar/toplam varlıklar; FTA, faaliyet karı/toplam varlıklar; TQ, (piyasa değeri+toplam borçlar)/defter değeri şeklinde hesaplanmıştır. TKAL, KKAL ve UKAL sırasıyla toplam borç, kısa vadeli borç ve uzun vadeli borçların toplam varlıklara bölünmesiyle elde edilmiştir. BUY, firma büyüklüğünü (toplam varlıkların doğal logaritması); SBUY, firma büyümesini (satışlardaki yıllık deęişim) ve VY, firma varlık yapısını (duran varlıklar/toplam varlıkları) göstermektedir.

Toplam borç oranı TKAL, kısa vadeli borç oranı KKAL ve uzun vadeli borç oranı (UKAL), performans deęiřkenleri (ROA, FTA ve TQ) ile negatif ilişkilidir. Bu ilişkilerden KKAL ile TQ arasındaki korelasyon katsayısı anlamsız iken dięerleri %1 düzeyinde anlamlıdır. Benzer şekilde firmanın varlık yapısı ile ROA, FTA ve TQ arasında negatif ve anlamlı bir ilişki vardır. Firma büyüklüğü (BUY) ve firma büyümesi SBUY ile ROA ve FTA arasındaki korelasyon katsayıları pozitif ve %1 düzeyinde anlamlı iken SBUY ile TQ arasındaki katsayısı pozitif ve anlamsız, BUY ile TQ arasındaki korelasyon katsayısı ise negatif ve %1 düzeyinde anlamlıdır. Tüm bu sonuçlar dikkate alındığında çalışmadaki modellerde kullanılacak bağımlı ve açıklayıcı deęiřkenler arasında yüksek bir korelasyonun olmadığı görölmektedir. Farklı modellerde kullanacak deęiřkenler arasındaki en yüksek korelasyon katsayısı (-0.38), VY ile KKAL arasında iken en düşük korelasyon katsayısı (0.01, anlamsız) ise SBUY ile TQ ve TKAL arasındadır.

4.2. Yatay Kesit Bağımlılık ve Panel Birim Kök Testleri

Panel birim kök testleri, bir serinin ortalaması, varyansı ve otokovaryansının zaman içinde sabit olması şeklinde tanımlanan durağanlık varsayımını test etme imkânı sunmaktadır. Serinin birim kök içermesi, durağan olmadığı anlamına gelmektedir. Durağan olmayan veriler ise sahte regresyon problemini ortaya çıkarmaktadır (Tataoğlu, 2020). Dolayısıyla bu sorundan kaçınmak için deęiřkenlerin birim kök içerip içermedikleri dięer bir ifadeyle durağan olup olmadıkları test edilmeleri gerekmektedir. Ancak panel birim kök testlerine karar verilmeden önce birimler arasında korelasyonun (yatay kesit bağımlılık) kontrol edilmelidir. Çünkü panel birim kök testlerinden bazıları birimler arası korelasyonu dikkate alırken bazıları almamaktadır. Bağımlı ve açıklayıcı deęiřkenlerin kesitsel bağımlılıklarını belirlemek için literatürde yaygın olarak kullanılan Pesaran (2004) CD testi uygulanmıştır. Tablo 4'te bu testin sonuçları gösterilmektedir. Sonuçlara göre birimler arası korelasyon olmadığını gösteren temel hipotez reddedilmekte ve birimler arası korelasyon olduğunu gösteren alternatif hipotez kabul edilmektedir. Bu sonuçlara göre tüm deęiřkenlerde birimler arası korelasyon sorunu bulunmamaktadır. Birimler arası korelasyonu dikkate almayan tahminçiler sapmalı sonuç

vereceğinden kullanımları uygun değildir. Korelasyon sorunundan dolayı değişkenlerin durağan olup olmadıklarının belirlenmesinde ikinci nesil panel birim kök testlerinin kullanılması gerekmektedir. Birim kök testi için Pesaran (2007) tarafından geliştirilen CIPS testi yapılmıştır. Bu testin temel hipotezi, birimler birim kök içermektedir; alternatif hipotezi ise birimler durağandır. Bu testin sonuçları da Tablo 4’te yer almaktadır. Sonuçlara göre firma büyüklüğü ve firmanın varlık yapısı dışındaki tüm değişkenler serisi, ilgili dönemde analizde kullanılan bütün firmalar için düzeyde durağan oldukları görülmektedir. Firma büyüklüğü ve varlık yapısı değişkenleri düzeyde durağan olmadıkları için fark alınarak durağan hale getirilmiştir.

Tablo 4. Yatay Kesit Bağımlılık ve Birim Kök Testi

Değişkenler	CD Testi	CIPS Testi
ROA	13.07***	-2.36***
FTA	29.86***	-2.44***
TQ	76.72***	-2.176***
TKAL	52.41***	-2.040*
KKAL	33.13***	-2.417***
UKAL	28.83***	-2.56***
BUY	275.12***	-1.62
SBUY	244.61***	-3.19***
VY	36.29***	-1.57

Not: ***, ** ve * temel hipotezin sırasıyla %1, %5 ve %10 anlamlılık düzeylerinde reddedildiğini göstermektedir. CD, birimler arası korelasyonun olup olmadığı test etmektedir. CIPS, değişkenlerin durağan olup olmadıkları test etmektedir. CIPS için kritik değerler; %10 için -1.98, %5 için -2.04 ve %1 için -2.16’dır.

4.3. Regresyon Sonuçları

Tablo 5’te iki aşamalı sistem GMM sonuçları yer almaktadır. Bütün modellerde bağımlı değişkenler, firma performansdır. Model 1-6, sermaye yapısı ile finansal performans arasındaki ilişkiyi incelerken Model 7-9, sermaye yapısı ile piyasa performansı arasındaki ilişkiyi incelemektedir. Bağımlı değişkenler, Model 1, 2 ve 3’te ROA; Model 4, 5 ve 6’da faaliyet karlılığı (FTA); Model 7, 8 ve 9’da ise Tobin Q (TQ) oranıdır. Tablo 5’teki sonuçlara göre toplam borç oranı, firmanın finansal performansı negatif ve anlamlı bir şekilde etkilemektedir (Model 1 ve 4). Toplam borç ile piyasa performansı arasındaki ilişki ise anlamsızdır (Model 7). Benzer şekilde kısa vadeli borç (KKAL) ve uzun vadeli borç (UKAL) oranları ile finansal performans oranları (ROA ve FTA) arasındaki ilişki negatif (Model 2, 3, 5 ve 6) ve anlamlı iken firmanın piyasa performansı (TQ) arasındaki ilişkiler anlamsızdır (Model 8 ve 9). Firmanın sermaye yapısı ile firma performansı arasındaki ilişkiyi gösteren bu sonuçlar, daha fazla borcun finansal performansı düşürdüğünü göstermektedir. Diğer bir deyişle toplam borç, kısa vadeli borç ve uzun vadeli borçlarda 1 birimlik artış, firmanın aktif karlılığını sırasıyla 0.197, 0.202 ve 0.146 birim; firmanın faaliyet karlılığını ise sırasıyla 0.104, 0.121 ve 0.043 birim azaltmaktadır. Bu sonuçlar, sermaye yapısının firma performansı negatif yönde etkilediğini ileri süren Zeitun ve Tian (2007), Le ve Phan (2017), Nguyen ve Nguyen (2020), Boshnak (2023), Ronooowah ve Seetanah (2023) çalışmalarıyla uyumluluk göstermektedir. Kontrol değişkenlerinden olan firma büyüklüğü (BUY), firmanın finansal performansını pozitif etkilerken firmanın piyasa performansını negatif yönde etkilemektedir. Bu değişkenin katsayısı, Model 6’da %10; Model 3’te %5 anlamlı iken geriye kalan modellerde %1 anlamlılık düzeyinde anlamlıdır. Firmanın büyüme fırsatlarını temsil eden satışlarda değişim oranı SBUY, finansal performansı %1

(Model 3'te %5) anlamlılık düzeyinde pozitif etkilemektedir. SBUY ile TQ arasındaki iliřki ise anlamsızdır. Firmanın varlık yapısı, Model 9 hariç diğerk modellerde firmanın hem finansal hem de piyasa performansını negatif yönde ve anlamlı bir řekilde etkilemektedir.

Tablo 6'da bağımlı değıřkenleri sermaye yapısı olan iki ařamalı sistem GMM sonuçları yer almaktadır. Model 1-3'te bağımlı değıřken, toplam borç oranı; Model 4-6'da kısa vadeli borç oranı ve Model 7-9'da uzun vadeli borç oranı (UKAL)'dır. Model 1-3 sonuçlarına göre finansal performans (ROA ve FTA) katsayıları negatif iken sırasıyla %10 ve %1 anlamlılık düzeylerinde anlamlıdır. Piyasa performansı ile toplam kaldıraç arasındaki iliřki ise anlamsızdır. Model 4-6 sonuçlarına göre ROA ve FTA, kısa vadeli borç oranını %5-%1 anlamlılık düzeyinde negatif yönde etkilerken TQ katsayısı anlamsızdır. Model 7-9 sonuçlarına göre ROA, uzun vadeli borç oranı üzerinde negatif bir etkiye sahip iken FTA ve TQ değıřkenlerinin etkileri anlamsızdır. Bu sonuçlar, firmanın finansal performansının, sermaye yapısı üzerinde genellikle negatif bir etkiye sahip olduđunu gösterirken piyasa performansının sermaye yapısı üzerinde etkisinin ise anlamsız olduđunu göstermektedir. Bu bulgular, firma performansının sermaye yapısı üzerinde negatif bir etkisi olduđunu ileri süren Titman ve Wessels (1988), Rajan ve Zingales (1995), Booth vd. (2001), Tong ve Green (2005), Huang ve Song (2006), Frank ve Goyal (2009), Chakraborty (2010), Vo (2017) çalışmalarını desteklemektedir. Kontrol değıřkenlerine iliřkin sonuçlar ise firma büyüklüğünün (BUY), tüm modellerde pozitif ve %1-%5 düzeylerinde anlamlı; firma büyümesinin (SBUY) ise tüm modellerde anlamsız olduđunu göstermektedir. Firmanın varlık yapısı hem TKAL hem de KKAL üzerindeki etkisi negatif ve %1 anlamlılık düzeyinde anlamlıdır. Ancak varlık yapısının UKAL üzerindeki etkisi pozitif ve %1-%5 düzeylerinde anlamlıdır.

Tablo 5. GMM Sonuçları (Bağımlı Değişken = Firma Performansı)

Değişkenler	Bağımlı Değişken: ROA			Bağımlı Değişken: FTA			Bağımlı Değişken: TQ		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
L.#	0.252*** (0.034)	0.278*** (0.048)	0.338*** (0.068)	0.358*** (0.074)	0.367*** (0.078)	0.425*** (0.072)	0.574*** (0.109)	0.576*** (0.106)	0.578*** (0.111)
TKAL	-0.197*** (0.021)			-0.104*** (0.021)			-0.660 (0.562)		
KKAL		-0.202*** (0.024)			-0.121*** (0.027)			-0.739 (0.452)	
UKAL			-0.146*** (0.027)			-0.043** (0.020)			-0.796 (1.204)
BUY	0.010*** (0.002)	0.008*** (0.003)	0.006** (0.003)	0.007*** (0.002)	0.005*** (0.002)	0.004* (0.002)	-0.111*** (0.039)	-0.119*** (0.038)	-0.118*** (0.044)
SBUY	0.042*** (0.015)	0.039*** (0.012)	0.040** (0.016)	0.037*** (0.005)	0.038*** (0.005)	0.039*** (0.005)	0.116 (0.109)	0.114 (0.110)	0.116 (0.107)
VY	-0.129*** (0.028)	-0.163*** (0.032)	-0.057* (0.034)	-0.106*** (0.020)	-0.124*** (0.025)	-0.070*** (0.017)	-0.748*** (0.249)	-0.869*** (0.316)	-0.484 (0.339)
Sabit	-0.194** (0.095)	-0.125 (0.111)	-0.217** (0.101)	-0.129*** (0.046)	-0.103** (0.046)	-0.146*** (0.044)	3.545*** (0.903)	3.504*** (1.012)	3.081*** (0.833)
F istatistiği	35.44***	32.92***	24.96***	83.06***	70.86***	96.65***	257.38***	268.90***	285.21***
AR(2)	0.119	0.152	0.169	0.283	0.221	0.444	0.105	0.104	0.105
Hansen	0.312	0.274	0.391	0.414	0.276	0.351	0.105	0.115	0.103
Yıl kuklası					Var				
Firma sayısı					109				
Gözlem sayısı					1417				
Araç değişken					107				
Yıl					2010-2023				

Not: ***, ** ve * sırasıyla %1, 5% ve %10 anlamlılık düzeylerinde anlamlı katsayıları; parantez içindeki değerler, dirençli (robust) standart hataları göstermektedir. AR(2) ve Hansen istatistiği için olasılık değerleri rapor edilmiştir. L.#, ilgili modelde kullanılan bağımlı değişkenin 1 gecikmeli değerini göstermektedir. ROA, aktif karlılığı; FTA, faaliyet karlılığı; TQ, Tobin Q oranını; TKAL, KKAL ve UKAL sırasıyla toplam, kısa ve uzun borçlanma oranlarını; BUY, firma büyüklüğünü; SBUY, satışlardaki büyümeyi (büyüme fırsatlarını); VY, firmanın varlık yapısını temsil etmektedir.

Tablo 6. GMM Sonuçları (Bağımlı Değişken = Sermaye Yapısı)

Değişkenler	Bağımlı Değişken: TKAL			Bağımlı Değişken: KKAL			Bağımlı Değişken: UKAL		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
L.#	0.843*** (0.041)	0.870*** (0.024)	0.903*** (0.015)	0.644*** (0.043)	0.667*** (0.044)	0.684*** (0.046)	0.700*** (0.044)	0.711*** (0.043)	0.718*** (0.041)
ROA	-0.306* (0.172)			-0.305** (0.126)			-0.085* (0.050)		
FTA		-0.448*** (0.072)			-0.415*** (0.048)			-0.049 (0.044)	
TQ			-0.001 (0.002)			-0.001 (0.001)			-0.000 (0.001)
BUY	0.009*** (0.003)	0.009*** (0.002)	0.005*** (0.001)	0.008*** (0.003)	0.009*** (0.003)	0.006** (0.003)	0.006*** (0.002)	0.005** (0.002)	0.005** (0.002)
SBUY	0.013 (0.009)	0.014 (0.009)	0.002 (0.010)	0.006 (0.007)	0.007 (0.006)	-0.001 (0.007)	0.005 (0.006)	0.004 (0.006)	0.002 (0.006)
VY	-0.117*** (0.024)	-0.135*** (0.018)	-0.073*** (0.014)	-0.201*** (0.025)	-0.211*** (0.030)	-0.164*** (0.028)	0.041** (0.018)	0.044** (0.019)	0.048*** (0.018)
Sabit	-0.166*** (0.048)	-0.165*** (0.046)	-0.105** (0.044)	-0.006 (0.064)	-0.015 (0.062)	0.014 (0.071)	-0.144*** (0.049)	-0.129*** (0.047)	-0.113** (0.045)
F istatistiği	5364.52***	5225.89***	6046.10***	751.25***	896.83***	791.19***	419.70***	472.97***	524.75***
AR(2)	0.158	0.278	0.376	0.127	0.241	0.242	0.388	0.347	0.345
Hansen	0.285	0.283	0.245	0.433	0.376	0.448	0.118	0.136	0.155
Yıl kuklası					Var				
Firma sayısı					109				
Gözlem sayısı					1417				
Araç değişken					107				
Yıl					2010-2023				

Not: ***, ** ve * sırasıyla %1, 5% ve %10 anlamlılık düzeylerinde anlamlı katsayıları; parantez içindeki değerler, dirençli (robust) standart hataları göstermektedir. AR(2) ve Hansen istatistiği için olasılık değerleri rapor edilmiştir. L.#, ilgili modelde kullanılan bağımlı değişkenin 1 gecikmeli değerini göstermektedir. ROA, aktif karlılığını; FTA, faaliyet karlılığını; TQ, Tobin Q oranını; TKAL, KKAL ve UKAL sırasıyla toplam, kısa ve uzun borçlanma oranlarını; BUY, firma büyüklüğünü; SBUY, satışlardaki büyümeyi (büyüme fırsatlarını); VY, firmanın varlık yapısını temsil etmektedir.

Tablo 7. DCCE Sonuçları (Bağımlı Değişken = Firma Performansı)

Değişkenler	Bağımlı Değişken: ROA			Bağımlı Değişken: FTA			Bağımlı Değişken: TQ		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
L.#	0.043 (0.042)	0.100** (0.042)	0.181*** (0.038)	0.202*** (0.038)	0.201*** (0.039)	0.250*** (0.037)	0.213*** (0.051)	0.250*** (0.051)	0.281*** (0.044)
TKAL	-0.158*** (0.055)			-0.071*** (0.024)			1.033 (1.932)		
KKAL		-0.152*** (0.046)			-0.094*** (0.028)			1.131 (1.569)	
UKAL			-0.276** (0.115)			-0.004 (0.048)			0.553 (5.425)
BUY	-0.005** (0.002)	-0.003** (0.001)	-0.007*** (0.001)	-0.004*** (0.001)	-0.003*** (0.001)	-0.004*** (0.001)	0.177*** (0.045)	0.155*** (0.035)	0.160*** (0.023)
SBUY	0.010*** (0.003)	0.011*** (0.003)	0.010*** (0.004)	0.007* (0.004)	0.006 (0.004)	0.007* (0.004)	-0.242*** (0.092)	-0.275*** (0.089)	-0.213* (0.114)
VY	-0.154*** (0.042)	-0.179*** (0.040)	-0.065 (0.040)	-0.191*** (0.032)	-0.205*** (0.034)	-0.148*** (0.033)	-0.593 (0.835)	-0.381 (0.839)	-2.202** (0.956)
Sabit	0.308 (0.223)	0.250 (0.204)	0.240 (0.182)	0.255*** (0.072)	0.252*** (0.064)	0.202*** (0.066)	-1.940 (2.795)	-1.490 (2.842)	-1.266 (3.059)
F istatistiği	5.978***	4.358***	3.531***	6.929***	6.824***	6.803***	2.681***	2.391***	2.627***
Firma sayısı	109								
Gözlem sayısı	1417								
Yıl	2010-2023								

Not: ***, ** ve * sırasıyla %1, 5% ve %10 anlamlılık düzeylerinde anlamlı katsayıları; parantez içindeki değerler, standart hataları göstermektedir. L.#, ilgili modelde kullanılan bağımlı değişkenin 1 gecikmeli değerini göstermektedir. ROA, aktif karlılığı; FTA, faaliyet karlılığı; TQ, Tobin Q oranını; TKAL, KKAL ve UKAL sırasıyla toplam, kısa ve uzun borçlanma oranlarını; BUY, firma büyüklüğünü; SBUY, satışlardaki büyümeyi (büyüme fırsatlarını); VY, firmanın varlık yapısını temsil etmektedir.

Tablo 8. DCCE Sonuçları (Bağımlı Değişken = Sermaye Yapısı)

Değişkenler	Bağımlı Değişken: TKAL			Bağımlı Değişken: KKAL			Bağımlı Değişken: UKAL		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
L.#	0.580*** (0.033)	0.633*** (0.036)	0.590*** (0.033)	0.329*** (0.036)	0.337*** (0.038)	0.321*** (0.038)	0.388*** (0.034)	0.420*** (0.038)	0.383*** (0.037)
ROA	-0.614*** (0.058)			-0.441*** (0.064)			-0.222*** (0.065)		
FTA		-0.449*** (0.081)			-0.399*** (0.076)			-0.018 (0.060)	
TQ			-0.000 (0.010)			0.014 (0.009)			0.010 (0.009)
BUY	-0.012*** (0.001)	-0.016*** (0.002)	-0.014*** (0.002)	0.002 (0.001)	-0.000 (0.002)	0.002 (0.002)	-0.008*** (0.001)	-0.010*** (0.001)	-0.013*** (0.001)
SBUY	-0.007** (0.003)	-0.012*** (0.004)	-0.014*** (0.004)	0.004 (0.003)	-0.000 (0.004)	-0.000 (0.004)	-0.005* (0.003)	-0.007** (0.003)	-0.009*** (0.003)
VY	-0.288*** (0.049)	-0.319*** (0.051)	-0.244*** (0.052)	-0.403*** (0.056)	-0.399*** (0.058)	-0.317*** (0.056)	0.108*** (0.037)	0.108*** (0.039)	0.093** (0.042)
Sabit	0.613*** (0.111)	0.695*** (0.113)	0.604*** (0.121)	0.410*** (0.129)	0.467*** (0.125)	0.335** (0.141)	0.224*** (0.071)	0.244*** (0.083)	0.297*** (0.073)
F istatistiği	27.173***	21.546***	20.688***	13.976***	12.681***	12.222***	8.232***	7.630***	8.140***
Firma sayısı	109								
Gözlem sayısı	1417								
Yıl	2010-2023								

Not: ***, ** ve * sırasıyla %1, 5% ve %10 anlamlılık düzeylerinde anlamlı katsayıları; parantez içindeki değerler, standart hataları göstermektedir. L.#, ilgili modelde kullanılan bağımlı değişkenin 1 gecikmeli değerini göstermektedir. ROA, aktif karlılığını; FTA, faaliyet karlılığını; TQ, Tobin Q oranını; TKAL, KKAL ve UKAL sırasıyla toplam, kısa ve uzun borçlanma oranlarını; BUY, firma büyüklüğünü; SBUY, satışlardaki büyümeyi (büyüme fırsatlarını); VY, firmanın varlık yapısını temsil etmektedir.

Genellikle panel verilerinin tahmininde sabit etkiler, rassal etkiler ve GMM yöntemleri kullanılmaktadır. Bu çalışmada da ilk olarak iki aşamalı sistem GMM tahminci tercih edilmiş ve sonuçları Tablo 5 ve 6’da raporlanmıştır. Ancak bu sonuçlar, yatay kesit bağımlılığını dikkate almamaktadır. Tablo 4’de Pesaran (2004) CD testine göre bu çalışmada kullanılan tüm değişkenlerde birimler arası korelasyon sorunu bulunmamaktadır. Birimler arası korelasyonu dikkate almayan tahminciler sapmalı sonuç ortaya çıkarabilmektedir. Dolayısıyla GMM sonuçları desteklemek ve güvenilirliği artırmak amacıyla t boyutunun kısa olduğu dinamik modellerde yatay kesit bağımlılığını dikkate alan Chudik ve Pesaran (2015) tarafından önerilen DCCE yaklaşımı kullanılmıştır. Bu yaklaşım, diğer geleneksel yöntemler tarafından ele alınmayan sorunları dikkate almaktadır. Bu yaklaşımın en önemli özelliğinden biri kesitlerin ortalamasını alarak kesit bağımlılığını dikkate alması, heterojen eğimlere ve dinamik ortak korelasyonu ilişkilere izin vermesidir (Ali vd., 2020). DCCE sonuçları Tablo 7 ve 8’de gösterilmektedir. Tablo 7, bağımlı değişkenlerin firma performansı olduğu dokuz farklı modelin sonuçlarını göstermektedir. İlk üç modelde bağımlı değişken, aktif karlılığı; sonraki üç modelde faaliyet karlılığı; son üç modelde ise Tobin Q oranıdır. DCCE yaklaşımından elde edilen sermaye yapısı değişkenlerinin katsayıları Tablo 5’te yer alan katsayılar ile benzerlik göstermektedir. Sermaye yapısı katsayıları, Model 1-5 arasında negatif ve anlamlı iken diğer modellerde anlamsızdır.

