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EXPLORING THE IMPACTS OF FINANCIAL FAILURE RISK ON SUSTAINABLE GROWTH POLICIES: EVIDENCE FROM THE BIST SUSTAINABILITY INDEX COMPANIES*

Finansal Başarısızlık Riskinin Sürdürülebilir Büyüme Politikaları Üzerindeki Etkileri: BIST Sürdürülebilirlik Endeksi Şirketlerinden Kanıtlar

Fatih GÜZYURDU [**] **& Serdar YAMAN** [***]

Keywords:
Sustainable Growth, Financial Failure Risk, BIST Sustainability Index, Panel Data Analysis

JEL Codes:
C33, G32, G33, Q56

Abstract

This study investigates the impacts of financial failure risk on firms' sustainable growth policies using econometric analysis and aims to identify suitable financial failure models for the sustainable growth policies developing process. The study covers data from 38 non-financial firms listed in the Borsa Istanbul Sustainability Index (XUSRD) for 2010-2022. Sustainable growth is calculated by Higgins's (1977) sustainable growth rate (HSGR), while financial failure risks are assessed through Altman's (1983) Z'-score, Springate (1978) S-score, Taffler (1983) T-score, Fulmer et al. (1984) H-score and Legault (1987) CA-score models. The econometric approach employs a five-stage panel data methodology, including the pre-tests of multi-collinearity, cross-sectional dependency, slope homogeneity, stationarity, autocorrelation, and heteroskedasticity. Panel regression results reveal positive relationships between financial success and sustainable growth. However, the statistical significance of these relationships varies across different financial failure models. The effects of T and H-scores are statistically significant, whereas Z', S, and CA-scores do not exhibit statistically significant effects. Consequently, the findings suggest that T and H-score models should be prioritized in sustainable growth policy development.

Anahtar Kelimeler:
Sürdürülebilir Büyüme, Finansal Başarısızlık Riski, BIST Sürdürülebilirlik Endeksi, Panel Veri Analizi

JEL Kodları:
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Öz

Bu çalışma, finansal başarısızlık riskinin firmaların sürdürülebilir büyüme politikaları üzerindeki etkilerini ekonometrik analiz yoluyla belirlemeyi ve sürdürülebilir büyüme politikaları geliştirme sürecinde kullanılabilecek uygun finansal başarısızlık modellerini tespit etmeyi amaçlamaktadır. Çalışma, Borsa İstanbul Sürdürülebilirlik Endeksi'nde (XUSRD) işlem gören finansal olmayan firmaların 2010-2022 dönemi verilerini kapsamaktadır. Sürdürülebilir büyüme politikaları Higgins (1977) sürdürülebilir büyüme oranı (HSGR) kullanılarak, finansal başarısızlık riskleri ise Altman (1983) Z'-score, Springate (1978) S-score, Taffler (1983) T-score, Fulmer ve diğerleri (1984) H-score ve Legault (1987) CA-score modelleri kullanılarak ölçülmüştür. Ekonometrik çerçeve çoklu doğrusal bağlantı, yatay kesit bağımlılığı, eğim katsayılarının homojenliği, durağanlık, otokorelasyon ve değişen varyans ön testleri ve panel regresyon analizi dahil olmak üzere beş aşamalı bir panel veri metodolojisi içermektedir. Panel regresyon sonuçları, finansal başarısızlık riski ile HSGR arasında pozitif ilişkiler olduğunu ortaya koymaktadır. Ancak, bu ilişkiler tüm finansal başarısızlık modelleri için istatistiksel olarak anlamlı değildir. Sonuçlar, Z', S ve CA skorlarının sürdürülebilir büyüme politikaları üzerinde istatistiksel olarak anlamlı etkilerinin olmadığını, T ve H skorlarının etkilerinin ise istatistiksel olarak anlamlı olduğunu göstermektedir. Bulgular, sürdürülebilir büyüme politikalarının geliştirilmesinde T-skor ve H-skor modellerinin diğer modellere göre tercih edilmesi gerektiğini göstermektedir.

* This study is derived from the master's thesis entitled "The Relationship Between Financial Failure Risk and Sustainable Growth: An Application on Istanbul Stock Exchange Sustainability Index" completed by Fatih Güzyurdu under supervision of Assoc. Prof. Dr. Serdar Yaman.

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1. Introduction

Climate change, global natural resource scarcity, extreme poverty, demographic shifts, and evolving economic and financial conditions profoundly influence how organizations envision the future (Karaçayır and Afşar, 2024). The concepts of corporate social responsibility (CSR) and corporate social performance (CSP) have gained prominence amid inquiries into companies' obligations to stakeholders beyond solely maximizing investor profits. There's a growing recognition of the significance of fostering a sustainable economy, preserving the environment, and nurturing a socially sustainable structure alongside traditional business objectives (Ateş, 2021a). The adoption of frameworks guiding sustainability efforts, including the Sustainable Development Goals, the UN Framework Convention on Climate Change, and the Paris Agreement, has catalyzed substantial transformations in the business landscape. This has accelerated the implementation of a new socioeconomic model known as environmental, social, and governance (ESG), signaling a shift towards more holistic and responsible business practices (Shih et al., 2023). According to Davis and Blomstrom (1975), CSR, as a managerial obligation, entails a company's efforts to promote, safeguard, and enhance societal welfare while also pursuing its own interests. Carroll (1979) categorizes a company's responsibilities into economic, legal, ethical, and discretionary realms, with CSR encompassing economic, environmental, and social obligations, as per Elkington's (1998) Triple Bottom Line approach. The measurement of companies' CSR initiatives has given rise to the concept of CSP (Ates, 2021a). CSP refers to the outcomes of companies' CSR activities and gauges the degree of active engagement in CSR initiatives (De Bakker et al., 2005; Conway, 2018). Companies that prioritize ESG sustainability activities can enhance firm value by effectively managing risks, proactively addressing regulatory requirements, accessing new markets, and concurrently fostering the sustainable development of the communities where they operate (Dmuchowski et al., 2023). Although companies may face upfront costs for CSR activities in the short term, they stand to reap long-term benefits that can significantly enhance company performance. These benefits include bolstered brand reputation, lowered expenses stemming from improved energy efficiency, competitive advantages, heightened employee productivity, and fortified relations with stakeholders and investors (Haanes et al., 2010).

Sustainability activities serve as guiding principles for businesses, encompassing environmental, social, and economic dimensions. The economic dimension of sustainability delves into the profit-making capacity and long-term viability of businesses. The social dimension underscores the notion that businesses are social entities and should actively address social issues rather than remain indifferent. Meanwhile, the environmental dimension directs businesses in minimizing resource wastage, mitigating environmental degradation, and safeguarding the living standards of future generations (Heybet and Duran, 2023). The concept of sustainable growth was introduced to ascertain and assess whether the growth attained by enterprises through their activities aligns with financial policies (Higgins, 1977). The concept of sustainable growth was first articulated by David Packard, the founder of Hewlett-Packard, in 1950 as the ability of a business to reach its targeted profit level without the need for any additional capital (Van Horne and Wachowicz, 2008). Essentially, the concept of sustainable growth embodies the optimal growth that firms can attain while considering environmental, social, and financial factors as integral components of economic and managerial sustainability.

Sustainable growth, a pivotal component of economic and governance sustainability, entails the optimal utilization of investments and resources to maintain ongoing economic

activities. Within competitive market environments, achieving growth targets stands as a primary objective for firms and a key indicator of performance. Sustaining growth necessitates firms' ability to adapt to economic, social, and environmental dynamics. Sustainable growth encompasses value management and the prudent allocation of financial resources to ensure continuity. While effective value and financial management can foster sustainable growth, erroneous value management strategies may precipitate financial distress (Ashraf et al., 2019). Decisions regarding sustainable growth-oriented policies carry significant weight, as missteps in policy formulation can compromise a company's financial performance, particularly in the short term (Modigliani and Pogue, 1974). Consequently, financing growth holds equal importance to achieving and sustaining growth. Although sustainability policies developed within the context of long-term planning may initially curtail firm profitability, they can confer substantial competitive advantages and bolster profitability in the long term (Şamiloğlu and Demirgüneş, 2008).

Sustainable growth is intricately linked to firms' management of resources in their growth endeavors, reflecting their commitment to sustainability. This concept can be quantified through various ratios across different dimensions. For instance, the growth achieved by firms without relying on external financial resources is termed the internal growth rate (IGR) (Amouzesh et al., 2011). On the other hand, the growth achieved by firms with a fixed borrowing rate and internal resources, without capital increment, is known as the sustainable growth rate (SGR) (Higgins, 2012). The evolution in the realm of finance, the proliferation of diverse financial products, and the enhancement of financing opportunities have heightened the significance of borrowing in growth strategies. The sustainable growth model (HSGR), pioneered by Robert C. Higgins in 1977, incorporates variables such as capital increment, autofinancing, and utilization of external resources, enabling a comprehensive analysis of growth dynamics. HSGR serves to compute the SGR and assess the alignment between an enterprise's targeted growth rate for the future and its established financing policy to achieve this target. In this model, inflation is disregarded, the existing depreciation structure is maintained, and it is assumed that businesses seeking to expand their sales will persist if market conditions remain favorable (Higgins, 1977).

Robert C. Higgins (1977) conceptualizes sustainable growth in firms as contingent upon dividend distribution, financing decisions, profitability, and productivity. Discrepancies between HSGR suggested by Higgins (1977) and actual growth rates (AGR) provide valuable insights into firms' growth trajectories and guide financing strategies. Firms with an HSGR below AGR encounter issues of overgrowth, while those with an HSGR surpassing AGR face challenge of slow growth. Overly rapid growth can strain financing capabilities and trigger financial distress costs, whereas slow or stagnant growth may lead to stagnation and an increased risk of financial failure. Consequently, the HSGR serves as a diagnostic tool to identify potential growth constraints in firms and assess the impact of financial performance on growth policies (Şahin and Ergün, 2018). The escalating risk of financial failure stemming from flawed financing policies, low financial performance, and diminished productivity precipitates financial distress, bankruptcy, and liquidation costs, potentially derailing firms from their sustainable growth trajectories.

A high risk of financial failure can erode investor and financial institution confidence in companies, making it challenging for them to access suitable sources of financing and constraining the resources necessary for sustainable growth (Platt et al., 1995). Furthermore, operational constraints such as cash flow challenges, supply chain disruptions, or cost overruns

can further impede growth for companies facing a high risk of financial failure. These companies may witness a deterioration in market reputation, declining customer loyalty, and encounter obstacles in penetrating new markets. Consequently, these developments can curtail the market opportunities crucial for sustainable growth. Financially robust companies often can invest more and foster innovation. Conversely, companies with a heightened risk of financial failure may struggle to make such investments, thereby diminishing their ability to sustain long-term growth (Raza et al., 2020). In this context, the risk of financial failure is anticipated to exert a negative impact on companies' SGRs. Implementing measures such as establishing a robust financial footing, adopting effective risk management strategies, and enhancing operational efficiency can assist companies in realizing their sustainable growth objectives (Fonseka et al., 2012; Raza et al., 2020). Therefore, it is important to examine the repercussions of financial failure risk on sustainable growth policies and determine the most suitable financial failure approach for firm managers, investors, and researchers to mitigate these risks and uphold sustainable growth objectives.

This study endeavors to assess the impact of financial failure risk on sustainable growth policies through rigorous econometric analyses. Additionally, it aims to identify financial failure models applicable to the development of sustainable growth policies, catering to the needs of stakeholders such as firm managers, researchers, and investors. Through econometric analyses, the study addresses two pivotal questions: (1) Is financial failure risk a critical consideration in the formulation of sustainable growth policies? This inquiry delves into whether factors such as firms' short-term debt obligations, financial distress costs, bankruptcy risks, capital structure decisions, and working capital management practices significantly influence the sustainability of growth policies. (2) Which financial failure risk model holds the utmost significance for both theorists and practitioners in fostering sustainable growth policies? The response to this question furnishes empirical evidence crucial for firm managers and investors in the process of developing sustainable growth policies. By addressing these questions, the study aims to provide actionable insights that can inform strategic decision-making processes and enhance the resilience and sustainability of firms' growth trajectories. To the best of our knowledge, this study represents the pioneering attempt to explore the implications of financial failure risks on sustainable growth policies in firms. While existing literature extensively investigates the relationships between sustainability performance and firm value, financial performance, and corporate governance factors, and inclusions of firms in sustainability indices (Altınay et al., 2017; Parlakkaya et al., 2019; Geçim, 2020; Sak and Dalgar, 2020; Acar et al., 2021; Korga and Aslanoğlu, 2022; Kulalı, 2022; Atichasari et al., 2023; Günay, 2023; Perdana et al., 2023), the relationship between the risk of financial failure and sustainable growth remains unexplored. This study distinguishes itself significantly from existing literature by elucidating the impact of financial failure risk on sustainable growth policies and identifying the most pertinent financial failure model applicable to the development of sustainable growth policies. By filling this gap in the literature, the study endeavors to enrich the understanding of the intricate dynamics between financial risk management and sustainable growth, offering practical guidance for stakeholders navigating the complexities of contemporary business environments.

The study utilizes data from non-financial firms listed in the XUSRD for the period 2010-2022, with regularly available data. The Sustainability Index serves as a gauge of enterprises' activities across economic, social, and environmental dimensions, as well as their responsiveness to these dimensions. Given that sustainable growth, the focal point of this study,

constitutes a component of economic sustainability, the study sample was comprised of XUSRD companies. Sustainable growth policies within firms are evaluated using Higgins's (1977) HSGR, while financial failure risks are assessed through Altman's (1983) Z'-score, Springate's (1978) S-score, Taffler's (1983) T-score, Fulmer et al.'s (1984) H-score, and Legault's (1987) Canada-CA score models. Since increases in the values calculated using the Z'-score, S-score, T-score, H-score, and CA-score models signify a reduction in the risk of financial failure for companies, while decreases indicate an escalation in risk, a positive relationship between these scores and HSGR is anticipated. This study is expected to offer original insights and contribute significantly to the academic literature by identifying the most suitable failure model for assessing the risk of financial failure during the development of sustainable growth policies. Moreover, it aims to uncover the diverse impacts of financial failure models on sustainable growth policies. The study is structured into five main sections. Section 1 outlines the theoretical framework and research questions. Section 2 reviews the relevant academic literature. Section 3 details the data, variables, and methodology employed in the analysis. Section 4 presents the findings, evaluations, and discussions. Finally, Section 5 offers insights, conclusions, and policy recommendations.

2. Literature Review

The rising importance of sustainable development, with its ESG dimensions, compels firms to accord significance to non-financial activities. Sustainable growth objectives, integral to governance sustainability, exhibit substantial correlations with financial activities such as working capital management, capital structure decisions, dividend pay-out decisions, and financial performance. However, the implications of financial activities on long-term sustainability policies, and consequently on sustainable development, often remain overlooked. A review of the relevant literature underscores a notable upsurge in studies scrutinizing the relationship between financial decisions and sustainability in recent years. This section succinctly summarizes recent studies exploring the financial aspect of sustainable growth, the relationship between sustainability performance and financial variables, and the evolution of the concept of sustainable finance along with their key findings based on their respective scopes.

The literature review indicates a scarcity of studies that have explored the financial aspect of sustainable growth. Examining sustainable growth policies in companies, Niu (2016) underscored the necessity of examining the relationship between financial structure and sustainable growth. Within the framework of financial hierarchy theory, Niu (2016) investigated sustainable growth policies in firms utilizing the Higgins (1977) model. Soytaş et al. (2017) delved into the impact of sustainability on the financial performance of Turkish companies. Their research uncovered evidence of a positive relationship between sustainable growth and financial performance. Şahin and Ergün (2018) conducted a study examining the relationship between AGR and SGR differences in financial ratios in publicly traded manufacturing firms. Their objective was to determine the most influential components of SGR. Their findings revealed a negative correlation between the difference of AGR-SGR and return on assets (ROA), as well as return on equity (ROE). Furthermore, they identified profit margin as the most significant component of SGR in influencing this relationship. Raza et al. (2020) investigated the relationship between financial failure risk and sustainable growth by employing the Higgins (1977) SGR models, along with the Altman Z-score financial failure risk model.

Their findings suggest a link between firms' financial failure forecasts and financial sustainability. Yaman and Gür (2023) conducted a study investigating the relationship between financial risks and sustainable growth among BIST firms. They underscored the critical importance of effective risk management in shaping sustainable growth policies. Through regression analyses, they determined that interest rate risk and liquidity risk exert negative effects on Higgins' (1977) HSGR, whereas capital risk has a positive impact. This highlights the nuanced interplay between financial risk factors and sustainable growth strategies within BIST firms. In a more recent study, Gülener et al. (2023) examined the effects of financial management decisions on sustainable growth policies. Their findings revealed that decisions aimed at increasing working capital and dividend payout contribute positively to sustainable growth. Conversely, decisions to increase financial leverage were found to have a negative impact.

Existing literature extensively investigates the relationships between sustainability performance and firm value, financial performance, and corporate governance factors. Ece Çokmutlu and Kılıç (2020) delved into the relationship between sustainability and financial performance by transforming firms' economic, environmental, and social sustainability performances into a singular metric. Their study revealed that while sustainability performance and financial performance do not consistently correlate, they did not find statistical evidence suggesting that sustainability performance is reflected in financial performance. Investigating the relationship between corporate governance and financial sustainability Geçim (2020) observed that the financial sustainability and corporate governance ratings of BIST companies did not align in the same direction during the 2013-2018 periods. Sak and Dalgar (2020), on the other hand, explored the correlation between corporate sustainability practices and financial performance in firms and revealed that corporate sustainability practices exert a statistically significant and positive effect on the financial performance of enterprises. Analyzing the effects of financial and non-financial factors on firms' sustainability performance for BIST firms, Acar et al. (2021) identified several significant determinants. These include board size and independence, audit committee independence, sustainability strategy, and capital structure policies. Acar et al. (2021) notably highlighted a positive relationship between leverage ratio (LEV) and sustainability performance. Emir and Kıymık (2021) delved into the relationship between sustainability levels and financial performance among BIST firms based on Global Reporting Initiative (GRI) principles. Their findings revealed that ROE, ROA, pre-tax profit, and return on capital employed significantly positively affect sustainability performance. Conversely, the growth in assets (GIA) was found to have a significant negative effect. In another study exploring the linkage between financial performance and sustainability performance, Korga and Aslanoğlu (2022) reported that there is no statistically significant relationship between financial performance and sustainability performance. Investigating the relationship between firms' ESG performance and market capitalization, considering the influence of firm size, Kulalı (2022) revealed that all components of ESG exert a significant positive effect on market capitalization, particularly under the influence of firm size. Moreover, Kulalı (2022) noted that the positive impact of ESG factors on market capitalization intensifies as firm size increases. Günay (2023) analyzed the relationship between ESG and financial performance in banks and found that there exists an inverse relationship between ESG performance and financial performance. Günay (2023) suggested that financially successful banks may not prioritize ESG investments, or alternatively, banks focusing on ESG investments

may exhibit poorer financial performance. This observation underscores the complexity of balancing ESG considerations with financial outcomes within the banking sector. Investigating the compatibility between firms' sustainability activities and academic studies within the framework of signaling theory, Heybet and Duran (2023) found that sustainability activities are not compatible with academic studies. In another study investigating the relationship between ESG scores and firm performance, Korkmaz and Nur (2023) discovered a significant positive relationship between ESG scores and firm performance in the banking sector. Additionally, they observed that firm age exerts a significant positive moderating effect on this relationship. These findings suggest that higher ESG scores are associated with improved firm performance in the banking sector, and this relationship is strengthened by the age of the firm.

The impact of firms' inclusion in sustainability indices on their financial performance and stock prices has been identified as another significant research topic in the literature. Altınay et al. (2017) explored the implications of Turkish banks' inclusion in the BIST Sustainability Index on their stock values. However, their study did not discern a significant effect arising from this inclusion. In an investigation regarding the impact of firms' inclusion in sustainability indices on their stock values, Parlakkaya et al. (2019) echoed the conclusions drawn by Altınay et al. (2017), indicating that inclusion in sustainability indices did not yield a significant effect on stock returns. Recently, significant studies have been conducted on the advancement of the concepts of sustainable finance and sustainable capital markets, as well as the influence of risk management on sustainability. Sepetis (2020), who defines sustainable capital market theory and holistic sustainable finance models, emphasizes that it is difficult to create a complementary methodology in the field of sustainable finance and that sustainable finance and sustainable capital markets should be surrounded by theories like any new scientific field and draws attention to the importance of developing holistic sustainable finance models. Arpaci (2023) conducted a study to assess the factors predicting financial sustainability in cryptocurrencies. They employed multiple analytical approaches, integrating Artificial Neural Network (ANN) with Structural Equation Modeling (SEM) based on Expectation Confirmation Theory (ECT). Their findings indicated that perceived risk, regulations, volatility, innovativeness, and confirmation of expectations emerge as significant predictors of financial sustainability within the cryptocurrency market. This research sheds light on the multifaceted dynamics influencing the sustainability of cryptocurrencies from various angles, providing valuable insights for stakeholders in the digital currency space. Examining the non-performing loans on corporate financial sustainability Atichasari et al. (2023) obtained findings underscore the importance of proactive risk management, holistic risk assessment, and NPL mitigation strategies in ensuring financial stability and sustainability amid changing economic dynamics. Perdana et al. (2023) investigated the influence of capital and sustainable finance on firm values within banks listed on the ASEAN stock Exchange. Their study revealed a noteworthy impact of capital and sustainable finance on firm value. Moreover, Perdana et al. (2023) noted that institutional ownership played a moderating role in the association between sustainable finance and firm value, although it did not exhibit a similar influence on the connection between capital and firm value. Additionally, institutional ownership was found to affect the relationship between sustainable finance and firm value, as banks aimed to align with international societal expectations or bolster their firm value.

The literature review highlights that the relationships between firms' sustainability performance and SGRs and various intra-firm factors such as firm value, financial performance,

and corporate governance have been frequently investigated. However, there is a notable gap in the literature concerning the relationship between the risk of financial failure and sustainable growth. This study is akin to some existing research in terms of its scope and methodology. Nevertheless, it distinguishes itself from the literature by elucidating the effects of financial failure risk on sustainable growth policies. Furthermore, it aims to identify the most suitable financial failure model that can inform the development of sustainable growth policies for stakeholders such as firm managers, researchers, and investors. By addressing this gap, the study not only contributes to the existing body of knowledge but also offers valuable insights into the complex dynamics between financial risk and sustainable growth within firms.

3. Data, Variables and Methodological Design

This study investigates the impact of financial failure risk on sustainable growth policies within firms listed in the BIST Sustainability Index (XUSRD). The dataset encompasses annual financial statement data spanning from 2010 to 2022, focusing on 38 firms listed in XUSRD, for which data are consistently available. Out of the 73 firms listed in the XUSRD, 23 entities such as holdings, banks, insurance companies, etc., are excluded due to disparities in their financial statement structures. An additional 12 firms are omitted because their data couldn't be accessed regularly after the starting date of the study, 2010. Appendix 1 lists the XUSRD firms included in the study, providing transparency regarding the sample composition. The study commences in 2010 to mitigate the potential influence of the 2008 mortgage crisis, ensuring more reliable and unbiased econometric analyses. By 2010, the effects of the crisis had largely subsided in Turkey. It's important to note that the study faces limitations in both time series and cross-sectional dimensions. The dataset is panel data, featuring a cross-sectional dimension (N) of 38 firms and a time dimension (T) of 13 years, resulting in a total of 494 firm/year observations. Given the dataset's multidimensional structure, the relationship between sustainable growth and the risk of financial failure is analyzed using panel regression analysis. This comprehensive approach aims to elucidate the intricate dynamics between financial risk and sustainable growth policies, offering valuable insights for stakeholders navigating the realm of corporate sustainability.

In the panel regression models, the HSGR formulated by Robert C. Higgins in 1977, which is employed in sustainable growth calculations incorporating variable autofinancing and variable borrowing assumptions, is utilized as the dependent variable. The independent variables encompass the Altman (1983) Z'-score, Springate (1978) S-score, Taffler (1983) T-score, Fulmer et al. (1984) H-score, and Legault (1987) CA-score models, which are widely recognized in the financial failure literature for their high predictive success. To enhance the significance levels of the econometric models and minimize inconsistencies and deviations in estimations, several control variables are included. These variables comprise the leverage ratio, ROA, and GIA. Financial data utilized in the calculation of the SGR, financial failure risk, and control variables are sourced from the Financial Information News Network (FINNET) Hisse Expert financial database. The variables incorporated into the econometric models are summarized in Table 1, offering transparency and clarity regarding the analytical framework adopted in the study.

Table 1. Variables

Group	Variable	Acronym	Definition and Calculation
Dependent Variable	Higgins (1977) Sustainable Growth Rate	HSGR	$\frac{p(1-d)(1+L)}{t-p(1-d)(1+L)}$ p = Profit margin after tax, d = Dividend payout ratio L = Total debt/Equity t = Total assets/Net sales
Independent Variables	Altman (1983) Z′ Score	Z′	X_1 = Net working capital/Total assets X_2 = Retained earnings/Total assets X_3 = Earnings before interest and tax (EBIT)/Total assets X_4 = Book value of equity/Book value of total debt X_5 = Sales/Total assets $Z' = 0.717X_1 + 0.847X_2 + 3.107X_3 + 0.420X_4 + 0.998X_5$
	Springate (1978) S Score	S	X_1 = Working capital/ Total assets X_2 = Earnings before interest and tax (EBIT)/Total assets X_3 = Profit before tax/Short-term liabilities X_4 = Sales/Total assets S Skor $= 1.03X_1 + 3.07X_2 + 0.66X_3 + 0.4X_4$
	Taffler (1983) T Score	T	X_1 = Earnings before tax/Average short-term liabilities X_2 = Current assets/Total liabilities X_3 = Short-term liabilities/Total assets X_4 = (Current assets–Inventories- Short-term liabilities)/(Net sales-Earnings before tax+Depreciation) $T = 3.20 + 12.18X_1 + 2.5X_2 - 10.68X_3 + 0.03X_4$
	Fulmer et al. (1984) H Score	H	X_1= Retained earnings/Total assets X_2 = Sales/Total assets X_3 = Profit before tax/Equity X_4 = Cash/Total debt X_5 = Total debt/Total assets X_6 = Short-term liabilities/Total assets X_7 = log (Tangible fixed assets) X_8= Working capital/Total debt X_9 = log Earnings before interest and tax (EBIT)/Interest $H = 5.528X_1 + 0.212X_2 + 0.073X_3 + 1.270X_4 - 0.120X_5 + 2.335X_6 + 0.575X_7 + 1.083X_8 + 0.894X_9 - 6.075$
	Legault (1987) Kanada-CA Score	CA	X_1= Shares/Total assets$_{t-1}$ X_2 = Operating profit/Loss+Finance Expense$_{t-1}$/Total assets$_{t-1}$ X_3 = Sales$_{t-2}$/Total assets$_{t-2}$ $CA = 4.59X_1 + 4.51X_2 + 0.3936X_3 - 2.76$
Control Variables	Leverage Ratio	LEV	Total debt/Total assets
	Return on Assets	ROA	Net income/Total assets
	Growth in Assets	GIA	Percentage growth in total assets

Source: Higgins (1977), Springate (1978), Altman (1983), Taffler (1983), Fulmer et al. (1984), Legault (1987).

The control variables incorporated in the models are selected based on their presumed impact on firms' SGRs. Each variable undergoes standardization through percentage transformation, enabling the elucidation of the change in the dependent variable resulting from a 1-unit change in both the independent and control variables. A total of 6 panel data models are constructed to explore the relationship between sustainable growth policies and the financial

failure risk. In each model, the HSGR serves as the dependent variable, while the Altman (Z'), Springate (S), Taffler (T), Fulmer et al. (H), and Legault (CA) scores are included as independent variables, separately assessing the impact of each financial failure model on sustainable growth. Additionally, a single model is devised wherein all financial failure risk scores are integrated as independent variables. This enables an examination of the collective explanatory power of financial failure models in elucidating changes in sustainable growth. The analysis is conducted using EViews 12 and Gauss 22 econometric analysis package programs.

The panel data analyses in this study encompass both time series and cross-sectional series, requiring adherence to the assumptions of both types of analyses. To ensure robustness and accuracy, a comprehensive five-stage methodological approach, including assumption tests, is adopted. In the first stage, the potential for multicollinearity among the independent and control variables is examined. Spearman correlation analysis and Variance Inflation Factor (VIF) analysis are utilized for this purpose. The second stage involves testing for horizontal cross-section dependence and coefficient homogeneity. The Pesaran (2004) CD test assesses horizontal cross-section dependence, while the Pesaran and Yamagata (2008) delta test evaluates coefficient homogeneity ($\tilde{\Delta}$ and $\tilde{\Delta}_{adj}$). In the third stage of the analysis, the stationarity of the series is evaluated using panel unit root tests. This involves applying the Levin, Lin, and Chu (2002) LLC test, which is a first-generation unit root test, and the Pesaran (2007) CIPS test, a second-generation unit root test. These tests are conducted on the series at both the level and first difference. The LLC test and CIPS test are essential tools for assessing the stationarity of panel data, helping to determine whether the variables exhibit unit roots, indicating non-stationarity, or are stationary. The choice of LLC and CIPS tests is based on the results of the CD and, $\tilde{\Delta}$ and $\tilde{\Delta}_{adj}$ tests used in the earlier stages of the analysis. The fourth stage involves diagnostic tests to identify potential issues such as autocorrelation and heteroscedasticity in the models. Baltagi and Li (1991) LM_p and Born and Breitung (2016) LM_p^* tests are emploted for testing the autocorrelation, and Breusch and Pagan (1979) LM_h test is employed for testing the heteroscedasticity problems. For models exhibiting autocorrelation and/or heteroscedasticity issues, estimations are conducted using the Period SUR robust estimator based on Period Corrected Standard Errors (PCSE) developed by Beck and Katz (1995). Finally, in the fifth and final stage, panel regression models are estimated according to equations 1-6, allowing for a comprehensive analysis of the relationships between the variables under investigation. This rigorous methodological approach ensures the validity and reliability of the panel regression analyses, enabling robust insights into the complex dynamics of sustainable growth policies and financial risk factors in firms.

Model 1 $$HSGR_{it} = \beta_0 + \beta_1 Z'_{it} + \beta_2 LEV_{it} + \beta_3 ROA_{it} + \beta_4 GIA_{it} + u_{it} \quad (1)$$

Model 2 $$HSGR_{it} = \beta_0 + \beta_1 S_{it} + \beta_2 LEV_{it} + \beta_3 ROA_{it} + \beta_4 GIA_{it} + u_{it} \quad (2)$$

Model 3 $$HSGR_{it} = \beta_0 + \beta_1 T_{it} + \beta_2 LEV_{it} + \beta_3 ROA_{it} + \beta_4 GIA_{it} + u_{it} \quad (3)$$

Model 4 $$HSGR_{it} = \beta_0 + \beta_1 H_{it} + \beta_2 LEV_{it} + \beta_3 ROA_{it} + \beta_4 GIA_{it} + u_{it} \quad (4)$$

Model 5 $$HSGR_{it} = \beta_0 + \beta_1 CA_{it} + \beta_2 LEV_{it} + \beta_3 ROA_{it} + \beta_4 GIA_{it} + u_{it} \quad (5)$$

Model 6 $$HSGR_{it} = \beta_0 + \beta_1 Z'_{it} + \beta_2 S_{it} + \beta_3 T_{it} + \beta_4 H_{it} + \beta_5 CA_{it} + \beta_6 LEV_{it} + \beta_7 ROA_{it} + \beta_8 GIA_{it} + u_{it} \quad (6)$$

For each specified panel regression model in Equations 1-5, the relationship between financial failure risk and sustainable growth policies is examined through a different financial failure risk measurement method. Additionally, Model 6 assesses the combined explanatory power of financial failure models regarding changes in sustainable growth policies. The alternative hypotheses tested for the models are outlined as follows:

H_1: Z' score positively affects sustainable growth policies.

H_2: S score positively affects sustainable growth policies.

H_3: T score positively affects sustainable growth policies.

H_4: H score positively affects sustainable growth policies.

H_5: CA score positively affects sustainable growth policies.

H_6: Financial failure scores affect sustainable growth policies.

In Equation 1-6, β_0 is the constant, β_n (n: 1, …, N) is the slope coefficient of the independent variable, u_{it} is the error term, t is time dimension (years), where t: 1, …, T, and i denotes cross-sections (firms).

4. Findings and Discussion

Before proceeding to the empirical findings regarding the relationship between sustainable growth and financial failure risk, the characteristics of the variables are explored through descriptive statistics and normality analysis. Additionally, the linear link between sustainable growth policies and financial failure risk scores is examined and visualized via scatter diagrams and regression lines. Descriptive statistics and Jarque-Bera (J-B) normality analysis results for the variables are presented in Table 2, while the scatter diagrams and regression lines between HSGR and financial failure scores are presented in Figure 1.

Table 2. Descriptive Statistics and the Test of Normality

	Variables				
	HSGR	**Z'**	**S**	**T**	**H**
Mean	0.003018	0.024617	0.017768	-0.1227	0,06782
Median	-0.07763	-0.00825	-0.00411	-0.04864	0,034246
Max.	19.09121	2.525555	13.16348	13.31661	7,782628
Min.	-23.0837	-0.70407	-6.49732	-47.8031	-0,61786
Std. Dev.	2.648527	0.257994	0.918197	3.12068	0,415061
Skewness	-1.05358	3.331636	4.736187	-7.98543	13,16032
Kurtosis	30.15121	27.42526	98.97347	121.4239	243,1826
J-B	15265.18***	13193.76***	191438***	293915.3***	1201665***
	CA	**LEV**	**ROA**	**GIA**	
Mean	-0.42627	0.025294	-0.08373	0.271864	
Median	-0.00502	0.015608	-0.04611	0.205862	
Max.	10.28211	0.966838	55.96938	1.709319	
Min.	-121.905	-0.36269	-72.5847	-0.21246	
Std. Dev.	5.763895	0.12959	5.120187	0.271782	
Skewness	-19.1532	1.593132	-1.81025	1.807532	
Kurtosis	401.5331	11.30856	126.8705	7.225342	
J-B	3299426***	1629.881***	316098.4***	636.4821***	

Note: *** indicates 1% significance level.

Descriptive statistics show that the Fulmer et al. (1984) H-score has the highest mean value with 0.06 among the financial failure scores, the mean value of the dependent variable HSGR is 0.003, and GIA has the highest mean value of 0.27 overall. ROA demonstrates the widest range of values, with the highest maximum value recorded at 55.96 and the lowest minimum value at -72.58. Additionally, ROA also displays the highest standard deviation, measured at 5.12. When interpreting the descriptive statistics, it is crucial to consider that the variables included in the model are based on percentage change values rather than raw values. The analysis reveals that HSGR, T-score, CA-score, and ROA exhibit left skewness, whereas the other variables demonstrate right skewness. Furthermore, all variables display leptokurtic distributions. The J-B statistics and associated probability values indicate that none of the variables are normally distributed at the 1% significance level. Specifically, the discrepancy between mean and median values, along with kurtosis and skewness values deviating from 0, further corroborates the non-normal distribution of all variables. This information underscores the importance of understanding the distributional characteristics of the variables, which can significantly influence the statistical analysis and interpretation of results in the model. Scatter diagrams and regression lines offer a clear depiction of the potential linear association between sustainable growth policies and financial failure risk scores, aiding in the initial exploration of the relationship. The scatter diagrams and regression lines reveal a positive association between sustainable growth and financial failure scores. Specifically, the regression lines between HSGR and Altman Z' (1983), Taffler (1983) T, and Fulmer et al. H (1984) exhibit a positive slope. This suggests that enhancements in firms' financial stability, characterized by a reduction in the risk of financial failure, positively influence the sustainability of growth policies. Conversely, the regression lines between HSGR and Springate (1978) S, as well as Legault (1987) CA, appear flat, indicating an insignificant relationship between these variables. This observation suggests that variations in S and CA scores do not significantly impact sustainable growth policies.

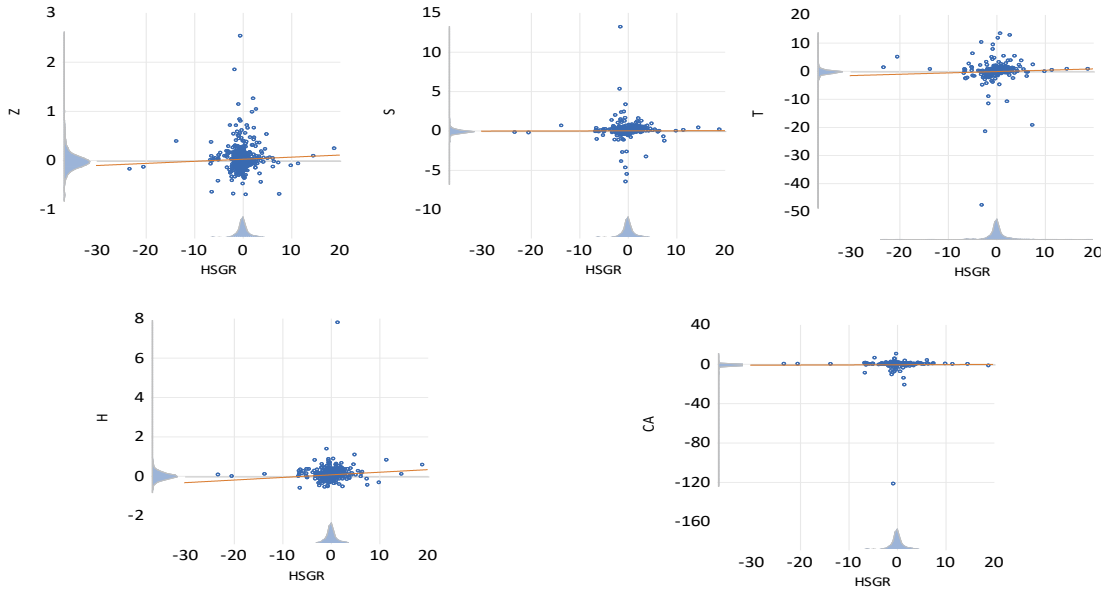

Figure 1. Scatter Diagram and Regression Line Between HSGR and Financial Failure Scores

Multi-collinearity was assessed through Spearman correlation and VIF analyses. With ρ representing the correlation coefficient, the pairs of independent variables with ρ>0.75 and ρ<-0.75 were considered to indicate multi-collinearity if included in the same model Furthermore, a threshold value of 4 was accepted for the VIF analysis. It was acknowledged that variables with a VIF value greater than 4 when included together as independent variables in the panel regression model, could contribute to multi-collinearity problems. The Spearman correlation matrix and VIF analysis results are presented in Table 3. According to the Spearman correlation analysis, it is found that the explanatory variable pair with the highest ρ value is Z' and H (ρ=0.21), while the pair with the lowest ρ value is Z' and LEV (ρ=−0.40). Regarding the VIF analysis, it is found that the variable with the highest VIF value is Z' (1.26), and the one with the lowest VIF value is CA (1.00). The Spearman correlation analysis results indicated that none of the explanatory variable pairs met the conditions ρ>0.75 and ρ<−0.75. Similarly, the VIF analysis results showed that none of the explanatory variables met the condition VIF>4. In light of these findings, it is assumed that the explanatory variables included in the models would not cause deviations stemming from multi-collinearity.

Table 3. Spearman Correlation Matrix and VIF Analysis Results

Variables	**Z'**	**S**	**T**	**H**	**CA**	**LEV**	**ROA**	**GIA**
Z'	1.00000							

S	0.133119	1.00000						
	(0.003)***	---						
T	-0.04101	-0.02544	1.00000					
	(0.363)	(0.5727)	---					
H	0.219186	0.019636	0.055291	1.00000				
	(0.0000)***	(0.6633)	(0.2199)	---				
CA	0.017119	-0.00035	-0.00039	0.011764	1.00000			
	(0.7043)	(0.9937)	(0.9931)	(0.7942)	---			
LEV	-0.40936	-0.10605	-0.07055	-0.13149	-0.00521	1.00000		
	(0.0000)***	(0.0184)*	(0.1174)	(0.0034)**	(0.9081)	---		
ROA	0.039225	0.002881	0.047127	0.046127	-0.00505	-0.12322	1.00000	
	(0.3843)	(0.9491)	(0.2958)	(0.3062)	(0.9109)	(0.0061)***	---	
GIA	-0.04617	0.012712	0.010395	0.03946	-0.05552	0.12301	0.034352	1.00000
	(0.3058)	(0.7781)	(0.8177)	(0.3815)	(0.218)	(0.0062)**	(0.4462)	---
Variables	**Z'**	**S**	**T**	**H**	**CA**	**LEV**	**ROA**	**GIA**
R^2	0.20934	0.022476	0.016733	0.057707	0.003506	0.202419	0.020054	0.024602
VIF	1.264766	1.022993	1.017018	1.061241	1.003518	1.253791	1.020464	1.025223

Note: Signs ***, **, and * indicate 1%, 5% and 10% significance levels, respectively.

Testing for cross-sectional dependency and slope homogeneity in coefficients is essential for understanding the characteristics of the dataset and selecting the correct stationarity test (De Hoyos and Safaridis, 2016). Given that the dataset of the study exhibits N>T, cross-sectional dependence on a variable basis is assessed using the Pesaran (2004) CD test, while the homogeneity of slope coefficients is examined using the Pesaran and Yamagata (2008) $\tilde{\Delta}$ and $\tilde{\Delta}_{adj}$ tests. The results of the CD, $\tilde{\Delta}$ and $\tilde{\Delta}_{adj}$ tests are presented in Table 4. The CD test outcomes reveal that all variables, except for S and T variables, exhibit horizontal cross-section dependence at the 1% significance level. On the other hand, $\tilde{\Delta}$ and $\tilde{\Delta}_{adj}$ tests demonstrate reveal that the slope coefficients are homogeneous across all variables, except for CA.

Table 4. Cross-section Dependence and Slope Homogeneity Test Results

Variables	CD	$\tilde{\Delta}$	$\tilde{\Delta}_{adj}$
HSGR	2.708185***	-0.129	-0.147
Z'	9.984605***	0.158	0.18
S	0.837574	0.932	1.062
T	0.70536	-1.772	-2.02
H	30.66571***	-0.028	-0.032
CA	6.29914***	2.654***	3.026***
LEV	4.125579***	-0.827	-0.943
ROA	3.227562***	0.017	0.020
GIA	45.04331***	0.446	0.509
Null Hypothesis for CD Test	H_0: No cross-sectional dependency.		
Null Hypothesis for $\tilde{\Delta}$ and $\tilde{\Delta}_{adj}$ Test	H_0: No heterogeneity in slope coefficients.		

Note: *** indicates 1% significance level.

Following the results of the CD test and $\tilde{\Delta}$ and $\tilde{\Delta}_{adj}$ tests, the HSGR, Z', H, CA, LEV, ROA, and GIA undergo stationarity testing using the Pesaran (2007) CIPS test, a second-generation unit root test. Meanwhile, the S and T variables undergo stationarity testing with the Levin, Lin, and Chu (2002) LLC unit root test, a first-generation unit root test. The outcomes of the unit root tests are displayed in Table 5. Results of the LLC and CIPS panel unit root tests indicate that all variables do not contain unit roots at the 1% significance level in both intercept and intercept-trend models. Based on the first and second-generation unit root tests, all dependent, explanatory, and control variables are stationary at the level. This outcome suggests that all variables demonstrate a tendency to revert to the mean in the long-run and can be integrated into panel regression models in their current form.

Table 5. Unit Root Test Results

First-Generation Unit Root Test		**Levin, Lin and Chu (2002) LLC**				
Model		Intercept		Intercept and Trend		Decision
Variables		Statistic	Probability	Statistic	Probability	
S		-16.9406***	0.00000	-14.5019***	0.00000	I(0)
T		-19.0694***	0.00000	-15.1429***	0.00000	I(0)
Second-Generation Unit Root Test		**Pesaran (2007) CIPS**				
Model		Intercept		Intercept and Trend		Decision
Variables		CIPS	Truncated CIPS	CIPS	Truncated CIPS	
HSGR		-0.272217***	-2.72217***	-3.38826***	-3.04228***	I(0)
Z'		-3.33808***	-3.22647***	-3.29116***	-3.18283***	I(0)
H		-3.41318***	-3.34564***	-3.40962***	-3.36131***	I(0)
CA		-3.30448***	-3.38994***	-4.38825***	-4.10144***	I(0)
LEV		-3.18587***	-3.18587***	-3.09864***	-3.08733***	I(0)
ROA		-5.14024***	-3.43824***	-5.64579***	-3.98295***	I(0)
GIA		-3.22650***	-3.16767***	-3.33236***	-3.29125***	I(0)
Critical Values	1%	-2.41	-2.37	-3.09	-2.98	
	5%	-2.19	-2.18	-2.82	-2.74	
	10%	-2.08	-2.07	-2.68	-2.62	
Null Hypothesis for LLC and CIPS Tests		H_0: No stationary.				