Tablo 8, bağımlı değişkenlerin sermaye yapısı olduğu DDCE yaklaşımının sonuçlarını göstermektedir. Bağımlı değişken; Model 1-3’te toplam borçlanma, Model 4-6’da kısa borçlanma ve Model 7-9’da uzun vadeli borçlanma oranlarıdır. Firma performansının sermaye yapısı üzerindeki etkisine dönük sonuçlar, Tablo 6’da yer alan GMM tahminleri ile benzerlik göstermektedir. Model 1, 2, 4, 5 ve 6’da firma performans katsayıları negatif ve anlamlı iken diğer modellerde anlamsızdır. Tobin Q’nun kullanıldığı modellerde çoğunluk anlamsız katsayılar elde edilmiştir. Bunun çeşitli nedenleri olabilir. Özellikle q oranının firma performansı veya firma değeri için iyi bir gösterge olmayacağı tartışılmaktadır. Dybvig ve Warachka (2012), Tobin q yüksekliğinin yüksek firma performansı ile ilişkili olmadığını dolayısıyla da bu oranın firma performansı için iyi bir gösterge olmadığını ifade etmiştir. Ayrıca Q oranı, firma değeri üzerinde etkili olabilecek çeşitli faktörleri dikkate almamaktadır. Firmanın gelecekteki nakit akışlarını sadece maddi varlıklara yaptığı yatırımlardan sağlayacakmış gibi ele almaktadır. Oysa maddi olmayan varlıklar (fikri mülkiyet, itibar, marka tanınırlığı gibi) da firma performansı için önemli olmaktadır. Bununla birlikte Q oranı gelecekte beklenen gelişmeleri yansıtmakta ve yatırımcı psikolojisinden etkilenmektedir (Demsetz ve Lehn, 1985; Demsetz ve Villalonga, 2001).

Şimdiye kadar yapılan tahminlerde imalat sektöründe yer alan bütün firmalar bir bütün olarak incelenmiştir. Ancak Türkiye’de imalat sektörü 8 farklı alt sektörden oluşmaktadır. Bunlar; (1) Ana Metal Sanayi, (2) Gıda, İçecek ve Tütün, (3) Kâğıt ve Kâğıt Ürünleri Basım (4) Kimya İlaç Petrol Lastik ve Plastik Ürünler, (5) Metal Eşya Makine Elektrikli Cihazlar ve Ulaşım Araçları, (6) Orman Ürünleri ve Mobilya, (7) Taş ve Toprağa Dayalı ve (8) Tekstil, Giyim Eşyası ve Deri alt sektörleridir. Bu alt sektörlerde yer alan her firmanın, finansman kaynağına ulaşım ve elde etme koşulları farklılık gösterebilmektedir. Dolayısıyla finansman kaynakları ve sermaye yapıları farklı olabilir. Bu da sermaye yapısı ve firma performansı arasındaki ilişkiyi etkileyebilmektedir.

Ayrıca çeşitli nedenlerden dolayı 2018 yılının ağustos ayında başlayan kur krizi ile birlikte Türkiye’de finansal alanda dalgalanmalar yaşanmıştır. 2018 yılında Türk lirasının dolar

karşı aşırı değer kaybetmesi, yüksek enflasyona ve yüksek faize neden olurken ekonominin büyümesini de yavaşlatmıştır. Yüksek enflasyonla birlikte talebin azalması ve üretimdeki daralmalar, firmaları olumsuz etkilemiştir. Faiz oranlarının artması, bazı işletmelerinin borç ödemede zorlanmasına ve yurtiçi birikimlerinin yurtdışına aktarılmasına neden olmuştur. (Sezal, 2020; Öksüz ve Aydın, 2022). Bu etkiler, firmaların borçlanma maliyetini dolayısıyla da sermaye yapısı kararlarını ve performanslarını etkileyebilmektedir.

Tablo 9’da hem sektör hem de 2018-2019 etkilerini dikkate alan DCCE tahminleri yer almaktadır. Tabloda bağımlı değişken aktif karlılığı iken bağımsız değişken toplam borçlanma oranıdır. Elde edilen tahminler, daha önce yapılan analizler (Tablo 5 ve 6’daki sonuçlar) ile benzerlik göstermektedir. Buna göre toplam borçlanma katsayıları 3 alt sektör hariç (Kâğıt ve Kâğıt Ürünleri Basım, Taş ve Toprağa Dayalı ve Tekstil, Giyim Eşyası ve Deri) diğer sektörlerde negatif ve anlamlıdır. Diğer bir deyişle sermaye yapısındaki artış firma performansını olumsuz etkilemektedir. Örneklemdaki firmaların sermaye yapılarındaki borç oranının yüksek olması ve faiz oranlarının yüksekliği bu sonuçları anlamlı kılmaktadır. Kriz kuklası ise sadece iki sektörde (Orman Ürünleri ve Mobilya; Taş ve Toprağa Dayalı) anlamlı çıkmıştır.

Tablo 9. İmalat Alt Sektörler için DCCE Sonuçları (Bağımlı değişken=Aktif karlılığı)

Değişkenler	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
L.ROA	0.023 (0.118)	0.004 (0.085)	-0.235* (0.135)	-0.113 (0.136)	-0.042 (0.093)	0.045 (0.139)	0.106 (0.135)	-0.066 (0.180)
TKAL	-0.204*** (0.059)	-0.247*** (0.075)	-0.075 (0.281)	-0.182* (0.092)	-0.211* (0.111)	-0.195* (0.092)	-0.116 (0.102)	0.013 (0.339)
BUY	-0.012*** (0.002)	-0.009* (0.005)	-0.021*** (0.005)	-0.007* (0.004)	0.010*** (0.003)	0.009*** (0.003)	0.011*** (0.004)	-0.025* (0.013)
SBUY	0.018* (0.009)	0.013 (0.009)	0.037*** (0.007)	0.015* (0.008)	0.005 (0.006)	-0.005 (0.026)	0.003 (0.004)	0.007 (0.013)
VY	-0.260*** (0.076)	0.007 (0.127)	-0.654*** (0.121)	-0.283*** (0.094)	-0.287*** (0.095)	-0.122*** (0.019)	-0.171 (0.111)	0.021 (0.179)
Kriz Kuklası	0.018 (0.011)	-0.002 (0.011)	0.027 (0.016)	-0.007 (0.010)	0.017 (0.016)	-0.043** (0.019)	-0.024* (0.013)	0.022 (0.022)
Sabit	0.498** (0.202)	0.335 (0.336)	0.884* (0.477)	0.432** (0.189)	0.108 (0.183)	0.031 (0.347)	-0.022 (0.213)	0.535 (1.644)
F istatistiği	3.707***	3.634***	6.169***	4.323***	10.780***	3.301***	4.935***	4.199***
Firma sayısı	16	18	6	16	22	2	15	14
Gözlem	208	234	78	208	286	26	195	182
Yıl	2010-2023							

Not: ***, ** ve * sırasıyla %1, 5% ve %10 anlamlılık düzeylerinde anlamlı katsayıları; parantez içindeki değerler, standart hataları göstermektedir. ROA, aktif karlılığı; L.ROA, ROA’nın 1 gecikmeli değerini; FTA, faaliyet karlılığı; TQ, Tobin Q oranını; TKAL, KKAL ve UKAL sırasıyla toplam, kısa ve uzun borçlanma oranlarını; BUY, firma büyüklüğünü; SBUY, satışlardaki büyümeyi (büyüme fırsatlarını); VY, firmanın varlık yapısını temsil etmektedir. Kriz kuklası, 2018-2019 krizini göstermekte olup 2018 ve 2019 yılları için 1, diğer yıllar için 0 değerini almaktadır. (1)= Ana Metal Sanayi, (2)= Gıda, İçecek ve Tütün, (3)= Kâğıt ve Kâğıt Ürünleri Basım, (4)= Kimya İlaç Petrol Lastik ve Plastik Ürünler, (5)= Metal Eşya Makine Elektrikli Cihazlar ve Ulaşım Araçları, (6)= Orman Ürünleri ve Mobilya, (7)= Taş ve Toprağa Dayalı, (8)= Tekstil, Giyim Eşyası ve Deri alt sektörleri göstermektedir.

4.4. Nedensellik Sonuçları

Sermaye yapısı ile firma performansı arasında bir nedensellik olup olmadığını belirlemek için Dumitrescu ve Hurlin (2012) ve Emirmahmutoglu ve Köse (2011) panel nedensellik testleri uygulanmıştır. İki test de heterojen panel verilerde kullanılmaktadır. Ayrıca Dumitrescu ve

Hurlin (2012), çalışmalarında Monte Carlo simülasyonlarının, birimler arası korelasyonun varlığında bile bu testin güçlü sonuçlar üretebileceğini ifade etmişlerdir. İki testin temel hipotezi, panelde yer alan değişkenler arasında nedensellik ilişkisi olmadığı; alternatif hipotez ise en az bir birimde nedensellik ilişkisi olduğu şeklinde kurulmaktadır. Bu testlerin sonuçları, Tablo 10’da gösterilmektedir. Tabloda finansal performans göstergelerinden (ROA, FTA, TQ) kaldıraç oranlarına (TKAL, KKAL, UKAL) doğru ve kaldıraç oranlarından finansal performans göstergelerine doğru ayrı ayrı hipotezler sınanmıştır.

Tablo 10. Panel Nedensellik Test Sonuçları

	Dumitrescu ve Hurlin (2012)		Emirmahmutoglu ve Köse (2011)	
	Z-bar	Olasılık	Panel Fisher Test	Asimptotik Olasılık
Panel A: ROA ile TKAL, KKAL ve UKAL arasında nedensellik ilişkisi				
ROA=>TKAL	11.853**	0.033	350.811***	0.000
TKAL=>ROA	12.204*	0.061	314.621***	0.000
ROA=>KKAL	10.124***	0.002	398.789***	0.000
KKAL=>ROA	2.576	0.593	267.479**	0.012
ROA=>UKAL	5.429	0.130	253.137*	0.051
UKAL=>ROA	8.415	0.191	341.091**	0.000
Panel B: FTA ile TKAL, KKAL ve UKAL arasında nedensellik ilişkisi				
FTA=>TKAL	10.869***	0.007	313.307***	0.000
TKAL=>FTA	5.629	0.225	339.164***	0.000
FTA=>KKAL	9.611***	0.007	325.398***	0.000
KKAL=>FTA	6.877*	0.082	325.946***	0.000
FTA=>UKAL	7.267	0.230	357.530***	0.000
UKAL=>FTA	6.974	0.280	287.254***	0.001
Panel C: TQ ile TKAL, KKAL ve UKAL arasında nedensellik ilişkisi				
TQ=>TKAL	21.063**	0.010	403.710***	0.000
TKAL=>TQ	18.480**	0.038	376.294***	0.000
TQ=>KKAL	12.516**	0.025	390.743***	0.000
KKAL=>TQ	8.794*	0.084	376.232***	0.000
TQ=>UKAL	11.928	0.118	251.547*	0.059
UKAL=>TQ	16.614***	0.008	467.403***	0.000

Not: ***, ** ve * sırasıyla %1, 5% ve %10 anlamlılık düzeylerini göstermektedir. Dumitrescu ve Hurlin (2012) panel nedensellik testinde olasılık değerleri, 1000 bootstrap dağılımından elde edilmiştir. Optimal gecikme uzunlukları Akaike bilgi kriterine göre belirlenmiştir. ROA, aktif karlılığı; FTA, faaliyet karlılığı; TQ, Tobin Q oranını; TKAL, KKAL ve UKAL sırasıyla toplam, kısa ve uzun borçlanma oranlarını; BUY, firma büyüklüğünü; SBUY, satışlardaki büyümeyi (büyüme fırsatlarını); VY, firmanın varlık yapısını temsil etmektedir.

Tablo 10’da Panel A kısmında firmanın finansal performans göstergelerinden olan aktif karlılığı ile firma sermaye yapısı oranları arasındaki nedensellik ilişkileri gösterilmektedir. Dumitrescu ve Hurlin (2012) testi sonuçlarına göre aktif karlılığı ile toplam borç oranı arasında çift yönlü bir nedensellik ilişkisi vardır. Aktif karlılığından toplam borç oranına doğru nedensellik ilişkisi %5 düzeyinde anlamlı iken toplam borçtan aktif karlılığına doğru olan nedensellik ilişkisi ise %10 anlamlılık düzeyinde anlamlıdır. Aktif karlılığı ile kısa vadeli borç oranı arasında tek yönlü bir nedensellik ilişkisi vardır. Bu ilişki, %1 düzeyinden anlamlı olup aktif karlılığından kısa vadeli borç oranına doğrudur. Aktif karlılığı ile uzun vadeli borç arasında ise bir nedensellik ilişkisi yoktur. Emirmahmutoglu ve Köse (2011) testi sonuçlarına göre aktif karlılığı ile toplam borç, kısa vadeli borç ve uzun vadeli borç oranları arasında çift yönlü bir nedensellik ilişkisi vardır.

Panel B kısmında firmanın finansal performans göstergelerinden olan faaliyet karlılıđı ile firma sermaye yapısı oranları arasındaki nedensellik ilişkileri gösterilmektedir. . Dumitrescu ve Hurlin (2012) testi sonuçlarına göre faaliyet karlılıđı ile toplam borç oranı arasında tek yönlü bir ilişki vardır. Bu ilişki, faaliyet karlılıđından toplam borca doğrudur. Faaliyet karlılıđı ile kısa vadeli borç oranı arasında çift yönlü bir nedensellik ilişkisi varken faaliyet karlılıđı ile uzun vadeli borç oranı arasında nedensellik ilişkisi anlamlı değildir. Emirmahmutoglu ve Köse (2011) testi sonuçlarına göre faaliyet karlılıđı ile toplam borç, kısa vadeli borç ve uzun vadeli borç oranları arasında çift yönlü bir nedensellik ilişkisi vardır.

Son olarak Panel C, firmanın piyasa performans göstergelerinden Tobin Q oranı ile sermaye yapısı oranları arasındaki nedensellik ilişkilerini göstermektedir. Dumitrescu ve Hurlin (2012) testi sonuçlarına göre piyasa performansı ile toplam ve kısa vadeli borç oranları arasında çift yönlü bir nedensellik ilişkisi varken uzun vadeli borç arasında tek yönlü bir nedensellik vardır. Bu ilişki, uzun vadeli borç oranından piyasa performansına doğrudur. Emirmahmutoglu ve Köse (2011) testi, Panel A ve B’de yer alan sonuçlarla benzerlik göstermektedir. Tablo 10’da yer alan tüm sonuçlar dikkate alındığında iki panel nedensellik testleri arasında farklılıklar görülmektedir. Tablo 4’de yer alan CD testine göre bu çalışmada kullanılan bağımlı ve açıklayıcı değişkenlerde birimler arası korelasyonun varlığı saptanmıştı. Bu sorunun üstesinden gelmek için Dumitrescu ve Hurlin (2012) testinde olasılıklar ve kritik değerler, bootsrapt dağılımından elde edilmiştir. Emirmahmutoglu ve Köse (2011) testinde ise bootsrapt metodu uygulanmamıştır. Dolayısıyla Dumitrescu ve Hurlin (2012) testi sonuçları dikkate alınmıştır.

5. Sonuç

Bu çalışma, sermaye yapısı ile firma performansı arasındaki ilişkiyi ve bunlar arasındaki nedenselliđi arařtırmaktadır. Sermaye yapısını ölçmek için kaldıraç oranları kullanılmıştır. Bu değişkenler toplam, kısa ve uzun vadeli borçların, toplam varlıklara bölünmesi ile elde edilmiştir. Firma performansını temsilen üç değişken kullanılmıştır. Birincisi, aktif karlılıđıdır. Bu değişken toplam karın toplam varlıklara bölünmesi ile elde edilmiştir. İkincisi, faaliyet karlılıđıdır. Bu değişken, faaliyet karının toplam varlıklara bölünmesiyle elde edilmiştir. Son değişken ise piyasa değeri ile toplam borçların toplam varlıklara bölünmesiyle elde edilen Tobin Q oranıdır. Ayrıca firma büyüklüğü, firmanın büyüme fırsatları ve firmanın varlık yapısı kontrol değişkenler olarak kullanılmıştır. Sermaye yapısı ile firma performansı arasındaki ilişkiyi incelemek için genelleştirilmiş iki aşamalı sistem GMM ve DCCE tahminci kullanılmıştır. Ayrıca Dumitrescu-Hurlin (2012) ve Emirmahmutoglu-Köse (2011) panel nedensellik testleri, iki değişken arasındaki nedensellik ilişkisini incelemek için kullanılmıştır. Ancak Dumitrescu-Hurlin testinde olasılıklar ve kritik değerler, bootsrapt dağılımından elde edildiđi için bu testin sonuçları dikkate alınmıştır.

Analizlerden elde edilen sonuçlar, sermaye yapısı oranlarının finansal performans göstergeleri üzerinde negatif ve anlamlı bir etkiye sahip olduğunu göstermektedir. Ancak piyasa performansı üzerindeki etkileri ise anlamsızdır. Kontrol değişkenlere ilişkin sonuçlar, firma büyüklüğünün, firmanın varlık yapısının ve firma büyümesinin hem firma performansı hem de sermaye yapısının belirlenmesinden önemli değişkenler olduğunu göstermektedir. Ayrıca panel nedensellik testlerinden Dumitrescu ve Hurlin (2012) testine göre sermaye yapısı ile finansal (aktif karlılıđı) ve piyasa (Tobin Q) performansı arasında çift taraflı bir nedensellik ilişkisi bulunmaktadır.

Sermaye yapısının firma performansı üzerinde olumsuz etkisinin çeşitli nedenleri olabilir. Çalışma örnekleminde yer alan firmaların toplam borç oranı yaklaşık %51 iken kısa ve uzun vadeli borçların oranı ise sırasıyla %37 ve %21’dir. Sermaye yapısına ilişkin bu veriler, 2010-2023 yılları arasında Borsa İstanbul’da faaliyet gösteren imalat firmalarının finansman ihtiyaçlarının yaklaşık yarısını borçla karşıladıklarını göstermektedir. Ayrıca bu oranlar, Türkiye’de imalat firmalarının uzun vadeli borçlanmada sıkıntı çektiklerini dolayısıyla faaliyetlerini finanse etmek için kısa vadeli borçlanmaya yöneldiklerini göstermektedir. Kısa vadeli borçlanma, Türkiye’de faiz oranlarının 2010’dan buna yana artış halinde olması durumu dikkate alındığında firma performansı üzerinde olumsuz bir etki yaratabilmektedir. Faiz oranlarındaki artışlar, Türk firmalarının maliyetlerini artırabilmekte dolayısıyla da performans üzerinde olumsuzluklara neden olabilmektedir.

Sonuç olarak bu bulgular, borç finansmanının firma performansı üzerinde olumsuz bir etkiye sahip olduğunu, sermaye yapısının finansal performansı şekillendiren önemli bir faktör olduğunu göstermektedir. Firma yöneticileri, borcun vergi avantajından faydalanmak isteyebilirler ancak bulgular, firma performansına odaklanan firma yöneticilerinin performanslarını artırmaları için sermaye yapısı içinde borç oranının daha ılımlı hale getirmeleri gerektiğini göstermektedir. Türkiye’de faiz oranlarının yüksek olması diğer bir deyişle borçlanma maliyetinin yüksek olması, yöneticilerin faaliyetlerin finansmanında öncelikle iç kaynaklara yönelmeleri gerektiğini ortaya koymaktadır. Ayrıca çalışma bulguları, gelecekteki finansman stratejilerinin nasıl olması gerektiği konusunda da firma yöneticilerine fikir vermektedir. Firma yöneticileri gibi potansiyel yatırımcılar ve borç verenler de çalışmanın sonuçlarından faydalanabilirler. Potansiyel yatırımcılar, çalışmanın bulgularını firmaların risk profilini değerlendirmek için kullanabilir, portföylerini buna göre şekillendirebilirler. Potansiyel yatırımcılar ayrıca çalışmada kullanılan kontrol değişkenlerin özellikle firma yapısı ve büyüklüğünün performans üzerinde etkili olabileceğini göz önünde bulundurmalıdırlar. Diğer yandan borç sağlayanlar, firmaların finansal sağlamlıklarını ve kredibilitelerini değerlendirmek amacıyla bu çalışmanın sonuçlarından faydalanabilirler.

Bu çalışmanın önemli iki kısıtı bulunmaktadır: (1) Çalışma, sadece imalat sektöründeki firmalara odaklanmaktadır. Çalışmanın sonuçları genelleştirilirken bu kısıt dikkate alınmalıdır. Çalışmanın sonuçları, imalat sektöründe yer alan firmalar için değerli çıkarımlar sağlarken her sektörün farklı dinamiklere sahip olabileceği ve sermaye yapısı kararlarının farklı olabileceği unutulmamalıdır. (2) 2010-2023 yılları arasında çalışmada kullanılan finansal verilerin eksikliğinden dolayı imalat sektöründen yer alan tüm firmalar analize dahil edilememiştir. Bu kısıtlar, gelecekte yapılacak çalışmalara için bir öneri olabilir. Veri setinin yıl ve sektör olarak genişletilmesi, sonuçların genelleştirilebilir sorununa çözüm olabilir. Çoğu çalışmada olduğu gibi bu çalışmada da sermaye yapısı ile firma performansı arasında doğrusal bir ilişki varsayılmıştır. Gelecekteki çalışmalar, doğrusal olmayan (ters U gibi) bir ilişkinin olabileceğini de dikkate alabilir. Ayrıca bu çalışmada firma piyasa performans göstergesi olarak Tobin Q oranı kullanılmıştır. GMM ve DCCE yaklaşımları, Tobin Q ile sermaye yapısı göstergeleri arasında genellikle anlamsız bir ilişki olduğunu ortaya koymaktadır. Sermaye yapısı ile piyasa performansı arasındaki ilişkinin daha net ortaya konması için gelecekteki çalışmalar, firma piyasa performansını ölçmek farklı göstergeler kullanabilir. Son olarak ekonomik ve kurumsal yönetim faktörleri, ülkede faaliyet gösteren firmaların önemli kararlarında (finansman gibi) etkili olabilmektedir. Makroekonomik faktörlerin ve kurumsal özelliklerin, sermaye yapısını

nasıl etkilediđi ve bunların performans üzerindeki etkileri arařtırılabilir. Bu önerilerle birlikte Türkiye’de sermaye yapısı ile performansı arasındaki ilişkiye daha net olarak ortaya konulabilir.

Arařtırma ve Yayın Etiđi Beyanı

Etik kurul izni ve/veya yasal/özel izin alınmasına gerek olmayan bu çalışmada arařtırma ve yayın etiđine uyulmuřtur.

Arařtırmacıların Katkı Oranı Beyanı

Yazar, makalenin tamamına yalnız kendisinin katkı sağlamıř olduđunu beyan eder.