Note: Lag lengths are determined according to the Schwarz Information Criterion.
*** indicates 1% significance level. The decision I(0) implies stationarity at the level.

Before conducting panel regression analysis, it is imperative to test two critical assumptions: autocorrelation, which evaluates significant relationships between successive error

terms, and heteroskedasticity, which assesses differences in error term variances across cross-sections or the presence of non-zero error term covariances.

Autocorrelation testing in this study relies on the Baltagi and Li (1991) LM_p test and Born and Breitung (2016) LM_p^* test, an improved version of LM_p test. Hetetoskedasticity testing, on the other hand, relies on the Breusch and Pagan (1979) LM_h test. Furthermore, the F, Breusch and Pagan (1980) LM, and Honda (1985) tests are employed for estimator specification. The F test examines the variations in the fixed parameter, and the Breusch and Pagan (1980) LM and Honda (1985) tests determine the presence of random effects in the model. The diagnostic tests and estimator specification test results are presented in Table 6.

Table 6. Diagnostic and Estimator Specification Tests Results

Tests		**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
Baltagi and Li (1991) LM_p		2.736654*	2.81625*	2.938835*	2.611733	2.819041*	2.572022
Born and Breitung (2016)		12.02761**	12.19553**	12.45175**	11.76151**	12.20139**	11.67623**
Breusch and Pagan (1979)		477.3533**	479.0106**	480.0232**	480.302***	478.965***	482.7967**
Tests	**Models**	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
F Test	Group FE	1.414212*	1.410463*	1.386941*	1.391508*	1.406844*	1.370535*
	Time FE	1.763629*	1.744525*	1.769796*	1.695502*	1.734768*	1.730089*
	Two-way FE	1.502008**	1.505492**	1.499247**	1.473799**	1.501015**	1.466442**
Breusch and Pagan(198	Group RE	2.059179	2.17284	1.94128	1.92116	2.174781	1.707256
	Time RE	1.257367	1.607381	1.825417	1.340532	1.51215	1.229612
	Two-way RE	3.316545	3.780221	3.766697	3.261692	3.686931	2.936868
Honda (1985) Test	Group RE	1.434984*	1.474056*	1.393298*	1.386059*	1.474714*	1.30662*
	Time RE	1.121324	1.267825	1.35108*	1.157813	1.229695	1.108879
	Two-way RE	1.807582	1.938803**	1.940568**	1.79879**	1.912306**	1.708015**
Null hypothesis	LM_p and LM_p^*	H_0: No serial correlation.					
	LM_h	H_0: No heteroskedasticity.					
	Group FE/RE	H_0: While there is a cross-section effect, there is no time effect.					
	Time FE/RE	H_0: While there is a time effect, there is no cross-section effect.					
	Two-way	H_0: No cross-section or time effect.					

Note: Signs ***, **, and * indicate 1%, 5%, and 10% significance levels, respectively.

The Baltagi and Li (1991) LM_p test results reject the null hypothesis at the 10% significance level in Models 1, 2, 3, and 5. On the other hand, the Born and Breitung (2016) LM_p^* test results reject the null hypothesis at the 1% significance level in all models. These results indicate the presence of an autocorrelation problem in all models. The Breusch and Pagan (1979) LM_h test results reject the null hypothesis at the 1% significance level in all models, suggesting the presence of a heteroskedasticity problem in all models. In order to avoid the inconsistent and biased results stemming from autocorrelation and heteroscedasticity issues, estimations are conducted using the Period SUR (PCSE) robust estimator, developed by Beck and Katz (1995). The F test results reveal that the probability values for the group fixed effects and time fixed effects are greater than 0.05 across all models, indicating the absence of cross-sectional or time fixed effects in the models. Similarly, the LM and Honda test results indicate the absence of random effects in both the cross-sectional and time dimensions. Baltagi (2014) proposes a fixed effects model when the data set focuses on a specific group of firms, countries, or individuals, and the findings are confined to the behavior of these groups. Consequently, the F test findings guide the selection of the estimator specification. Thus, the pool model is

employed in the panel regression analyses. Finally, the estimation outcomes of the panel regression models designed to ascertain the relationship between sustainable growth policies and the financial failure risk are presented in Table 7.

Tablo 7. Panel Regression Results

Ind. Variables		Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Z'	Coef.	0.405411					0,176995
	t-Stat.	1.093774					0,452089
S	Coef.		0.008427				0,012169
	t-Stat.		0.129828				0,187664
T	Coef.			0.489732			0,505101
	t-Stat.			2.918285***			3,130656***
H	Coef.				0.562578		0,541900
	t-Stat.				2.827543***		2,62401***
CA	Coef.					0.012188	0,012556
	t-Stat.					0.46807	0,478714
LEV	Coef.	-0.869531	-1.18051	-1.24447	-0.829774	-1.189513	-0,733613
	t-Stat.	-1.553253	-2.398381**	-2.61966***	-1.64547	-2.423209**	-1,334958
ROA	Coef.	0.042283	0.042582	0.039076	0.041542	0.042374	0,037948
	t-Stat.	2.652943***	2.654382***	2.46711**	2.597598***	2.637625***	2,404837**
GIA	Coef.	0.697715	0.679034	0.648254	0.644042	0.692704	0,606719
	t-Stat.	2.098192**	2.059805**	2.046729**	1.961122**	2.102396**	1,896194*
C	Coef.	-0.120283	-0.102526	-0.09768	-0.141495	-0.102162	-0,144934
	t-Stat.	-1.015774	-0.882039	-0.86777	-1.200024	-0.87889	-1,258729
R^2		0,378190	0.362754	0.539938	0.528276	0.366653	0.730781
Adjusted R^2		0,299480	0.283922	0.462553	0.450794	0.287859	0.657883
F-Statistic		4,805055***	4.601533***	6.977387***	6.81824***	4.652863***	4.779631***
Prob(F-Statistic)		0,000826	0.001177	0.000018	0.000024	0.001077	0.00001
D-W Stat.		1,983449	1.986811	1.989785	1.983695	1.98539	1.994833

Note: Signs ***, **, and * indicate 1%, 5% and 10% significance levels, respectively.
In all models, the F-test results were considered in the estimator specification, and the analyses were conducted using the pooled model approach.

The results of the panel regression analysis reveal that all models exhibit F-probability values below 0.01, signifying statistical significance at the 1% level. This suggests that financial failure scores, along with control variables, collectively elucidate the variations in sustainable growth policies in a statistically significant manner. The significant F-probability values across the models enable the testing of alternative hypotheses regarding the impact of financial failure scores on sustainable growth policies. Among the models, Model 3 stands out with the lowest F-probability value (0.000018), alongside the highest F-statistic (6.977387) and R^2 (0.539938). According to the findings, the combination of Z'-score and control variables in Model 1 accounts for 38% of the changes in sustainable growth policies, while this explanatory capability extends to 36% for Model 2, 54% for Model 3, 53% for Model 4, and 37% for Model 5. In Model 6, where all financial failure scores are incorporated as independent variables, a substantial 73% of the changes in sustainable growth policies are explained collectively in a statistically significant manner. The D-W stat. (Durbin-Watson statistic) values for the models closely approximate 2, suggesting that the robust estimators effectively eliminated the autocorrelation issue.

Models 1-5 demonstrate that all financial failure risk indicators have positive effects on sustainable growth policies as suggested by Platt et al., (1995), Fonseka et al. (2012) and Raza et al. (2020). However, these effects are not statistically significant across all financial failure risk models. Specifically, the results from Models 1, 2, and 5 indicate that the Altman (1983) Z'-score, Springate (1978) S-score, and Legault (1987) CA-score financial failure risk indicators fail to significantly explain the changes in sustainable growth policies of BIST Sustainability Index companies. Consequently, the alternative hypotheses H_1, H_2 and H_5 are rejected based on the findings. The outcomes from Models 1, 2, and 5 suggest that factors such as difficulties in short-term debt repayments, costs of financial distress, bankruptcy costs, capital structure decisions, working capital management decisions, and financial failure risks may not be pivotal factors influencing firms' sustainable growth policies. This finding not only diverges from traditional finance theory and is inconsistent with the findings of Platt et al., (1995), Fonseka et al. (2012) and Raza et al. (2020) but also seems unrealistic. Consequently, it can be inferred that the information and insights provided by the Altman (1983) Z'-score, Springate (1978) S-score, and Legault (1987) CA-score financial failure models may not offer valuable insights for both theorists and practitioners in understanding the relationship between firms' sustainable growth policies and financial performance. On the contrary, the outcomes from Models 3-4 highlight that the Taffler (1983) T-score and Fulmer et al. (1984) H-score financial failure risk indicators strongly explain the changes in sustainable growth policies at the 1% significance level. Consequently, the alternative hypotheses H_3 and H_4 cannot be rejected. Aligned with traditional finance theory, the results from Models 3-4 suggest that financial management decisions, financial success, and financial performance play crucial roles in the sustainability of growth policies. This finding is significantly consistent with the findings of the Platt et al., (1995), Fonseka et al. (2012) Raza et al. (2020), Niu (2016), Soytaş et al. (2017), Yaman and Gür (2023), Gülener et al. (2023). In this context, Taffler's (1983) T-score and Fulmer et al.'s (1984) H-score financial failure models offer valuable insights into understanding the connections between firms' sustainable growth policies and their financial performance. Assessing the impacts of the T-score and H-score financial failure risk indicators on the HSGR reveals that a 1-unit change in the T-score corresponds to a 0.49-unit change in the HSGR, while a 1-unit change in the H-score results in a 0.56-unit change in the HSGR. Although the Fulmer et al. (1984) H-score model may appear to be a more practical indicator for formulating sustainable growth policies in firms, the t-statistics values for the T and H score variables (2.9.8285 and 2.827573, respectively) indicate that Taffler's (1983) T-score model holds more significant potential for assisting firm managers in developing sustainable growth policies. Additionally, the superior performance of Model 3, which incorporates the T-score financial failure risk factor, is evidenced by its higher F-statistic and R^2 values compared to Model 4. Furthermore, the statistical significance of all control variables' t-statistics in Model 3, as opposed to the financial leverage variable's lack of statistical significance in Model 4, further reinforces the superiority of Model 3.

Model 6 is a statistically significant model due to its high F-statistic. Consequently, the alternative hypothesis H_6 cannot be rejected. The outcomes of Model 6 are fully consistent with the findings observed in Models 1-5. Specifically, Model 6 reveals that the impacts of Z', S, and CA financial failure risk scores on sustainable growth policies lack statistical significance, while the effects of T and H financial failure risk scores are statistically significant. Furthermore, in Model 6, the T-score variable exhibits a higher t-statistic compared to the H-score variable. This

observation aligns with the results from Models 3-4, underscoring the importance of scrutinizing Taffler's (1983) T-score model in the context of developing sustainable growth policies.

5. Conclusions and Recommendations

Sustainable growth relies on the effective generation and allocation of internal resources, as well as the efficient utilization of external resources. A sustainable environment requires a sustainable economic and financial system, at a macro-scale. A sustainable economic system, on the other hand, requires a high level of endogenous resource creation capabilities of micro units that are compatible with environmental conditions and social standards. Ultimately, the sustainable growth performance of economic entities is an important component of environmental, social, and governance sustainability. Examining the determinants of sustainable growth performance offers valuable insights for stakeholders such as corporate managers and investors at the micro level, as well as policymakers shaping economic and environmental strategies at the macro level. This study aims to provide information to macro and micro beneficiaries in developing sustainability policies and to contribute to the sustainable growth literature by examining the effects of financial failure risk on firms' sustainable growth policies. The research encompasses non-financial entities listed in the BIST Sustainability Index, with accessible data spanning from 2010 to 2022. In calculating firms' SGRs, the study employs the HSGR ratio as proposed by Higgins (1977), while assessing the risk of financial failure through the Altman (1983) Z'-score, Springate (1978) S-score, Taffler (1983) T-score, Fulmer et al. (1984) H-score, and Legault (1987) CA-score models. The analysis follows a five-stage panel data methodology, including the pre-tests of multi-collinearity, cross-sectional dependency, slope homogeneity, stationarity, autocorrelation and heteroskedasticity, and panel regression analysis.

The panel regression analysis reveals the significance of all developed models. In particular, the statistical significance of the model in which all financial failure scores are included together as independent variables answers the first research question positively. This affirmative response to the initial research question suggests a positive impact of financial failure scores on the SGR of BIST Sustainability Index firms, as suggested by Platt et al., (1995), Fonseka et al. (2012) and Raza et al. (2020). However, not all financial failure models yield significant results. Specifically, the analysis indicates that financial failure scores derived from the Altman (1983) Z'-score, Springate (1978) S-score, and Legault (1987) CA-score models do not significantly influence firms' sustainable growth policies. This implies that factors such as short-term debt repayment challenges, financial distress expenses, bankruptcy outlays, capital structure decisions, and working capital management decisions may not substantially shape firms' sustainable growth strategies. Conversely, the statistically significant relationships observed between Taffler (1983) T-score and Fulmer et al. (1984) H-score financial failure scores and SGRs highlight the pivotal role of financing decisions in shaping growth strategies and fostering sustainable growth. Thus, it is suggested that Taffler's (1983) T-score and Fulmer et al. (1984) H-score financial failure models be prioritized over Altman (1983) Z'-score, Springate (1978) S-score, and Legault (1987) CA-score models in the process of developing sustainable growth policies for firms.

The comparison of the explanatory power between the Taffler (1983) T-score and Fulmer et al. (1984) H-score financial failure models underscore the superiority of the T-score, directly addressing the second research question. The findings strongly suggest that the Taffler (1983) T-score model stands out as the most beneficial financial failure model for scrutinizing the risk of financial failure in the development of sustainable growth policies. Examining the components and coefficients of the Taffler (1983) T-score model reveals that enhancements in pre-tax profits, a flexible working capital investment policy, a balanced working capital financing policy, and a high net working capital level significantly contribute to the sustainability of growth policies. These results underscore the significance of short-term investment and financing decisions alongside long-term financial strategies for sustainable growth. The examination of the components and coefficients of the Fulmer et al. (1984) H-score model elucidates the positive impact of autofinancing policy and working capital investments on attaining sustainable growth, and negative impact of high debt financing. The findings generally suggest that companies at a high risk of financial failure may encounter operational constraints, such as cash flow issues, supply chain disruptions, or rising costs, which may limit their growth and steer them away from sustainability goals. The analysis reveals that balanced financing policy and flexible investment policy in working capital management, along with autofinancing decisions, positively contribute to sustainable growth, whereas high debt levels have adverse effects. Remarkably, these findings align significantly with previous studies by Platt et al., (1995), Fonseka et al. (2012), Raza et al. (2020), Niu (2016), Soytaş et al. (2017), Yaman and Gür (2023), and Gülener et al. (2023). Consistent with the analysis findings, it can be inferred that establishing a solid financial footing, implementing effective risk management strategies, and enhancing operational efficiency are crucial steps for BIST Sustainability Index companies to attain their sustainable growth objectives.

The findings of the study are believed to provide valuable insights to firm managers and investors at the micro level, and to environmental and economic policymakers at the macro level and contribute to the existing literature, and provide valuable resources for theoreticians. However, it's essential to handle the cross-sectional and time dimension constraints of the study carefully while evaluating the findings. Since the study covers non-financial firms, a similar evaluation of the findings for financial sector firms may lead to inaccurate results. Furthermore, the exclusion of factors other than the risk of financial failure that could influence sustainable growth policies represents a significant limitation of the study. In future research, incorporating factors such as dividend policy, internal capital market variables, agency costs, and macroeconomic indicators as determinants of sustainable growth policies alongside financial failure risk may provide valuable insights across various segments and further enrich the literature 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 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.

References

Acar, M., Durmaz, Ş. and Çoşgunaras, Ş.N. (2021). A research on financial and non-financial determinants of sustainability performance: BIST Sustainability Index case. *Journal of Accounting and Taxation Studies*, 14(1), 129-160. https://doi.org/10.29067/muvu.719005

Altınay, A., Kaki, B., Kestane, A., Soba, M., Dinçer, Ö. and Şık, E. (2017). The effects of sustainability index on banking sector share center values, an investigation on the BIST Sustainability Index. *The Journal of Social Economic Research*, 13(34), 264-284. https://doi.org/10.30976/susead.337089

Altman, E.I. (1983). Why businesses fail. *The Journal of Business Strategy*, 3(4), 15–21. https://doi.org/10.1108/eb038985

Amouzesh, N., Moeinfar, Z. and Mousavi, Z. (2011). Sustainable growth rate and firm performance: Evidence from Iran stock exchange. *International Journal of Business and Social Science*, 2(23), 249-255. https://www.ijbssnet.com/index.php/home

Arpaci, I. (2023). Predictors of financial sustainability for cryptocurrencies: An empirical study using a hybrid SEM-ANN approach. *Technological Forecasting and Social Change*, 196, 122858. https://doi.org/10.1016/j.techfore.2023.122858

Ashraf, S., Félix E.G.S. and Serraqueiro, Z. (2019). Do traditional financial distress prediction models predict the early warning signs of financial distress? *Journal of Risk and Financial Management*, 12(2), 55. https://doi.org/10.3390/jrfm12020055

Asteriou, D. and Hall, S.G. (2007). *Applied econometrics: A modern approach using Eviews and microfit*. New York: Palgrave Macmillan.

Ates, S. (2021). Market reaction to corporate social performance: Evidence from BIST. *The Journal of Accounting and Finance*, 90, 149-164. https://doi.org/10.25095/mufad.827626

Atichasari, A.S., Ratnasari, A., Kulsum, U., Kahpi, H.S., Wulandari, S.S. and Marfu, A. (2023). Examining non-performing loans on corporate financial sustainability: Evidence from Indonesia. *Sustainable Futures*, 6, 100137. https://doi.org/10.1016/j.sftr.2023.100137

Baltagi, B. and Li, Q. (1991). A joint test for serial correlation and random individual effects. *Statistics and Probability Letters*, 11, 277-280. https://doi.org/10.1016/0167-7152(91)90156-L

Baltagi, B.H. (2014). *Econometric analysis of panel data*. New York: John Wiley & Sons Ltd.

Beck, N. and Katz, J.N. (1995). What to do (and not to do) with time-series cross-section data. *American Political Science Review*, 89(3), 634-647. https://doi.org/10.2307/2082979

Born, B. and Breitung, J. (2016). Testing for serial correlation in fixed-effects panel data models. *Econometric Reviews*, 35(7), 1290-1316. https://doi.org/10.1080/07474938.2014.976524

Breusch, T.S. and Pagan, A.R. (1979). A simple test for heteroskedasticity and random coefficient variation. *Econometrica*, 47(5), 1287-1294. https://doi.org/10.2307/1911963

Breusch, T.S. and Pagan, A.R. (1980). The LaGrange multiplier test and its applications to model specification in econometrics. *Review of Economic Studies*, 47(1), 239-253. https://doi.org/10.2307/2297111

Carroll, A.B. (1979). A three-dimensional conceptual model of corporate performance. *Academy of Management Review*, 4(4), 497-505. https://doi.org/10.5465/amr.1979.4498296

Conway, E. (2018). Sustainability, the triple bottom line and corporate social responsibility. In E. Conway and D. Byrne (Eds.), *Contemporary issues in accounting* (pp. 15-35). London: Palgrave Macmillan.

Davis, K. and Blomstrom, R. (1975). *Business and society: Environment and responsibility*. New York: McGraw-Hill.

De Bakker, F.G., Groenewegen, P. and Den Hond, F. (2005). A bibliometric analysis of 30 years of research and theory on corporate social responsibility and corporate social performance. *Business & Society*, 44(3), 283-317. https://doi.org/10.1177/0007650305278086

Dmuchowski, P., Dmuchowski, W., Baczewska-Dąbrowska, A.H. and Gworek, B. (2023). Environmental, social, and governance (ESG) model; Impacts and sustainable investment - Global trends and Poland's perspective. *Journal of Environmental Management*, 329, 117023. https://doi.org/10.1016/j.jenvman.2022.117023

Ece Çokmutlu, M. and Kılıç, M. (2020). Comparison of sustainability performances and financial performances of the manufacturing industry companies in the Borsa Istanbul sustainability index. *Journal of Management and Economics Research*, 18(3), 96-115. https://doi.org/10.11611/yead.767972

Elkington, J. (1998). *Cannibals with forks: The triple bottom line of 21st century business.* Gabriola Island: New Society Publishers.

Emir, S. and Kıymık, H. (2021). Evaluation of the effect of sustainability level on financial performance: A study in Borsa Istanbul. *Journal of Accounting and Taxation Studies*, 1(14), 101-128. https://doi.org/10.29067/muvu.718278

Fonseka, M.M., Ramos, C.G. and Tian, G. (2012). The most appropriate sustainable growth rate model for managers and researchers. *The Journal of Applied Business Research*, 28(3), 481-500. https://doi.org/10.19030/jabr.v28i3.6963

Fulmer, J.G., Moon, J.E., Gavin, T.A. and Erwin, M. (1984). A bankruptcy classification model for small firms. *Journal of Commercial Bank Lending*, 66(11), 25–37. Retrieved from https://library.villanova.edu/

Geçim, M. (2020). *The relationship between corporate governance and financial sustainability* (Unpublished doctoral dissertation). Izmir University of Economics, İzmir, Türkiye.

Gülener, N., Korkmaz, T. and Yaman, S. (2023). Internal determinants of sustainable growth policies in businesses: An application on Borsa Istanbul. *Journal of Emerging Economies and Policy,* 8(2), 480-497. Retrieved from https://dergipark.org.tr/en/pub/joeep/

Günay, F. (2023). Bankalarda çevresel, sosyal ve yönetişim (ESG) performansı ile finansal performans ilişkisinin IDOCRIW-WASPAS yöntemiyle değerlendirilmesi: ABD bankaları örneğinde bir uygulama. B. Medetoğlu ve Y.B. Kavas (Eds.), *Finans: Model ve uygulamalar* içinde (s. 219-248). İstanbul: Filiz Kitabevi.

Haanaes, K., Balagopal, B., Arthur, D., Kong, M.T., Velken, I., Kruschwitz, N. and Hopkins, M.S. (2010). First look: The second annual sustainability & innovation survey. *MIT Sloan Management Review*, 52(2), 76-84. Retrieved from https://sloanreview.mit.edu/

Heybet, K. and Duran, C. (2023). Analysis of the activity and sustainability reports as a sustainability signal: A study in the BIST Sustainability Index. *Journal of Emerging Economies and Policy*, 8(1), 23-28. https://dergipark.org.tr/en/pub/joeep/

Higgins, R.C. (1977). How much growth can a firm afford? *Financial Management*, 6(3), 7-16. https://doi.org/10.2307/3665251

Higgins, R.C. (2012). *Analysis for financial management*. New York: McGraw-Hill.

Honda, Y. (1985). Testing the error components model with non-normal disturbances. *Review of Economic Studies*, 52, 681-690. https://doi.org/10.2307/2297739

Karaçayir, E. and Afşar, A. (2024). The effects of environmental, social, and governance performance on financial performance: The case of Borsa Istanbul. *Trends in Business and Economics*, 38(1), 48-55. https://doi.org/10.5152/TBE.2024.23227

Korga, S. and Aslanoğlu, S. (2022). A research on the relationship of sustainability performance and financial performance. *Journal of Selçuk University Social Sciences Vocational School*, 25(2), 633-645. https://doi.org/10.29249/selcuksbmyd.1114641

Korkmaz, T. and Nur, T. (2023). The effect of ESG sustainability on firm performance: A view under size and age on BIST bank index firms. *Journal of Research in Economics, Politics & Finance*, 8(2), 208-223. https://doi.org/10.30784/epfad.1278491

Kulalı, G. (2022). Impacts of environmental, social and governance (ESG) performance on market value: The role of firm size. *Eskişehir Osmangazi University Journal of Economics and Administrative Sciences*, 17(3), 787-809. https://doi.org/10.17153/oguiibf.1098419

Legault, J. (1987). C.A. -score, a warning system for small business failures. *Bilanas*, 6, 29-31.

Levin, A., Lin, C.F. and Chu, C.S.J. (2002). Unit root tests in panel data: Asymptotic and finite-sample properties. *Journal of Econometrics*, 108, 1-24. https://doi.org/10.1016/S0304-4076(01)00098-7

Modigliani, F. and Pogue, G.A. (1973). *An introduction to risk and return concepts and evidence* (Financial Analysts Federation Working Paper No. 646-73). Retrieved from https://core.ac.uk/download/pdf/4379523.pdf

Niu, Y. (2016). An Analysis of e-commerce enterprises sustainable development and financing structure. *Theoretical Economics Letters*, 6(5), 1105-1114. https://doi.org/10.4236/tel.2016.65106

O'Brien, R.M. (2007). A caution regarding rules of thumb for variance inflation factors. *Quality and Quantity*, 41(5), 673-690. https://doi.org/10.1007/s11135-006-9018-6

Parlakkaya, R., Kahraman, Ü.M. and Cihan, Y. (2019). The effects of inclusion in the BIST sustainability index: An application on Borsa Istanbul. *Journal of Financial Letters*, 111, 33-50. https://doi.org/10.33203/mfy.455322

Perdana, M.R., Sudiro, A., Ratnawati, K. and Rofiaty, R. (2023). Does sustainable finance work on banking sector in ASEAN?: The effect of sustainable finance and capital on firm value with institutional ownership as a moderating variable. *Journal of Risk and Financial Management*, 16(10), 449. https://doi.org/10.3390/jrfm16100449

Pesaran, M.H. (2004). *General diagnostic tests for cross section dependence in panels* (Cambridge Working Papers in Economics No. 435). http://dx.doi.org/10.2139/ssrn.572504

Pesaran, M.H. (2007). A simple panel unit root test in the presence of cross section dependence. *Journal of Applied Econometrics*, 22, 265–312. https://doi.org/10.1002/jae.951

Pesaran, M.H. and Yamagata, T. (2008). Testing slope homogeneity in large panels. *Journal of Econometrics*, 142, 50–93. https://doi.org/10.1016/j.jeconom.2007.05.010

Platt, H.D., Platt, M.B. and Chen, G. (1995). Sustainable growth rate of firms in financial distress. *Journal of Economics and Finance*, 19(2), 147-151. https://doi.org/10.1007/BF02920515

Raza, H., Gillani, S.M.A.H., Ramakrishnan, S., Gillani, S.M.A.H. and Qureshi, M.I. (2020). Nonsystematic review of financial sustainability and financial distress. *International Journal of Psychosocial Rehabilitation*, 24(6), 885-900. https://doi.org/10.37200/V24I6/13305

Sak, A.F. and Dalgar, H. (2020). The effect of corporate sustainability on financial performance of firms: A research on the firms in BIST corporate sustainability index. *The Journal of Accounting and Finance*, 1(85), 173-186. https://doi.org/10.25095/mufad.673722

Şahin, A. and Ergün, B. (2018). Financial sustainable growth rate and financial ratios: A research on Borsa Istanbul manufacturing firms. *Journal of Business Research Turk*, 10(1), 172-197. https://doi.org/10.20491/isarder.2018.376

Şamiloğlu, F. and Demirgüneş, K. (2008). The effect of working capital management on firm profitability: Evidence from Turkey. *The International Journal of Applied Economics & Finance*, 2(1), 44-50. Retrieved from https://www.ansinet.com/

Sepetis, A. (2020). A holistic sustainable finance model for the sustainable capital market. *Journal of Financial Risk Management*, 9(2), 99-125. https://doi.org/10.4236/jfrm.2020.92006

Shih, C., Gwizdalski, A. and Deng, X. (2023). *Building a sustainable future: Exploring green finance, regenerative finance, and green financial technology* (Nanyang Business School Research Paper No. 23-18). https://dx.doi.org/10.2139/ssrn.4449096

Springate, G.L.V. (1978). *Predicting the possibility of failure in a Canadian firm: A discriminant analysis* (Unpublished Doctoral Dissertation). Simon Eraser University, Burnaby.

Taffler, R.J. (1983). The assessment of company solvency and performance using a statistical model. *Accounting and Business Research*, 13(52), 295–308. https://doi.org/10.1080/00014788.1983.9729767

Uşar, D.D., Soytaş, M.A., Denizel, M. and Ersoy, İ. (2017). Corporate sustainability investments and financial performance relationship in Turkey. *Journal of Management and Economics Research*, 15(2), 140-162. http://dx.doi.org/10.11611/yead.316847

Van Horne, J.C. and Wachowicz, J.M. (2008). *Fundamentals of financial management*. Harlow: Pearson Education Limited.

Yaman, S. and Gür, K.E. (2023). Effects of financial risks on sustainable growth and profitability: An application on BIST100 Index firms. *International Journal of Economics, Politics, Humanities & Social Sciences*, 6(2), 64-88. https://doi.org/10.59445/ijephss.1223020

Appendix 1.

BIST Sustainability Index Firms Included in the Study

No	Code	Firm Title	No	Code	Firm Title
1	AKCNS	Akçansa Çimento Sanayi ve Ticaret A.Ş.	20	KORDS	Kordsa Teknik Tekstil A.Ş.
2	AKENR	Akenerji Elektrik Üretim A.Ş.	21	LOGO	Logo Yazılım Sanayi ve Ticaret A.Ş.
3	AKSA	Aksa Akrilik Kimya Sanayi A.Ş.	22	MGROS	Migros Ticaret A.Ş.
4	AKSEN	Aksa Enerji Üretim A.Ş.	23	NETAS	Netaş Telekomünikasyon A.Ş.
5	AEFES	Anadolu Efes Biracılık ve Malt Sanayi A.Ş.	24	OTKAR	Otokar Otomotiv ve Savunma Sanayi A.Ş.
6	ARCLK	Arçelik A.Ş.	25	PNSUT	Pınar Süt Mamulleri Sanayi A.Ş.
7	ASELS	Aselsan Elektronik Sanayi ve Ticaret A.Ş.	26	SISE	Türkiye Şişe ve Cam Fabrikaları A.Ş.
8	AYGAZ	Aygaz A.Ş.	27	TATGD	Tat Gıda Sanayi A.Ş.
9	BIMAS	BİM Birleşik Mağazalar A.Ş.	28	TAVHL	Tav Havalimanları Holding A.Ş.
10	BIZIM	Bizim Toptan Satış Mağazaları A.Ş.	29	TOASO	Tofaş Türk Otomobil Fabrikası A.Ş.
11	BRISA	Brisa Brıdgestone Sabancı Lastik Sanayi ve Ticaret A.Ş.	30	TUPRS	Tüpraş-Türkiye Petrol Rafinerileri A.Ş.
12	CIMSA	Çimsa Çimento Sanayi ve Ticaret A.Ş.	31	THYAO	Türk Hava Yolları A.O.
13	CCOLA	Coca-Cola İçecek A.Ş.	32	TTKOM	Türk Telekomünikasyon A.Ş.
14	DOCO	Do & Co Aktıengesellschaft	33	TTRAK	Türk Traktör ve Ziraat Makineleri A.Ş.
15	DOAS	Doğuş Otomotiv Servis ve Ticaret A.Ş.	34	TCELL	Turkcell İletişim Hizmetleri A.Ş.
16	ENKAI	Enka İnşaat ve Sanayi A.Ş.	35	ULKER	Ülker Bisküvi Sanayi A.Ş.
17	EREGL	Ereğli Demir ve Çelik Fabrikaları T.A.Ş.	36	VESTL	Vestel Elektronik Sanayi ve Ticaret A.Ş.
18	FROTO	Ford Otomotiv Sanayi A.Ş.	37	VESBE	Vestel Beyaz Eşya Sanayi ve Ticaret A.Ş.
19	KARSN	Karsan Otomotiv Sanayi ve Ticaret A.Ş.	38	ZOREN	Zorlu Enerji Elektrik Üretim A.Ş.

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DETERMINANTS OF FINANCIAL EFFICIENCY AND PERFORMANCE IN BIG-CAP CHAIN HOTELS

Büyük Sermayeli Zincir Otellerde Finansal Verimlilik ve Performansın Belirleyicileri

Berk YILDIZ*

Keywords:
RevPAR,
Panel Data,
Financial Performance,
Market Capitalization,
Agency Cost Theory

JEL Codes:
G21, G32, C33

Abstract

Chain hotels with $1 billion in market capitalization not only contribute to employment creation and indirectly become a driving force in the regeneration of local economies but also play an essential role in recovering local economies with their high revenue per available room (RevPAR) values. Besides, the financial stability of these hotel chains directly influences the popularity of destinations, resulting in an influx of tourists to nearby regions, which in turn generates an economic contribution to the overall development of the tourism industry. Therefore, the aim of this paper is to determine the financial factors that are affecting the RevPAR (RPR), their role in the industry, and the validity of the agency cost theory of nine chain hotels that have at least $1 billion in market capital listed in U.S. stock markets over the period 2013–2022. The results show that, in contrast to the debt service coverage ratio, receivables turnover ratio, and book value per share variables, the day sales outstanding ratio and current ratio have a negative impact on chain hotels' RevPAR.

Anahtar Kelimeler:
Oda Başına Gelir,
Panel Veri,
Finansal Performans,
Piyasa Değeri,
Temsil Maliyeti Teorisi

JEL Kodları:
G21, G32, C33

Öz

Piyasa değeri 1 milyar doları olan aşmakta olan zincir oteller, istihdam yaratılmasına katkıda bulunmanın ve dolaylı olarak yerel ekonomilerin yenilenmesinde itici bir güç olmanın yanı sıra, yüksek oda başına gelir (revenue per available room, RevPAR) değerleriyle yerel ekonomilerin toparlanmasında da önemli bir rol oynamaktadır. Ayrıca, bu otel zincirlerinin finansal istikrarı destinasyonların popülerliğini doğrudan etkileyerek yakın bölgelere turist akınına neden olmakta ve bu da turizm endüstrisinin genel gelişimine ekonomik bir katkı sağlamaktadır. Bu nedenle, bu çalışmanın amacı, 2013-2022 döneminde Amerika Birleşik Devletleri (ABD) menkul kıymet borsalarında işlem görmekte olan ve piyasa değeri en az 1 milyar dolar olan dokuz zincir otelin oda başına gelirlerini etki eden finansal faktörleri, bunların sektördeki rolünü ve temsil maliyeti teorisinin bu sektör üzerindeki geçerliliğini belirlemektir. Sonuçlar, borç servisi karşılama oranı, alacak devir hızı oranı, hisse başına defter değeri değişkenlerinin aksine, borç ödeme vadeleri ile cari oran değişkenlerinin zincir otellerin oda başına gelirleri üzerinde negatif bir etkileri olduğunu göstermektedir.

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1. Introduction

Travel and tourism activity is an important source of job creation and a driver of economic activity, supporting 10.3% of global GDP and over 333 million jobs in 2019. The sector directly generated 3.2% of GDP as well as providing wider impacts indirectly through supply chain spending and induced employee wages that support spending (WTTC, 2022: 7). Also, the lodging sector is a crucial component of the tourism and hospitality industry, which is a worldwide phenomenon. Highly capitalized hotels are particularly important in this sector, characterized by large investments, sophisticated operations, and complex financial structures, generating revenues, employing millions of people, and impacting tourism and related sectors as a significant contributor to the global economy. They are globally recognized chains with diverse properties, often publicly traded, catering to various guest segments and budgets, advancing financially, and embracing new technology, marketing methods, and guest experiences. Some of the most well-known of them are Hilton Worldwide Holdings, Inc. which is known for its brands Hilton Hotels & Resorts, Conrad Hotels & Resorts, Waldorf Astoria Hotels & Resorts, DoubleTree by Hilton, and Hampton by Hilton, which also have over 6,800 hotels and timeshare properties across 122 countries, and it is traded on the New York Stock Exchange (NYSE) as well. Marriott International, Inc. is another leading global hospitality company that is traded on the Nasdaq Stock Exchange and has over 7,800 hotels in 133 countries, including brands like Marriott Hotels & Resorts, JW Marriott Hotels & Resorts, The Ritz-Carlton, Sheraton Hotels & Resorts, Westin Hotels & Resorts, and W Hotels. Moreover, Intercontinental Hotels Group, Hyatt Hotels, and H World Group are the others with a market capitalization exceeding $10 billion.

On the other hand, the ever-increasing demand for hotels has made the financial performance of hotel chains an important issue. Understanding the financial health factors of these hotels is not only vital for guests, policymakers, and managers but also for investors to make informed investment decisions and enhance profitability and growth in the sector. Because the hotel industry's cyclical nature and sensitivity to economic fluctuations can result in volatile dividends and stock prices, posing a higher risk. Additionally, agency theory issues can affect brand perception and investor confidence due to negative publicity, ethical concerns about labor practices, or environmental impacts. But in contrast to these potential risks, highly capitalized hotels offer investors a combination of financial stability, growth potential, liquidity, and reduced management risk, making them attractive investment options for many. Therefore, understanding the financial performance of hotel chains valued at over $1 billion is critical for the industry's overall health and future. Thus, the aim of this paper is to explore the financial performance of hotel chains with market capitalization exceeding $1 billion, their role in the industry, and the validity of agency cost theory in the hotel industry, focusing on chain hotels. The study employs the panel data method and covers the years 2013–2022, thereby providing a more comprehensive analysis of the factors influencing the financial performance of major industry players in comparison to studies that consider a wider range of hotel sizes. The metric RevPAR gauges the financial performance of hotels and other lodging companies. This is a pivotal performance indicator in the hospitality industry, encompassing both occupancy and average daily rates (ADR), which reflect the pricing strategy. Furthermore, it is a crucial metric for evaluating the validity of agency theory for chain hotels. Agency theory posits that managers may prioritize short-term gains over long-term value creation. Consequently, RevPAR, which reflects short-term revenue generation, may be an unreliable indicator of long-term value creation.

The remaining sections of this paper are structured as follows: The subsequent section presents a theoretical framework for agency cost theory and a comprehensive literature review, encompassing studies on both financial performance and agency cost analysis. Section 3 requires a detailed overview of the study's methodology, model, sample, and data collection processes. It also includes specific definitions of the variables in the model and the resulting empirical findings. The concluding part of the study analyzes the results and concludes with recommendations for further studies.

2. Theoretical Framework and Literature Review

The agency cost theory examines the potential conflicts of interest that may arise when one party (the principal) engages another party (the agent) to act on its behalf. Although the principal authorizes the agent to make decisions, there is a possibility that the agent's objectives may not always align perfectly with the principal. The theory is based on Smith's 1776 work, The Wealth of Nations, which introduced the principal-agent relationship by arguing that principals cannot supervise a company as rigorously as sole traders or partnerships owned by principals. Since then, Berle and Means (1933) have continued to examine the separation of ownership and control in corporations worldwide, revealing various levels of self-interest motives (Nguyen et al., 2020).

Additionally, Stephen Ross formally proposed economic agency theory in 1973, emphasizing the design of contracts to minimize conflicts of interest between principals and agents. Barry Mitnick, meanwhile, developed institutional agency theory in "Fiduciary Rationality and Public Policy: The Theory of Agency and Some Consequences," highlighting the role of social norms, institutions, and power dynamics in shaping principal-agent relationships. Besides, Jensen and Meckling's 1976 paper, considered the formal inception of agency theory, which combined theories of agency, property rights, and finance to develop a firm ownership structure. They focused on the relationship between shareholders and managers, defined agency costs, and explored the types of agency costs arising from debt and outside equity. Also, Fama and Jensen (1983) contributed to a significant body of literature by demonstrating that agents who hold equity in a firm are more likely to embrace the actions desired by principals as their own.

In a subsequent study, Eisenhardt (1989) proposed that agents act in the principal's interest when their actions are outcome-based. However, when agents perceive an unfair situation, they may act in their own best interests, which may result in information gaps that complicate the principal's ability to monitor their agents' actions. This is known as principal-agent research on agency problems, which encompasses risk-sharing and agent monitoring. In contrast, the positivist perspective focuses on crucial governance mechanisms that prevent agents from acting in their own self-interest. However, the agency problem is a persistent and challenging issue in joint-stock companies, affecting organizations in various forms. It has evolved over time, requiring a comprehensive understanding of its manifestations and associated costs. Hence, academic fields like finance and economics have widely observed the presence of agency issues, making this theory one of the most pivotal in finance and economic literature (Panda and Leepsa, 2017).

Accordingly, agency cost theory-based problems are crucial for chain hotels and industries. Financial performance measurement is essential for reducing agency costs. Companies can create a system that encourages managers to act in the best interests of shareholders by selecting

appropriate metrics and interpreting them within their long-term strategy. Moreover, the complex and interconnected relationship between the hospitality industry and tourism demand is critical to the overall performance of the tourism industry. Numerous studies have thoroughly examined the financial performance of hotels and assessed their impact on the tourism industry. Nevertheless, the research on the impact of agency theory is insufficient. This section of the study comprises a review of the literature on financial performance measurement and the effects of agency costs in various sectors. However, this review prioritizes the tourism and hospitality sectors.

Morck et al. (1988) is a primary source that investigates the relationship between management ownership and the firm's market valuation, as measured by Tobin's Q. A cross-sectional analysis of 371 Fortune 500 firms in 1980 showed that Tobin's Q increases initially as the proportion of shares owned by the board of directors rises, then declines before slightly rising as the proportion of shares rises. The study suggests that running a firm by a founding family member lowers Tobin's Q compared to an officer unrelated to the founder. Haubrich's (1994) paper represents the agency cost impact, employing numerical solutions to the principal-agent problem and comparing these solutions to CEO compensation. Using the Grossman and Hart, Holmstrom, and Milgrom models, he derives numerical predictions and concludes that providing correct incentives can significantly enhance a firm's performance. He found that CEO compensation can increase by $10 for every $1,000 of additional shareholder value, with some cases reaching as low as 0.003 cents. The study of Dahlstrom et al. (2009) examines the principal-agent perspective in the hotel industry, focusing on entrepreneurs' motivations to join hotel alliances. The study explores the decision between independent ownership, affiliation with a voluntary chain, integration, and franchising. Data from 650 hotels revealed that factors such as size, amenities, population, and headquarters distance have a significant impact on hotel governance. Guillet and Mattila's (2010) study on corporate governance in the U.S. hospitality industry revealed that firms with weaker shareholder rights tend to be larger, have higher earnings per share, lower capital expenditure per asset, and have higher leverage ratios. Furthermore, the study identified significant discrepancies in performance metrics between high- and low-corporate governance firms across various hospitality sectors, including hotels, restaurants, and casinos.

In addition, Ozdemir and Upneja's 2012 study identified a positive correlation between CEO compensation and the proportion of outside board members in US lodging firms. However, their findings contradict previous research, which suggested that larger boards weaken board effectiveness and control over CEO actions. In another study, Ozdemir et. Al (2013) examines the relationship between CEO compensation and risk (systematic risk) in the U.S. restaurant industry. It investigates whether CEOs in restaurant firms with high-risk profiles should be rewarded with higher incentive-based compensation to motivate them to perform at their full potential for the mutual benefit of the CEO and shareholders. Moreover, the study examines whether firm risk moderates the relationship between firm performance and CEO total compensation, controlling for firm size and CEO ownership. The findings indicate that firm risk is associated with higher incentive-based compensation for CEOs of restaurant firms. Additionally, the moderating effect of firm risk on the relationship between pay and performance in the restaurant industry is not evident.

In a separate study, Ozdemir et al. (2013) explored the relationship between CEO compensation and risk in the U.S. restaurant industry. They found that high-risk firms reward CEOs with higher incentive-based compensation to encourage them to reach their full potential.

The study also examined how firm risk moderates the relationship between firm performance and CEO total compensation. The findings suggest that firm risk is associated with higher incentive-based compensation for CEOs in restaurant firms, but the moderating effect on pay and performance is not evident. Freedman and Kosová's (2014) study investigated the impact of ownership structures on hotel compensation and human resource strategies. The study builds on previous research (Krueger 1991, Rebitzer 1995, Rebitzer and Taylor 1995), examining the complex relationship between supervision, pay, and personnel practices in the hotel industry. The study highlights the labor-intensive nature of the industry and the use of technology as a substitute for human supervision, as well as contractual differences between salaried managers and franchisees. The study reveals that workplace agency issues impact pay timing and employers' tendency to use performance-based incentives like bonuses and merit-based raises. Furthermore, Bianchi and Chen's 2016 study examines the relationship between CEO compensation and firm performance in both the hospitality and non-hospitality industries. They used a fixed effects model to address the principal-agent problem in CEO compensation between 1992 and 2010. The findings showed a lower compensation rate for CEOs in the hospitality industry compared to other industries, primarily due to higher salaries, bonuses, long-term incentive plans, non-equity incentives, and restricted stocks. The study also found that incentives provided to CEOs did not resolve the principal-agent problem in both industries. In their 2022 study, Liang et al. employed dynamic panel regression tests to assess the influence of board size, age, and education on the performance of Chinese hotel firms. The results showed that board size and age had nonlinear effects on performance, whereas board education had no significant effect. Board size's effect on growth opportunities was cubic, supporting agency and resource dependence theories. Board age's influence on growth opportunities was quadratic, with an optimal point of 51. The study emphasizes the importance of hotel directors' resources and experience for success.