Arařtırmacıların Çıkar Çatıřması Beyanı

Bu çalışmada herhangi bir potansiyel çıkar çatıřması bulunmamaktadır.

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EXAMINING PANEL CAUSALITY BETWEEN CAPITAL STRUCTURE AND FIRM PERFORMANCE

EXTENDED SUMMARY

Objective of Study

This study examines the relationship between capital structure and the performance of 109 companies operating in Borsa Istanbul's manufacturing sector over the period 2010-2023. The study measured company performance using both accounting (return on assets and operating profitability) and market-based (Tobin Q) variables. To measure capital structure, total, short-term, and long-term debt ratios were used. In addition, some variables that may affect the relationship between capital structure and company performance were used as control variables.

Literature Review

Many theories examine the relationship between capital structure and firm performance, including Modigliani and Miller's irrelevance theory (1958), Kraus and Litzenberger's trade-off theory (1973), and Myers and Majluf's pecking order theory (1984). There have been debates about the general validity and superiority of these theories for years. However, the results of studies on the theories show no universal theory. For example, the results of some studies show that capital structure has a negative effect on firm performance (Zeitun and Tian, 2007; Le and Phan, 2017; Nguyen and Nguyen, 2020; Boshnak, 2023; Ronoowah and Seetanah, 2023). Other studies show that capital structure has a positive effect on firm performance (Abor, 2005; Margaritis and Psillaki, 2007; Gill, Biger, and Mathur, 2011; Detthamrong, Chancharat, and Vithessonthi, 2017).

Methodology

This study first runs the two-stage system generalized method of moments (GMM) and dynamic common correlated effects (DCCE) estimator to examine the relationship between capital structure and firm performance. We then use Dumitrescu and Hurlin (2012) and Emirmahmutoglu and Köse (2011) panel causality tests to identify the causality relationship between the two variables.

Findings

The results suggest that there is a negative and significant relationship between capital structure and financial performance and an insignificant relationship between capital structure and market performance, using two-stage GMM and DCCE. In addition, the causality results show that there is a bidirectional causality relationship between return on assets and total debt, and between Tobin's Q and total debt.

Conclusion

The results of this study show that capital structure has a negative effect on firm performance in Turkey. There may be several reasons for this result. The total debt ratio of the firms in the study sample is approximately 51%, while the ratio of short-term and long-term debts is 37% and 21%, respectively. These data on capital structure show that manufacturing companies operating on Borsa Istanbul met nearly half of their financing needs with debt between 2010 and 2023. In addition, these rates indicate that manufacturing firms in Turkey have difficulty obtaining long-term debt and therefore tend to rely on short-term debt to finance their activities. Short-term borrowing can have a negative impact on firm performance, given that interest rates in Turkey have been rising since 2010. Rising interest rates can increase costs for Turkish companies, which can negatively affect performance.

This information indicates that managers focusing on firm performance should have a more moderate leverage ratio in their capital structure to improve their performance. The high interest rates in Turkey, i.e., the high cost of borrowing, indicate that managers should primarily rely on internal resources to finance their activities. In addition, the results of the study provide managers with ideas on how to structure their financing strategies in the future.

KATILIM BANKALARININ KREDİ KALİTESİNİ ETKİLEYEN BANKAYA ÖZGÜ VE MAKRO EKONOMİK FAKTÖRLER: PANDEMİ DÖNEMİNİ İÇEREN TÜRKİYE ÖRNEĞİ

Bank-Specific and Macroeconomic Factors Affecting the Credit Quality of
Participation Banks: The Case of Türkiye During the Pandemic Period

Ahmet ÇAKMAK^{*}, Onur SUNAL^{**} & Ünal EFE^{***}

Öz

Finansal sektörün en önemli yapı taşlarından birisi olan bankalarının mali yapılarının güçlü olması ülke ekonomileri için son derece önemlidir. Mevcut bankacılık sistemi içerisinde farklı finansman modelleri ile bankacılık sisteminin tamamlayıcısı konumunda olan katılım bankaları, bu farklı finansman modelleri ile kullanırmış oldukları fonları gününde tahsil etmeyi önceliklemektedir. Ancak kullanılan fonlar her zaman geri ödenmemekte ve takibe düşmektedir. Bu durumda da bankalar kredi riski ile karşı karşıya kalabilmektedir. Bankaların maruz kaldığı önemli riskler arasında kredi riski yer almakta olup, kullanılan kredilerin kalitesi banka içi ve banka dışı çeşitli faktörlerden etkilenebilmektedir. Bu çalışmada Türk Bankacılık Sisteminde yer alan katılım bankalarının 2011 yılı 1. çeyrek ve 2023 yılı 4. çeyrek arası çeyrek dönemlik verileri ve yine çeyrek dönemlik makro ekonomik veriler kullanılarak, Covid-19 dönemini de kapsayacak şekilde katılım bankalarının kredi kalitesini etkileyen bankaya özgü ve makro ekonomik faktörler panel veri analiziyle belirlenmeye çalışılmıştır. Covid-19 dönemini de kapsayacak şekilde yapılan Panel ARDL analizi sonucunda bankaya özgü oranlardan, LKD ve ROA ile kredi kalitesini simgeleyen NPL arasında negatif yönlü bir ilişki tespit edilmiştir. Makro ekonomik değişkenlerden GSMH ile NPL arasında negatif, faiz ve Covid-19 dönemi arasında ise pozitif yönlü bir ilişki tespit edilmiş olup, bulgular literatürde yer alan çalışmalarla uyum göstermektedir.

Abstract

The strong financial structures of banks, one of the most important cornerstones of the financial sector, are extremely important for national economies. Participation banks, which are complementary to the banking system with different financing models within the existing banking system, prioritize collecting the funds they have made available through these different financing models on time. However, the funds disbursed are not always repaid and are subject to follow-up. In this case, banks may face credit risk. Credit risk is one of the most important risks that banks are exposed to, and the quality of the loans extended can be affected by various internal and external factors. In this study, by using quarterly data of participation banks in the Turkish Banking System between the 1st quarter of 2011 and the 4th quarter of 2023 and quarterly macroeconomic data, bank-specific and macroeconomic factors affecting the credit quality of participation banks, including the Covid-19 period, were tried to be determined by panel data analysis. As a result of the Panel ARDL analysis, including the Covid-19 period, a negative relationship was found between LKD and ROA, which are bank-specific ratios, and NPL, which symbolizes credit quality. Among the macroeconomic variables, there is a negative relationship between GNP and NPL and a positive relationship between interest rate and the Covid-19 period, and the findings are consistent with the studies in the literature.

Anahtar

Kelimeler:

Bankacılık,
Kredi Riski,
İslami Finans,
Katılım
Bankacılığı,
Panel Veri,
Covid-19

JEL Kodları:

G21, G32,
G33

Keywords:

Banking,
Credit Risk,
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Participation
Banking,
Panel Data,
Covid-19

JEL Codes:

G21, G32,
G33

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1. Giriş

Bankacılık sistemi, küresel ekonomik sistemde olduğu gibi, Türkiye ekonomisinde de farklı görev ve fonksiyonlarıyla büyük öneme sahiptir. Güçlü ve etkin bankacılık sektörünün, ülke ekonomilerinin istikrar başta olmak üzere birçok risk ve performans kriteri açısından olumlu etkileri bulunduğu kabul edilmektedir. Son yıllarda küresel ölçekte finansal sistemde önemli değişimler gözlenmekte olup, son yarım asırlık sürede Dünya’da ve Türkiye’de faizsiz bankacılık sektörü de bu değişimden önemli pay almıştır. Oluşturulan katılım finans ekosistemi kapsamında kalkınma planlarına dâhil edilmeleri ve bu kapsamda özel sermayeli kurumlara ilaveten kamu sermayeli katılım bankalarının da dahil olmasıyla, sektörün büyüme ve gelişmesinde katkı sağlanırken, Türk Finansal Sistemi ve bankacılık sektörü içerisindeki payı artış göstermiştir.

Birçok ekonomide olduğu gibi ülkemiz ekonomisinde de büyüme ve kalkınmanın finansmanı, önemli bir fon transfer mekanizması niteliğindeki bankalar tarafından fon kullanılmasıyla sağlanmaktadır. Bankalar, ekonomik sistemdeki farklı ölçekteki tüketim gruplarına, gereksinim halinde kredi kanallarıyla destek sunmaktadır. Bu nedenle etkin işleyen bir kredi mekanizmasının varlığı, büyüme, istikrar ve diğer açılardan ülke ekonomisi için büyük öneme sahiptir. Ekonomideki liberalleşme sürecinin etkisiyle 1980’li yıllardan itibaren banka kredileri ekonomik büyümenin finansmanında tercih edilmeye başlamış, 2000’li yıllardan itibaren kullanılan kredi miktarındaki artışla kredi piyasası daha derin ve etkin hale gelmiş, banka kredileri parasal aktarım mekanizmasının önemli bir parçası haline gelmiştir. BDDK Haziran 2024 raporuna göre yaklaşık 28.1 Milyar TL aktif büyüklüğe ulaşan bankacılık sektöründe, banka türlerine göre farklılık göstermekle birlikte yıllar itibariyle kredi/mevduat rasyosu %120’ler seviyesine kadar yükselmiştir.

Büyük hacim ve yüksek kaldıraç düzeylerinde faaliyetlerini sürdüren bankalar gerek küresel gerek yerel ekonomide yaşanan türbülanslardan etkilenmekte, farklı risklerin etkisi altında faaliyetlerini sürdürmektedir. Bankaların maruz kaldığı kredi riski maruz kalınan önemli riskler arasında yer almakla birlikte, kullanılan kredilerin kalitesi banka içi ve banka dışı çeşitli faktörlerden etkilenebilmektedir. Temeli itibariyle borç verme-ödünç alma niteliğinde olan kredi işlemine bağlı maruz kalınan risklerin yönetimi hayati derecede önem arz etmektedir. Literatürde Türk Bankacılık sistemini örneklem olarak, kredi kalitesi, aktif kalitesi bankaların performans ölçümleri, makro ekonomik ve diğer performans kalemleriyle olan ilişkilerini belirlemeye dönük amaçlarla kredileri ele alınan akademik çalışmalar mevcuttur. Bu çalışmada Türk Bankacılık Sisteminde yer alan katılım bankalarının 2011 yılı 1. çeyrek ve 2023 yılı 4. çeyrek dönemlik verileri ve yine çeyrek dönemlik makro ekonomik veriler kullanılarak, Covid-19 dönemini de kapsayacak şekilde katılım bankalarının kredi kalitesini etkileyen bankaya özgü ve makro ekonomik faktörler panel veri analiziyle belirlenmeye çalışılmıştır.

Literatürde yer alan çalışmaların büyük kısmı kredi kalitesini etkileyen bankaya özgü faktörler belirlenmeye dönük ve benzer şekilde ticari nitelikteki bankaları örneklemeye dahil etmiş olup, bu çalışmada farklı bir çalışma modeline sahip katılım bankaları örneklemine bankaya özgü faktörlerin yanı sıra makro ekonomik faktörlerin belirlenmesi amaçlanmıştır.

2. Literatür

2.1. Bankacılık ve Katılım Bankacılığı Kavramı

Bankalar, ülkelerin finansal sistemlerinin en önemli yapıtaşları arasında olan ve bir güven unsuru olan kurumlardır. Finansal sistemin önemli güven unsuru olan bankaların faaliyetlerini ve karlılıklarını sorunsuz sürdürebilmeleri ülke ekonomileri için son derece önemli ve gereklidir. Bankaların temel faaliyetleri mevduat toplamak ve bu mevduatları kredi olarak vermektedir. Bankaların verdikleri kredileri zamanında ve sorunsuz tahsil edebilmeleri sadece banka karlılığı açısından değil aynı zamanda ülkedeki tüm finansal sistemin istikrarı açısından da önemlidir. Sorunsuz ve günlüde tahsil edilen krediler bankaların aktif kalitesini de olumlu olarak etkilemektedir (Telçeken ve Kadioğlu, 2022). Karşılıklı güvene dayalı bir ticari faaliyet olan bankacılık sektöründe banka, mevduat toplayarak güvenilen tarafta, kredi vererek de güvenen taraftadır. Kendisine emanet edilen parayı korumak ve bunu en verimli şekilde değerlendirmekle mükellef olan banka, mevduat sahibinin güvenini sarsıcı bir faaliyette bulunamaz. Mevduat sahibi açısından bakıldığında bankanın kendisine güvenilen bir konumda olduğu görülmektedir. Diğer tarafta ise banka, elinde emanet olarak tuttuğu mevduatı ödünç olarak kişilere ve kurumlara vererek bu mevduatın belirli vadelerde geri ödemesini beklemektedir. Bu durumda da bankanın kredi verdiği kişi veya kuruma karşı güveni söz konusudur. Banka ile kredi müşterisi arasındaki güven ilişkisinin zarar görmesi ihtimali bulunmakta ve bu gibi durumlarda kredi riski ortaya çıkmaktadır. Banka bilançolarının aktifinde önemli bir ağırlığa sahip olan kredilerin geri ödemelerinde gecikmeler söz konusu olduğunda kredilerin takibe intikal etmesi gibi sorunlu bir durumun meydana gelebilmektedir. Bankacılıkta aktif kalitesi, kredi kalitesi gibi önemli veriler temel olarak takipteki krediler verisi üzerinden takip edilmektedirler (Özel, 2022).

Yapılan literatür çalışmalarında özel finans kurumu, yatırım bankacılığı, İslami bankacılık, faizsiz bankacılık gibi isimlerle ifade edilen katılım bankacılığı, günümüzde finansal sektör içerisinde klasik bankaların yaptıkları birçok bankacılık faaliyetlerini yapmaktadırlar. Ayrıca sigortacılık, takas, finansal kiralama ve benzeri finansman yöntemleri gibi diğer ticari faaliyetlerde bulunan katılım bankaları, faizle ilgili olmayan hemen hemen tüm bankacılık hizmetlerini farklı usullerle yapabilmektedir. Bu yönleriyle katılım bankaları, geleneksel bankalara önemli bir alternatif olurken diğer taraftan geleneksel bankaların yaptıkları ve faize dayanan kimi işlemleri yapamadıkları için de bir bakıma onları tamamlayan ve finans sektörüne derinlik ve çeşitlilik kazandıran kuruluşlar olarak ön plana çıkmaktadır (Özulucan ve Deran, 2009). Katılım bankacılığı sisteminde müşterilere temel olarak üç tür kredi sözleşmesi sunulmaktadır. Bunlar; özkaynağa dayalı, ticarete dayalı ve desteğe dayalı kredi sözleşmeleridir (Misman vd., 2013). Khan ve Ahmed (2001), özkaynağa dayalı mudaraba ve müşaraka sözleşmelerinin daha yüksek kredi riskine sahip olduklarını belirtmektedirler. Buna karşın Ahmed ve Khan (2007) tarafından 18 banka çalışanı üzerinde yapılan çalışmada müşaraka sözleşmesinin en yüksek riske sahip sözleşme olduğu, mudaraba sözleşmesinin ise en düşük kredi riskine sahip sözleşme olduğu belirtilmiştir. Misman vd. (2013), yapmış oldukları çalışmada, özkaynağa dayalı kredi sözleşmelerinin, ticarete dayalı kredi sözleşmelerine göre daha riskli olduklarını tespit etmişlerdir. İslami bankacılık sistemi ve geleneksel bankacılık sisteminin kredi risklerini karşılaştıran çalışmalarda Masood vd. (2012) ile Kabir vd. (2014) genel olarak İslami bankaların, geleneksel bankalardan daha düşük kredi riskine maruz kaldıklarını tespit etmişlerdir.

Katılım bankacılığı sistemi, faizi yasaklayan işlemlere aracılık etmesinin yanında, haramdan uzak durma, risk paylaşımı, garar, kumar yasağı ve varlığa dayalı finansman şeklinde prensiplere de sahip bir finansman anlayışıdır (Yalpar, 2014). Dini sebeplerden ötürü ekonomiye kazandırılmayan ve yastık altı olarak adlandırılan ekonomik sistemin dışındaki âtil kaynakların ekonomiye kazandırılması, katılım bankalarının ekonomiye katkısının başında gelmektedir. Katılım bankacılığı sisteminde toplanan fonların tamamı reel sektöre İslami kredi olarak aktarılmaktadır. Katılım bankaları sadece faturalandırılmış mal ve hizmetlerin finansmanına aracılık ettiklerinden dolayı vergi kayıp ve kaçığını önlemekte, devletin vergi gelirlerinin artmasını katkı sağlamaktadır (Güler, 2016).

Katılım bankacılığının Türkiye’deki son 11 yılındaki aktif gelişimi Şekil 1’de gösterilmiştir.



Şekil 1. Türkiye’de Katılım Bankalarının 2024 Aralık İtibariyle Aktif Gelişimi

Kaynak: TKBB (2024).

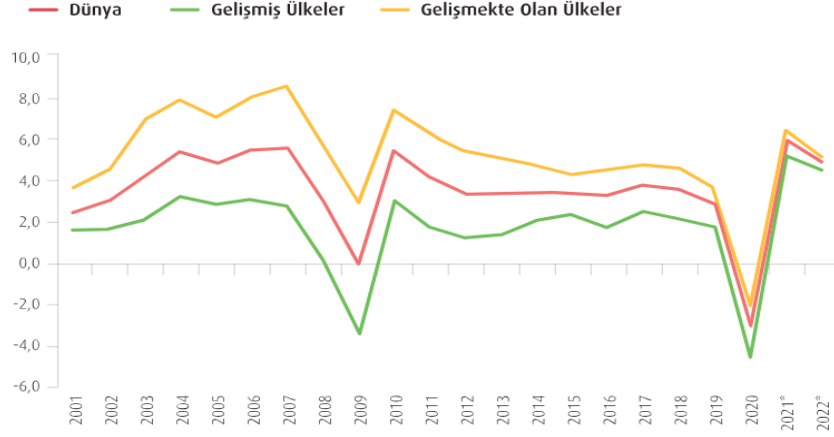
Şekil 1’de de görüleceği üzere Türkiye’de katılım bankacılığı %8,14 pazar payına sahip konumdadır. 2016 yılından 2023 yılına kadar sürekli artan hızda bir gelişim gösteren katılım bankacılığı, 2023 yılından 2024 yılı Aralık ayına gelindiği %8,67 pazar büyüklüğünden %8,14 pazar büyüklüğüne gerilemiştir.

Toplumu oluşturan en önemli unsurlar hane halkı, şirketler, kamu kurum ve kuruluşları ve toplumdaki tüm tüketim gruplarıdır. Toplumsal yapının bu önemli unsurları ihtiyaç duyduklarında finansal kurumlara müracaat ederek kredi kullanıp finansman ihtiyaçları karşılarlar. Ülkeden ülkeye farklılık arz etmekle birlikte en büyük destek bankalar tarafından sağlanmaktadır. Bankalar bu süreci gerçekleştirirken bankaya özgü ve banka dışı, doğrudan ve dolaylı olarak çeşitli risklere maruz kalmaktadır. Bu risklerden bankalar için oldukça önemli olan bir tanesi de kredi riskidir. Literatürde, bankaların kredi risklerin belirlenmesi, ölçülmesi, yönetilmesi, kredi kalitesinin ölçülmesi, etkileyen unsurların tespiti, farklı ülke ve bankacılık modelleri için tespitleri içeren birçok çalışma yer almaktadır. Çalışmaların büyük kısmı ticari bankacılık örneklemini üzerinde gerçekleştirilmiş, katılım bankaları için yapılan çalışmalar daha sınırlı alanda kalmıştır. (Angbazo, 1997; Berger ve De Young, 1997; Cebenoyan ve Strahan, 2004; Ahmad ve Ariff, 2007).

Literatür incelendiğinde ağırlıklı olarak bankaya özgü belirleyicilerin tespit edilmesine dönük çalışmalar olmak üzere her iki belirleyici grubu için de çalışma yapıldığı ve sonuçlara ulaşıldığı görülmektedir. Konuyla ilgili Covid-19 dönemini içeren, Türk Bankacılık Sektörü ve katılım bankacılığı sektörü özelinde yapılan çalışmalar oldukça sınırlı kalmış olmakla birlikte, farklı çalışma kural ve prensiplerine sahip katılım bankacılığı özelindeki bu çalışmayla ulusal ölçekte yapılan sınırlı miktardaki çalışmalara bir çeşitlilik kazandırılması ve profesyonellerin çalışmalarına katkı sağlanması amaçlanmaktadır.

2.2. Covid-19 ve Ekonomik Etkileri

2020 yılı Mart ayı itibariyle Dünya Sağlık Örgütü (DSÖ) tarafından “pandemi” olarak tanımlanan Covid-19, ilk olarak 2019 yılı Kasım ayında Çin’in Wuhan kentinde görülmüştür. Ortaya çıktığı günden itibaren dünyaya çok hızlı yayılan virüs, çıktığı günden itibaren artan hızda tüm dünya ekonomisini de olumsuz olarak etkilemeye başlamıştır. Covid-19 salgınının ekonomik etkilerinin olumsuz sonuçları görülmeye başlandıkça OECD, virüsten kaynaklanan etkilerin 2008 küresel mali krizinden daha büyük olacağını açıklamıştır. Başlangıçta bir sağlık krizi olarak beliren virüs, insan sağlığına verdiği zararın yanında ekonomik düzene, toplumsal düzene ve sağlık sistemine kadar çok geniş alanda etkisini göstermiştir. Covid-19 salgını her geçen gün endişe verici bir hızla yayıldı ve milyonlarca kişiyi etkisi altına aldı. Ülkeler, virüsün yayılmasını durdurmak için sıkı önlemler almaya başladılar ve bu durum da ekonomik faaliyetleri neredeyse durma noktasına getirdi. İnsan kayıpları arttıkça, ekonomik hasar da daha net bir şekilde ortaya çıkmaya başladı. Kayıplarla birlikte dünyanın on yıllardır yaşadığı en büyük ekonomik şok da belirginleşmeye başladı. Covid-19’un neden olduğu ekonomik durgunluk, 1990’dan bu yana tüm dünyada yaşanmış olan durgunluklar içinde en hızlı en sert düşüşlerin görüldüğü bir ekonomik kriz olarak ortaya çıkmış oldu (Koç vd., 2021). Ekonomik aktivitelerde hem arz tarafındaki hem de talep tarafındaki dengeleri bozan Covid-19, iş gücündeki azalmalar, kısıtlamalar nedeniyle kapanmalar, sosyal mesafe kısıtlamaları gibi etkenler nedeniyle ekonomideki üretim sürecini ve dolayısıyla arz dengesini olumsuz etkilemiştir. Covid-19’un talep tarafındaki olumsuz etkileri ise, karantina uygulamaları, hastalıklar, işten çıkarmalar ve kötüleşen ekonomik aktiviteler nedeniyle firmaların yatırımlarını kısmak zorunda kalmaları ve bunun sonucunda hane halkı tüketimlerinin azalması şeklinde kendini göstermiştir (Chudik vd., 2020). Covid-19 pandemisinin tüm dünya ekonomisine olan etkisi Şekil 2’de görülmektedir. Şekil 2’ye bakıldığında Covid-19 salgının başladığı 2019 yılından itibaren tüm dünya ekonomilerinde negatif büyümelerin olduğu görülmektedir. Pandeminin zirve yaptığı 2020 yılında tüm dünya ekonomilerinin %5’e yakın küçüldükleri anlaşılmaktadır.