The study of Bresciani et al. (2015) on the Italian hotel industry is one of these that investigates the impact of factors such as size, category (stars), and service variety on performance. The study analyzed 450 hotels and found a strong correlation between a hotel's star rating and its performance. However, no significant impact on performance was found from size or service variety. In another study, Aznar-Alarcón and Sayeras Maspera (2015) analyzed the financial structure, size, and profitability of hotels in three Spanish coastal regions: Costa Brava, Costa Dorada, and Costa del Sol. The analysis of around 100 hotels revealed significant differences in their performance within these regional clusters of the hospitality industry. The study revealed that the three regions have significant differences in hotel size, financial structure, and economic performance. Costa del Sol's larger hotels result in higher debt and interest payments, negatively impacting profits. Costa Dorada's larger hotels allow for economies of scale with manageable interest payments, leading to better economic performance due to their size and higher occupancy rates.

A recent study by Babajee et al. (2022) explored the link between corporate social responsibility (CSR) activities and found that CSR activities significantly impacted firm financial performance in 43 hotels from 2007 to 2018. Growth opportunities mediated the relationship, and high-growth hotels had better opportunities to engage in CSR activities, which positively impacted their performance. Temelkov's 2022 study examined the financial impact of COVID-19 on hotels in 2020 compared to 2019, finding a decrease in operational efficiency and increased revenue spending. Hotels implemented cost-cutting strategies, while government support programs and domestic tourism promotion helped mitigate the pandemic's negative effects.

Moreover, Raguseo and Vitari's 2017 study analyzed the impact of electronic word of mouth (e-WOM) on the performance of branded chain hotels in France, using financial data and 34,164 online customer reviews from TripAdvisor. The research explored 221 hotels, including both branded and non-branded chains in France, from 2005 to 2013. The study reveals that the volume of online reviews does not impact RevPAR growth for branded chain hotels, but it positively affects it for non-branded chain hotels. The valence of online reviews and their interaction with the yearly and cumulative volume of reviews directly affect RevPAR growth and sales profitability for non-branded chain hotels, but not for branded chain hotels. The study contributes to the literature on e-WOM and suggests that branded chain hotel managers may face challenges in utilizing e-WOM to achieve higher revenue per available room and sales profitability.

The study by Sharma and Upneja (2005) is one of the primary ones to examine the effective factors of the financial performance of small hotels, with a focus on developing countries such as Tanzania. The study involved the use of financial ratio analysis on business performance data collected through face-to-face interviews with small hotel owners in Tanzania. The main findings indicate that inefficiencies resulting from inadequate employee training, low investments in fixed assets and technology, as well as government policies that overlook the importance of ensuring safety and security and expediting the processing of licenses and permits, may equally contribute to low profitability in small hotels. In a similar study, Sardo et al. (2018) analyzed the effect of intellectual capital on small and medium-sized hotel financial performance for the period between 2007 and 2015, using a sample of 934 Portuguese small and medium-sized hotels with a dynamic panel data method. The study reveals that human capital, structural capital, and relational capital are key components of intellectual capital that positively impact hotel financial performance. These components are essential for service quality in the hotel sector, and establishing and maintaining long-term relationships with key stakeholders also capitalizes on human and structural capital. Also, Sainaghi’s (2010) paper is among the earliest ones that explore identifying the determinants of RevPAR for individual firms located in a destination of 72 individual firms operating in the 3–5-star range using data from financial statements and questionnaires, focusing on 'what' and 'where' dimensions. The study reveals that room count, employee count, refurbishment history, market orientation, and centrality within the destination impact the positioning of the "what" and confirm the relevance of location, particularly centrality within the destination.

Furthermore, Nunes and Cardoso Vieira Machado (2012) emphasized the importance of financial measures in hotel performance assessment but suggested that non-financial measures should be used to consider the industry's unique characteristics and hotel service. Singh and Schmidgall's (2012) study examined the U.S. lodging industry's financial profile by analyzing 2,091 financial statements from hotels with asset sizes ranging from $500 thousand to $250 million. The study found that the industry's financial performance varies based on hotel size and sample quartiles. Asdullah and Rehman (2015) analyzed the financial performance of the Serena Hotel and the Marriott Hotel in Pakistan, finding that both hotels performed better in 2012 but didn't maintain sufficient assets compared to liabilities. The Serena Hotel had a higher profit margin ratio than the Marriott Hotel. Jawabreh et al. (2017) explored strategies for managing hotel income and costs, revealing that the number of guests and their spending power significantly impact a hotel's revenues, with single guests' spending power having the greatest impact on

profitability. Both changing and fixed costs directly affect the hotel sector's profitability and activity, requiring careful planning, monitoring, and follow-up.

Both Pacheco (2016) and Chattopadhyay and Mitra (2019) conducted studies on RevPAR and room ADR in the hotel industry. Pacheco's study found that local variables significantly impact hotel performance in Portugal, particularly for 4-star hotels, accounting for 55% of changes in RevPAR. The hotel sector's performance is linked to cyclical factors, particularly tourism growth, but is vulnerable to uncontrollable, volatile variables. In their study, Chattopadhyay and Mitra predicted RevPAR in Sweden using multiple regression and the MARS (Multivariate Adaptive Regression Splines) model. The study analyzed monthly seasonality, yearly trends, and nonlinear price and demand influences. The findings indicated that MARS could establish a nonlinear relationship between RevPAR and other determining variables, which suggests the potential for developing an improved forecasting model.

Also, Jiang and Taylor (2020) studied price determinants in the lodging industry. They found that factors such as hotel class, operation, location, size, and seasonality significantly influence the ADR and RevPAR. The study emphasizes the importance of these determinants in revenue management and provides guidelines for pricing decisions in resort areas. The data indicates that independent hotels typically have higher ADR and RevPAR than chain hotels, whereas franchised hotels tend to have lower ADR and RevPAR. Occupancy does not appear to be a determining factor for prices, and older hotels tend to have higher ADR and RevPAR. Also, increased passenger arrivals have a positive effect on ADR and RevPAR. In Jakaša's (2017) study, the financial performance of Croatia's 40 largest hotel companies was analyzed, with a focus on factors such as size based on sales, leverage, coverage ratio I, and coverage ratio II. The study found that leverage had a negative correlation with net margin performance, making it the most significant variable. Only the coverage ratio had a significant impact on performance when it came to ROE (Return on Equity), whereas the independent variables had no significant impact on ROA (Return on Assets). Shieh et al. (2018) investigated the factors that impact the financial performance of international tourist hotels in Taiwan using moving average regression and panel data regression. The study identified four key factors that affect financial performance: domestic visitors, occupancy rate, operation year, and joining a chain system.

Besides, in two separate studies on Kenya, Chebii and Kaplelach (2019) conducted a study on the factors affecting the financial performance of 67 Star Hotels in Kwale County, Kenya. The research, based on open-ended and closed questionnaires, secondary sources, and annual financial reports, revealed that hotel ownership, organizational structure, capital structure, and working capital all positively impact the financial performance of hotels. In 2021, Murimi et al. did a study on revenue management practices (RM) and how they affect a hotel's financial performance. They did this in two steps: first, they looked at previous research on RM practices and what factors affect them; and second, they improved the framework. They present a theoretical framework that explains the impact of revenue management practices on the financial performance of Kenyan hotels by using contingency theory and its strengths and weaknesses in revenue management studies. Furthermore, Abdelmawgoud and Abd El Salam's (2022) study is one of the latest to examine operational and financial performance indicators in Cairo's four- and five-star hotels. The study found high variation in performance indicators, with factors such as hotel manager gender, chain type, and nationality having a significant impact on hotel performance. The study found a positive correlation between total room revenues and the average daily rate, RevPAR,

total rooms sold, and annual rooms. Additionally, a strong direct relationship was observed between the average daily rate and RevPAR at the 0.01 level.

On the other hand, despite being an integral component of the tourism sector and playing a vital role in supporting the economic well-being of destinations, fostering job creation, and ensuring a smooth and enjoyable travel experience for tourists, there are relatively few studies on the financial performance of chain hotels. It is important to objectively evaluate their financial impact to better understand their contribution to the industry. Thaothampitak and Wongsuwatt's (2019) study is one of them, which investigates the effect of chain hotel employees' perceived risk on their hotel's financial performance and the moderating role of hotel employees' job roles in Thailand using a questionnaire survey. The results of their study revealed that the perceived risks of chain hotels are a significant instrument for enhancing all three aspects of hotel performance, including profitability, growth, and market value. Yang's 2019 study is another one that examined the correlation between the amount of money spent, the number of hotels acquired, and the financial performance of acquirer hotel groups post-acquisition. The results showed that the increase in EBITDA and operating efficiency ratio is more dependent on the number of target hotels acquired than the amount of money invested. The study also found that when more target hotels are acquired, the annual EBITDA increases at a lower percentage, while the operating efficiency ratio increases at a higher percentage. The size of the acquisitions significantly impacts the financial performance of the groups.

3. Model and Findings

3.1. Data and Variables

Table 1 presents characteristics selected from scholarly literature, including nine U.S. stock market-listed group hotels with a minimum capital market value of $1 billion, sourced from official websites and annual reports covering the period from 2013 to 2022 and, Table 2 shows the descriptive statistics.

Table 1. The Variables and Definitions

Variables	Symbols	Definitions
Dependent Variable		
RevPAR	RPR	Total Room Revenue / Number of Available Rooms
Explanatory Variables		
Operating Cash Flow per Share	OCF	(Operating Cash Flow-Preferred Dividends) / Total Common Shares Outstanding
Price to Book Ratio	PBR	Market Value per Share / Book Value per Share
Price to Earnings Ratio	PER	Market Value per Share / Earnings per Share
Price to Sales Ratio	PSR	Market Value per Share / Total Revenues
Book Value per Share	BVS	(Total Equity-Preferred Equity) / Total Shares Outstanding
Day Sales Outstanding	DSO	(Accounts Receivable / Total Credit Sales) x Number of Days
Receivable Turnover	RTV	Net Credit Sales / Average Accounts Receivable
Debt Service Coverage Ratio	DSC	Net Operating Income / Total Debt Service
Current Ratio	CUR	Current Assets / Total Assets
Return on Investment	ROI	(Net Income / Total Investment) x 100
Return on Assets	ROA	Net Income / Average Total Assets
Return on Equity	ROE	Net Income / Shareholder Equity

Table 2. Descriptive Statistics

	RPR	OCF	DSC	RTV	DSO	BPS	PER	PSR	PBR	ROE	ROI	ROA	CUR
Mean	106.81	0.16	0.21	12.03	46.17	8.61	21.80	3.00	-0,26	-10.81	14.49	6.08	1.07
Median	102.96	0.13	0.12	7.49	46.93	3.34	20.48	2.55	2.65	3.69	10.54	5.27	1.03
Max.	246.25	9.06	1.25	61.46	125.86	41.56	88.50	8.30	80.78	383.7	91.39	32.48	2.60
Min.	0.0000	-9.76	-0.14	0.000	0.000	-14.00	-59.70	0.000	-239.14	-947.97	-21.04	-14.98	0.42
Std. Dev.	54.240	2.12	0.31	13.02	26.41	14.82	21.52	1.91	33.58	141.29	19.72	8.01	0.45
Skewness	0.4115	-0.11	2.25	2.54	0.49	0.89	0.28	0.92	-4.19	-3.68	1.38	0.20	1.13
Kurtosis	2.3704	10.60	7.35	8.66	3.33	2.51	5.82	3.69	31.1	25.45	5.59	3.78	4.52
J-B	4.0267	216.89	147.13	217.79	4.17	12.83	31.18	14.66	3224.2	2094.54	53.85	2.88	27.92
Prob.	0.1335	0.000	0.000	0.000	0.12	0.001	0.000	0.000	0.000	0.000	0.000	0.23	0.000
Sum	9613.7	15.17	19.63	1083.4	4155.48	775.01	1962.1	270.35	-24.19	-972.68	1304.79	547.88	97.19
Obs.	90	90	90	90	90	90	90	90	90	90	90	90	90

3.2. Panel Regression Model

Equation (1) is designed to calculate the determinant financial factors for the RevPAR model (RPR), which represents financial efficiency.

$$RPR_{it} = \beta_0 + \beta_1 OCF_{it} + \beta_2 PBR_{it} + \beta_3 PSR_{it} + \beta_4 BVS_{it} + \beta_5 DSO_{it} + \beta_6 RTV_{it} + \beta_7 DSC_{it} + \beta_8 CUR_{it} + \beta_9 ROI_{it} + \beta_{10} ROA_{it} + \beta_{11} ROE_{it} + \varepsilon_{it} \quad i = 1, \dots, 9 \tag{1}$$

Panel regression is a commonly used econometric technique for analyzing cross-sectional and time-series data. However, it is important to check for prerequisites such as autocorrelation, heteroscedasticity, and multicollinearity before using it. Additionally, it is also necessary to ensure that there are no issues with stationarity or cross-sectional dependence (CSD).

Ragnar Frisch introduced the term multicollinearity' to describe the precise linear relationship between independent variables in a regression model, which can lead to estimation errors when analyzing time and cross-sectional series. To reduce biased coefficients, highly correlated variables can be removed from the model by eliminating those strongly linked to the VIF (Variance Inflation Factor). But multicollinearity is usually not a big problem with panel data that includes more than one thing, and it is still a good idea to do correlation matrix or VIF tests to make sure there isn't any problematic multicollinearity. In this paper, VIF analysis is performed to identify potential factors causing multicollinearity using a test based on the variance inflation factor. Besides, some studies consider a VIF score exceeding 5 to be concerning, while others adopt a more prudent stance and establish a threshold value of 2.5 (Gujarati and Porter, 2009: 340). The analysis revealed that the variable with the highest VIF value was 3.59. Therefore, the findings suggest that the model did not exhibit any issues with multicollinearity.

3.2.1. Cross Sectional Dependency

CSD and unit root tests are crucial in econometrics, particularly when analyzing panel data. Despite their differences, they interact with and impact each other. Thus, the cross-section dependence test developed by Pesaran (2004) was primarily conducted, and the results are presented in Table 3.

Table 3. Cross Sectional Dependency Analysis

H_0: No cross-section dependence				
Variables	**CD-test**	**p-value**	**Corr**	**abs(corr)**
RPR	9.17	0.000	0.483	0.554
OCF	7.98	0.000	0.420	0.510
PBR	-0.81	0.419	-0.043	0.496
PER	1.36	0.173	0.072	0.378
PSR	2.46	0.014	0.130	0.616
BVS	-0.02	0.984	-0.001	0.494
DSO	4.64	0.000	0.245	0.484
RTV	5.58	0.000	0.294	0.515
DSC	8.95	0.000	0.472	0.472
CUR	1.83	0.067	0.097	0.316
ROI	7.36	0.000	0.388	0.414
ROA	9.01	0.000	0.475	0.488
ROE	2.11	0.035	0.111	0.281

Table 3 shows that certain variables have probability values below the critical threshold of 0.05, indicating the presence of CSD among these series. If CSD is detected, various methods can be used to address it. However, it can make rejecting the null hypothesis of a unit root more challenging, even when the series is stationary. To detect and eliminate the problem of CSD in unit root testing, several second-generation panel unit root tests must be applied.

3.2.2. Panel Unit Root Tests

This section of the paper includes panel tests for unit roots. The decision on which unit root tests to apply is contingent upon the results of the CSD test, as shown in Table 1. Therefore, it is necessary to examine the stationarity of the series that display CSD (RPR, OCF, PSR, DSO, RTV, DSC, ROI, ROA, and ROE) using the second-generation unit root test. Hence, the Pesaran-CADF test, developed by Pesaran in 2003, was applied to the series showing CSD, and unit root tests were analyzed, and the results are shown in Table 4. For series that do not exhibit CSD, stationarity is evaluated using first-generation unit root tests such as LLC and IPS, and non-stationary series are transformed into stationary ones by taking the first difference.

Table 4. Pesaran's CADF Test Results

H_0: Unit root		
Series	**Z[t-bar]**	**P-value**
RPR	-2.492	0.006
OCF	-3.771	0.000
PSR	-2.131	0.017
DSO	-2.592	0.005
RTV	-1.864	0.031
DSC	-1.917	0.028
ROI	-2.228	0.013
ROA	-2.237	0.013
ROE	-3.473	0.000

3.2.3. Panel Data Regression

After ensuring the series is stationary through differencing, an F test was conducted to determine the most appropriate model between the fixed/random effects models and the pooled model. The results of the F test [F (12, 60) = 16.87, P = 0.000<.01] revealed that the pooled regression model was not suitable for estimation. Thus, the Hausman test is used to determine whether a panel model should use a fixed effect or a random effect. The results of the Hausman test (prob>chi2 = 0.0240) showed that the fixed effect estimator was consistent at a significance level of 0.05, disconfirming the null hypothesis that random effects are valid and suggesting the fixed effects model is more appropriate.

Following both a modified Breusch-Pagan / Cook-Weisberg test was also used to check for heteroscedasticity, and the null hypothesis of constant variance was accepted depending on the chi-square test statistic (chi2 (1) = 1.27, prob>chi2 = 0.2604>.01). The series is also checked for serial correlation and autocorrelation in panel data using the Wooldridge test. The results of this test showed that there is evidence to suggest that there is a serial correlation in the data (Prob > F = 0.0194).

Ultimately, as shown in Table 5, Beck and Katz's (1995) period SUR (PCSE) method heteroscedasticity-consistent standard error estimator re-estimates the model. This method is useful for estimating when both heteroscedasticity and autocorrelation are present.

Table 5. Beck and Katz's Panel Corrected Standard Errors Estimator Results

Dependent Variable: RPR				
	[Coefficient]	**[Std.Error]**	**[z Statistics]**	**[p-value]**
OCF	-1.001702	1.565786	-0.64	0.522
DSC	57.26488	10.97273	5.22	0.000*
RTV	1.798869	0.3263034	5.51	0.000*
DSO	-0.5883361	0.1377212	-4.27	0.000*
BVS	1.139649	0.2904194	3.92	0.000*
PER	0.0666387	0.1373087	0.49	0.627
PSR	2.671174	2.369638	1.13	0.260
PBR	0.0450221	0.085138	0.53	0.597
ROE	0.0045562	0.027191	0.17	0.867
ROI	0.2653914	0.2309649	1.15	0.251
ROA	0.9737203	0.8634342	1.13	0.259
CUR	-18.92321	9.282876	-2.04	0.041**
CONSTANT	92.34342	17.12572	5.39	0.000
Observations			81	
Adj. R^2			0.6350	
Prob > chi2			0.0000	

Note: The model was applied with a White's heteroscedasticity-consistent standard error estimator.
*Statistical significance at 1% level. **Statistical significance at 5% level

Table 5 indicates a positive correlation between the RPR and the DSC. DSC is a key financial statistic in the hotel industry and quantifies a hotel's capacity to cover its debt payments using its operational cash flow. The calculation involves dividing the net operating income (NOI) by the total debt service. Therefore, it may be inferred that the correlation between RPR and DSC is contingent upon a high RPR. Since RPR generally results in increased net operating income,

which subsequently leads to a higher DSR, this is due to the fact that RPR is a direct factor influencing NOI.

RTV has a positive relationship with the model, and Beck and Katz’s (1995) panel-corrected standard errors estimator shows that this is statistically significant. Hotels facilitate credit sales by providing customers with the choice to pay using a credit or debit card, and this payment method enables consumers to delay payment for their lodgings to boost sales. Furthermore, BVS has a positive effect, whereas RPR has an inverse correlation with both DSO and CUR; however, the impact of CUR on RPR is relatively weaker.

4. Conclusion

Chain hotels possess the ability to attract a larger percentage of tourists to a specific location due to their established brand recognition, esteemed reputation for excellence, and consistent service standards. This power serves as a catalyst for stimulating local economies by encouraging increased expenditure on lodging, food and beverage, and other tourism-related services. Additionally, these organizations also operate as important employers within the tourism industry, offering employment opportunities to a diverse array of the public, including hotel staff, tour guides, and transportation suppliers. Simultaneously, they are making substantial investments in their properties and neighboring areas to foster the development of new infrastructure, attractions, and amenities. Nevertheless, it is equally uncontested that chain hotels generate substantial economic value and exert a considerable influence on both national and global economies. Moreover, since their operations generate cash flows that are contingent on foreign currency transactions, they also have an impact on countries' balances of payments. They also contribute to infrastructure development and knowledge transfer, providing a more skilled workforce and a more attractive environment for further economic growth. Therefore, this study was conducted to identify the financial factors that affect the financial performance and financial sustainability of chain hotels, which are among the important stakeholders in economies, and to test the effects of agency costs on these institutions. Hence, I employ panel data methodology to assess the financial factors that influence the financial performance of large chain hotels and to evaluate the impact and validity of the agency cost theory in these hotels.

The findings revealed a positive correlation between RevPAR and debt service coverage ratio in chain hotels with $1 billion in market capitalization. This supports the efficient management of agency costs in the hotel industry, despite anticipated agency costs due to ownership separation, operational complexity, information asymmetry, and misalignment of incentives. Large chain hotels effectively manage these costs by monitoring, aligning incentives, and increasing transparency. Established chain brands, due to their higher brand awareness and customer loyalty, can benefit from higher occupancy rates and implement more flexible pricing strategies. This aligns the interests of managers (agents) with those of shareholders (principals), thereby reducing the likelihood of them engaging in risky ventures that could jeopardize the firm's solvency and their position. This result is consistent with the findings in the literature (Corgel and Gibson, 2005).

Moreover, the findings showed that there is also a positive relationship between RevPAR and RTV, and this is a clear sign of the revenue generation capability and debt collection efficiency of these hotels. By maintaining strong RevPARs and optimizing RTVs, they enhance

their financial stability, investor appeal, and long-term growth prospects. In contrast, RevPAR has a negative correlation with days sales outstanding, which is consistent with the positive RevPAR-RTV relationship and emphasizes the importance of accounts receivable management for hotels. Because hotels can achieve long-term success and sustainability in the competitive hospitality business by prioritizing the reduction of DSO, this strategy improves cash flow, minimizes financial risks, and enhances overall financial health. This positive relationship suggests that there is an alignment between the interests of management (agents) and shareholders (managers) in chain hotels. A higher RevPAR indicates the hotel's effective room sales and revenue generation, while a higher receivables turnover rate confirms the effective collection of revenue. This reduces the risk of negative debt and, potentially, increases profitability by freeing up cash flow for reinvestment. The positive correlation between these variables suggests that the management of working capital is effective, which in turn indicates that the financial health of chain hotels is robust. Consequently, these fosters enhanced investor confidence and a reduced cost of capital for chain hotel companies. According to shareholders, the reduction of agency costs and the improvement of financial performance are both desirable outcomes. In fact, various studies (Warrad and Omari, 2015; Blal et al., 2018; Yamin and Prawiti, 2020; Annaria et al., 2021) that investigated the impact of various financial ratios on profitability (ROE, ROA) and financial performance (revenue growth) have found a positive relationship between receivables turnover rate and RevPAR. This is because efficient accounts receivable management, along with other operational aspects, can improve financial performance, which is likely to have a positive impact on RevPAR for hotels.