Şekil 2. Covid-19 Salgının Tüm Dünyadaki Ekonomik Büyümeye Olan Etkisi (%)
Kaynak: Vakıfbank (2022).

3. Ekonometrik Analiz ve Bulgular

Çalışmamızın yapıldığı dönemde Türkiye’de faaliyet gösteren 5 katılım bankasının (Kuveyt Türk Katılım Bankası, Albaraka Türk Katılım Bankası, Türkiye Finans Katılım Bankası, Ziraat Katılım Bankası, Emlak Katılım Bankası ve Vakıf Katılım Bankası) bulunmaktaydı. Ancak verileri analiz ettiğimiz 2011 yılı 1. çeyrek ve 2023 yılı 4. çeyrek dönemlerinin tamamında Türkiye’de faaliyet gösteren 3 katılım bankasının (Kuveyt Türk Katılım Bankası, Albaraka Türk Katılım Bankası, Türkiye Finans Katılım Bankası) verileri analiz edilmiştir. Bu 3 katılım bankası için 2011 yılı 1. çeyrek ve 2023 yılı 4. çeyrek periyodunu kapsayan çeyreklik dönemlerde takipteki kredi oranını (NPL-Non Performing Loans) etkilediği düşünülen bankalara özgü rasyolar ve makro ekonomik değişkenler kullanılmıştır.

3.1. Analiz Edilen Modeller

Ekonomide üstlendikleri rollerden bir tanesi de finansal aracılık olan bankalar ekonomik birimlerin tasarrufları başta olmak üzere çeşitli kaynakları kaynağa dönüştürerek, ekonomik birimlerin ihtiyaçları doğrultusunda kredi olarak kullanırmakta ve bu işlemler neticesinde gelir elde etmektedir. Kullanılan kredilerin geri ödemelerinde problem yaşanması, kullanılan kredilerin takip aşamasına düşmesi, bankalar için oldukça hayati olmakla birlikte, bankaların kredi portföylerinin kalitesi büyük önem arz etmektedir. Yapılan çalışmalarda kredi portföyünün kalitesini etkileyen faktörler belirlenmeye çalışılmıştır. Banka tarafından kontrol edilmesi mümkün olan, bankaya özgü değişkenlerin yanı sıra, banka tarafından doğrudan kontrol edilemeyen makro ekonomik faktörler de kredi portföyünün kalitesini etkiler niteliktedir.

3.1.1. Bankaya Özgü Faktörler

Bankaya özgü birçok faktör banka kredilerini etkilemekle birlikte yapılan çalışmalarda yüksek korelasyona sahip olduğu görülen bankaya özgü temel faktörler ve etki yönü aşağıda belirtilmektedir. Rasyoların hesaplanmasında kullanılan formüller ve metodoloji Tablo 1’de detaylı olarak sunulmuştur.

Farklı risk unsurlarının etkisi altında, yüksek hacim ve kaldıraç oranlarıyla faaliyetlerini sürdüren bankaların kredi kalitesi doğrudan ve dolaylı olarak bankalara özgü ve bankacılık dışı faktörlerden etkilenebilmektedir. Yapılan çalışmalarda bankalara özgü unsurlardan kredi büyüklüğü, aktif rasyosu, sermaye yeterliliğı, likidite yeterliliğı, aktif ve sermaye karlılığı, kredi çeşitlendirmesi ile kredi kalitesini temsil eden takipteki krediler arasında negatif yönlü, faiz, aktif büyüklüğü, kredi mevduat oranı, (Berger ve Deyoung, 1997; Boudriga vd., 2010; Macit ve Keçeli, 2012; Al-Wesabi ve Ahmad, 2013; Makri vd., 2014; Gezu, 2014; Ghosh, 2015; Yağcılar ve Demir, 2015; Suryanto, 2015; Konstantakis vd., 2016; Rajha, 2016 Amuakwa-Mensah vd., 2017; Torun ve Altay, 2019; Zheng vd., 2019; Zhen vd., 2020; Rahmah ve Armina, 2020, Ayaydın vd., 2021; Sevinç, 2021; Bekereci vd., 2023; Erdoğan, 2024) arasında pozitif yönlü ilişki bulunduğu ortaya konulmuştur.

Sermaye Yeterliliğı: Bankalar için sermayenin önemi büyüktür. Yüksek ve kaliteli sermayeye sahip bankaların olası bir finansal bir risk halinde daha rahat hareket edebildiğı görülmektedir. Risk miktarı arttıkça bankaların sermaye ilave etmeleri gerekecektir. Sermaye Yeterlilik Rasyosu özet olarak bankanın öz kaynaklarının risk ağırlıklı varlıkların toplamına oranı olarak hesaplanmaktadır. İki taraflı geçişken bir ilişkiye sahip olmakla birlikte, sermaye yeterliliğı yüksek olan bankaların kredi portföyünün görece daha kaliteli olması ve takipteki kredi oranlarının düşük olması beklenir. Birçok çalışmada sermaye yeterliliğı ile takipteki krediler arasında negatif ilişki bulunduğu sonucuna ulaşılmıştır (Salas ve Saurina, 2002; Makri vd., 2014; Amuakwa-Mensah vd., 2017; Torun ve Altay, 2019; Zheng vd., 2019; Zhen vd., 2020; Rahmah ve Armina, 2020, Ayaydın vd., 2021; Sevinç, 2021; Bekereci vd., 2023; Erdoğan, 2024).

Özkaynak Karlılığı: Özkaynak karlılığı bir işletmenin sermayesini ne derece etkin kullandığının bir göstergesi olarak da kabul edilmekte olup önemli performans göstergelerinden bir tanesidir. İşletmenin dönem sonu net kar ya da zararın toplam varlık değerine bölünmesi ile hesaplanan özkaynak karlılığı sermayedarlar için de önemli performans göstergelerinden biridir. Birçok çalışmada (Klein, 2013; Makri vd., 2014; Ha ve Hang, 2016) özkaynak karlılığı ile takipteki krediler arasında negatif ilişki bulunduğu sonucuna ulaşılmıştır.

Aktif Karlılığı: Aktif karlılığı rasyosu dönem net karının banka aktif toplamına oranını temsil etmekle birlikte, bankaların varlıklarını görece daha etkin kullandıklarını göstermektedir. Aktiflerini daha etkin kullanan bankanın gelir seviyesi daha yüksek olabilecek, takipteki kredilerin olumsuz etkisi sınırlı seviyede kalacaktır. Gelirlerini artırmak isten bir banka aktiflerini yüksek gelirli alanlara sevk ederken makul bir risk seviyesini de gözeteyeğinden, görece riskli kredileri kullandırmaktan uzak duracaktır. Bu gerekçeyle takipteki kredi oranlarıyla aktif karlılığı oranı arasında negatif yönlü bir ilişki olması beklenmektedir (Rahmah ve Armina, 2020; Zhen vd., 2020; Ayaydın vd., 2021; Sevinç, 2021; Bekereci vd., 2023; Erdoğan, 2024).

Toplam Kredi / Toplam Aktif: Bankaların temel fonksiyonlarından bir tanesi kredi kullandırmaktır. Toplanan mevduatların krediye dönüşmesi banka için gelir imkânı anlamına gelmektedir. Bankanın aktif toplamı içerisinde kredi miktarının artması, bankanın kullandığı kredi miktarının artması, mevcut takipteki kredi miktarının görece azalmasını sağlayacaktır. Bu nedenle toplam kredi / toplam aktif rasyosu ile takipteki krediler arasında negatif yönlü bir ilişki olması beklenmektedir (Macit ve Keçeli, 2012).

Kredi/Mevduat Oranı: Mevduatların kredilere dönüşümünü ifade eden kredi mevduat rasyosu bankalar için temel performans ve etkinlik göstergelerinden biridir. Bankalardan beklenen, likidite ve diğer riskleri dikkate alarak mevduatların krediye dönüşümünü sağlamasıdır. Likidite kontrolüne sağlamak durumunda olan bankalar görece temkinli hareket edecek olup daha düşük miktarda kredi sağlayacaklardır. Bu nedenle takipteki kredi miktarının görece düşük seyretmesi beklenmektedir. Her iki rasyo arasında negatif bir ilişkinin varlığı beklenmektedir (Macit ve Keçeli, 2012, Dimitrios vd., 2016; Kabataş ve Karamustafa, 2019; Rahmah ve Armina, 2020).

Net Faiz Marjı: Literatürde yapılan çalışmalarda net faiz marjı ile takipteki krediler arasında farklı yönde ilişkilerin bulunduğu sonucuna ulaşan çalışmalar mevcuttur. Bazı çalışmalarda bankaların daha yüksek net faiz marjı hedefi, kredi borçlusunun daha yüksek baskı altında kalmasına neden olabileceğinden kredi geri ödenmesini zorlaştıracak, dolayısıyla bankaların takipteki kredi miktarının artışına neden olacaktır. Dolayısıyla net faiz marjı ile takipteki krediler arasında pozitif yönlü bir ilişki mevcuttur (Salas ve Saurina, 2002; Radivojevic ve Jovovic, 2017). Diğer çalışmalarda ise net faiz marjının yüksek olmasıyla, bankaların olası bir risk durumu karşısında finansal açıdan daha dayanıklı olacakları belirtilmiştir. Bu nedenle rasyolar arasında negatif yönlü bir ilişki mevcuttur (Fofack, 2005; Amuakwa-Mensah ve Boakye-Adjei, 2015).

Likidite: Uluslararası mutabakat bankası likiditeyi varlık fiyatlarındaki artışlar başta olmak üzere vadesi gelen yükümlülükleri karşılayabilme kapasitesi olarak tanımlamaktadır. (BIS, 2008) Bankacılık sektörü yapısı gereği piyasa likiditesi, fonlama likiditesi gibi farklı likidite eksikliklerine bağlı etkilere maruz kalmaktadır. Gerek bankaya özgü değişimler gerekse banka dışı faktörlere bağlı değişimler likidite yeterliliğini etkilemektedir. Bankalar açısından yönetilmesi hayati öneme sahip likidite, finansal sistemin istikrarı için de önem arz etmektedir. Farklı çalışmalarda likidite yeterlilik rasyosunun farklı formları dikkate alınarak hesaplamalar yapılmış olmakla birlikte, çalışmada Likit Aktifler / Kısa Vadeli Yükümlülükler¹ rasyosu dikkate alınarak hesaplama yapılmıştır.

Takipteki Krediler: Temel görevi fon açığı olanlarla fon fazlası olanları bir araya getirmek olan bankalar, toplanan fonların karşılığında kaydi para oluşturmakta ve sonrasında bunu kredi olarak vermektedir. Zaman zaman farklı amaçlarla kullanılan kredilerin tahsilinde gecikmeler yaşanmakta, hatta geri ödenmesi dahi mümkün olamayabilmektedir. Mevzuat gereği bu kredilerin yönetimi adına, banka farklı bir metodoloji ile bu kredileri izlemekte, ilave kaynak ayırmakta, tahsili için idari ve hukuki işlemleri sürdürmektedir. Temel olarak bu tip kredilerin raporlama ve hesaplamalarında Takipteki Krediler/ Toplam Krediler rasyosu kullanılmaktadır. Toplanan ve kullanılan fonlar arasındaki vade ve miktar uyumsuzluğu, idari ve yasal takip işlemlerinin doğuracağı ilave harcamalar, yabancı para cinsinden kullanılan krediler ve emtia fiyatlarındaki yükseliş bankalar için ilave kaynak ihtiyacını doğurabilecektir. Takipteki kredi miktarının artması bankanın özkaynak kalitesi başta olmak üzere karlılık, özkaynak ve likidite yeterliliği gibi temel fonksiyonlarını doğrudan etkilemektedir. Çalışma kapsamında kredi kalitesinin bir göstergesi olarak rasyo bağımlı değişken olarak tercih edilmiştir.

¹ Likit Varlıklar için; Nakit ve Nakit Benzerleri (Nakit Değerler ve Merkez Bankası + Bankalar + Para Piyasalarından Alacaklar) Beklenen Zarar Karşılıkları (-), Kısa Vadeli Yükümlülükler için; Bankalarca Kamuya Açıklanacak Finansal Tablolar ile Bunlara İlişkin Açıklama ve Dipnotlar Hakkında Tebliğ" kapsamındaki Dipnotların "Mali Bünye" ile ilgili bölümündeki Likidite Riski tablosundan "Vadesiz" ve "1Aya Kadar" bilgileri kullanılmıştır.

3.1.2. Makro Ekonomik Faktörler

Bankaya özgü faktörlerin yanı sıra banka kredilerini etkileyen, yapılan çalışmalarda yüksek korelasyona sahip olduđu görülen makro ekonomik faktörler ve etki yönü ařağıda belirtilmektedir:

Gayri Safı Yurtiçi Hasıla: Yapılan çalışmalarda ekonomik büyümenin takipteki krediler üzerinde önemli etkilerinin olduđu görülmektedir. Ekonomik büyümedeki artışın, takipteki kredi oranını düşürdüđu, buna karşılık olarak ekonomik yavaşlamanın da kredi kalitesini olumsuz etkilediđi yapılan çalışmalarda ortaya konmaktadır (Salas ve Saurina, 2002; Saurina ve Jimenez, 2006; Khemraj ve Pasha, 2009; Dash ve Kabra, 2010; Ćurak vd., 2013; Messai ve Jouin, 2013; Makri vd., 2014; Beck vd., 2015; Ha ve Hang, 2016; Karadima ve Louri, 2020; Zheng vd., 2019; Jakubik ve Kadioglu, 2021). Ekonomik büyüme oranı ile takipteki kredilerin oranı arasında ters korelasyon bulunmaktadır. Ekonomik büyüme ile beraber kişilerin ve şirketlerin gelirleri artmakta böylece kişilerin ve şirketlerin borçlarını ödeyebilme kapasiteleri de artmaktadır. Bu durumda takipteki kredilerin oranının düşmesine yol açmaktadır (Telçeken ve Kadiođlu, 2022).

İřsizlik: Ekonomide işsizlik miktarının artması kredi borçlularının bankalara olan borçlarını ödeyememesine neden olmakta, takipteki kredi miktarını artırmaktadır. Yapılan çalışmalar işsizliđin takipteki krediler ile negatif bir ilişkiye sahip olduđu sonucunu göstermektedir (Quagliariello, 2003; Škarica, 2014; Lee ve Rosenkranz, 2020; Makri vd., 2014).

Enflasyon: Yapılan çalışmalarda enflasyonun takipteki kredi oranları üzerindeki etkisi hususunda farklı sonuçlar elde edilmiştir. Bazı çalışmaların sonucunda (Baboucek ve Jancar, 2005; Nkusu, 2011; Klein, 2013; Messai ve Jouini, 2013; Ha ve Hang, 2016; Us, 2016, 2017; Radivojevic ve Jovovic, 2017) enflasyonist dönemlerde geleceđe ait belirsizliđin etkisiyle alınan aksiyonlara bađlı olarak geliri azalan kredi borçlularının yükümlölüklerini yerine getirememesi nedeniyle takipteki kredilerde bir artışın olması beklenmektedir. Enflasyon ile takipteki krediler arasında pozitif yönlü ilişki olduđunu savunan bu çalışmaların yanında enflasyon ile takipteki krediler arasında negatif yönlü bir ilişki olduđunu savunan az da olsa bazı çalışmalar bulunmaktadır (Shu, 2002; Amuakwa-Mensah ve Boakye-Adjei, 2015).

Döviz Kuru: Literatürde döviz kurundaki artışların kredi kullananların genel finansal durumlarının bozulmasına neden olmakla birlikte farklı para birimlerinde kullanılan kredilerin miktarsal olarak artmasına neden olabileceđinden takipteki kredi oranlarının yükselmesine neden olabileceđi sonucuna ulaşan çalışmalar mevcuttur (Fofack, 2005; Beck vd., 2015; Tanasković ve Jandrić, 2015).

3.2. Veri Seti

Çalışmamıza konu olan verilere ilişkin tanımlayıcı bilgiler, teori ve önceki çalışmaların bulguları dahilinde derlenen beklenen etkiler sütunu ve betimleyici istatistikler ařağıda yer alan Tablo 1 ve Tablo 2’de özetlenmiştir.

Tablo 1. Betimleyici Bilgiler

Değişken	Tanım	Ölçüm Birimi	Beklenen İşaret	Kaynak
NPL	Takipteki Krediler/Toplam Krediler (Brüt)	Rasyo		TKBB
LKD	Likit Aktifler /Kısa Vadeli Yükümlülükler	Rasyo	(-)	TKBB
ROA	Net Kar / Toplam Aktif	Rasyo	(+)	TKBB
ROE	Net Kar / Toplam Aktif	Rasyo	(-)	TKBB
SYR	Sermaye Yeterliliği Standart Oranı	Yüzde	(-)	TKBB
KM	Toplam Krediler / Toplam Mevduat	Rasyo	(+)	TKBB
FAIZ	Ağırlıklandırılmış Ticari Kredi Faiz Oranı	Yüzde	(+)	EVDS
GSMH	Gayri Safi Yurtiçi Hâsıla Çeyreklik Büyüme Oranı	Oran	(+)	TÜİK
ENF	Enflasyon Çeyreklik Oranı (TÜFE)	Oran	(+) (-)	TÜİK
EXC	Reel Efektif Döviz Kuru	Oran	(+) (-)	EVDS
COVID	COVID-19 Dummy		(-)	

Veri setinin yatay kesitini 3 katılım bankası ve zaman boyutunu 2011 yılı 1. çeyrek ve 2023 yılı 4. çeyrek arasında yer alan 52 tane çeyreklik dönem oluşturmaktadır. Çalışmada her ne kadar yatay kesit sayısı n küçük olsa da t zaman boyutunun büyük olması birim kök varlığı söz konusu olduğunda sahte regresyon sorununa yol açabileceğinden statik bir model (sabit - tesadüfi etkiler) tercihi yapılmasının uygun olmayacağı düşünülmüştür. Yatay kesit bağımlılığının varlığı da düşünülerek 2. nesil birim kök testleri sonucunda serilerin farklı düzeylerde durağan olması durumlarında da kullanılabilen Panel ARDL (PMG) yöntemiyle katsayıların tahmin edilecek olmasının tutarlı sonuçlar doğuracağı düşünüldüğünden bu yöntem tercih edilmiştir. Ayrıca Panel ARDL yöntemi değişkenlerin gecikmelerini de hesaba katarak hem uzun hem de kısa dönem ilişkileri ortaya koymaktadır. Ne var ki, değişken sayısının çok olması nedeniyle öncelikli olarak ileriye doğru adımlama yöntemi kullanılmak suretiyle (stepwise) çalışmaya hangi değişkenlerle devam edileceği belirlenecektir. Böylece oluşturulacak olan modelde bağımlı değişkeni (NPL) açıklamak konusunda anlamlı olarak ortaya çıkmış olan bağımsız değişken seti önceliklenmiş olacaktır. Ayrıca bağımsız değişken setinin hem zaman hem de yatay kesite göre değişen bankalara özgü rasyolar ve zaman göre değişen ancak yatay kesite göre değişmeyen (cross – invariant) makro ekonomik göstergelerden oluşması nedeniyle iki farklı grup değişken için 2 ayrı model oluşturulmasının daha anlamlı sonuçlar doğuracağı düşünülmektedir.

Tablo 2. Tanımlayıcı İstatistikler

	Ortalama	Medyan	Maximum	Minimum	Std. Dev.	Gözlem Sayısı
NPL	0.035322	0.026780	0.180000	0.012000	0.021888	156
FAIZ	0.171836	0.147923	0.512677	0.085392	0.072207	156
GSMH	0.066588	0.040649	0.272866	-0.089545	0.072626	156
COVID	0.153846	0.000000	1.000.000	0.000000	0.361963	156
LKD	0.445556	0.421140	1.329.721	0.157160	0.155858	156
ROA	0.008097	0.006650	0.040843	0.000165	0.007048	156
ROE	0.103135	0.078564	0.842193	0.003187	0.104666	156
SYR	0.161923	0.153200	0.260000	0.121100	0.032471	156
KM	0.927852	0.954392	1.322.611	0.581628	0.187126	156
EXC	8.446.519	9.117.500	1.126.600	4.761.000	2.068.394	156
ENF	4.603.000	3.109.317	1.804.997	1.837.433	3.669.528	156

Kaynak: Yazarlar tarafından oluşturulmuştur.

Buradan hareketle modeller ve kullanılacak olan değişkenlerin belirlenmesine ilişkin analizlerin ardından veri setine uygun olan panel modelin seçimi için öncelikli olarak serilerin durağanlıklarına bakılmıştır. Bilindiği üzere yazında birim kök içeren serilerin modellerde kullanılacak olması sahte regresyon sorununa neden olmaktadır. Dolayısıyla, çalışmamızda öncelikli olarak serilerin durağanlıkları test edilmiştir. Panel modellerde genel olarak yatay kesit bağımlılığı bulunması durumunda ikinci nesil birim kök testlerden aksi takdirde ise birinci nesil birim kök testlerden faydalanılmaktadır. Çalışmada yatay kesit bağımlılığının varlığını sınamak için, Breusch and Pagan LM (1980), Pesaran Scaled LM (2004) and Pesaran CD (2004) testleri yapılmıştır. Sonrasında ise ikinci nesil birim kök testi olan Bai ve Ng (2004) kullanılmıştır. Bu test her yatay kesit için ayrı ayrı yapılmış ADF test istatistiklerinin havuzlanması yoluyla ilgili değişkenin durağanlığını göstermektedir. Bütün bunların ışığında bu çalışmada, bağımlı değişkenin birinci farkı alındığında I(1) durağan olması koşuluyla diğer bağımsız değişkenlerin durağanlık düzeyinden bağımsız olarak analiz yapabilmeyi mümkün kılan Pesaran vd. (1999) tarafından geliştirilmiş Panel ARDL modelinin kullanılmasının uygun olacağı düşünülmüştür. Ayrıca panel ARDL modeli, katsayıların kısa dönemde heterojen, uzun dönemde ise homojen olduğunu varsaymaktadır. Dolayısıyla, bankaların kısa vadede farklı finansal ve operasyonel uygulamalara sahip olma eğiliminde olması nedeniyle bu varsayımın veri setimiz için uygun olduğu düşünülmüştür. Diğer taraftan Kao (1999) eş-bütünleşme testleri de yapılarak ARDL tahmin sonuçları desteklenmiştir.

$$\Delta npl_{it} = \mu_i + \gamma_{1i} npl_{i,t-1} + \gamma_{2i} lkd_{i,t-1} + \gamma_{3i} roa_{i,t-1} + \sum_{j=1}^{p-1} \delta_{1ij} \Delta npl_{i,t-j} + \sum_{j=0}^{q-1} \delta_{2ij} \Delta lkd_{i,t-j} + \sum_{j=0}^{q-1} \delta_{3ij} \Delta roa_{i,t-j} + \epsilon_{it} \quad (1)$$

Bu varsayımların altında modellerimize (I ve II) ilişkin Eşitlik 1 ve 2 Pesaran vd. (1999) tarafından önerildiği şekliyle ARDL formunda aşağıdaki gibi oluşturulmuştur.

$$\Delta npl_{it} = \mu_i + \gamma_{1i} npl_{i,t-1} + \gamma_{2i} gsmh_{i,t-1} + \gamma_{3i} faiz_{i,t-1} + \gamma_{4i} covid_{i,t-1} + \sum_{j=1}^{p-1} \delta_{1ij} \Delta npl_{i,t-j} + \sum_{j=0}^{q-1} \delta_{2ij} \Delta gsmh_{i,t-j} + \sum_{j=0}^{q-1} \delta_{3ij} \Delta faiz_{i,t-j} + \sum_{j=0}^{q-1} \delta_{4ij} \Delta covid_{i,t-j} + \epsilon_{it} \quad (2)$$

Yukarıdaki özdeşliklerde γ_{1i} uzun dönem katsayıları δ_{1ij} kısa dönem katsayıları μ_i ve ϵ_{it} ise sabit ve hata terimini simgelemektedir. Diğer taraftan (p,q) ise bağımlı ve bağımsız değişkenler için (AIC) Akaike Bilgi Kriteri referans alınarak belirlenmiş optimum gecikme katsayılarını temsil etmektedir. Bunlarla birlikte Pesaran vd. (1999) referans alınarak aşağıdaki hata düzeltme modelleri oluşturulmuştur.

$$npl_{it} = \alpha_i + \sum_{j=1}^{p-1} \omega_{1ij} \Delta npl_{i,t-j} + \sum_{j=0}^{q-1} \omega_{2ij} \Delta lkd_{i,t-j} + \sum_{j=0}^{q-1} \omega_{3ij} \Delta roa_{i,t-j} + \phi_i ECT_{i,t-1} + \epsilon_{it} \quad (3)$$

$$npl_{it} = \alpha_i + \sum_{j=1}^{p-1} \omega_{1ij} \Delta npl_{i,t-j} + \sum_{j=0}^{q-1} \omega_{2ij} \Delta gsmh_{i,t-j} + \sum_{j=0}^{q-1} \omega_{3ij} \Delta faiz_{i,t-j} + \sum_{j=0}^{q-1} \omega_{4ij} \Delta covid_{i,t-j} + \phi_i ECT_{i,t-1} + \epsilon_{it} \quad (4)$$

Eşitlik 3 ve 4 sırasıyla model I ve II için oluşturulmuş olan hata düzeltme denklemlerini temsil etmektedir. Buna göre ω_{1ij} kısa dönem katsayılarını, $ECT_{i,t-1}$ hata düzeltme terimini ϕ_i ise uyarılama hızını göstermektedir. Alan yazından bilindiği gibi uzun dönem denge durumuna yakınsama için ϕ_i (0-1) arasında olmalı ve işareti de negatif olmalıdır.