Additionally, BVS exerts a positive influence on RevPAR. The findings indicated a positive correlation, suggesting that hotels with consistently high RevPAR tend to have a greater book value per share. This is due to RevPAR's role in mitigating agency conflicts and enhancing financial performance. A high RevPAR indicates a hotel's financial health, as increased revenue generation per available room correlates with improved profitability. Hotels with high RevPAR have greater financial resources to reinvest in property upgrades, staff training, or brand development. This virtuous cycle fosters long-term financial sustainability and growth, resulting in improved operational efficiency and a stronger brand. Furthermore, a high RevPAR is also associated with a decrease in agency conflicts. If financial pressures mount due to low RevPAR, managers may be inclined to prioritize their own interests over those of shareholders. This may manifest as excessive compensation or short-sighted cost-cutting measures that ultimately erode shareholder value. On the other hand, robust RevPAR performance provides financial stability, thereby reducing the pressure to engage in such behavior. In fact, the results suggest that hotel management can create a more shareholder-friendly environment by prioritizing strategies that increase RevPAR, resulting in enhanced financial performance and a higher book value per share.

Also, within the framework of agency theory, the relationship between the current ratio and RevPAR is complex. A robust RevPAR is indicative of financial stability. This allows hotels to invest in growth opportunities that may lead to a short-term decrease in the current ratio. Moreover, such investments have the potential for long-term profitability gains, including property expansion, brand acquisition, and technological advancements. Similarly, high occupancy rates in the hotel industry led to industry-specific working capital requirements, resulting in a lower current ratio compared to other industries. Large hotel chains frequently franchise their brands, reducing the amount of property, plant, and equipment (PP&E) on their balance sheet, resulting in a lower current ratio, even with a robust RevPAR. Seasonal fluctuations

are also important because RevPAR varies depending on the season, allowing hotels to strategically adjust their working capital. During peak seasons, hotels may invest in additional inventory or staffing to meet demand, temporarily decreasing the current ratio. Conversely, during low seasons, they may reduce inventory levels, increasing the current ratio but potentially impacting the guest experience during peak periods.

A high RevPAR, on the other hand, is a sign of strong financial performance. However, it can also prompt managers to prioritize investments that advance their careers or visibility, even if they do not yield the highest return on investment (ROI). This can result in increased expenditure on non-economically viable projects or lavish perks, which in turn reduces the current ratio without clear long-term benefits for shareholders, according to agency theory. The analysis shows that there is a negative correlation between RevPAR and the current ratio; the presence of extraordinary circumstances during the COVID-19 pandemic caused a significant downturn in the hospitality sector, resulting in a decline in RevPAR. However, chain hotels with strong financial management, such as those in this study, were able to maintain a high current ratio, which is consistent with previous research findings (Temelkov, 2022; Nicolau et al., 2023; Singh and Corsun, 2023).

The findings exposed a negative correlation between RevPAR and day sales outstanding in chain hotels with $1 billion in market capitalization. Furthermore, the evidence from studies of working capital management, profitability, and financial performance confirms a negative relationship between DSO and RevPAR (Cumbie and Donnellan, 2017; Nguyen, 2023). A longer DSO can lead to lower profitability, which in turn can translate into lower RevPAR for hotels due to revenue collection delays. Effectively managing DSO is critical to optimizing financial performance and potentially increasing RevPAR in the hospitality industry.

In conclusion, RevPAR is a key indicator of a hotel chain's efficiency in managing agency costs. A higher RevPAR indicates better financial health, profitability, and shareholder value, suggesting efficient resource utilization. Conversely, a negative correlation between RevPAR and metrics like days sales outstanding suggests longer collection periods lead to lower RevPAR. This suggests challenges in managing accounts receivable, potentially impacting cash flow and overall financial performance. This could indicate inefficiencies in hotel credit and collection processes, which in turn could affect agency cost management. The analysis emphasizes agency theory's concern.

Future research could investigate the variation in agency costs and management strategies across chain hotels in different geographical regions. Additionally, it could investigate the influence of market competition, seasonality, and economic conditions on the relationship between RevPAR and days sales outstanding, as well as on agency costs in the hotel industry.

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 are no potential conflicts of interest in this study.

References

Abdelmawgoud, M.T.A. and Abd El Salam, M.A.E.M.E. (2022). Factors affecting operational and financial performance indicators of rooms division in four and five-star hotels in Cairo. *International Journal of Heritage, Tourism, and Hospitality,* 16(3), 113-135. https://doi.org/10.21608/jihtha.2022.280467

Annaria, M.M., Marpaung, B.S. and Hasibuan, D.H. (2021). The effect of activity ratios to company profitability in the trading, services, and investment sectors. *Journal of Accounting, Business and Finance Research,* 11(1), 38-45. https://doi.org/10.20448/2002.111.38.45

Asdullah, M.A. and Rehman, Z. (2015). A comparative study on financial performance of hotel industry in Pakistan (Sarena Hotel and Marriott Hotel). *Journal of Tourism, Hospitality and Sports,* 8, 42–54. https://doi.org/10.7176/JTHS

Aznar-Alarcón, J.P. and Sayeras Maspera, J.M. (2015). The financial and economic performance of hotels in Spanish beach tourist destinations. *Athens Journal of Tourism,* 2(3), 141-152. https://doi.org/10.30958/ajt.2-3-1

Babajee, R.B., Seetanah, B., Nunkoo, R. and Gopy-Ramdhany, N. (2022). Corporate social responsibility and hotel financial performance. *Journal of Hospitality Marketing and Management,* 31(2), 226–246. https://doi.org/10.1080/19368623.2021.1937433

Bianchi, G. and Chen, Y. (2016). CEO compensation and the performance of firms in the hospitality industry: A cross-industry comparison. *International Journal of Tourism Sciences*, 15(3-4), 121–138. https://doi.org/10.1080/15980634.2016.1181320

Blal, I., Singal, M. and Templin, J. (2018). Airbnb's effect on hotel sales growth. *International Journal of Hospitality Management,* 73, 85-92. https://doi.org/10.1016/j.ijhm.2018.02.006

Bresciani, S., Thrassou, A. and Vrontis, D. (2015). Determinants of performance in the hotel industry an empirical analysis of Italy. *Global Business and Economics Review,* 17(1), 19-34. https://doi.org/10.1504/GBER.2015.066531

Chattopadhyay, M. and Mitra, S.K. (2019). Determinants of revenue per available room: Influential roles of average daily rate, demand, seasonality and yearly trend. *International Journal of Hospitality Management,* 77, 573-582. https://doi.org/10.1016/j.ijhm.2018.09.001

Chebii, R.K. and Kaplelach, S. (2019). Drivers of financial performance in hotel industry in Kwale County, Kenya. *International Journal of Economics, Commerce and Management,* 7(8), 538–571. Retrieved from https://ijecm.co.uk/

Corgel, J.B. and Gibson, S. (2005). The use of fixed-rate and floating-rate debt for hotels. *Cornell Hotel and Restaurant Administration Quarterly,* 46(4), 413–430. https://doi.org/10.1177/0010880405277072

Cumbie, J.B. and Donnellan, J. (2017). The impact of working capital components on firm value in us firms. *International Journal of Economics and Finance*, 9(8), 138-150. https://doi.org/10.5539/ijef.v9n8p138

Dahlstrom, R., Haugland, S.A., Nygaard, A. and Rokkan, A.I. (2009). Governance structures in the hotel industry. *Journal of Business Research,* 62(8), 841–847. https://doi.org/10.1016/j.jbusres.2007.07.033

Eisenhardt, K.M. (1989). Agency theory: An assessment and review. *The Academy of Management Review*, 14(1), 57-74. https://doi.org/10.2307/258191

Fama, E. and Jensen, M.C. (1983). Separation of ownership and control. *The Journal of Law & Economics*, 26(2), 301– 325. Retrieved from https://www.jstor.org/

Freedman, M. and Kosová, R. (2014). Agency and compensation: Evidence from the hotel industry. *Journal of Law Economics and Organization*, 30(1), 72–103. https://doi.org/10.1093/jleo/ews027

Guillet, B.D. and Mattila, A.S. (2010). A descriptive examination of corporate governance in the hospitality industry. *International Journal of Hospitality Management*, 29(4), 677–684. https://doi.org/10.1016/j.ijhm.2010.01.004

Gujarati, D.N. and Porter, D.C. (2009). *Basic econometrics.* NY: The McGraw- Hill/Irwin.

Haubrich, J.G. (1994). Risk aversion, performance pay, and the principal-agent problem. *Journal of Political Economy*, 102(2), 258– 276. https://doi.org/10.1086/261931

Jakaša, P. (2017). Financial determinants of hotel performance. *International Education and Research Journal*, 3(12), 62-64. Retrieved from https://www.croris.hr/

Jawabreh, O.A.A., Mahmoud, R.M., Alshatnawi, E. and Al Momani, E. (2017). Using financial analysis methods in the hotel sector for the purposes of planning and monitoring case study Al Zaitonia Hotel. *International Journal of Economics and Financial Issues*, 7(4), 162–173. Retrieved from https://dergipark.org.tr/en/pub/ijefi/

Jensen, M.C. and Meckling, W.H. (1976). Theory of the firm: Managerial behavior, agency costs and ownership structure. *Journal of Financial Economics*, 3(4), 305– 360. https://doi.org/10.1016/0304-405X(76)90026-X

Jiang, L. and Taylor, M.H. (2020). What hotel attributes matter? Understanding the price determinants in the lodging industry. *Journal of Hospitality Financial Management*, 28(1), 55–64. https://doi.org/10.7275/3m88-qe37

Liang, C., Chen, M.H., Zhu, D., Kot, H.W. and Yang, Z. (2021). Nonlinear effects of board characteristics on China's hotel firm performance. *Tourism Economics*, 28(8), 1998–2020. https://doi.org/10.1177/13548166211025335

Mitnick, B.M. (1973). *Fiduciary rationality and public policy: The theory of agency and some consequences.* Papers presented at the 1973 Annual Meeting of the American Political Science Association. New Orleans, LA. Retrieved from https://ssrn.com/abstract=1020859

Morck, R., Shleifer, A. and Vishny, R.W. (1988). Management ownership and market valuation: An empirical analysis. *Journal of Financial Economics*, 20, 293–315. https://doi.org/10.1016/0304-405X(88)90048-7

Murimi, M., Wadongo, B. and Olielo, T. (2021). Determinants of revenue management practices and their impacts on the financial performance of hotels in Kenya: A proposed theoretical framework. *Future Business Journal*, 7(2), 2–7. https://doi.org/10.1186/s43093-020-00050-9

Nguyen, A.H., Doan, D.T. and Nguyen, L.H. (2020). Corporate governance and agency cost: Empirical evidence from Vietnam. *Journal of Risk and Financial Management*, 13(5), 103. https://doi.org/10.3390/jrfm13050103

Nguyen, N.L. (2023). Effect of net working capital management on the profitability of energy business companies listed on the stock market of Vietnam. *Journal of Economics, Finance and Management Studies*, 06(04), 1809-1817. https://doi.org/10.47191/jefms/v6-i4-44

Nicolau, J., Xiang, Z. and Wang, D. (2023). Daily online review sentiment and hotel performance. *International Journal of Contemporary Hospitality Management*, 36(3), 790-811. https://doi.org/10.1108/ijchm-05-2022-0594

Nunes, C.R. and Cardoso Vieira Machado, M.J. (2012). Financial assessment of performance in the hotel industry. *European Journal of Tourism, Hospitality and Recreation*, 3(Special Issue), 97-109. Retrieved from https://vtechworks.lib.vt.edu/

Ozdemir, O. and Upneja, A. (2012). Board structure and CEO compensation: Evidence from U.S. lodging industry. *International Journal of Hospitality Management*, 31(3), 856–863. https://doi.org/10.1016/j.ijhm.2011.10.004

Ozdemir, O., Kizildag, M. and Upneja, A. (2013). Does risk matter in CEO compensation contracting? Evidence from US restaurant industry. *International Journal of Hospitality Management*, 34, 372–383. https://doi.org/10.1016/j.ijhm.2012.11.012

Pacheco, L. (2016). RevPAR determinants of Portuguese hotels: The global and the local factors. *Tourism*, 64(2), 219–230. Retrieved from https://hrcak.srce.hr/

Panda, B. and Leepsa, N.M. (2017). Agency theory: Review of theory and evidence on problems and perspectives. *Indian Journal of Corporate Governance,* 10(1), 74-95. https://doi.org/10.1177/0974686217701467

Pesaran, M.H. (2004). *General diagnostic tests for cross section dependence in panels* (The Institute for the Study of Labor Discussion Paper Series No. 1240). Retrieved from https://docs.iza.org/dp1240.pdf

Raguseo, E. and Vitari, C. (2017). The effect of brand on the impact of e-WOM on hotels' financial performance. *International Journal of Electronic Commerce,* 21(2), 249-269. https://doi.org/10.1080/10864415.2016.1234287

Ross, S.A. (1973). The economic theory of agency: The principal's problem. *The American Economic Review,* 63(2), 134-139. Retrieved from https://www.jstor.org/

Sainaghi, R. (2010). RevPAR determinants of individual hotels: Evidence from Milan. *International Journal of Contemporary Hospitality Management,* 23(3), 297–311. https://doi.org/10.1108/09596111111122497

Sardo, F., Serrasqueiro, Z. and Alves, H. (2018). On the relationship between intellectual capital and financial performance: A panel data analysis on SME hotels. *International Journal of Hospitality Management,* 75, 67-74. https://doi.org/10.1016/j.ijhm.2018.03.001

Sharma, A. and Upneja, A. (2005). Factors influencing financial performance of small hotels in Tanzania. *International Journal of Contemporary Hospitality Management*, 17(6), 504–515. https://doi.org/10.1108/09596110510612149

Shieh, H.S., Hu, J.L. and Chang, Y.C. (2018). An investigation of factors affecting financial performance of Taiwanese international tourist hotels. *The Journal of Hospitality Financial Management,* 26(1), 25-35. https://doi.org/10.7275/R5W37TJD

Singh A.J. and Schmidgall, R.S. (2012). Does financial performance depend on hotel size? Analysis of the financial profile of the U.S. lodging industry. *Hospitality Review Journal,* 30(2), 109-126. Retrieved from https://digitalcommons.fiu.edu/

Singh, A. and Corsun, D. (2023). Price elasticity of demand and its impact on hotel revenue performance during the Covid-19 pandemic. *Cornell Hospitality Quarterly,* 64(4), 415-435. https://doi.org/10.1177/19389655231184475

Temelkov, Z. (2022). Financial performance of selected hotel groups and resorts during COVID-19 pandemic: 2019/2020 comparison. *Hotel and Tourism Management,* 10(1), 41-51. https://doi.org/10.5937/menhottur2201041T

Thaothampitak, W. and Wongsuwatt, S. (2019). Perceived risk and firm performance for chain hotels in Thailand: Moderating roles of work roles. *Journal of Community Development Research (Humanities and Social Sciences),* 12(4), 25–36. https://doi.org/10.14456/jcdr-hs.2019.33

Warrad, L. and Omari, R.A. (2015). The impact of turnover ratios on Jordanian services sectors' performance. *Journal of Modern Accounting and Auditing,* 11(2), 77-85. https://doi.org/10.17265/1548-6583/2015.02.001

WTTC. (2022). *Cities economic impact 2022* (World Travel and Tourism Council World Cities Economic Impact Report December 2022, 7. Retrieved from https://wttc.org/Portals/0/Documents/Reports/2023/WTTC-Cities-Economic-Impact-Final.pdf

Yamin, M. and Pratiwi, A. (2020). The effect of working capital turnover and receivables turnover of return on equity: A case study form cooperative. *Jurnal Inovasi Ekonomi,* 5(01). https://doi.org/10.22219/jiko.v5i01.11352

Yang, Y. (2019). Effects of the size of acquisition on a hotel group's financial performance. *Journal of Hospitality Financial Management,* 27(1), 49-54. https://doi.org/10.7275/kpvx-q091

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THE EFFECT OF INTEREST RATES ON PORTFOLIO INVESTMENTS AND FOREIGN DIRECT INVESTMENTS IN TÜRKİYE*

Türkiye'de Faiz Oranlarının Portföy Yatırımları ve Doğrudan Yabancı Yatırımlara Etkisi

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Keywords:
Foreign Direct Investment, Portfolio Investment, Interest Rate Rates, ARDL Border Test, Toda-Yamamoto Causality Test

JEL Codes:
C22, E20, F21

Abstract

This study aims to analyse the relationship between foreign direct investments (FDI) and portfolio investments (PI) and interest rates. Firstly, ADF and PP unit root tests were applied to determine whether the variables were stationary or not. Since the series became stationary at different levels, the ARDL (Autoregressive Distributed Lag Bound Test) test, one of the cointegration tests, was applied. Afterward, Toda-Yamamoto tests were utilized to determine whether there is causality between the variables and if there is a causality relationship, to determine its directions. According to the ARDL bound test results, it is concluded that there is no short-term asymmetric relationship between PI and other independent variables. In other words, there is no statistically significant relationship between PI and EUR, USD and TL interest rates. On the other hand, it is concluded that the FDI dependent variable and other independent variables are long-run cointegrated in the relevant period. According to the results of the Toda-Yamamoto causality test where FDI and TL, EUR, and USD are independent variables, it is concluded that there is a Granger causality relationship between FDI and TL and EUR interest rates.

Anahtar Kelimeler:
Doğrudan Yabancı Yatırımlar, Portföy Yatırımları, Faiz Oranları, ARDL Sınır Testi, Toda-Yamamoto Nedensellik Testi

JEL Kodları:
C22, E20, F21

Öz

Bu çalışmada, doğrudan yabancı yatırımlar (DDY) ve portföy yatırımları ile faiz oranları arasındaki ilişkiyi analiz etmeyi amaçlamıştır. İlk olarak, değişkenlerin durağan olup olmadıklarının tespiti için ADF ve PP birim kök testleri uygulanmıştır. Eşbütünleşme testlerinden ARDL (Autoregressive Distributed Lag Bound Test) testi uygulanmıştır. Sonrasında, değişkenler arasında nedenselliğin olup olmadığı, nedensellik ilişkisi varsa yönlerinin tespit edilebilmesi için Toda-Yamamoto testlerinden yararlanılmıştır. ARDL sınır testi sonuçlarına göre, portföy yatırımları ile diğer bağımsız değişkenler arasında kısa dönemli asimetrik ilişkinin olmadığı sonucuna varılmıştır. Yani, portföy yatırımları ile EUR, USD ve TL faiz oranları arasında istatistiki anlamda herhangi bir ilişki bulunamamıştır. Diğer taraftan hesaplanan F istatistiği %1 önem seviyesindeki kritik değerlerden büyük olduğu için DDY bağımlı değişkeni ile diğer bağımsız değişkenlerinin ilgili dönemde uzun dönemli eşbütünleşik olduğu sonucuna varılmıştır. Toda-Yamamoto nedensellik testlerinin sonuçlarına göre ise; DYY ile TL, EUR ve USD bağımsız değişken olduğu Toda-Yamamoto nedensellik testi sonuçlarına göre, DYY ile TL ve EUR faiz oranları arasında Granger nedensellik ilişkisinin olduğu sonucuna varılmıştır.

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1. Introduction

With globalization after the 1980s, portfolio investments (PI) and FDI have grown worldwide. PI and FDI used to take place from developed countries to other countries in order to benefit from the production factors and underground resources of developing countries. In the 2000s, these investments started to be demanded intensively by developed countries as well. Today, the phenomenon of liberalization has become widespread along with the liberal policies that have made their impact felt all over the world. As countries adopt such policies more and more, the barriers to capital mobility have started to disappear, and as a result, both foreign direct capital movements and monetary capital movements have started to gain momentum.

While physical investments made by savers in another country in order to achieve higher returns are referred to as FDI, investments in capital market instruments such as public or private sector bonds and stocks are characterized as PI (Mucuk, 2011: 11-12). In other words, it can be defined as a multinational company shifting its production to a country outside its headquarters, establishing another company with partners, acquiring an existing company, or increasing its capital (Kurtaran, 2007: 367).

The shallow supply of financial funds in developing countries leads to high returns on financial instruments. Therefore, there has been a significant flow of financial resources from developed countries, where the supply of funds is abundant and therefore the returns on financial instruments are low, to these countries. In this way, there has been a significant amount of financial capital inflow to the capital and money markets of developing countries in the form of portfolio and other investments. PI are expected to provide financing opportunities for investments and support financial development, while direct investments are expected to positively affect economic growth through technology, capital and knowledge. However, this effect is limited by the fact that PI generally come in the form of short-term profits without turning into investments in the form of production and FDI come in the form of mergers and acquisitions. In addition, both forms of investment may not contribute to economic growth in countries that have not reached a certain technological level, have not achieved financial development, and have a weak institutional and legal framework (De Vita and Kyaw, 2009: 281; Gök and Güvercin, 2020: 59-60; Durham, 2004: 285).

As a developing country, Türkiye has implemented significant reforms in the capital markets with the policies implemented since the early 1990s. As a result, especially in the recent period, there has been a significant inflow of FDI and PI to Türkiye. Therefore, our study aims to analyze the relationship between FDI and PI and interest rates. When the studies in the literature are analyzed, it is observed that the studies mostly consist of studies that consider FDI and PI separately and include different macroeconomic independent variables. Our study differs from the other studies in the literature in this respect as it examines the relationship between interest rates by considering FDI and PI as two dependent variables. Therefore, this study is expected to contribute to the literature. In this framework, ARDL test, one of the cointegration tests, was applied by using quarterly values between 2010 and 2023. Then, the Toda-Yamamoto test is used to examine the causality relationship between the variables. In the second section of the study after the introduction, the literature on FDI and PI is reviewed. The third section provides information on the data set, methodology, and econometric results obtained. In the conclusion section, empirical findings are interpreted and a general evaluation of the study is made.

2. Literature Review

When the studies in the literature on PI and FDI are examined, it is seen that the studies generally focus on the relationship with macroeconomic factors. It is observed that macroeconomic factors such as inflation, exchange rate, economic growth, and CDS premiums are used with PI and FDI.

Clark and Berko (1996) conducted a correlation analysis for the Mexican stock market. They found that a 1 percent increase in the amount of foreign portfolio investment increased Mexican stock prices by 13 percent. A similar study was conducted by Lin and Swanson (2003) for the Taiwanese economy. The behavior of foreign investors investing in 60 large companies listed on the Taiwan Stock Exchange was investigated. Strong evidence was found that foreign investors use a momentum strategy by buying stocks that have won in the past and selling stocks that have lost in the past.