4. Bulgular

Çalışmada NPL bağımlı değişkeninin yorumlanması düşünülen bankalara özgü beş rasyodan ve beş makroekonomik değişken hangilerinin modellerde kullanılacağına ileriye doğru adımlama (stepwise least squares) regresyon yöntemi ile karar verilmiştir. Buna ilişkin regresyon sonuçları aşağıda Tablo 3 ve 4’te gösterilmiştir. Model I için syr, km ve roe değişkenleri anlamlı olmadığı için dışarıda bırakılmış lkd ve roa değişkenlerinin ise hem işaretleri beklendiği yönde çıkmış hem de anlamlı oldukları için Model I’e dahil edilmiştir. Diğer taraftan faiz, gsmh ve Covid değişkenleri de Model II’ye dahil edilmiştir.

Tablo 3. İleriye Doğru Adımlama (Model I)

Değişken	Katsayı	t-değeri
C	0.057789	11.31506***
LKD	-0.039348	-3.675342***
ROA	-0.609523	-2.574406**

Not: ***(%1), **(%5) ve *(%10) anlamlılık düzeyinde H0 hipotezinin reddedildiğini ifade eder.

Tablo 4. İleriye Doğru Adımlama (Model II)

Değişken	Katsayı	t-değeri
C	0.023464	5.3018***
FAİZ	0.076724	3.1024***
COVID	0.013140	2.7860***
GSMH	-0.050268	-2.0244**

Not: ***(%1), **(%5) ve *(%10) anlamlılık düzeyinde H0 hipotezinin reddedildiğini ifade eder.

Çalışmanın bir sonraki aşamasında ise durağanlık analizleri yapılmıştır. Ne var ki daha önce de belirtildiği gibi öncelikli olarak yatay kesit bağımlılığına ilişkin bulgular değerlendirilmiş ve bu çerçevede birim kök test seçimi yapılmıştır. Tablo 5 ve 6’da görüldüğü gibi yatay kesti bağımlılığı testlerinin boşluk hipotezi her iki model için de bütün test istatistikleri dikkate alındığında reddedilmiştir. Bir başka deyişle her iki model için de (Model I için Pesaran CD hariç) yatay kesit bağımlılığının var olduğu bulunmuştur. Bu nedenle çalışmaya ikinci nesil birim kök testlerinden olan Bai ve NG (2004) kullanılarak devam edilmiştir.

Tablo 5. Yatay Kesit Bağımlılığı Testleri (Model I)

Test	Değer
Breusch-Pagan LM	9.595460**
Pesaran scaled LM	2.692585***
Pesaran CD	-1.298176

Tablo 6. Yatay Kesit Bağımlılığı Testleri (Model II)

Test	Değer
Breusch-Pagan LM	11.10505**
Pesaran scaled LM	3.308874***
Pesaran CD	1.771674*

Tablo 7’de görüldüğü gibi serilerde birim kök vardır boşluk hipotezi NPL ve GSMH için düzeyde farklı veri trendleri göz önünde bulundurulduğunda reddedilememiştir. Diğer bir deyişle NPL ve GSMH serileri düzeylerinde durağan değildir. ROA bütün trend alternatifleri dikkate alındığında 0.01 anlamlılık seviyesinde durağandır. FAİZ ve LKD ise birer seri trendleri dikkate alındığında düzeylerinde birim kök içermektedir. Ne var ki birinci farklarında her iki değişkende durağan hale gelmektedir. Birim kök testlerine ilişkin bulgular değerlendirildiğinde serilerin I(0) veya I(1) olmak üzere farklı düzeylerde durağan olmaları panel bir ARDL modelinin kullanılabilmesini mümkün kılmaktadır. Buradan hareketle öncelikli olarak kısa ve uzun dönem katsayı tahminleri gecikme uzunluğuna duyarlı olduğu için farklı bilgi kriterlerine göre oluşturulmuş alternatif modeller içerisinde AIC kriteri göz önünde bulundurularak değişkenler için optimum olan gecikme belirlenmiştir.

Tablo 7. Bai ve NG (2004) Birim Kök Testleri

	Düzy			Birinci Fark		
	Sabit	Sabit ve Trend	Hiçbiri	Sabit	Sabit ve Trend	Hiçbiri
NPL	-0.6580	0.04763	-0.65771	2.97322***	2.88883***	3.01566***
LKD	4.2680***	-0.23731	4.35307***	14.2207***	10.8503***	11.8195***
ROA	7.1582***	4.9185***	7.07232***	-	-	-
GSMH	0.90723	-155.259	0.99040	2.04211**	-1.73188*	1.96541**
FAİZ	-102.152	-8.3951***	-4.4828***	2.8115***	104.114	2.6245***

Not: ***(%1), **(%5) ve *(%10) anlamlılık düzeyinde H0 hipotezinin reddedildiğini ifade etmektedir.

Tablo 8 ve 9, Model I ve II için sırasıyla ARDL (3, 3, 3) ve ARDL (3, 2, 2, 2) gecikmelerinin seçilecek olmasının (AIC bilgi kriterine göre mutlak değer olarak en yüksek test istatistiğine sahip oldukları için) optimum sonuçlar vereceğini göstermektedir.

Tablo 8. Model I için Optimum Gecikme Testleri

LogL	AIC*	BIC	HQ	Spesifikasyon
526.472612	-6.867675	-6.207717	-6.599505	ARDL(3, 3, 3)
527.185410	-6.835908	-6.114079	-6.542598	ARDL(4, 3, 3)
528.235926	-6.808832	-6.025132	-6.490381	ARDL(3, 4, 4)
508.307470	-6.782048	-6.369574	-6.614442	ARDL(3, 1, 1)
508.564871	-6.743957	-6.269611	-6.551209	ARDL(4, 1, 1)

Not: ***(%1), **(%5) ve *(%10) anlamlılık düzeyinde H0 hipotezinin reddedildiğini ifade eder.

Tablo 9. Model II için Optimum Gecikme Testleri

LogL	AIC*	BIC	HQ	Spesifikasyon
536.832093	-6.854858	-6.183537	-6.582093	ARDL(3, 2, 2, 2)
545.770140	-6.854016	-5.999606	-6.506860	ARDL(3, 3, 3, 3)
530.427762	-6.686092	-5.892712	-6.363733	ARDL(2, 3, 3, 3)
515.101371	-6.681651	-6.193417	-6.483277	ARDL(3, 1, 1, 1)
520.205638	-6.669464	-6.059172	-6.421496	ARDL(2, 2, 2, 2)

Tablo 10 oluşturulmuş olan iki farklı ARDL modeli için kısa ve uzun dönem katsayı tahminlerini göstermektedir. Her iki model için de uzun dönem eş-bütünleşme söz konusudur ve hata düzeltme terimleri beklendiği gibi eksi işaretlere sahip ve 0.01 düzeyinde anlamlıdır. Diğer

tarafından model I ve II için sırasıyla katsayıların -0.26 ve -0.28 olduğu düşünülürse bu da herhangi bir değişkenin uzun dönem denge düzeylerinden sapmaları durumunda kısa bir zamanda - yaklaşık üç çeyrek içinde- modellerin dengeye gelme durumunu göstermektedir. Bunlarla birlikte beklendiği gibi LKD ve ROA değişkenleri uzun dönemde NPL ile sırasıyla .1 ve .01 düzeyinde ters yönlü bir ilişkiye sahiptir. Ayrıca ROA ve LKD rasyolarındaki bir birimlik değişim NPL üzerinde -0.63 ve -0.0006 seviyesinde bir değişiklik yaratmaktadır. Diğer taraftan GSMH ve FAİZ değişkenleri beklenen işaretlere sahiptir ve 0.01 ve 0.10 düzeyinde NPL ile anlamlı bir ilişki içinde bulunmaktadır. Bir başka deyişle katılım bankalarının finansal açıdan sağlamlığını gösteren iki önemli rasyo olan karlılık ve likidite arttıkça takipteki krediler azalmaktadır. Ayrıca ekonomik büyüme beklendiği gibi NPL rasyosunu düşürmekte ve faizlerdeki yükselme geri ödenmeme riskini arttırdığı için takipteki kredileri arttırmaktadır. Kısa dönemde değişkenlerin NPL üzerinde anlamlı bir etkisi olmadığı sonucuna ulaşılmıştır. Covid-19 döneminde firmaların faaliyet döngüsü ve özellikle nakit akışındaki bozulma kredi geri ödemelerinde gecikmeler yaşanmasında neden olmuştur. İlgili dönemde kredi gruplarındaki bozulmalara bağlı olarak takipteki kredi rasyosu sınırlı da olsa artış göstermiştir. Covid-19 döneminin NPL değişkeni arasında 0,01 düzeyinde anlamlı ve pozitif yönlü bir ilişkisi bulunmakla birlikte, ilgili dönemde NPL +.099 değişiklik meydana gelmiştir.

Tablo 10. Panel ARDL Kısa ve Uzun Dönem Katsayı Tahminleri

Model I			Model II		
Değişken	Katsayı	T İstatistiği	Değişken	Katsayı	T İstatistiği
Uzun Dönem			Uzun Dönem		
LKD	-0.006830	-1.8142*	GSMH	-0.102644	-3.4493***
ROA	-0.630731	-3.8891***	FAİZ	0.043914	1.8663*
			COVID	0.009904	3.7964***
Kısa Dönem			Kısa Dönem		
COINTEQ01	-0.268136	-2.9869***	COINTEQ01	-0.284201	-3.5297***
D(NPL(-1))	-0.166103	-0.4635	D(NPL(-1))	-0.079318	-0.2130
D(NPL(-2))	-0.147845	-0.3973	D(NPL(-2))	-0.298572	-0.8329
D(LKD)	-0.009665	-0.7419	D(GSMH)	-0.009795	-0.4677
D(LKD(-1))	-0.005818	-12.509	D(GSMH(-1))	0.000907	0.0347
D(LKD(-2))	-0.045322	-11.581	D(FAİZ)	0.029990	0.7126
D(ROA)	-0.326952	-0.6646	D(FAİZ(-1))	-0.163963	-11.031
D(ROA(-1))	-0.346050	-0.6338	D(COVID)	-0.002188	-13.255
D(ROA(-2))	0.344851	2.1189**	D(COVID(-1))	0.002252	0.3493
C	0.011856	3.0208***	C	0.009920	2.6789***

Not: ***(%1), **(%5) ve *(%10) anlamlılık düzeyinde H0 hipotezinin reddedildiğini ifade eder.

Bütün bunlara ek olarak uzun dönem ilişkilerin varlığı Kao (1999) panel eş-bütünleşme testleri ile de aşağıdaki gibi ARDL model sonuçlarını destekler şekilde Tablo 11’de ortaya konulmuştur.

Tablo 11. Kao (1999) Eş-Bütünleşme Test Sonuçları

	Hata Terim Varyansı	HAC Varyans	T- İstatistiği
Model I	0.000498	0.000117	-1.568760*
Model II	0.000487	0.000137	-1.879837**

5. Sonu

2008 kresel ekonomik kriz sonrasında katılım bankacılıęının konvansiyonel bankacılık sistemine gre mali yapısı gl ve istikrarlı duruř sergilemesi, alıřma modeline olan ilgiliyi artırmıřtır. Katılım bankalarının faaliyetlerinde varlık temelli ve varlıęa dayalı alıřma prensibini benimsemeleri bu srete nemli rol oynamıřtır. Bankacılık sistemi iin hayati neme sahip olan kullandırılan kredilerin kalitesi gerek dnyada gerekse Trkiye’de finansal sistem ierisindeki payı her geen gn artıř sergileyen katılım bankacılıęı iin de byk neme sahiptir. Bu alıřmada Covid-19 dnemini de kapsayacak řekilde, geleneksel bankacılık sistemine gre alıřma metotları farklı olan, katılım bankalarının kredi kalitesini etkileyen bankaya zg ve makro ekonomik faktrlerin panel veri analiziyle belirlenmesi amalanmıřtır. İlgili dnemde Trkiye’de faaliyette bulunan katılım bankalarına ait veriler analize dahil edilmiřtir.

alıřmamızın bulguları, nceki blmlerde daha ayrıntılı olarak ele alındıęı zere ilgili literatrle uyumludur. Sonularımız, bankaya zg oranlardan LKD ve ROA ile kredi kalitesini simgeleyen NPL arasında negatif ynl bir iliřki (Amuakwa-Mensah vd., 2017; Torun ve Altay, 2019; Zheng vd., 2019; Zhen vd., 2020; Rahmah ve Armina, 2020, Ayaydın vd., 2021; Sevin, 2021; Bekereci vd., 2023; Erdoęan, 2024) tespit edilmiřtir. Makro ekonomik deęiřkenlerden GSMH ile NPL arasında negatif, faiz ve Covid-19 dnemi arasında ise pozitif ynl bir iliřki tespit edilmiř olup, bulgular literatrde yer alan alıřmalarla uyum gstermektedir (De Lis vd., 2001; Salas and Saurina, 2002; Fofack, 2005; Das and Ghosh, 2007; Wiryono and Effendi, 2018; Szarowska, 2018).

alıřma deęiřen kořullar nedeniyle katılım bankalarının kredi kalitesinin etkilendięini ortaya koymaktadır. Bu kapsamda kredi risk ynetim srelerinin ifade edilen hususları da kapsaması nem arz etmektedir. Farklı metodolojilerle alıřan katılım bankacılıęı iin kredi riskinin ynetiminde geleneksel risk ynetim aralarının dıřında faizsizlik ilkesine uygun araların kullanılabilmesi kredi riski ynetiminde etkinlięin yakalanmasına yardımcı olacaktır. zellikle geleneksel kredi riskleri ile piyasa riskleri ve banka dıřı faktrlerden kaynaklı risklerin ynetilmesinde riskin aktarılmasını saęlayan geleneksel bir takım risk ynetim aralarının, yapılacak geliřtirmelerle faizsizlik esaslı formlarının kullanılabilmesi kredi riskinin ynetimi aısından nemlidir.

Katılım bankaların kredi kalitesini etkileyen birok faktr bulunmakla birlikte, bu alıřma ile Trkiye’de faaliyette bulunan katılım bankalarının isel ve dıřsal faktrleri dikkate almasının zgnlk aısından nemli olduęu dřnlmektedir. İlgili dnemde sektrde faaliyette bulunan banka sayısının ve dnem sayısındaki sınırlılıkla yapılan alıřmanın nmzdeki dnemde sektre yeni katılan ve farklı iř modelleriyle alıřan bankalara ait verilerinde dikkate alınarak geliřtirilebileceęi dřnlmektedir.

Arařtırma ve Yayın Etięi Beyanı

Etik kurul izni ve/veya yasal/zel izin alınmasına gerek olmayan bu alıřmada arařtırma ve yayın etięine uyulmuřtur.

Arařtırmacıların Katkı Oranı Beyanı

Yazarlar makaleye eřit oranda katkı saęlamıř olduklarını beyan eder.

Arařtırmacıların ıkar atıřması Beyanı

Bu alıřmada herhangi bir potansiyel ıkar atıřması bulunmamaktadır.

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BANK-SPECIFIC AND MACROECONOMIC FACTORS AFFECTING THE CREDIT QUALITY OF PARTICIPATION BANKS: THE CASE OF TURKIYE DURING THE PANDEMIC PERIOD

EXTENDED SUMMARY

Aim of the Study

This study aims to determine bank-specific factors as well as macroeconomic factors in a sample of participation banks with different working model. In this study, using quarterly data from 2011/03 to 2023/12 and quarterly macroeconomic data from participation banks in the Turkish Banking System, an attempt was made to determine bank-specific and macroeconomic factors affecting the credit quality of participation banks, including the Covid-19 period, using panel data analysis.

Literature

In the literature, there are academic studies that take the Turkish Banking System as a sample and examine loans for the purposes of determining their relationship with credit quality, asset quality, performance measures of banks, macroeconomic and other performance items. In this study, bank-specific and macroeconomic factors affecting the credit quality of participation banks in the Turkish Banking System, including the Covid-19 period, were tried to be determined by panel data analysis by using the 1st quarter 2011 and 4th quarter 2023 quarterly data and quarterly macroeconomic data. Most of the studies in the literature are aimed at determining bank-specific factors affecting credit quality and similarly include commercial banks in the sample. In this study, it is aimed to determine bank-specific factors as well as macroeconomic factors in the sample of participation banks with a different working model.

Methodology

In our study, bank-specific ratios and macroeconomic variables that are thought to affect the non-performing loan ratio (NPL) for Turkish participation banks in the quarterly periods covering the period 1st quarter of 2011 and the 4th quarter of 2023 were used. In this context, bank-specific and macroeconomic factors affecting the credit quality of participation banks, including the Covid-19 period, were tried to be determined by panel data analysis.

The cross-section of the data set consists of 3 banks and the time section consists of periods. Therefore, it is aimed to reveal the relationship between the variables by creating a panel model. However, due to the large number of variables, the stepwise method will be used first to determine which variables will be used to continue the study. Thus, the independent variable set that has emerged as significant in explaining the dependent variable (NPL) in the model to be created will be prioritized. In addition, since the independent variable set consists of bank-specific ratios that vary according to both time and cross-section and macroeconomic indicators that vary according to time but do not vary according to the cross-section (cross-invariant), it is thought that creating 2 separate models for two different groups of variables will

yield more meaningful results. In order to test the existence of cross-sectional dependency in the study, Breusch and Pagan LM (1980), Pesaran Scaled LM (2004) and Pesaran CD (2004) tests were conducted. Then, the second generation unit root test Bai and Ng (2004) was used.

In the study, it was considered appropriate to use the Panel ARDL model developed by Pesaran vd. (1999), which allows analysis to be performed independently of the stationarity level of other independent variables. On the other hand, Kao (1999) cointegration tests were also conducted and the ARDL estimation results were supported.

Findings

In the study, it was decided which of the three bank-specific ratios and five macroeconomic variables that are thought to predict the NPL dependent variable will be used in the models by using the forward stepwise least squares regression method. The regression results are shown in Tables 1 and 2 below. For Model I, the syr, km and roe variables were excluded because they were not significant, and the lkd and roa variables were included in Model I because their signs were in the expected direction and they were significant. On the other hand, the interest, gsmh and Covid variables were also included in Model II. In the next stage of the study, stationarity analyses were performed. However, as mentioned before, firstly the findings regarding the cross-sectional dependency were evaluated and within this framework, the unit root test selection was made.

Results

After the 2008 global economic crisis, participation banking's strong financial structure and stable stance compared to the conventional banking system increased the interest in the business model. Participation banks' adoption of the asset-based and asset-based operating principle in their operations played an important role in this process. The quality of the loans extended, which is of vital importance for the banking system, is also of great importance for participation banking, whose share in the financial system is increasing day by day both in the world and in Türkiye. In this study, it is aimed to determine the bank-specific and macroeconomic factors affecting the loan quality of participation banks, which have different working methods compared to the traditional banking system, by using panel data analysis, including the Covid-19 period. The data of participation banks operating in Türkiye during the relevant period are included in the analysis.

The findings of our study are consistent with the related literature, as discussed in more detail in the previous sections. Similar to the literature, our results show a negative relationship between LKD and ROA, which are bank-specific ratios, and NPL, which symbolizes credit quality (Amuakwa-Mensah vd., 2017; Torun and Altay, 2019; Zheng vd., 2019; Zhen vd., 2020; Rahmah and Armina, 2020, Ayaydın vd., 2021; Sevinç, 2021; Bekereci vd., 2023; Erdoğan, 2024). Among the macroeconomic variables, there is a negative relationship between GNP and NPL and a positive relationship between interest rate and Covid-19 period and the findings are consistent with the studies in the literature (De Lis vd., 2001; Salas and Saurina, 2002; Fofack, 2005; Das and Ghosh, 2007; Szarowska, 2018; Wiryono and Effendi, 2018).

Conclusion and Policy Implications

The study reveals that the credit quality of participation banks is affected by changing conditions. In this context, it is important that credit risk management processes cover the mentioned issues. For participation banking, which works with different methodologies, the use of tools that comply with the interest-free principle in addition to traditional risk management tools in the management of credit risk will help to achieve efficiency in credit risk management. Especially in the management of traditional credit risks, market risks, and risks arising from non-bank factors, it is important for the management of credit risk to be able to use interest-free forms of traditional risk management tools that enable the transfer of risk.

Although there are many factors affecting the credit quality of participation banks, it is considered important in terms of originality that this study takes into account the internal and external factors of participation banks operating in Türkiye. It is thought that the study, which was conducted due to the limited number of banks operating in the sector in the relevant period and the number of periods, can be improved by taking into account the data of banks that have recently joined the sector and operate with different business models in the coming period.

It is important from a policy perspective that all institutions and organizations that shape the economies of countries with their decisions take decisions by taking into account both internal factors specific to banks and macroeconomic factors at the same time during periods of slowdown in economic activities, such as Covid-19. In this way, it may be much easier to overcome the resulting economic recession and possible loan repayment problems in the aftermath, and the possible damage can be overcome at less cost.

İKLİM DEĞİŐİKLİĐİ RİSKLERİNİN BANKACILIK SEKTÖRÜNE ETKİLERİ: BRICS ve G7 ÜLKELERİ ÖRNEĐİ

The Effect of Climate Change Risks on the Banking Sector: A Case Study of the BRICS and G7 Countries

Gizel Busem SAYIL*^{id} & Müzeyyen Esra ATUKALP**^{id}

Öz

Sanayi devrimiyle başlayan iklim deėiőikliĐi riskleri her geen gün artarken sürdürülebilir kalkınma ve sürdürülebilir finans hedefleri daha da önemli hale gelmektedir. Bu alıőmanın temel motivasyonu iklim deėiőikliĐi risklerinin firmaların faaliyetlerini olumsuz etkileyerek ödeme güçlüĐüne yol açabileceĐi ve bunun da bankacılık sisteminin aktif kalitesini zayıflatacaĐı beklentisidir. Bu doĐrultuda, alıőmanın amacı karbon emisyonu ve ekolojik ayak izi bileőenlerinin ve ekonomik büyümenin bankaların takipteki kredileri üzerine etkisini BRICS ve G7 ülkelerinde tespit etmektir. alıőmada 2013-2022 dönemi ele alınmış ve panel veri analizi kullanılmıştır. Analiz sonucunda karbon ayak izinin (CO₂ emisyonu) banka takipteki kredi oranına G7 ülkelerinde pozitif yönlü etkinin bulunduĐu, BRICS ülkelerinde ise etkisinin bulunmadıĐı belirlenmiştir. Öte yandan takipteki kredi oranına ekolojik ayak izi toplam deĐerinin ise anlamlı bir etkisi bulunmamıştır. Büyüme ise takipteki kredi oranlarını BRICS ve G7 ülkelerinde negatif etkilemektedir. Bankacılık sisteminin evresel sürdürülebilirlikle iliőkisi ele alındıĐında sektörün aktif kalitesini iyileőtirmek için sürdürülebilirlik odaklı kredi politikaları geliőtirmesi önem taşımaktadır. Firmaların yenilenebilir enerji yatırımlarına yönelmeleri sera gazı emisyonlarını azaltırken, bankaların da kredilendirme süreçlerinde bu hedefleri gözetmeleri gerektiĐi anlaşılmaktadır. Ayrıca, kamu otoriteleri uygun politikalar geliőtirerek bu süreci desteklemelidir.

Anahtar

Kelimeler:

Karbon Ayak İzi,
Ekolojik Ayak İzi,
CO₂ Emisyonu,
GSYİH, BRICS,
G7, Panel Veri

JEL Kodları:

G21, C33, Q51

Abstract

As the risks of climate change, which began with the industrial revolution, grow by the day, the aim of sustainable development and sustainable finance is coming to the fore. The main motivation of this study is the expectation that climate change risks will negatively affect the activities of firms and they will experience payment difficulties, which will affect the asset quality of the banking system. The aim of this study is to determine the effect of carbon footprint and the total of ecological footprint components on non-performing bank loans in BRICS and G7 countries. In the study, the period 2013-2022 was considered, and panel data analysis was used. As a result of the analysis, it was determined that the carbon footprint (CO₂ emission) has a positive effect on the bank's non-performing loan ratio in G7, and it was not found to have a significant effect in BRICS. On the other hand, the total value of the ecological footprint did not have a significant effect on the non-performing loan ratio. Growth, on the other hand, negatively affects the non-performing loan ratio in BRICS and G7 countries. When examining the relationship between the banking system and environmental sustainability, it becomes evident that developing sustainability-oriented credit policies is essential for improving the asset quality of the banking sector. Firms' renewable energy investments help reduce emissions, while banks should align lending with sustainability goals. The public authorities should support the transition by implementing appropriate policies.

Keywords:

Carbon Footprint,
Ecological
Footprint, CO₂
Emissions, GDP,
BRICS, G7, Panel
Data

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1. Giriş

İklim değişikliği, iklim sisteminde görülen uzun vadeli değişiklikler olarak tanımlanmakta olup, bu değişiklikler esas olarak doğal süreçler ve insan faaliyetlerinden kaynaklanan sera gazı emisyonları tarafından tetiklenmektedir. İklim değişikliğin en belirgin etkisi küresel ısınma olmakla beraber buzulların erimesi, deniz seviyelerinin yükselmesi, kuraklıklar ve aşırı hava olaylarının artışı gibi geniş kapsamlı etkileri içermektedir (Fawzy vd., 2020: 2070; Harper vd., 2018: 2).

Başlıca sera gazları sırasıyla karbondioksit (CO₂), metan (CH₄) ve diazot monoksit (N₂O) olup kömür, petrol, doğalgaz gibi fosil yakıtların başta enerji üretimi olmak üzere sanayi, ulaşım, bina ısınması gibi alanlarda yoğun şekilde kullanımıyla atmosfere salınmaktadır (IPCC, 2021). Sera gazlarının artışıyla yükselen sıcaklıklar neticesinde iklim sisteminde geri döndürülemez etkiler yaratabilecek değişimler kaçınılmaz olmaktadır (UNEP, 2022).

İklim değişikliği insan sağlığı, enerji, çevre, su ve gıda gibi hayati alanlar üzerinde önemli olumsuz etkiler yaratmaktadır. Bu durum, çimento, havacılık, tarım ve enerji üretimi gibi birçok sektörde gelir kayıplarına neden olmakta, işletmelerin ve toplumların karşı karşıya kaldığı riskleri artırmaktadır (Dlugolecki ve Lafeld, 2005: 6).

Bu bağlamda, sera gazlarının en önemli bileşeni olan karbon emisyonuna ilişkin riskler firmaların gelecekteki nakit akışlarını belirsizleştirerek ödeme gücüne düşme olasılıklarını artırmaktadır. Bu durum bankaların kredi riskini doğrudan tetikleyerek banka bilançolarının bozulmasına yol açabilmektedir. Dolayısıyla karbon emisyonuna bağlı riskler, yalnızca firmaların değil, bu firmalara finansman sağlayan bankaların da finansal istikrarını tehdit eden önemli bir faktör olmaktadır (Jung vd., 2018: 1156; BDDK, 2021: 6).

Bununla birlikte, iklim değişikliği bankaların bilançoları üzerinde kredi risklerinin yanı sıra dolaylı yollarla da etkili olabilmektedir. Sürdürülebilir hedefler gözetilenlerin yerine karbon yoğun projelere kredi tahsis edilmesi, bankaların imajını olumsuz etkileyerek itibar kayıplarına yol açabilmektedir. Bu durum, kredi veren kurumların uzun vadeli finansal istikrarını ve nakit akışını olumsuz etkileyebilmektedir (Thomson, 1998: 245).

İklim değişikliği riskleri ve bu risklere karşı geliştirilebilecek stratejiler bakımından bankalar kritik bir role sahiptir. Bankalar, risklerle doğrudan karşı karşıya olmakla beraber kredi sağlayan kurumlar olarak hem kaynakları çevreci projelere yönlendirerek hem de kurumsal politikalarıyla iklim değişikliğiyle mücadelede etkin rol alabilmektedir (OECD, 2020: 94; Monasterolo vd., 2024: 2-5). Bu yaklaşımlar, bankaların hem finansal istikrarını korumasını hem de sürdürülebilir kalkınmaya katkıda bulunmasını sağlayabileceğinden önemlidir.

Sera gazı emisyonlarının oldukça önemli bir kısmı sınırlı sayıda ülke tarafından üretilmekte olup; en fazla salınımına sahip ülkeler arasında Çin, ABD, Hindistan ve Rusya yer almaktadır (Global Historical Emissions, 2024). Bu çalışmanın amacı, karbon emisyonu ve ekolojik ayak izi bileşenlerinin bankaların takipteki kredileri üzerine etkisinin BRICS (Brezilya, Rusya, Hindistan, Çin, Güney Afrika) ve G7 (Kanada, Fransa, Almanya, İtalya, Japonya, Birleşik Krallık, Amerika Birleşik Devletleri) ülkelerinde belirlenmesidir. Bu ülke gruplarının ekonomik, politik ve çevresel yapıları farklılık gösterse de her iki grupta çevresel riskleri yüksek ülkeler yer almaktadır. Bu amaçla yapılan çalışmada, 2013-2022 dönemi, panel veri analizi ile değerlendirilmiştir.

Çalışma, iklim değişikliği ile ilgili önemli risk kaynaklarının, firmalar üzerinde dolaylı etkilerine işaret ederek bankacılık, finans ve sürdürülebilirlik ilişkisini ele alan çalışmalara katkı

sağlamayı amaçlamaktadır. Bununla birlikte, bazı ülkelerin mevcut üretim bantlarını aktardıkları ve bu doğrultuda da yüksek karbon salınımına sahip BRICS ülkeleri ile çevresel düzenlemelerin daha katı olduđu G7 ülkelerinin karşılaştırılması, ekonomik ve çevresel dinamikler açısından gelişmiş ve gelişmekte olan ülkeler arasındaki farklılıkların ortaya konulması yoluyla literatüre katkı sunmayı hedeflemektedir.

Çalışmada elde edilmesi beklenen sonuç, karbon yoğunluğunun bankaların aktif kalitesini olumsuz etkilemesi yönünde olup, bankaların kredi politikalarını çevresel riskleri gözeterek düzenlenmesi gereğini ortaya koymaktadır. Çevresel politikalar kapsamında hassasiyete sahip firmalara ülke ekonomileri bazında sunulan / sunulacak avantajların, ilgili firmaların finansman teknikleri ve ödeme güçlerini de etkileyebileceği göz önüne alındığında, bankaların kredi politikalarını düzenlerken çevresel hassasiyete sahip firmalara öncelik ve önem verilmesi noktasında yaklaşıma sahip olması beklenebilir. Bununla birlikte, bankacılık sektörü önemli rol üstlense de; kamu otoriteleri ve düzenleyici kurumların bu süreci destekleyen teşvik politikaları uygulamaları önemlidir.

Çalışma altı bölümden oluşmaktadır. Çalışmanın girişten sonraki ikinci bölümünde sürdürülebilirlik ve finans ilişkisi ele alınırken, üçüncü bölümde literatür taraması yapılmıştır. Çalışmanın dördüncü bölümünde analize ilişkin veri seti ele alınmış, beşinci bölümünde analiz yöntemi ve elde edilen bulgular açıklanmıştır. Çalışmanın altıncı bölümünde ise analizde elde edilen bulgular doğrultusunda önerilere ve analizin genel değerlendirmesine yer verilmiştir.

2. Sürdürülebilirlik ve Finans

Finansal kuruluşlar dâhil olmak üzere tüm firmaların faaliyetlerini sürdürürken çevresel, sosyal ve yönetim unsurlarını dikkate alması sürdürülebilirlik kavramıyla ifade edilmektedir. Bu faktörlerin etkin uygulanması, kurum ve kuruluşların kalitesini olumlu etkileyerek uzun vadeli değerini artırma potansiyeline sahip olduğundan önemlidir (Bumin, 2023: 388).

Sürdürülebilirlik faktörlerin ilkiyle ilişkili olan iklim dengesinde yaşanan geri dönüşü olmayan dönüşüm, kaynakların tükenmesi, doğal yaşam alanları ve canlı çeşitliliğinin azalması, eşitsizlik ve yoksulluk sorununun hızla büyümesi gibi sorunları beraberinde getirmiştir. Dünyada iklim krizi giderek artarken orman yangınları, kuraklıklar, aşırı hava olaylarının şiddeti ortak bir akılla hareket ederek sürdürülebilirlik faaliyetlerinin benimsenmesini zorunlu kılmaktadır (TBB, 2022: 11). Bu bağlamda, devam eden küresel ısınma problemleri ve artan enerji ihtiyacı kurumlar ve hükümetleri temiz enerji kaynaklarına yönlendirmektedir. Uluslararası Enerji Ajansı (IEA) tarafından yayınlanan rapora göre, Çin'in güneş enerjisi kapasitesinde dikkat çeken öncülüğünün etkisiyle, 2023 yılında yenilenebilir enerji kapasitesi rekor seviyede artış göstermiştir. Bunun yanında ABD, Brezilya, Hindistan ve Avrupa ülkeleri de önemli düzeyde yenilenebilir kapasitesi artışları kaydetmiştir. Söz konusu raporda, küresel ölçekte destekleyici politikalar sayesinde kısa vadede büyük dönüşümler beklendiği vurgulanmaktadır. Rüzgâr ve güneş enerjilerinin 2025 ve 2026 yıllarında nükleer enerjiyi geçmesi, 2028 yılında ise yenilebilir enerji yatırımlarının, küresel elektrik üretiminin %42'sini oluşturması beklenmektedir. Bu gelişmeler, esasında yenilenebilir enerjinin küresel ölçekte merkezi rol üstleneceğine işaret etmektedir (IEA, 2023: 8).

İklim değişikliği riskleri ve sürdürülebilir kalkınma hedefleri daha ziyade genel ekonomi açısından ele alınsa da finans sektörünün rolü kritiktir. İklim değişikliğinin getirdiği riskler ve bu risklere karşı geliştirilebilecek stratejiler bakımından başta bankalar olmak üzere finans kurumları

oldukça önemli bir yere sahiptir. Bankalar, hem diğer sektörler gibi risk ve fırsatları yönetmek zorundadır, hem de aracılık işlevleri gereği olarak, kaynakları çevreci yatırımlara yönlendirerek sürdürülebilir kalkınmayı destekleyecek öneme sahiptir (Lalon, 2015: 34; Scholtens, 2006: 22).

Bankacılık, temelde risk yönetim faaliyetidir ve çeşitli riskleri yöneterek sürdürülebilir büyümeye destek olmaktadır. Bankalar, doğrudan ve dolaylı olarak iklimle bağlantılı risklere maruz kalmaktadır. Doğrudan riskler, daha çok fiziksel olaylarla ilgili olup operasyonel risk olarak adlandırılmaktadır. Dolaylı risk sınıfında yer alan kredi ve likidite riski ise, kredi kullanan kişi ya da kurumların ödeme güçlüğüne düşmesi halinde ortaya çıkmaktadır. İklim riskleri neticesinde borçluların zarara uğraması ve ödemelerini gerçekleştiremeyecek duruma gelmeleri söz konusuysa yeni kredi taleplerinde önemli bir artış beklenmektedir. Sonuç olarak, borçlarını tahsil etmekte güçlük çeken bankalar yeni kaynak yaratmakta sorun yaşayacaktır. Bu da likidite riskini doğururken teminat değeri, hisse senedi ve diğer yatırım araçlarının değerinde düşüş riskleri anlamına gelmektedir (BDDK, 2021: 6).

İklim risklerinin finansal sistem üzerinde belirgin hale gelmesi ilk olarak 2015 yılında imzalanan Paris Anlaşması ile olurken kredi kaynaklarının çevreci faaliyetlere yönlendirilmesinin öneminin burada anlaşıldığı söylenebilir (Bruno ve Lombini, 2023: 63). Finansal kurumlar için iklim değişikliğinin getirdiği riskler ve bilançolara olan etkilerinin tespitinin önemi günden güne artarken kurumlar politikalarını bu yönde geliştirmektedirler. Bankalar, iklim değişikliğinin getirdiği risk ve fırsatları kredi değerlemelerine yansıtmak üzere çalışmalar yürütmektedir (Marlin, 2018: 1).

Benzer şekilde, uluslararası düzenleme otoriteleri iklimle ilişkili finansal risklerin belirlenmesi ve yönetilmesi hususunda çalışmaktadır. Bu alanda öncü yaklaşımlardan biri, G20’ye bağlı Finansal İstikrar Kurulu (FSB) tarafından kurulan oluşumun 2017 yılında tüm sektör ve ülkelerdeki kuruluşlara, finansal raporlarda iklim değişikliği ile alakalı bilgileri yansıtmasına yönelik sunduğu tavsiye raporudur (BDDK, 2021: 7). Benzer şekilde, bankacılık sektörünün iklimle bağlantılı finansal risklerini ele almak amacıyla 2020 yılında BASEL Komitesi tarafından İklimle Bağlantılı Finansal Riskler Çalışma Grubu kurulması önemli bir adımdır. Bu çalışma grubu, iklimle ilgili finansal risklerin belirlenmesi, bu risklerin bankacılık sektörü üzerinde potansiyel etkilerinin ölçülmesi gibi hedefler taşımaktadır (BCBS, 2022: 2). Bununla birlikte, 2020 yılında AB’de sürdürülebilir yatırımların artırılması ve çevresel hedeflere ulaşılmasının desteklenmesi amaçlarıyla AB Taksonomi sistemi oluşturulmuştur. Bu sistem, hangi ekonomik faaliyetlerin çevresel olarak sürdürülebilir kabul edileceğini belirleyen kriterler sunmaktadır. Avrupa Bankacılık Otoritesi (EBA) ise, 2021 yılında bankacılık sektöründe sürdürülebilir finans hedeflerine uyum sağlamak amacıyla çeşitli kriter ve temel performans göstergelerinden oluşan bir rapor sunmuştur. Rapor, bankaların çevresel sürdürülebilirliğini ölçmek amacıyla oluşturulan ve taksonominin uzantısı olan Yeşil Varlık Oranını da içermesi bakımından önemlidir (EBA, 2021: 7-10-31).

Bununla birlikte, sürdürülebilir büyüme yalnızca gelişmiş ülkelerin değil Türkiye dâhil olmak üzere gelişmekte olan ekonomilerin ortak hedefidir. Türkiye, Paris Anlaşması kapsamında emisyon azaltımı yönünde taahhüt vermiş olmakla beraber sürdürülebilir hedeflerin sağlanmasında bankacılık sektörünün rolü kritiktir. Bu bağlamda, 2021 yılında “Sürdürülebilir Bankacılık Stratejik Planı (2022-2025)” oluşturularak, sektör üzerinde etkilerinin değerlendirilmesi amacıyla çalışmalar yürütülmüştür. 2022 yılında ise, BDDK ve TBB işbirliğiyle oluşturulan yeşil varlık çalışma grubu, AB uygulamalarını esas alan fakat yerel

kořulları gözeten taksonomi taslağı sunmuřtur. Ayrıca, Türkiye’deki bankaların sürdürülebilirlik, iklimle iliřkili finansal riskler ve politikaları hakkında detaylı veriler toplamak üzere ‘‘Sürdürülebilir Bankacılık Soru Seti’’ hazırlanmıřtır. Bu uygulama ile bankacılık sektörünün sürdürülebilir finans bağlamında risk yönetimi, mevcut durumu ve farkındalığının belirlenmesi amaçlanmıřtır (BDDK, 2023: 24-25). Devam etmekte olan çalışma ve uygulamalara karřın, iklim değıřikliğinin bankaların risk yönetimi üzerine etkisinin halen yeni bir konu olduğı, öneminin her geçen gün artmakta olduğı söylenebilir.

Son olarak, iklimle bağlantılı riskin boyutuna örnek vermek gerekirse, S&P 500’de yer alan řirketlerin neredeyse %60’ı fiziksel iklim değıřikliğı kaynaklı yüksek riskli varlıklara sahiptir (Lord vd., 2019). Bu durum, kredi risk değıřerlemede iklim faktörlerinin önemine dikkat çekmektedir. Kredilendirme süreçlerinde sürdürülebilirlik ilkelerinin gözetilmesi hem çevresel hem de finansal risklerin daha iyi yönetilmesine katkı sağılamakta; bu bağlamda çevre yönetimi ile kredi risklerini azaltması, aktif kalitesini iyileřtirmesi ve iřletme değıřerini arttırmasıyla risk yönetiminin önemli bir parçası olarak düşünölmektedir (Nath vd., 2014: 49; Sürdürülebilir Finans, 2024).

Özetle, çevresel risk yönetiminin yalnızca ekosistem için değıl finansal istikrar için de temel gereklilik olduğı anlařılmaktadır. Bu çalışmada, çevresel risklerin bankaların aktif kalitesine etkisi takipteki krediler üzerinden ele alınmakta; iklim risklerinin bankacılık sektöründe potansiyel risk etkileri analiz edilmektedir.

3. Literatür Özeti

İklim değıřikliğı, finansal sistemin istikrarı açısından giderek artan öneme sahiptir. Bankacılık sektörü, çevresel risklere maruz kalmakla birlikte bu riskleri finansal sistemin geneline yayma potansiyeli bulundurmaktadır. Aynı zamanda çevresel sürdürülebilirliğı gözeten yatırımları destekleyerek risklerin yönetilmesinde kilit bir rol üstlenmektedir. Bu alanda yapılan çalışmalar hem reel sektör hem de bankacılık sektörü üzerinde yoğunlařmaktadır.

Literatür incelendiğinde kurumsal sürdürülebilirlik derecesi, kredi notları ve kredi riski arasındaki iliřkinin firma özelinde incelendiğı çalışmaları geniş yer bulduğı görölmektedir. Bu çalışmalar genel olarak, firmaların kurumsal sürdürülebilirlik derecelerinin kredi riskleri ve finansman maliyetleri üzerinde önemli etkisini ortaya koymaktadır. Sürdürülebilirlik performansları düşük olan firmaların daha yüksek borçlanma maliyetlerine maruz kaldığını, temerrüt risklerinin daha fazla olduğı ve daha düşük kredi derecelendirme notuna sahip olduğı görölmektedir (Goss ve Roberts, 2011; Attig vd., 2013; Jung vd., 2018; Barth vd., 2019; Höck vd., 2020; Nguyen vd., 2021). Özetle, sürdürülebilirlik ilkelerine uyum sağılayan firmaların daha düşük kredi maliyeti ve finansal risk taşıdığı anlařılmaktadır.

Bunun yanında, literatürde karbon emisyonu verileriyle, çevre riskleri ve kredi riski iliřkisinin incelendiğı çalışmalara rastlanmaktadır. Bu çalışmalar, daha yüksek sera gazı ve iklim risklerine sahip firmaların kredi risklerinin daha fazla olduğına iřaret etmektedir. Yüksek çevresel risklerin daha düşük kredi notu, yüksek temerrüt riski ve finansmana erişim güçlükleri anlamına geldiğı görölmektedir. Ayrıca, iklim risklerinin firmaların sermaye ve kârlılıklarını olumsuz etkilediğı, likidite kapasitelerini zayıflatığı vurgulanmaktadır (Chava, 2011; Delis vd., 2018; Dafermos vd., 2018; Lamperti vd., 2019; Carbona vd., 2021; Huang vd., 2021; Javadi ve

Masum, 2021; Kabir vd., 2021; Kling vd., 2021; Seltzer vd., 2022; Çokmutlu ve Özen, 2023; Owolabi vd., 2024).

Literatürde, bankalar özelinde ele alınan çalışmaların nispeten sınırlı olduğu söylenebilir, ancak bulgular önemlidir. Bu çalışmalar genel olarak, iklim kaynaklı risklerin bankaların kredi risklerini artırdığını ortaya koymaktadır. Thomson, 1998 yılında bankaları ele aldığı çalışmada, sektörde çevresel sorunların, kredi risklerini artırmakla beraber çevre dostu yatırımların yeni kredi fırsatları yaratabileceğini ifade etmektedir (Thomson, 1998).