Pal (2006) investigated the impact on the Indian economy. He also stated that FPI affect the stock market, which in turn has a significant impact on the real economy. He concluded that the impact of FPI on the stock market and the real economy is not positive in his analyses.

Duasa and Kassim (2009) examined the relationship between Malaysia's economic performance and PI using Toda and Yamamoto causality test. Quarterly data were used in the study covering the years 1991-2006. As a result of the study, it was found that economic performance is an important factor in attracting foreign investments to the country. It is emphasized that foreign investors will feel secure if the economy has a healthy and sustainable growth policy.

In another study, Acaravcı and Bostan (2011) investigated the effects of macroeconomic variables on FDIs using the ARDL bounds test and Granger causality models for the period 1992Q1- 2007Q1. The results of the study show that there is a significant relationship between FDI and selected macroeconomic variables such as economic growth in the long run. According to the findings, an increase in GDP and domestic investments leads to an increase in FDI in the long run, while an increase in FDI leads to an increase in economic growth in the short run.

In his study, Okafor (2012) focused on the impact of macroeconomic variables on capital flows in Nigeria and conducted an analysis using the Ordinary Least Squares (OLS) method. The findings show that real GDP, interest rate and real exchange rate are the main determinants of FDI in Nigeria. The result shows that macroeconomic variables are critical for FDI inflow. Therefore, policymakers should endeavour to improve the macroeconomic environment to encourage the flow and benefits of FDI in Nigeria.

Wu et al. (2012), on the other hand, investigated the relationship between the governance structure and environment of a country and FDI inflows into the country using correlation analysis. As a result of the study, it was observed that countries based on the principle of rule-based governance have a lower share of foreign direct investment than other countries, but their stock markets are stronger than other countries because they have better public order.

The aim of Asaad (2014) is to analyse the effect of three macroeconomic variables (inflation rate, interest rate and exchange rate) on FDI in Iraq by multiple regression method for the period 2004-2011. The results of the study show that inflation and interest rate do not have a significant effect on FDI in Iraq, while exchange rate has a negative and significant effect. Therefore, the Iraqi government has focused on creating an effective monetary policy by fixing

the exchange rate in order to attract more FDI in the process of economic development and reconstruction.

Albulescu (2014) analyzed the impact of direct physical investment and portfolio investment in the form of equity securities on 13 Eastern European countries using a panel data set for the period 2005-2012. Econometric results show that both types of capital inflows have made a significant contribution to economic growth in these countries. In this study, especially equity investments within PI are analyzed and it is pointed out that PI in the form of debt securities create problems in economies due to the burden they create on external debt stock. Moreover, it is emphasized that equity capital inflows are more important in the relationship between PI and growth.

Pala and Orgun (2015) analyzed the determinants of PI in Türkiye and examined the effect of national income on PI by regression analysis for the period between 1998 and 2012. Empirical results reveal that the level of national income positively affects PI in addition to the level of interest rate and current account deficit. Thus, with the monetary and fiscal policies to be implemented, it will be possible to increase PI in Türkiye with the changes to be created in these variables and especially on growth.

Gülmez (2015) investigated the effects of physical direct investments and PI in Türkiye as external financing sources on economic growth by using the ARDL bounds test and Toda-Yamamoto causality test method using annual data for the period between 1986 and 2014. The empirical results reveal that there is a causality relationship from both FDI and PI to economic growth. More specifically, it is calculated that a 1% increase in PI leads to a 0.34% increase in economic growth. Thus, it is determined that policies aimed at attracting foreign capital investments to Türkiye will yield effective results in terms of economic growth.

Çiftçi and Yıldız (2015), on the other hand, aimed to empirically analyze the factors that may affect foreign direct investment flows to the Turkish economy within the framework of relevant theoretical approaches using data for the period 1974-2012. They conclude that in the long run, GDP, real exchange rate and financial development variables have a positive effect on FDI, while trade deficit and foreign debt have negative effects.

Telatar (2016) analyzed the relationship between PI in Türkiye and economic growth using data from 1998 to 2016. The results of the nonlinear cointegration and error correction model reveal that PI in Türkiye make a positive contribution to economic growth. However, it is pointed out that the economic growth process in Türkiye is vulnerable to internal and external shocks due to the hot money nature of PI.

Zghidi et al. (2016) analyzed the relationship between growth, economic freedom, and FDI for the period 1980-2013, covering the countries of Egypt, Morocco, Tunisia, and Algeria. A positive relationship was found between the variables. In addition, economic freedoms were found to be complementary to FDI.

Kazemi and Saini (2017) analyzed FDI and democracy variables in 87 countries. They used panel data analysis in the study covering the period 1981-2010. As a result of the study, they found that economic freedoms positively affect FDI. The findings of the analysis show that democracy does not have a significant role in attracting FDI.

A study conducted for the Chinese economy by Haider et al. (2017) aimed to determine the impact of FPI on stock market performance and inflation. They found that PI increase stock market performance and have a positive impact on the stock market.

Şahin (2018) analyzed the relationship between FDI and economic growth in his study on BRICS-T countries. In the study covering the period 1995-2014, he used bootstrap panel causality analysis after horizontal cross-section dependence and heterogeneity tests. As a result of the study, it is concluded that the causality from economic freedom to FDI is found only in Türkiye.

In his study, Anetor (2020) examined the relationship between FDI, financial development and economic growth on 28 Sub-Saharan African countries. According to the results of the study covering the years 1995-2017, FDIs have a significant and negative impact on economic growth. On the other hand, he found that FDIs have a statistically insignificant effect on economic growth.

Shamim et al. (2021) used annual time series data for the years 1984-2015 in order to determine the impact of PI on stock market performance in Pakistan. Multiple econometric techniques were used to examine the relationship between variables. In the study, Johansen cointegration analysis was performed to verify the long-run relationship. The results of the study show that PI has a positive impact on stock market capitalization. They also found that PI has a significantly positive impact on stock market capitalization in Pakistan with a bidirectional causal relationship.

Şahin et al. (2021) investigated the effect of macroeconomic variables on FDI in their study covering the period 1980-2020 for the Turkish economy. Using cointegration and Granger causality tests, they found that there is a bidirectional causality relationship between inflation and FDI in the period. However, a unidirectional Granger causality relationship was found from economic growth to FDI.

In their study, Karahan and Bayır (2022) focused on the financial factors affecting foreign direct investment inflows to Türkiye. In their study covering the period 2008-2019, they investigated the effect of exchange rate, interest rate and stock market index on FDI. Using the ARDL bounds test, they did not find a statistically significant relationship between FDI and interest rates. On the other hand, it is concluded that changes in the stock market index are the most important factor affecting FDI inflows to Türkiye.

3. Data and Methodology

As a developing country, Türkiye has realized significant reforms in capital markets with the policies implemented since the early 1990s. As a result, there has been a significant inflow of foreign direct investment and portfolio investment in Türkiye, especially in the recent period. Therefore, our study aims to analyze the relationship between FDI and PI and interest rates.

The data set used in the study covers the period 2010Q4-2023Q4. The data is obtained from the Central Bank of the Republic of Türkiye's Electronic Data Distribution System (EDDS). PI and FDI data are normalized by taking their natural logarithms. Time series analysis is used to examine the relationship between variables. ADF and PP unit root tests were applied to determine the stationarity levels of the variables. Since the series became stationary at different levels, the ARDL test, one of the cointegration tests, was applied. Afterwards, Toda-Yamamoto tests were

utilized to determine whether there is causality between the variables and if there is a causality relationship, to determine its directions.

3.1. ADF and PP Unit Root Tests

The Extended Dickey-Fuller unit root test is frequently used in research to determine whether the series contains unit roots. This unit root test can be characterized as a different version of the ADF unit root test based on the AR(1) process. However, in time series, εt (error/residual terms) loses its clean series property if there is a higher order correlation in the series. To solve this problem, the ADF test utilizes the AR(p) process rather than the AR(1) process and includes "p" lagged difference terms in the equation (Dickey and Fuller, 1979). Thus, ADF equations without constant term and trend (none), with constant term (intercept) and with constant term and trend (intercept&trend) respectively:

$$\Delta y_t = \delta y_{t-1} + \sum_{i-1}^{p} \beta_i \, \Delta y_{t-i} + \varepsilon_i \tag{1}$$

$$\Delta y_t = \mu + \delta y_{t-1} + \sum_{i-1}^{p} \beta_i \, \Delta y_{t-i} + \varepsilon_i \tag{2}$$

$$\Delta y_t = \mu + \beta t + \delta y_{t-1} + \sum_{i-1}^{p} \beta_i \, \Delta y_{t-i} + \varepsilon_i \tag{3}$$

is expressed as follows. In equations 1, 2, and 3, μ corresponds to the constant term, t to the trend, p to the number of lags, and εt to the error term series. For all three ADF equations, the null hypothesis is formulated in the same way and states that the series contains a unit root. Therefore, the null hypothesis states the existence of a non-stationary series (Gujarati, 2015: 328). The hypotheses for the existence of a unit root for these models are as follows:

H_0: δ=0 (The series is non-stationary)

H_1: δ<0(ϕ1<1) (The series is stationary)

The ADF test is based on the basic assumptions that error terms are independent and constant variance. Moreover, the DF test does not provide adequate results in series with structural breaks. PP attempts to generalize the DF test by smoothing its assumptions about error terms (Demir, 2015: 28). In this transformation, the nonparametric method was utilized (İnce, 2015: 30).

As in the ADF test, the PP test is applied in three different ways: without constant, with constant, and with constant and trend (Samut, 2016: 40).

$$\Delta \boldsymbol{y_t} = \boldsymbol{a y_{t-1}} + \boldsymbol{x_t^l \delta} + \boldsymbol{\varepsilon_t} \tag{4}$$

is of the form. In equation 4, a= ρ -1, "xt " is the set of deterministic components (constant term or constant term and trend), and "εt " is the set of error (residual) terms. In the PP test, the main and alternative hypotheses are formulated as "H_0: α = 0 and H_1: α < 0" and the main hypothesis states that the series contains a unit root (Çağlayan and Saçalı, 2006: 125).

H_0: If δ = 0, there is a unit root.

H_1: If δ<0, there is no unit root.

3.2. Cointegration and ARDL Bounds Test

Cointegration means that linear combinations of multiple non-stationary time series are stationary and these series have an equilibrium relationship in the long run (Tarı, 2014: 415). Although there are different cointegration tests developed in the literature such as Engle and Granger (1987), Johansen (1988) and Phillips-Ouliaris (1990), in order to apply these cointegration tests, the series of all variables must be stationary in their first differences, i.e. I(1). However, the ARDL bounds test approach eliminates this constraint and allows cointegration analysis in all combinations where the variables are I (0) and I (1) (Pesaran et al., 2001: 289-290). In other words, cointegration relationships between time series with different stationarity levels can be realized with the ARDL bounds test approach. In addition, the dependent variable must be I(1) in the ARDL bounds test approach.

The bounds test, which is based on the estimation of the unrestricted error correction model, is applied in two stages: the first one is to establish the long-run relationship between the variables and the second one is to determine the cointegration relationship between the variables. The ARDL Border Test equation with two variables to be performed in order to reveal the cointegration relationship is as follows:

$$\Delta Y_t = \beta_0 + \sum_{i=1}^{m} \beta_{1i} Y_{t-i} + \sum_{i=1}^{m} \beta_{2i} X_{t-i} + \beta_{3i} Y_{t-1} + \beta_4 X_{t-1} + \varepsilon_t \quad (5)$$

In the equation; ΔY_t is the dependent variable, Xt is the independent variable, ε_t is the error term, m is the optimum lag length and m is the minimum value of the information criteria. The hypotheses regarding the existence of cointegration in the ARDL bounds test model are as follows:

H_0: $\beta_3 = \beta_4 = 0$ (There is no cointegration)

H_1: $\exists \delta_i < 0, i = 3,4$ (There is cointegration).

In the ARDL bounds test approach, the long-run relationship coefficients of the variables are examined after the cointegration relationship for the variables is revealed. In addition, the existence of short-run deviations from the long-run relationship can also be examined with the help of the error correction model. The equation for the long-run relationship is as follows:

$$Y_t = \beta_0 + \sum_{i=1}^{m} \beta_{1i} Y_{t-i} + \sum_{i=0}^{n} \beta_{2i} X_{t-i} + \varepsilon_t \quad (6)$$

In the equation, Yt is the dependent variable, Xt is the independent variable, β_0; is the constant term, ε_t; is the error term, and n and m are the optimal lag lengths.

3.3. Toda-Yamamoto Causality Analysis

The Toda Yamamoto causality test is based on the VAR (VectorAutoregressive) model. In the analysis, after determining the appropriate lag length of the VAR model (m) and the maximum degree of stationarity of the series used (d_{max}), a VAR model of size ($m+d_{max}$) is estimated. The VAR (m+dmax) model estimated in the Toda-Yamamoto causality approach consists of the following equations (Toda and Yamamoto, 1995).

$$"Y_t = \omega + \sum_{t-1}^{m} a_{1i}\, x_{t-i} + \sum_{i=1}^{m} \beta_{1i} Y_{t-i} + \sum_{j=m+1}^{dmax} \delta_{1i} X_{t-i} + \sum_{j=m+1}^{dmax} \theta_{1i} Y_{t-i} + \varepsilon_{1t} \quad (7)$$

$$"X_t = \varphi + \sum_{i=1}^{m} a_{2i}\, X_{t-i} + \sum_{i=1}^{m} \beta_{2i} Y_{t-i} + \sum_{j=m+1}^{dmax} \delta_{2i} X_{t-i} + \sum_{j=m+1}^{dmax} \theta_{2i} Y_{t-i} + \varepsilon_{2t}" \quad (8)$$

The appropriate lag length (m) can be determined with the help of information criteria and the maximum degree of integration (d_{max}) can be determined by unit root tests (Toda and Yamamoto, 1995).

4. Findings of the Research

In this section of the study, the tests applied in order to reveal the relationship between the variables and the results of the findings obtained are given.

4.1. ADF and PP Unit Root Test Results

Before proceeding to the causality analysis, it is necessary to check whether the series contains unit roots, that is, whether they are stationary. For this purpose, ADF (Augmented Dickey-Fuller) and PP (Phillips-Perron) tests were conducted. The purpose of these tests is to prevent spurious regression. The results of ADF and PP unit root tests are presented in Table 1 and Table 2.

Table 1. ADF Unit Root Test Results

	At Level				
	EUR	**logFDI**	**logPI**	**TL**	**USD**
With Constant	-1.8891	-5.7383	0.6591	1.7207	-2.7953
	0.3348	0.0000***	0.9900	0.9996	0.0660*
With Constant & Trend	-2.4711	-8.4290	-0.5940	-0.7795	-2.7581
	0.3406	0.0000***	0.9751	0.9607	0.2190
Without Constant & Trend	-0.9528	-0.5484	1.8765	1.3675	-0.8749
	0.2998	0.4745	0.9844	0.9553	0.3322
	At First Difference				
	d(EUR)	**d(logFDI)**	**d(logPI)**	**d(TL)**	**d(USD)**
With Constant	-4.7152	-9.0687	-9.1114	-2.2115	-4.5321
	0.0003***	0.0000***	0.0000***	0.2048***	0.0006***
With Constant & Trend	-4.7220	-8.9825	-9.2075	-2.5189	-4.5125
	0.0020***	0.0000***	0.0000***	0.3182	0.0037***
Without Constant & Trend	-4.7358	-9.1410	-8.2957	-2.0111	-4.5799
	0.0000***	0.0000***	0.0000***	0.0434**	0.0000***

Notes: "(*) Significant at the 10%; (**) Significant at the 5%; (***) Significant at the 1%. and (no) Not Significant.

Table 2. PP Unit Root Test Results

	At Level				
	EUR	**logFDI**	**logPI**	**TL**	**USD**
With Constant	-1.3423	-5.9515	0.8810	0.6322	-2.0894
	0.6031	0.0000***	0.9945	0.9894	0.2497
With Constant & Trend	-1.9597	-8.4584	-1.0484	-0.9624	-2.1204
	0.6090	0.0000***	0.9277	0.9403	0.5226
Without Constant & Trend	-0.9765	-0.3196	1.8765	1.4156	-0.4588
	0.2901	0.5656	0.9844	0.9592	0.5116
	At First Difference				
	d(EUR)	**d(logFDI)**	**d(logPI)**	**d(TL)**	**d(USD)**
With Constant	-4.3905	-33.3085	-9.1202	-4.4109	-4.2882
	0.0009***	0.0001***	0.0000***	0.1438	0.0012***
With Constant & Trend	-4.3669	-43.4938	-9.2075	-4.8018	-4.2456
	0.0055***	0.0001***	0.0000***	0.2034	0.0077***
Without Constant & Trend	-4.4287	-26.8680	-8.1977	-4.2065	-4.3447
	0.0000***	0.0000***	0.0000***	0.0276**	0.0000***

Notes: "(*) Significant at the 10%; (**) Significant at the 5%; (***) Significant at the 1%. and (no) Not Significant.

According to the results of the unit root test, it was concluded that some of the variables included in the research contain unit root, that is, they are non-stationary. The variables were transformed into stationary by taking the first differences of the non-stationary series.

4.2. ARDL Border Test Results

In time series analysis, whether the variables are related to each other in the long run is investigated by cointegration tests. Normally, for these tests to be applied, the series should be stationary. However, if non-stationary series form a stationary process when they come together, a long-run relationship between variables can be determined.

Since the data used in this study are 3 months old, the maximum lag number is taken as 4. After writing the maximum number of lags and determining the Schwarz Information Criterion as the information criterion, it is determined that the most appropriate ARDL model is the ARDL(1,3,4,1,4,4,3,3) model in the Eviews 9 program. Since this study uses two dependent variables, namely PI and FDI, firstly, the relationship between FDI and other independent variables for the ARDL(1,3,4,1,4,3,3) model is given in Table 3.

Table 3. F Statistic and Critical Values for PI Dependent Variable

Model	**K**	**M**	**F Statistic**	**Significance Level**	**Lower Bound**	**Upper Bound**
ARDL(1,3,4,1,4,3,)	3	4	2.2542	1%	3.65	4.66
				5%	2.79	3.67
				10%	2.37	3.40

Notes: M denotes the maximum number of lags, K denotes the number of explanatory variables and * denotes 1% significance level. The critical values used for lower and upper bounds are taken from Table CI(ii) in (Pesaran et al., 2001: 300).

Since the calculated F statistic is smaller than the critical values at the 5% significance level, it is understood that the PI dependent variable and other independent variables are not long-

run cointegrated in the relevant period. After determining the long-run cointegration relationship, the long-run and short-run coefficients of the variables can be calculated. The long-run and short-run coefficient estimates for the ARDL (1.3.4.1.4.4.3.3) model with a maximum of 4 lags and Schwarz Information Criterion are presented in Table 4.

Table 4. ARDL Long and Short Run Coefficients of the PI Dependent Variable

Long Run Coefficients				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
EUR	-5.605722	27.156680	-0.020642	0.9836
TL	-1.652342	80.603390	0.020500	0.9838
USD	2.045897	10.192096	0.020073	0.9841
Short Run Coefficients				
D(LOGPI)	-0.363122	0.138219	-2.627155	0.0123
D(EUR)	-0.059375	0.041299	-1.437663	0.1587
D(TL)	0.003816	0.01964	1.943469	0.0594
D(USD)	0,009266	0.020820	0.445065	0.6588
CointEq(-1)	0,001917	0.000564	3.397394	0.0016
Descriptive Tests				
"R-squared	0.313217	Mean dependent var		0.008227
Adjusted R-squared	0.132484	S.D. dependent var		0.027883
S.E. of regression	0.025971	Akaike info criterion		-4.268952
Sum squared resid	0.025630	Schwarz criterion		-3.844258
Log likelihood	115.5893	Hannan-Quinn criter.		-4.107824
F-statistic	1.733040	Durbin-Watson stat"		2.027234
Prob(F-statistic)	0.108608			

According to the short-term asymmetric relationship results in Table 4, changes in variables do not have an asymmetric effect on the FDI index. The existence of a short-term asymmetric relationship is evaluated according to the Wald test results. According to the results of the Wald test, the F statistic value is (1.733040) and the p probability value is (0.108608). These results prove that there is no short-run asymmetric relationship. As a result, there is no statistically significant relationship between FDI and EUR, USD, and TL interest rates.

The F statistics and critical values obtained for the ARDL (1.1.4.2) model for the relationship between FDI and other independent variables are given in Table 5.

Table 5. F Statistics and Critical Values for FDI Dependent Variable

Model	**K**	**M**	**F Statistic**	**Significance Level**	**Lower Bound**	**Upper Bound**
ARDL(1.1.4.2)	3	4	16.79940	1%	3.65	4.66
				5%	2.79	3.67
				10%	2.37	3.40

Notes: M denotes the maximum number of lags, K denotes the number of explanatory variables and * denotes 1% significance level. The critical values used for lower and upper bounds are taken from Table CI(ii) in (Pesaran et al., 2001, p. 300).

Since the calculated F statistic is greater than the critical values at the 1% significance level, it is understood that the FDI dependent variable and other independent variables are cointegrated in the relevant period. After determining the long-run cointegration relationship, the long-run and

short-run coefficients of the variables can be calculated. The long-run and short-run coefficient estimates for the ARDL(1.1.4.2) model with a maximum lag of 4 and the Schwarz Information Criterion are presented in Table 6.

Table 6. ARDL Long and Short Run Coefficients of FDI Dependent Variable

Long Run Coefficients				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
EUR	0.173785	0.051170	3.396225	0.0016
TL	-0.004773	0.007409	-0.644160	0.5234
USD	-0.055626	0.038263	-1.453801	0.1544
Short Run Coefficients				
D(EUR)	0.871455	0.232867	3.742289	0.0006
D(TL)	0.042661	0.012174	3.504136	0.0012
D(USD)	0,363154	0.123199	-2.247705	0.0055
CointEq(-1)	-1.226479	0.127127	-9.647683	0.0000
Descriptive Tests				
"R-squared	0.738388	Mean dependent var		0.006351
Adjusted R-squared	0.660611	S.D. dependent var		0.252360
S.E. of regression	0.147018	Akaike info criterion		-0.787634
Sum squared resid	0.799725	Schwarz criterion		-0.324331
Log likelihood	31.29703	Hannan-Quinn criter.		-0.611858
F-statistic	9.493711	Durbin-Watson stat"		1.942115
Prob(F-statistic)	0.000000			

According to the short-run asymmetric relationship results in Table 6, changes in the variables have an asymmetric effect on the FDI dependent variable. The existence of a short-term asymmetric relationship is evaluated according to the Wald test results. According to the results of the Wald test, the F statistic value is (9.493711) and the p probability value is (0.000). These results prove the existence of a short-run asymmetric relationship. When the short-run coefficients are analyzed, it is determined that a 1% increase in EUR interest rates increases the FDI variable by 0.87%, a 1% increase in TL interest rates by 0.042%, and a 1% increase in USD interest rates by 0.36%.