Ayrıca Brezilya, Endonezya, Kanada, Türkiye gibi farklı yapıda ekonomilerde yapılan ampirik çalışmalar, çevresel risklerin ve iklim kaynaklı olayların kredi temerrüt oranlarını artırdığını, kredi tahsis süreçlerini olumsuz etkilediğini göstermektedir. Coulson ve Monks (1999), çalışmalarında bankaların kredilendirme kararlarında çevresel etkileri değerlendirmeleri gerektiğine dikkat çekerken, Weber (2012), Kanada’da faaliyet gösteren bankaların kredi değerlendirme sürecinde çevresel faktörleri önemli finansal risk unsuru olarak değerlendirdiğini ifade etmiştir.

Miah vd. (2021), gelişmekte olan 22 ülkede finansal ve finansal olmayan firmalarda karbon emisyonlarının etkisini incelemişlerdir; sonuçlar karbon emisyonlarının kredi notunu olumsuz yönde etkilediğini ortaya koymuştur.

Oliveira (2022), 2002- 2013 döneminde iklimsel olayların etkilerini Brezilya’da BNB bankası kredileri üzerinde incelemiştir. Panel veri analizi kullanılan çalışma, sıcaklık ve yağışların yıllık ortalamadan sapmalarının temerrüt oranlarını önemli ölçüde artırdığını göstermiştir.

Aslan vd. (2022), Türkiye’de bankaların il düzeyinde iklim risklerine karşı tutumunu incelemişlerdir. Çalışma sonuçları, bankaların iklim değişikliği risklerini dikkate aldıklarını ve kredi tahsis süreçlerini buna göre düzenlediklerini göstermiştir.

Çizgici Akyüz (2023), 1990-2019 döneminde Türk bankacılık sektörü üzerinde, çevresel performansın finansal performans üzerindeki etkisini incelemiştir. Çalışmanın sonucunda, karbon emisyonlarından aktif kârlılığa pozitif yönde ve tek yönlü bir nedensellik ilişkisi belirlenmiştir.

Sugiarto vd. (2023), 2011-2021 döneminde Endonezya’da bankacılık sektöründe panel veri analizi kullanarak iklim risklerinin krediler üzerinde etkilerini incelemiştir. Sonuçlar, sel felaketlerinin kredileri azalttığını ve geri ödenme riskini artırdığını göstermiştir.

Bu çalışma ile bankacılık, finans ve sürdürülebilirlik ilişkisini ele alan çalışmalara katkı sağlanması amaçlanmaktadır. Bu bağlamda, hem gelişmekte olan (BRICS) hem de gelişmiş (G7) ülke ekonomilerini kapsayarak ekolojik ayak izi ve karbon emisyonlarının bankaların sorunlu kredileri üzerine etkileri analiz edilmektedir. Böylelikle çevresel sürdürülebilirliğin finansal istikrar üzerindeki yansımalarının ortaya konması ve ilgili alandaki çalışmalara yol gösterici olması hedeflenmektedir.

4. Veri Seti

Bankalar, iklim değişikliği riskleri ve bu doğrultuda geliştirilebilecek stratejiler bakımından sahip oldukları önem dolayısıyla iklim değişikliğiyle mücadelede etkin rol alabilmektedir. Bu husus bankaların finansal istikrarı ve sürdürülebilir kalkınma konusunda katkı

sağlayacaktır. Bankacılığın finans ve sürdürülebilirlik ilişkisine katkı sağlama amacıyla, karbon yoğunluğunun bankaların aktif kalitesine etkisinin belirlenmesi ve bu kapsamda bankaların kredi politikalarına ışık tutabilmesi açısından gerekli analizlerin yapılması gerekmektedir.

Bu çalışmada BRICS ve G7 ülkelerinde iklim değışikliğinin bankaların kredi riski üzerinde etkisi olup olmadığı, sorunlu krediler üzerinden araştırılmak istenmektedir. Panel veri analizi ile ele alınan çalışmada, incelenen tüm ülkelerde verilere ulaşılabilmesi ve süreklilik göstermeleri gözetilerek, 2013-2022 dönemi araştırılmıştır. Buna göre, yatay kesit birimlerinin zaman boyunca ele alınarak analiz edildiğı panel veri analizi kapsamında BRICS ve G7 ülkelerinin yatay kesit olarak yer aldığı 10 yıllık zaman süreci ele alınmıştır. Bu kapsamda ele alınan ülkeler Tablo 1’de yer almaktadır.

Tablo 1. Analizde Ele Alınan Ülkeler

BRICS	G7
Brezilya	Kanada
Rusya	Fransa
Hindistan	Almanya
Çin	İtalya
Güney Afrika	Japonya
	Birleşik Krallık
	Amerika Birleşik Devletleri

Bu çalışmada ele alınan veriler finansal sürdürülebilirliğin, çevre yönetiminin aktif kalitesi ile bağlantısını analiz etmek amacıyla derlenmiş, ayrıca GSYH makroekonomik değışkeni dâhil edilerek etkisi değerlendirilmiştir. Veriler, Tablo 2’de sunulduğu şekilde ele alınmış olup, Dünya Bankası ve Global Footprint Network (2024) internet kaynaklarından temin edilmiştir.

Tablo 2. Analizde Ele Alınan Değışkenler

Değışken Türü	Kısaltma	Değışkenler
Bağımlı	TKR	Toplam krediler içinde takipteki kredi oranı
Bağımsız	EKA	Ekolojik ayak izi toplam verisi
Bağımsız	CO ₂	Karbon emisyonu (CO ₂ emisyonu)
Bağımsız	GSYH	GSYİH büyümesi (yıllık %)

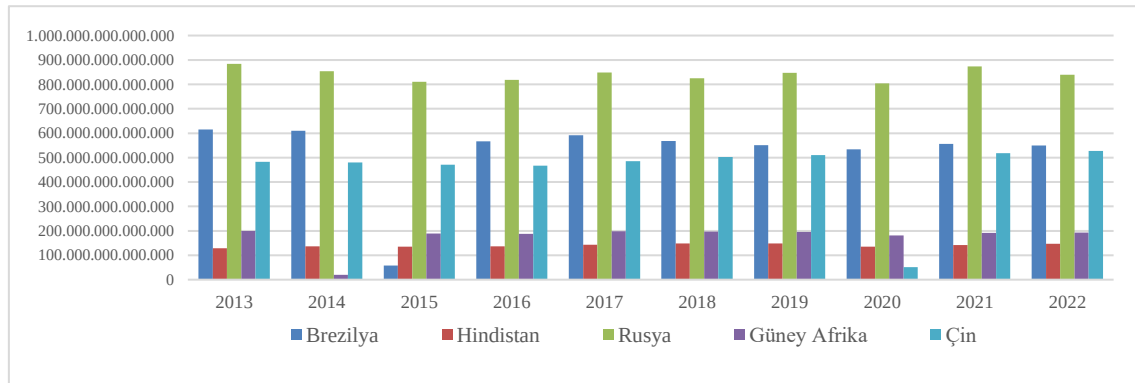
Çevresel risklerin esas olarak Sanayi Devrimiyle başladığı kabul edilir. Bu dönüşüme uyum sağlayan ülkeler üretime daha fazla katkıda bulunarak daha fazla ekonomik büyüme göstermiştir. Çevresel risklerin ve karbon salınımının büyük bir kısmının büyüyen ekonomilerden kaynaklandığı bilinmektedir. Dünyadaki sera gazı emisyonlarının yaklaşık %60’ının yalnızca 10 ülke tarafından üretildiğı belirtilirken, en büyük karbon salınımına neden olan ülke Çin’dir; bunu ABD, Hindistan ve Rusya takip etmektedir (Global Historical Emissions, 2024).

Araştırmada incelenen iki ülke grubu, farklı ekonomik ve çevresel dinamikler taşımalarına rağmen, yüksek karbon salınımı seviyelerine sahip ekonomilerdir. Dolayısıyla, bu çalışmada ele alınan BRICS ve G7 gruplarının genel olarak yüksek çevresel risk taşıdığı anlaşılmaktadır. Aynı zamanda, Çin küresel ölçekte lider ekonomiler arasında olmakla birlikte; ABD, Brezilya, Hindistan, Avrupa ülkeleri yenilenebilir enerji yatırımlarını önemli ölçüde artıran ve bu kapsamda politika destekleri sağlayan ülkelerdir (IEA, 2023: 8). Dolayısıyla, elde edilen sonuçların iki farklı

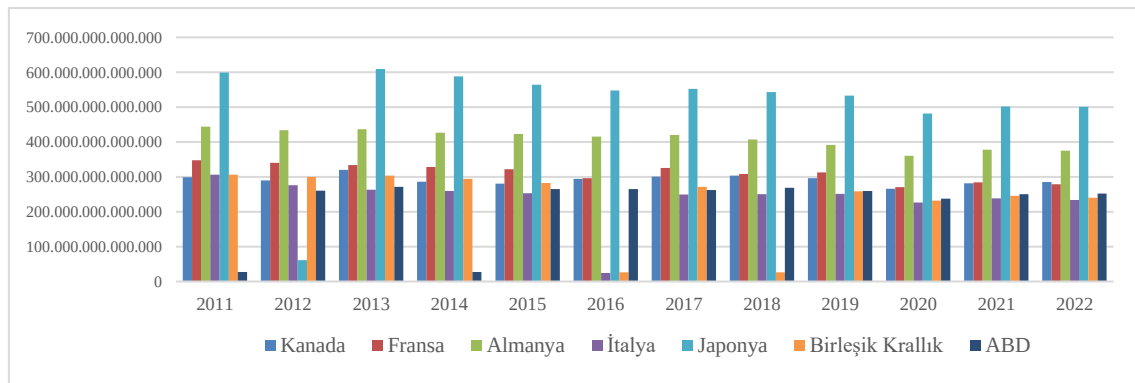
ülke grubu arasındaki benzerlikler ve farklılıklar açısından incelenmesi, çalışmanın önemli bir araştırma sorusunu oluşturmaktadır.

Bu çalışmada bağımsız değişken olarak ele alınan ekolojik ayak izi, doğa üzerinde insan faaliyetleri sonucunda ortaya çıkan talep ile doğal kaynak arzı arasındaki dengeyi ifade etmektedir. Bir ülkenin ayak izinin biyolojik kapasitesini aşması halinde ekolojik açık söz konusu olmaktadır. Bu açık ne kadar fazla ise küresel ekosistem üzerinde bozulma riski o kadar şiddetli olmaktadır. Bu durum sürdürülebilirlik açısından önemli bir tehlikeye işaret etmektedir (Kitzes vd. 2007: 8).

Ekolojik ayak izi verileri, GFN tarafından yıllık olarak yayınlanmakta olup günümüzde sürdürülebilirlik ölçütü olarak sıklıkla kullanılmaktadır (Footprint Standarts, 2009). Ekolojik ayak izi bileşenleri yapıli arazi, karbon, tarım alanı, balıkçılık alanları, orman arazisi, otlak alan verilerinden oluşmaktadır (Kitzes vd. 2007: 5). BRICS ve G7 ülkelerine ait ekolojik ayak izi verilerinin görünümü sırasıyla Şekil 1 ve Şekil 2’te verilmiştir.



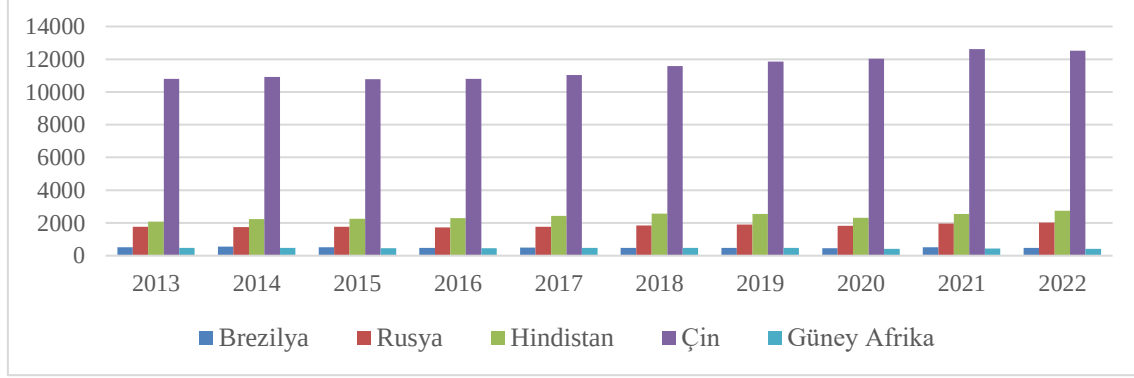
Şekil 1. BRICS Ülkeleri Toplam Ekolojik Ayak İzi Verileri (2013-2022)
Kaynak: Global Footprint Network, Footprints Data.



Şekil 2. G7 Ülkeleri Toplam Ekolojik Ayak İzi Verileri (2013-2022)
Kaynak: Global Footprint Network, Footprints Data.

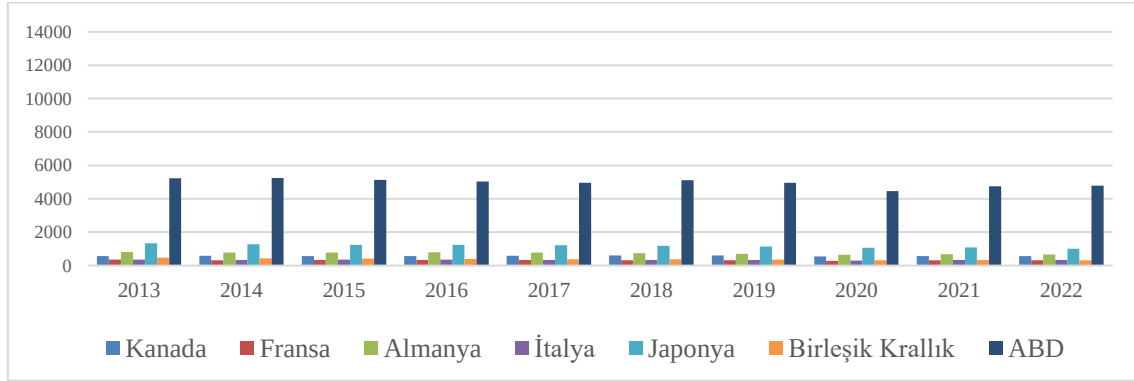
Küresel ısınmayı artıran tüm sera gazı bileşenleri içinde en yüksek pay karbondioksit (CO₂) aittir. Bu çalışmada yer alan diğer bağımsız değişken Dünya Bankası’ndan elde edilen karbon emisyonu toplam CO₂ emisyonu (kt) verisiyle ölçülmektedir. Bunlar arazi kullanım

deęiřiklięi ve ormancılık kaynaklı emisyon verilerinin dahil olmadıęı kresel karbon emisyonu verilerinden oluřmaktadır. řekil 3 ve řekil 4 sırasıyla BRICS ve G7 lkelerinin karbon emisyonu verilerine iliřkin genel bir grnm sunmaktadır.



řekil 3. BRICS lkeleri CO₂ Emisyon Verileri (2013-2022)

Kaynak: World Bank (2024a) World Development Indicators.

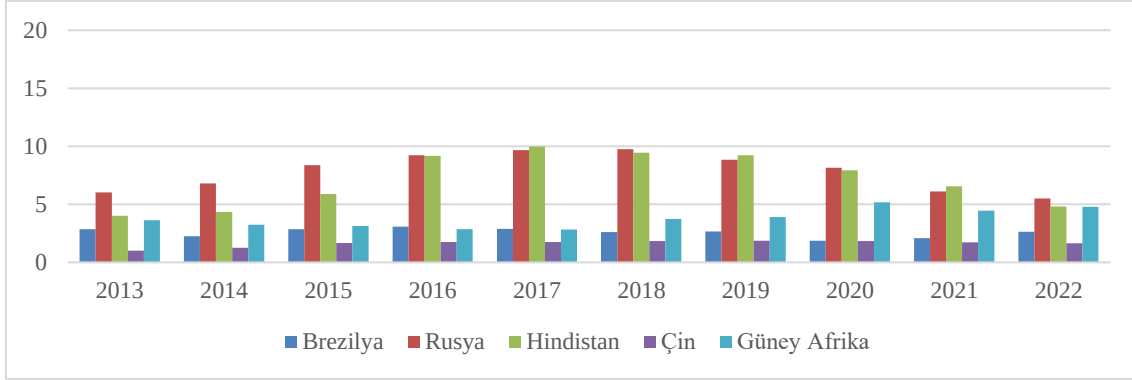


řekil 4. G7 lkeleri CO₂ Emisyon Verileri (2013-2022)

Kaynak: World Bank (2024a) World Development Indicators.

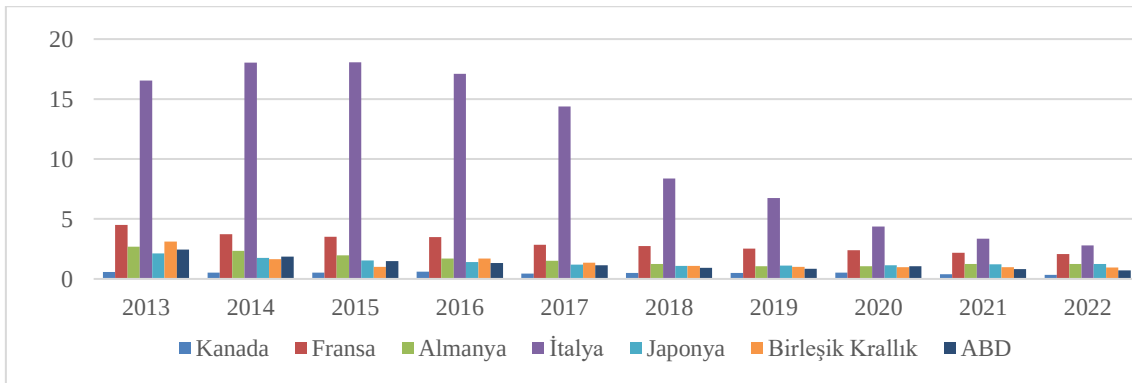
Bu alıřmada baęımlı deęiřken, bankaların takipteki kredi oranları olarak belirlenmiřtir. Takipteki kredi oranları, bankalarda kredi risk ynetimi ve bilanolarının saęlıęı aısından son derece nemli bir gstergedir. Yksek oranlar, aktif kalitesinde bozulma anlamına gelmekte olup, finansal sistemin istikrarına ynelik risklere iřaret etmektedir. Bu nedenle bankalar, kredi portfy ynetimi ve sorunlu kredi oranlarının makul dzeyde tutulması iin uygulamalar geliřtirmelidir (Eyraud vd., 2021: 25-32).

Son olarak, alıřmada baęımlı deęiřken olarak ele alınan bankacılık sektrnde toplam krediler iinde takipteki kredi oranının seyri, BRICS ve G7 lkeleri iin sırasıyla řekil 5 ve řekil 6'da gsterildięi gibidir. Veriler incelendięinde BRICS grubunda takipteki kredi oranının en dřk Çin'de, en yksek takipteki kredi oranının ise yıllara gre deęiřmekle birlikte Hindistan ve Rusya'da olduęu grlmektedir. G7 lkelerinde ise en yksek takipteki kredi oranları İtalya'da, en dřk oranlar Kanada'da grlmektedir.



Şekil 5. BRICS Ülkeleri Takipteki Kredilerin Toplam Kredilere Oranı (%) (2013-2022)

Kaynak: World Bank (2024), Global Financial Development.



Şekil 6. G7 Ülkeleri Takipteki Kredilerin Toplam Kredilere Oranı (%) (2013-2022)

Kaynak: World Bank (2024), Global Financial Development.

5. Yöntem ve Bulgular

Analiz kapsamında, eğim katsayılarının homojenliği test edilmiştir. Analizler gerek sabit etkiler modeli gerekse rassal etkiler modeli ile gerçekleştirilmiştir. Daha sonra Hausman testi ile söz konusu sabit etkiler modeli ve rassal etkiler modelinden analiz için uygun olanın belirlenmesi amaçlanmıştır. Değişen varyans sınaması ve otokorelasyon sınaması yapılmıştır. Değişkenlerde yatay kesit bağımlılığının varlığı araştırılmıştır. Sabit etkiler modeli ve rassal etkiler modelinden hangisinin analiz için uygun olduğunun belirlenmesi amacıyla Hausman testi yapılmıştır. Değişen varyans, otokorelasyon ve yatay kesit bağımlılığı durumu sonucunda dirençli tahminin yapılması sağlanmış ve karbon ayak izi ve ekolojik ayak izinin BRICS ve G7 ülkelerinde banka aktif kalitesine etkisi analiz sonuçlarına göre değerlendirilmiştir.

Analizde ilk önce eğim katsayılarının homojenliğinin testi gerçekleştirilmiştir. Pesaran ve Yamagata (2008) tarafından geliştirilen homojenlik testinin ele alındığı Delta testi için hipotezler aşağıdaki gibidir.

H_0 : Eğim katsayısı homojendir.

H_1 : Eğim katsayısı homojen değildir. $\tilde{\Delta}$ ve $\tilde{\Delta}_{adj}$ test istatistikleri eşitlik (1) ve eşitlik (2) ile hesaplanmaktadır (Pesaran ve Yamagata, 2008: 57).

$$\tilde{\Delta} = \sqrt{N} \left(\frac{N^{-1} \tilde{S} - k}{\sqrt{2K}} \right) \quad (1)$$

$$\tilde{\Delta}_{adj} = \sqrt{N} \left(\frac{N^{-1} \tilde{S} - E(\tilde{z}_{it})}{\sqrt{Var(\tilde{z}_{it})}} \right) \quad (2)$$

Burada, $E(\tilde{z}_{iT}) = k$, $Var(\tilde{z}_{iT}) = \frac{2k(T-k-1)}{T+1}$

Tablo 3'te sonuçları verilen Delta testi analizine göre hem BRICS hem de G7 için eğitim katsayılarının homojen olduğu belirlenmiştir.

Tablo 3. Delta Testi Analiz Sonuçları

	BRICS		G7	
	İstatistik	p	İstatistik	p
Delta	0.685	0.493	0.020	0.984
adj	0.969	0.333	0.029	0.977

Panel veri modeli genel olarak eşitlik (3)'te verildiği gibi yazılabilmektedir. Panel veri modelinin sabit ve rassal etkiler modeli yardımıyla ifadesi eşitlik (4) ve eşitlik (5)'te yer almaktadır (Yerdelen Tatoğlu, 2016: 4, 80, 103). Sabit etkili ve rassal etkili modellerin kullanımına ilişkin model tercihi Hausman testi kullanılarak yapılmaktadır. Hausman testinin test istatistiği eşitlik (6)'da yer almaktadır (Güriř, 2015: 37).

$$Y_{it} = \alpha_{it} + \beta_{it} X_{it} + u_{it} \quad j=1,...,N; t=1,...,T \quad (3)$$

$$Y_{it} = \beta_{0i} + \sum_{k=1}^K \beta_k X_{kit} + u_{it} \quad (4)$$

$$Y_{it} = \beta_{0i} + \sum_{k=1}^K \beta_k X_{kit} + (\mu_i + u_{it}) \quad (5)$$

$$HS = (\hat{\beta}_{SE} - \hat{\beta}_{RE})' (Var(\hat{\beta}_{SE} - \hat{\beta}_{RE}))^{-1} (\hat{\beta}_{SE} - \hat{\beta}_{RE}) \quad (6)$$

Panel veri analizinin gerçekleştirilmesi noktasında, sabit etkiler modeli ile rassal etkiler modeli arasında analiz için uygun olanın belirlenmesi amacıyla Hausman testi gerçekleştirilmiştir. Hausman testine ilişkin hipotezler řu řekilde sıralanabilir.

H₀: Rassal etkiler modeli geçerlidir.

H₁: Sabit etkiler modeli geçerlidir.

Tablo 4. Hausman Test Sonuçları

BRICS	Prob > chi2 = 0.9998
G7	Prob > chi2 = 0.0137

Test sonucuna göre BRICS ülkeleri için rassal etkiler modelinin geçerli olduğunu belirten H_0 hipotezi kabul edilmiş, G7 ülkeleri için ise H_0 hipotezi reddedilmiştir. Buna göre Hausman testi sonuçlarına göre, karbon ayak izi ve ekolojik ayak izinin banka aktif kalitesine etkisinin belirlenmesinde, BRICS ülkelerinde rassal etkiler ve G7 ülkelerinde sabit etkiler modelinin geçerli olduğu belirlenmiştir.

Panel veri analiz sonuçlarının etkinliğinin sağlanması noktasında heteroskedasite, otokorelasyon ve birimler arası korelasyon testleri yapılmalıdır. Yatay kesit birimler içinde hata süreci homoskedastik olduğunda varyansın birimlere göre değişebilmesi durumuna birimlere göre heteroskedasite denilmektedir (Yerdelen Tatoğlu, 2016: 220).

Rassal etkiler modelinde heteroskedasitenin sınanması, eş varyans uyup uymadığını test etmek için önerilen testler Levene (1960) ve Brown ve Forsythe (1974) testleridir (Yerdelen Tatoğlu, 2016: 235; Ün, 2015: 72). Heteroskedasitenin sınanmasında sabit etkiler modelinde değiştirilmiş Wald testi ele alınmıştır. Temel hipotezler şu şekildedir. (Yerdelen Tatoğlu, 2016: 220, 236).

H_0 : Varyanslar birimlere göre homoskedastiktir (eşittir). ($\sigma_i^2 = \sigma^2$)

H_1 : Varyanslar birimlere göre heteroskedastiktir (değişmektedir). ($\sigma_i^2 \neq \sigma^2$)

Bu doğrultuda Hausman testi sonucunda rassal etkiler modelinin geçerli olduğu BRICS ülkeleri için Levene, Brown ve Forsythe testi ve sabit etkiler modelinin geçerli olduğu G7 ülkeleri için ise değiştirilmiş Wald testi ile yapılan değişen varyans sınaması sonuçları Tablo 5’te yer almaktadır. Tablo 5’te verilen değerler ele alındığında BRICS ve G7 ülkeleri için H_0 hipotezi reddedilmekte, varyansın birimlere göre değiştiği ($\sigma_i^2 \neq \sigma^2$) görülmekte, diğer ifade ile birimlere göre değişen varyans sorununun olduğu sonucuna ulaşılmaktadır.

Tablo 5. Değişen Varyans Sınaması Sonuçları

BRICS		G7
W0= 13.3355	Pr>F=0.00000	chi (7) = 18855.19 Prob > chi2 = 0.0000
W50= 11.640424	Pr>F=0.00000	
W10=13.189839	Pr>F=0.00000	

Sabit ve rassal etkiler modelinde otokorelasyonun tespiti için Bhargava, Franzini ve Narendranathan tarafından önerilen Durbin Watson ve Baltagi-Wu’nun LBI testi ele alınmaktadır (Ün, 2015: 74). Temel hipotezler şu şekildedir (Yerdelen Tatoğlu, 2016: 237).

H_0 : Otokorelasyon katsayısı sıfıra eşittir.

H_1 : Otokorelasyon katsayısının sıfıra eşit değildir.

Tablo 6. Otokorelasyon Sınaması Sonuçları

BRICS	G7
Bhargava vd. Durbin Watson = 0.4865202	Bhargava vd. Durbin Watson = 0.26732593
Baltagi-Wu LBI = 0.82588548	Baltagi-Wu LBI = 0.52243298

Durbin Watson ve Baltagi-Wu’nun yerel LBI test istatistiklerine göre literatürde test istatistiklerinin 2’den küçük olması durumunda otokorelasyonun varlığından bahsedilmektedir

(Yerdelen Tatoęlu, 2016: 226). Tablo 6’da görüldüęü üzere, her iki testin deęerinin kritik deęer 2’den oldukça düşük olması modelde otokorelasyonun varlıęını ortaya koymaktadır.

Hata terimlerinin birimlere göre bağımsız olması, panel veri modelinin varsayımlarından biri olup, birimler arası korelasyonun varlığı ele alınmalıdır. Yatay kesit bağımlılıęını test etmek için rassal etkili modelde Frees testi, sabit etkiler modelinde test Breusch Pagan Lagrange Çarpanı (1980) testi ele alınacaktır (Ün, 2015: 77, 78). Yatay kesit bağımlılıęına ilişkin hipotezler ařağıdaki gibidir.

H_0 : Birimler arası korelasyon bulunmamaktadır.

H_1 : Birimler arası korelasyon bulunmaktadır.

Tablo 7. Yatay Kesit Bağımlılıęı Testi Sonuçları

BRICS	G7
Frees’ test = 0.595	
alpha=0.10 : 0.2559	Breusch-Pagan LM test chi2(21) =40.025
alpha=0.05 : 0.3429	Prob=0.0074
alpha=0.01 : 0.5198	

Tablo 7’de BRICS ülkeleri için Frees’ test yatay bağımlılık test istatistięi olan 0.595’in %90, %95 ve %99 güven düzeylerinde kritik deęerlerden yüksek olması (0.595>0.5198) nedeniyle (Yerdelen Tatoęlu, 2016: 233) birimler arası korelasyonsuzluęu iřaret eden H_0 hipotezi reddedilmektedir. G7 ülkeleri için Tablo 7’de yer alan sonuçlara göre, $p<0.01$ olması sebebiyle H_0 hipotezi reddedilmektedir. Buna göre G7 ülkeleri için de birimler arası korelasyon, yatay kesit bağımlılıęı vardır.

Panel veri modelinde heteroskedasite, otokorelasyon ve birimler arası korelasyon olduęu varsayımı altında dirençli standart hatalar ile hesaplanan istatistiklere göre tahminin yapılmasını saęlayan (Yerdelen Tatoęlu, 2016: 279) Driscoll ve Kraay (1998) tahmincisi ile analiz yapılmıřtır. Analizlere ilişkin sonuçlar Tablo 8’de yer almaktadır. BRICS ülkeleri için ekolojik ayak izi ve karbon emisyonunun banka takipteki kredi oranı üzerindeki etkisi anlamsızdır. GSYİH’deki artışın ise negatif etkisi bulunmaktadır. G7 ülkeleri için de ekolojik ayak izinin banka takipteki kredi oranı üzerindeki etkisi anlamsızdır. Banka takipteki kredi oranına, karbon emisyonunun pozitif yönlü, GSYİH’deki büyümenin ise negatif yönlü etkisinin bulunduęu belirlenmiřtir.

Tablo 8. Ekolojik ve Karbon Ayak İzi ile GSYİH’deki Büyümenin Takipteki Kredi Oranına (TKR) Etkisine İliřkin Sonuçlar

	BRICS	G7
EKA	0.289 (0.283)	-1.495 (0.117)
CO ₂	0.216 (0.955)	29.972 (0.000)***
GSYH	-0.074 (0.010)***	-0.158 (0.079)*

Not: *0.10’da anlamlı. *** 0.01’de anlamlı

Sera gazı emisyonuna ilişkin belirlenen sonuçlar doęrultusunda, çevresel sürdürülebilirlięi de engellemesi doęrultusunda sera gazı emisyonunun G7 ülkelerinde aktif kalitesine olumsuz etki

ettiği söylenebilir. Bankacılık sisteminin nihai olarak da ekonominin çevresel sürdürülebilirlikle göz ardı edilmez ilişkisi ele alındığında çalışmanın sonuçları, bankacılık aktif kalitesinin artırılması noktasında reel sektör başta olmak üzere çevresel düzenlemeler üzerine politikalar ve düzenlemeler yapılmasının gerekliliğine işaret etmektedir. Öte yandan BRICS ülkelerinde sera gazı emisyonunu aktif kalitesine etkisinin bulunmaması, ilgili ülkelerde finansal sürdürülebilirlik çalışmalarının yürütülmesine nispi olarak kısıtlı yönelimin bulunduğu ve bu kapsamda bankacılık yapısına etkisinin de bulunmaması ile açıklanabilir.

Ekolojik ayak izi değişkeni etkisi incelendiğinde, karbon ayak izinin bankacılık aktif kalitesine olumsuz etkisinin bulunmasına karşın, toplamında karbon ayak izini de bulunduran ekolojik ayak izinin aktif kalitesinde etkisinin olmadığı görülmüştür. Bu durum, CO₂ emisyonu ile ifade edilen karbon ayak izinin banka aktif kalitesine etkinin bulunduğu ancak ekolojik ayak izi bileşenleri içinde yer alan karbon ayak izinin toplam içinde nispi olarak düşük bir yüzdeye sahip olması nedeniyle, ekolojik ayak izinin aktif kalitesine etkisinde belirleyici olamadığı şeklinde ele alınabilir.

İklim değişikliğinden kaynaklanan riskler; fiziksel riskler ve düşük karbon ekonomisine geçiş riskleri olarak sınıflandırılabilir. Fiziksel riskler çerçevesinde, hava sıcaklıklarında artış, yağış düzenindeki değişimler ve deniz seviyesinin yükselmesi, sel, orman yangını ve kuraklık gibi riskler ve değişen iklim koşulları işletmelerin varlıklarına, üretim süreçlerine ve tedarik zincirlerine etki edebilmekte, bu da işletme maliyetlerinde artışa ve pazar kaybına yol açabilecektir. Geçiş riskleri açısından ise iklim politikaları, teknoloji, tüketici tercihleri ve finansal piyasa beklentilerindeki değişimler, maliyetleri artırıcı etki yapabilmektedir (TSKB, 2021: 8). Bunun sonucunda işletme gelirlerinde ve ödeme güçlerinde kayba ve dolayısıyla finansal sistemde ve ekonominin bütününde olumsuzluklara neden olabilecektir.

Bu doğrultuda, firmaların yenilenebilir enerji yatırımlarını artırarak, sera gazı salınımlarını azaltmalarının yanı sıra bankaların kredilendirme politikalarında sürdürülebilirlik hedeflerini gözetmelerinin gerekliliği anlaşılmaktadır. Bu amaçla, yoğun karbon riski barındıran projeler yerine, çevreci faaliyetlerin bankalarca desteklenmesi önemlidir.

6. Sonuç ve Öneriler

Bankalar, finansal sistemin önemli aktörleri olmakla birlikte, iklim değişikliğinin doğrudan ve dolaylı etkileneni konumundadır. Karbon emisyonu gibi iklim değişikliği riskleri, bankalarda kredi riski ve aktif kalitesini önemli ölçüde etkileyebilmektedir. Bu etki esas olarak, firmaların artan maliyetleri, kârlılık baskısı ve yaşanan kırılganlıklarla ödeme güçlüğüne düşmeleriyle ortaya çıkmaktadır. Bu gibi etkiler neticesinde bankacılık sektöründe takipteki kredi oranları artmaktadır. Dolayısıyla, iklim kaynaklı riskler yalnızca çevresel etkilere yol açmamakta; aynı zamanda bankaların aktif kalitesi yönetimini doğrudan etkileyen bir unsur olmaktadır.

Bu çalışmada, BRICS ve G7 ülkelerinde iklim değişikliğinden kaynaklanan risklerin bankaların aktif kalitesi üzerinde etkileri sorunlu krediler üzerinden incelenmiş; söz konusu riskler karbon emisyonu ve ekolojik ayak izi değişkenleri ile ölçülmüştür. Elde edilen bulgular, G7 ülkelerinde karbon ayak izinin (CO₂ emisyonu) bankaların takipteki kredi oranı üzerinde pozitif bir etkisi olduğunu ortaya koymuştur. Bu kapsamda G7 ülkelerinde karbon emisyonunun artmasının takipteki kredi oranını artıracağı, aktif kalitesini ise azaltacağı anlaşılmaktadır. İklim değişikliğinin sebep olacağı kuraklık ve doğal afetler şeklinde sıralanabilecek çevresel sorunların

evvela firmaların faaliyet sonuçlarına ve dolayısıyla finansal istikrarına olumsuz etki edeceđi söylenebilir.

Çalıřmada elde edilen bu bulgular, Thomson (1998), Sugiarto vd. (2023) çalıřmalarında iklim risklerinin bankacılık sektöründe geri ödenme riski üzerinde etkilerini gösteren bulgularıyla örtüşmektedir. Aynı zamanda, firmalar üzerinde incelenen Chava (2011), Dafermos vd. (2018), Jung vd. (2018), Lamperti vd. (2018), Carbone vd. (2021), Kling vd. (2021), Kabir vd. (2021), Çokmutlu ve Özen (2023), Owalabi vd. (2024) gibi çalıřmaların bulgularını destekler niteliktedir. Söz konusu çalıřmalarda, iklim deđiřikliđi risklerinin firmaların ödeme güçlüğüne düşme olasılıđını artırdıđı ve bu durumun finansman sıkıntısına yol açtıđı vurgulanmaktadır. Bu çalıřmada ulařılan bulgular ise, iklim kaynaklı risklerin finansal aracılık mekanizması üzerinden bankacılık sistemi üzerinde etkisini göstermektedir.

Literatürde yer alan iklim risklerini inceleyen çalıřmalar genellikle tek bir bölge veya ülkeye odaklanırken, bankacılık sektörü özelinde gerçekteřirilen çalıřmalar nispeten sınırlıdır. Bu çalıřmada mevcut literatüre katkı olarak daha genellenebilir ve küresel sonuçların elde edilmesi, makro etkilerden mikro çıkarımlarda bulunulması amaçlanmıřtır. Ek olarak, farklı dinamiklere sahip iki büyük küresel ekonomik güç sayılan BRICS ve G7 ülkelerinin incelenmesi, küresel finansal sistem üzerindeki çevresel etkilerin daha iyi anlařılması bakımından önemlidir.

Bankalarda aktif kalitesi riskleri yönetilmesi gereken en önemli risk unsurlarından biri olmakla beraber bankacılık sektöründe oluřabilecek krizler, tüm ekonomi için yıkıcı etkilere yol açabilmektedir. Bu çalıřma, küresel düzeyde karbon yoğun sektörlerin kredi portföylerindeki risklere yönelik farkındalıđı artırmayı amaçlamaktadır. Yeřil ekonomi ile uyumlu çalıřmayan işletmeler ve ayrıca finansal kurumlar geçiř riskleri ile karřılařacaklardır. İklım deđiřikliđinden kaynaklanan risklerin mikro olarak işletmeleri, makro düzeyde ise küresel finansal istikrarı tehdit ettiđi gün geçtikçe daha fazla kabul görmektedir. Sürdürülebilirlik konusunda finansal kurumların konuya verdiđi önemin artırılması ve kapasite gelişiminin sađlanabilmesi, paydař durumunda olan reel sektörü de etkileyecektir. Bu kapsamda çevre dostu projeler sunan firmaların karbon risklerinin analiz edilerek kredi faiz oranı vb. iyileřtirmelerin sađlanması, kısa vadede firmaları söz konusu avantajdan yararlanmak noktasında yönlendirecek, uzun vadede ise çevresel bilincin oluřması, çevre dostu projelerin yapılanması, finansal sistem ve ekonominin bütününün olumlu etkilenmesine neden olacaktır. Yeřil finansmanın teřvikinde para piyasasının yanı sıra sermaye piyasası araçlarının da benzer bilinçle hareket etmesi önem arz etmektedir. Sonuçlar, genel olarak karbon salınımının politika yapıcılar tarafından dikkate alınmaya deđer olduđunu göstermektedir.

G7 ülkelerinde karbon salınımının takipteki kredi oranları üzerinde pozitif etkisi görölmesine karřın, BRICS ülkelerinde anlamlı bir etki gözlenmemiřtir. Bu sonuç, gelişmekte olan ülkelerde çevresel risklerin henüz finansal göstergeler üzerinde belirgin bir etki oluřturmadıđını düşündürmektedir. Genel olarak bulgular, karbon riskleri ve çevresel sürdürülebilirliđin gelişmiş ülkelerde finansal sistemin önemli bir bileřeni olduđunu; gelişmekte olan ülkelerde ise bu entegrasyonun henüz gelişim ařamasında olduđuna iřaret etmektedir. Bu da çevresel göstergelerin finansal sisteme yansımalarının ülke gruplarına göre farklılařtıđını ortaya koymaktadır. Ek olarak sonuçlar hem BRICS hem de G7 ülkelerinde ekonomik büyümenin bankalarda takipteki kredi oranlarını negatif etkilediđini, bir bařka ifadeyle aktif kalitesini iyileřtiđini göstermektedir. Bu durum ekonomik kořullar iyileřtikçe kredi riskinin azaldıđı ve bankacılık sisteminin daha sađlıklı hale geldiđine iřaret etmektedir.

Son olarak, bu çalışmanın bazı kısıtları bulunmaktadır. Öncelikle, sürdürülebilir finans ve iklim risklerine ilişkin farklı verilerin incelenen ülkeler özelinde sürekli ve düzenli olarak elde edilememesi, analizde yer alan değişken çeşitliliğini sınırlandırmıştır. Ek olarak, çalışmada kullanılan değişkenlere ait verilere 2022 yılı sonuna kadar ulaşılmaktadır. Bu tarihten sonra güncel ve sürekli verilerin bulunmayışı çalışmanın bir diğer kısıtını oluşturmaktadır.

Bu bağlamda gelecek çalışmalarda, bu inceleme, analiz döneminin genişletilmesi ile daha uzun vadeli etkilerin gözlemlenmesine olanak tanıyabilir. Ayrıca, gelişmiş ülkelerdeki sera gazı emisyonlarının ve ekolojik ayak izinin bankaların aktif kalitesi üzerindeki etkisinin belirlenmesi için yatay kesit yapısının değiştirilmesi önerilmektedir. Son olarak, yenilenebilir enerji yatırımları, yeşil tahvil ihracı gibi sürdürülebilir finansman göstergeleri, doğal afetler ve sıcaklık artışı gibi fiziksel risklerin modele dâhil edilmesi ilgili literatürün zenginleşmesine katkı sağlayabilir. Bu analiz ise, söz konusu değişkenlere ait uzun vadeli verilerin ilgili ülkeler için erişilmesiyle mümkün olacaktır.

Araştırma ve Yayın Etiği Beyanı

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Araştırmacıların Katkı Oranı Beyanı

Yazarlar makaleye eşit oranda katkı sağlamış olduklarını beyan eder.

Araştırmacıların Çıkar Çatışması Beyanı

Bu çalışmada herhangi bir potansiyel çıkar çatışması bulunmamaktadır.

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THE EFFECT OF CLIMATE CHANGE RISKS ON THE BANKING SECTOR: A CASE STUDY OF THE BRICS AND G7 COUNTRIES

EXTENDED SUMMARY

Purpose of the Study

As the risks of climate change, which began with the Industrial Revolution, grow by the day, sustainable development and sustainable finance goals are coming to the fore. The study aims to contribute to studies on the relationship between banking, finance, and sustainability by highlighting the indirect effects of important sources of climate-related risk on companies. In addition, the study aims to contribute to the literature by examining BRICS countries with high carbon emissions and G7 countries with stricter environmental regulations, focusing on the differences between developed and developing countries in terms of economic and environmental dynamics. The expected result of the study is that carbon intensity has a negative impact on banks' asset quality, and that banks' credit policies should be regulated by considering environmental risks.

Literature

Studies focusing specifically on banks are relatively limited; however, their findings are significant. These studies generally reveal that climate-related risks increase the credit risk exposure of banks. Thomson (1998) highlighted that while environmental issues can heighten credit risk, environmentally friendly investments may also create new credit opportunities. Furthermore, empirical studies conducted in diverse economies such as Brazil, Indonesia, Canada, and Turkey demonstrate that environmental risks and climate-related events increase credit default rates and negatively impact credit allocation processes. Coulson and Monks (1999) emphasized the requirement for banks to consider environmental impacts in their lending decisions, while Weber (2012) reported that Canadian banks regard environmental factors as important financial risk components in their credit evaluation processes. Miah et al. (2021) examined the impact of carbon emissions on financial and non-financial firms in 22 developing countries and found that carbon emissions negatively affect credit ratings. Oliveira (2022) investigated the effects of climatic events on BNB Bank loans in Brazil over the period 2002–2013. Using panel data analysis, the study found that deviations in average annual temperature and precipitation significantly increased default rates. Aslan et al. (2022) explored how banks in Turkey respond to climate risks at the provincial level. The study's findings indicate that banks consider climate change risks and adjust their credit allocation processes accordingly. The comparison between BRICS countries and G7 countries, where environmental regulations are more stringent, aims to make a unique contribution to the literature by analyzing the differences in economic and environmental dynamics between developed and developing countries.

Data and Method

This study aims to investigate whether climate change affects the credit risk of banks in BRICS and G7 countries, focusing on non-performing loans. Using panel data analysis, the study

examines the period from 2013 to 2022. In this context, a 10-year time frame is analyzed through panel data analysis, where cross-sectional units consist of BRICS and G7 countries observed over time. Data obtained from the World Bank and GFN (Global Footprint Network) websites.

Findings

In BRICS countries, the effect of ecological footprint and carbon emissions on bank non-performing loan ratio is insignificant. The increase in GDP has a negative effect. In G7 countries, the effect of ecological footprint on bank non-performing loan ratio is insignificant. Carbon emission has a positive effect on bank non-performing loan ratios, while GDP growth has a negative effect. Ecological footprint does not appear to be a determinant of asset quality, as the carbon footprint, which is a component of the ecological footprint, constitutes a relatively low percentage of the total. Although carbon emissions have a positive effect on non-performing loan ratios in G7 countries, no significant effect is observed in BRICS countries. This result suggests that environmental risks have not yet had a significant impact on financial indicators in developing countries.

Conclusion

The comparison between the two major global economic powers, BRICS and G7, is important for a better understanding of the environmental impacts on the global financial system. Asset risk is one of the most important risk factors for banks to manage. Crises in the banking sector may have a devastating impact on the economy as a whole. This study aims to raise awareness of the risks associated with loan portfolios in carbon-intensive sectors on a global scale. Increasing the emphasis on sustainability by financial institutions and ensuring capacity development will also impact the real sector, which is a key stakeholder. In this context, analyzing the carbon risks of companies that offer environmentally friendly projects and providing incentives such as preferential loan interest rates will encourage firms to take advantage of these benefits in the short term. In the long term, this will promote environmental awareness, support the development of green projects, and positively influence both the financial system and the overall economy. In conclusion, banks should reorganize their risk management activities to include environmental risks. The issue should be tackled with a holistic approach, and methods should be implemented to encourage banks, regulators, governments, and firms to develop their policies in this direction.