When the short-term estimation results are analyzed, "Y1", which expresses the coefficient of the error correction term, corresponds to "CointEq(-1)" in this table. This coefficient is expected to be negative (-) and the probability value is expected to be less than 0.05. As can be seen in Table 5, the coefficient of the error correction term is -1.226479 with a probability value of 0.0000. The fact that the coefficient of the error correction term is negative and statistically significant provides additional evidence that the model is cointegrated (Akçay and Karasoy, 2017). A probability value less than 0.05 indicates that this coefficient is significant, while a negative (-) coefficient means that an imbalance in the model will be corrected (Göksu, 2023: 232).

The CUSUM and CUSUMQ graphs in Figure 1 are used to examine the long-run parameter stability. The graphs reveal that the long-run coefficients obtained from the long-run ARDL model are stable.

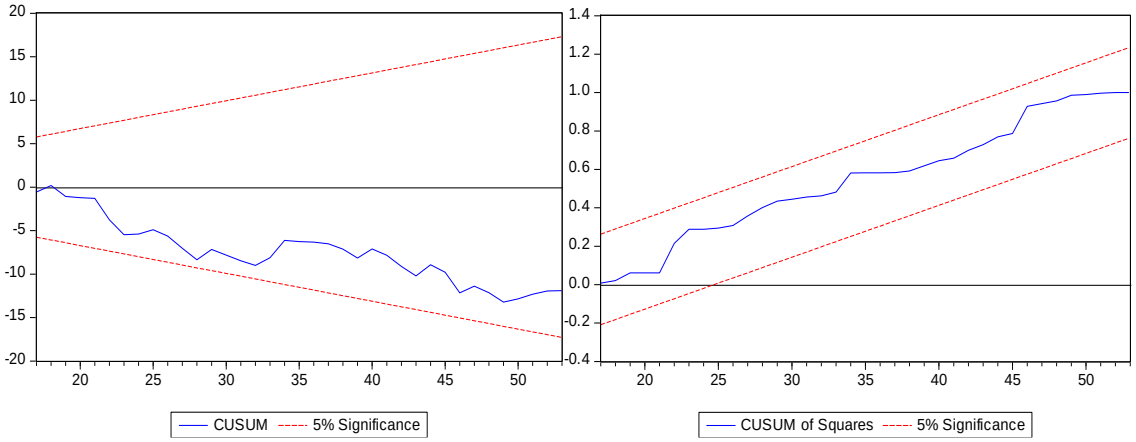

Figure 1. CUSUM and CUSUMQ Graphs

4.3. Todo-Yamamoto Causality Test Results

The traditional Granger (1969) Causality Test, which is used to determine the causality relationship between the data, requires the series to be stationary. However, when non-stationary series are differenced, information loss occurs. The test developed by Toda-Yamamoto (1995), which is based on the VAR (Vector Autoregression) model, does not take into account whether the series is stationary or not. Therefore, this test allows the model to be estimated using the level values of the series (Toda-Yamamoto, 1995: 225- 250).

While determining the causality between the series, the lag length (k) of the series is found according to the "Schwarz (SC) criterion" and the maximum degree of integration (dmax) is found according to the ADF unit root test. Then, the "Wald Statistic" was applied to the (k) lagged values of this model and it was mutually determined whether there was a causality relationship between the two dependent variables and the independent variables. Table 7 and Table 8 show the results of the Toda-Yamamoto Causality test.

Table 7. Toda-Yamamoto Causality Test Results-1

Dependent Variable	Independent Variable	d_{max}	k	Chi-Square Test Statistics	Chi-Square P - Value	Relationship and Direction
PI	TL	2	2	3.102.633	0.2120	No relationship
	EUR	2	2	0.000144	0.9904	No relationship
	USD	2	2	0.083866	0.9580	No relationship

Note: Statistically significant at the 5% level. The optimal lag length is determined according to the Schwarz (SC) criterion.

Table 7 and Table 8 present the results of the Toda-Yamamoto causality tests. Accordingly, it is seen that the H_0 hypothesis is accepted and the H_1 hypothesis is rejected in the hypotheses established between PM and TL, EUR, and USD variables at a 5% significance level. In other words, it is concluded that there is no Granger causality relationship between PM and TL, EUR, and USD interest rates as of the analyzed periods.

Table 8. Toda-Yamamoto Causality Test Results-2

Dependent Variable	Independent Variable	d_{max}	k	Chi-Square Test Statistics	Chi-Square P - Value	Relationship and Direction
TL		2	2	1.738.369	0.4193	No relationship
EUR	**PI**	2	2	0.040972	0.8396	No relationship
USD		2	2	0.872046	0.6466	No relationship

Note: Statistically significant at the 5% level. The optimal lag length is determined according to the Schwarz (SC) criterion.

According to the results of the Toda-Yamamoto causality tests in Table 9 and Table 10, it is seen that the H_0 hypothesis is rejected and the H_1 hypothesis is accepted in the hypotheses established between FDI and TL and EUR interest rates at a 5% significance level. In other words, it is concluded that there is a Granger causality relationship between FDI and TL and EUR interest rates as of the analyzed periods. On the other hand, no causality relationship was found between FDI and USD interest rates.

Table 9. Toda-Yamamoto Causality Test Results-3

Dependent Variable	Independent Variable	d_{max}	k	Chi-Square Test Statistics	Chi-Square P - Value	Relationship and Direction
FDI	TL	7	7	1.425.539	0.0468	TL ➡ FDI
	EUR	2	2	4.979.253	0.0257	EUR ➡ FDI
	USD	2	2	0.538691	0.1704	No relationship

Note: Statistically significant at the 5% level. The optimal lag length is determined according to the Schwarz (SC) criterion.

Table 10. Toda-Yamamoto Causality Test Results-4

Dependent Variable	Independent Variable	d_{max}	k	Chi-Square Test Statistics	Chi-Square P - Value	Relationship and Direction
TL		7	7	1.052.293	0.1608	No relationship
EUR	**FDI**	2	2	0.096481	0.7561	No relationship
USD		2	2	0.063162	0.9689	No relationship

Note: Statistically significant at the 5% level. The optimal lag length is determined according to the Schwarz (SC) criterion.

5. Conclusion and Recommendations

The global increase in portfolio and foreign direct investment flows has created an important opportunity for developing countries, which have problems in capital accumulation, to achieve sustainable high growth rates. In this framework, determining the factors affecting foreign investment inflows to developing countries has gained great importance for policymakers to design effective policies. Research in the literature has identified many factors affecting foreign investment inflows in developing countries. Especially in the recent period, due to the increase in the volume of transactions in financial markets, the relationship between financial indicators and portfolio and FDI in developing countries has gained much more importance. In this context, many studies have been conducted in the literature to investigate the impact of changes in global interest rates, stock prices, and exchange rates on foreign direct investment.

As a developing country, Türkiye has implemented significant reforms in the capital markets with the policies implemented since the early 1990s. As a result, there has been a

significant inflow of foreign direct investment and portfolio investment in Türkiye, especially in the recent period. Therefore, our study aims to analyze the relationship between FDI and PI and interest rates. Time series analyses were used to examine the relationship between the variables. ADF and PP unit root tests were applied to determine the stationarity levels of the variables. Since the series became stationary at different levels, the ARDL test, one of the cointegration tests, was applied. Afterwards, Toda-Yamamoto tests were utilized to determine whether there is causality between the variables and if there is a causality relationship, to determine its directions. According to the ARDL bound test results, it is concluded that there is no short-term asymmetric relationship between PI and other independent variables. In other words, there is no statistically significant relationship between PI and EUR, USD and TL interest rates. On the other hand, since the calculated F statistic is greater than the critical values at a 1% significance level, it is concluded that the FDI dependent variable and other independent variables are cointegrated in the long run in the relevant period.

According to the results of the Toda-Yamamoto causality tests, it is concluded that there is no Granger causality relationship between FDI and TL, EUR, and USD interest rates in the analyzed periods. According to the results of the Toda-Yamamoto causality test where FDI is the dependent variable and TL, EUR, and USD are the independent variables, it is concluded that there is a Granger causality relationship between FDI and TL and EUR interest rates at 5% significance level. On the other hand, no causality relationship was found between FDI and USD interest rates.

As a result of the study, no statistical relationship was found between PI and interest rates. The reason for the lack of a relationship, despite the expected relationship, can be attributed to the fact that one of the main indicators of portfolio investment inflows is affected by political and economic developments in the country. Looking at the last decade of the Turkish economy, it is thought that the Gezi Park events in 2013, the coup attempt in 2016, the Rahip Brunson crisis with the United States in 2018, and the COVID-19 pandemic crisis that affected the whole world in early 2020 negatively affected portfolio investment inflows.

One of the most important obstacles to economic growth is the lack of capital. Therefore, developing countries make arrangements to encourage portfolio investment and FDI movements in order to maximize the welfare of the country by making use of advanced technological investments for growth and development. In this direction, it is necessary to follow policies to create a favorable environment for increasing foreign capital investments, to ensure domestic economic and political stability, to realize incentive regulations, to encourage foreign investments by establishing facilitating structures for foreign investors and to increase the benefits to be obtained. In future studies, this study can be extended by using different macroeconomic factors and comparing different countries.

Declaration of Research and Publication Ethics
This study does not require ethics committee approval and/or legal/private authorization is compatible with research and publication ethics.

Researcher's Contribution Rate Declaration
The authors declare that they have contributed equally to the article.

Researcher's Conflict of Interest Declaration
There are no potential conflicts of interest in this study.

References

Acaravcı, A. and Bostan, F. (2011). The effects of macroeconomic variables on the foreign direct investmets: An empirical investigation on Turkish economy. *Çag University Journal of Social Sciences*, 8(2), 56-68. Retrieved from https://dergipark.org.tr/tr/pub/cagsbd

Akçay, S. and Karasoy, A. (2017). Remittances and calorie consumption nexus in Algeria. *International Migration,* 55(4), 103-117. https://doi.org/10.1111/imig.12348

Albulescu, C.T. (2014). Do foreign direct and portfolio investments affect long-term economic growth in Central and Eastern Europe? *Procedia Economics and Finance*, 23, 507-512. https://doi.org/10.1016/S2212-5671(15)00539-0

Anetor, F.O. (2020). Financial development threshold, private capital inflows and economic growth: Evidence from sub-Saharan African countries. *International Journal of Development Issues*, 19(1), 77-92. https://doi.org/10.1108/IJDI-06-2019-0099

Asaad, Z. (2014). The economic determinants of foreign direct investment inward to Iraq for period (2004-2011). *Journal of University of Duhok*, 17(1), 1192-2017. https://doi.org/10.2139/ssrn.3072682

Çağlayan, E. and Saçaklı, İ. (2006). Satın alma gücü paritesinin geçerliliğinin sıfır frekansta spektrum tahmincisine dayanan birim kök testleri ile incelenmesi. *Atatürk Üniversitesi İktisadi ve İdari Bilimler Dergisi,* 20(1), 121-137. Retrieved from https://dergipark.org.tr/tr/pub/trendbusecon

Çiftci, F. and Yıldız, R. (2015). The economic determinants of foreign direct investment: A time series analysis on the Turkish economy. *Business & Economics Research Journal*, 6(4), 71-95. Retrieved from https://www.berjournal.com/tr/

Clark, J. and Berko, E. (1997). *Foreign investment fluctuations and emerging market stock returns: The case of Mexico* (FRB of New York Staff Report, 24). Retrieved from https://www.newyorkfed.org

De Vita, G. and Kyaw, S.K. (2009). Growth effects of FDI and portfolio investment glows to developing countries: A disaggregated analysis by income levels. *Applied Economics Letters*, 16(3), 277-283. https://doi.org/10.1080/13504850601018437

Demir, A. Şahinoğlu, T. and Ersungur, Ş.M. (2021). The effect of macroeconomic variables on foreign direct investments: An evaluation in terms of Turkish economy. *Atatürk Üniversitesi Sosyal Bilimler Enstitüsü Dergisi,* 25 (4), 1396-1419. https://doi.org/10.53487/ataunisosbil.992617

Dickey, D.A. and Fuller, W.A. 1981. Distribution of the estimators for autoregressive time series with a unit root. *Econometrica*, 49, 1057-72. Retrieved from https://www.jstor.org

Duasa, J. and Kassim, S.H. (2009). Foreign portfolio investment and economic growth in Malaysia. *The Pakistan Development Review*, 48(2), 109-123. Retrieved from https://www.jstor.org/

Durham, J.B. (2004). Absorptive capacity and the effects of foreign direct investment and rquity foreign portfolio investment on economic growth. *European Economic Review*, 48(2), 285-306. https://doi.org/10.1016/S0014-2921(02)00264-7

Engle, R.F. and Granger, C.W.J. (1987). Co-integration and error correction: Representation, estimation and testing. *Econometrica,* 55(2), 251-276. Retrieved from https://www.jstor.org

Gök, A. and Güvercin, D. (2020). The interaction between foreign direct investment, foreign portfolio investment and economic growth: The case of Sub-Saharan African countries. *Akademik İncelemeler Dergisi,* 15(1), 57-82. https://doi.org/10.17550/akademikincelemeler.484712

Göksu, S. (2023). The effect of financing types provided by participation banks in Türkiye on economic growth. *Kocatepe İslami İlimler Dergisi*, 6(Özel Sayı), 217-237. https://doi.org/10.52637/kiid.1352885

Gülmez, A. (2015). The relationship between foreign sources of finance and economic growth in Turkey: An ARDL bounds testing approach. *Ekonomik ve Sosyal araştırmalar Dergisi*, 11 (2), 139-152. Retrieved from https://dergipark.org.tr/tr/pub/esad

Haider, M.A., Khan, M.A., Saddique, S. and Hashmi, S.H. (2017). The impact of stock market performance on foreign portfolio investment in China. *International Journal of Economics and Financial Issues*, 7(2), 460-468. Retrieved from https://www.econjournals.com

Karahan, Ö. and Bayır, M. (2022). The financial factors affecting foreign direct investments in Turkey. *Van Yüzüncü Yıl Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, 7(14), 165-181. https://doi.org/10.54831/vanyyuiibfd.1158476

Kazemi, M. and Saini, A. (2017). Foreign direct investment, economic freedom and democracy. *International Journal of Economics and Management*, 11(1), 1-15. Retrieved from http://www.ijem.upm.edu.my

Kurtaran, A. (2007). Doğrudan yabanci yatırım kararları ve belirleyicileri. *Atatürk Üniversitesi Sosyal Bilimler Enstitüsü Dergisi,* 10(2), 367-382. Retrieved from https://dergipark.org.tr/tr/pub/atasobed

Lin, A.Y. and Swanson, P.E. (2003). The Behavior and performance of foreign investors in emerging equity markets: Evidence from Taiwan. *International Review of Finance*, 4(3-4), 189-210. https://doi.org/10.1111/j.1468-2443.2005.00046.x

Mucuk, M. (2011). *Doğrudan yabancı sermaye yatırımları teori ve Türkiye uygulaması.* Konya: Çizgi Kitabevi.

Okafor, H.O. (2012). Do domestic macroeconomic variables matter for foreign direct investment inflow in Nigeria. *Research Journal of Finance and Accounting*, 3(9), 55 67. Retrieved from https://core.ac.uk

Pal, P. (2010). Foreign portfolio investment, stock market and economic development: A case study of India. *Capital Without Borders: Challenges to Development*, 1, 109-121. https://doi.org/10.2307/j.ctt1gsmzdw.11

Pala, A. and Orgun, B.O. (2015). The effect of macro economic variables on foreign portfolio investments: An implication for Turkey. *Journal of Business, Economics & Finance*, 4(1), 108 126. Retrieved from https://dergipark.org.tr/en/pub/jbef

Pesaran, M.H., Shin, Y. and Smith, R.J. (2001). Bounds testing approaches to the analysis of level relationship. *Journal of Applied Econometrics,* 16(3), 289-326. Retrieved from https://www.jstor.org/

Phillips, P.C.B. and Ouliaris, S. (1990). Asymptotic properties of residual based tests for cointegration. *Econometrica, 58*(1), 165-193. Retrieved from https://www.jstor.org/

Şahin, D. (2018). BRICS-T ülkelerinde ekonomik özgürlükler ve doğrudan yabancı sermaye yatırımları arasındaki ilişki: Bootstrap panel nedensellik testi. *Bingöl Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, 8(16), 285-294. https://doi.org/10.29029/busbed.389932

Samut, S. (2016). *Döviz kuru ve parite oynaklığının dış ticaret sektörü üzerindeki etkileri: Türkiye örneği*. (Yayımlanmamış doktora tezi). Karadeniz Teknik Üniversitesi Sosyal Bilimler Enstitüsü Ekonometri Anabilim Dalı, Trabzon.

Shamim, M.A., Perveen, S. and Hasan, S.W. (2021). Does foreign portfolio investment affect stock market performance? A case of Pakistan. *Bahria University Journal of Humanities & Social Sciences,* 4(1), 103-123. https://doi.org/10.58800/bujhss.v4i1.29

Tarı, R. (2014). *Ekonometri* (14. Ed.). Kocaeli: Umuttepe Yayınları.

Telatar, O.M. (2016). The effect of foreign portfolio investments on Turkish economic growth: A nonlinear approach. In D. Mihanovic, A. Hunjet and Z. Primorac (Eds.), *Book of proceedings* (pp. 612-618) Papers presented at the 18. International Scientfic Conference on Economic and Social development- Building Resilient Society, University North and Faculty of Management University of Warsaw, Crotia: University North Publishing.

Toda, H.Y. and Yamamoto, T. (1995). Statistical inference in vector autoregressions with possibly integrated processes. *Journal of Econometrics*, 66 (2), 225-250. https://doi.org/10.1016/0304-4076(94)01616-8

Wu, J., Li, S. and Selover, D.D. (2012). Foreign direct investment vs. foreign portfolio investment. *Management International Review*, 52, 643-670. https://doi.org/10.1007/s11575-011-0121-0

Zghidi, N., Sghaier, I. and Abida, Z. (2016). Does economic freedom enhance the impact of foreign direct investment on economic growth in North African countries? A panel data analysis. *African Development Review*, 28(1), 64-74. https://doi.org/10.1111/1467-8268.12167

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INTEREST RATE PASS-THROUGH IN TÜRKİYE: EVIDENCE OF THE MONETARY POLICY APPROACH

Türkiye'de Faiz Oranı Geçişkenliği: Para Politikası Yaklaşımından Kanıtlar

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NARDL

JEL Codes:
E40, E50, C22

Abstract

Central banks direct banks' rates by increasing or decreasing policy rates through the interest rate channel. The effectiveness of this channel is related to the interest rate pass-through. The pass-through of interest rates indicates the impact of changes in policy rates on the retail rates of banks. Pass-through is not only a prerequisite for the monetary transmission mechanism but also is the first stage of it. A complete and quick pass-through increases the effectiveness of the interest rate channel. This paper focuses on the monetary policy approach and uses the ARDL and NARDL models to analyze the relationship between the policy rate and the lending rate in order to test the interest rate pass-through for Türkiye. To enable a comparison of the degree of pass-through and the speed of adjustment, this paper focuses on two time periods: 2011:01–2016:12 and 2017:01–2023:10. The findings of the paper indicate that there are three shreds of evidence for the interest rate pass-through in Türkiye. It is symmetric for both periods. The level of pass-through in the initial period exceeds that of the subsequent period. The rate of adjustment in the second period is faster than in the first one.

Anahtar Kelimeler:
Faiz Oranı Geçişkenliği,
Türkiye,
ARDL,
NARDL

JEL Kodları:
E40, E50, C22

Öz

Merkez bankaları, faiz kanalı yoluyla politika faizlerini artırarak veya azaltarak bankaların faiz oranlarını yönlendirmektedir. Faiz kanalının etkinliği, faiz geçişkenliğine bağlı bulunmaktadır. Banka faiz oranlarının politika faiz oranlarındaki değişikliklere verdiği tepkiyi gösteren faiz geçişkenliği, parasal aktarım mekanizmasının sadece önkoşulunu değil, aynı zamanda ilk aşamasını oluşturmaktadır. Geçişkenliğin tam ve hızlı olması ise faiz kanalının etkinliğini artırmaktadır. Türkiye'de faiz geçişkenliğini, para politikası yaklaşımı çerçevesinde test eden bu çalışma, ARDL ve NARDL modellerini kullanarak politika faiz oranı ile kredi faiz oranı arasındaki ilişkiye odaklanmaktadır. Çalışma, faiz geçişkenliğinin derecesini ve ayarlanma hızını karşılaştırabilmek için iki dönemi (2011:01-2016:12 ve 2017:01-2023:10) esas almaktadır. Çalışmanın sonuçları, üç kanıtı ortaya koymaktadır. Türkiye'de faiz geçişkenliği her iki dönem için de simetriktir. Birinci dönemdeki geçişkenlik derecesi ikinci döneme göre daha yüksektir. Geçişkenliğin ayarlama hızı, ikinci dönemde, birinci döneme göre daha hızlıdır.

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1. Introduction

The monetary policy transmission mechanism is the process by which monetary policy decisions affect the economy and the price level through various channels. The interest rate channel, also known as the traditional Keynesian interest rate channel, is one of the channels of the transmission mechanism. As the central bank has the power to issue money, it also has the authority to set short-term nominal interest rates, such as policy rates. The change in the short-run nominal policy rates affects the long-run real money market rate and long-run real banks' rates (lending and deposit rates). The savings and investment decisions of firms and households are impacted by changes in deposit and lending rates. For instance, borrowing money for investment and consumption becomes more attractive when lending rates are lower. The amount of investment and consumption influences the aggregate demand and total output. When everything else is equal, increased investment and consumption lead to an increase in demand and output (CBRT, 2013: 5; ECB, 2024). Two stages exist in the interest rate channel: the pass-through from short-run nominal rates to long-run real rates, followed by the transmission of real rates to aggregate demand and production (Égert and MacDonald, 2008: 8).

Interest rate pass-through is the process by which the policy rate affects the other rates. It shows the speed and degree of the effect of policy rates on market rates and retail bank rates (Tai et al., 2012: 164). Interest rate pass-through is delineated through three distinct approaches within the existing literature: the "Monetary Policy Approach," the "Cost of Funds Approach," and the "Unifying Approach."(see Figure 1.).

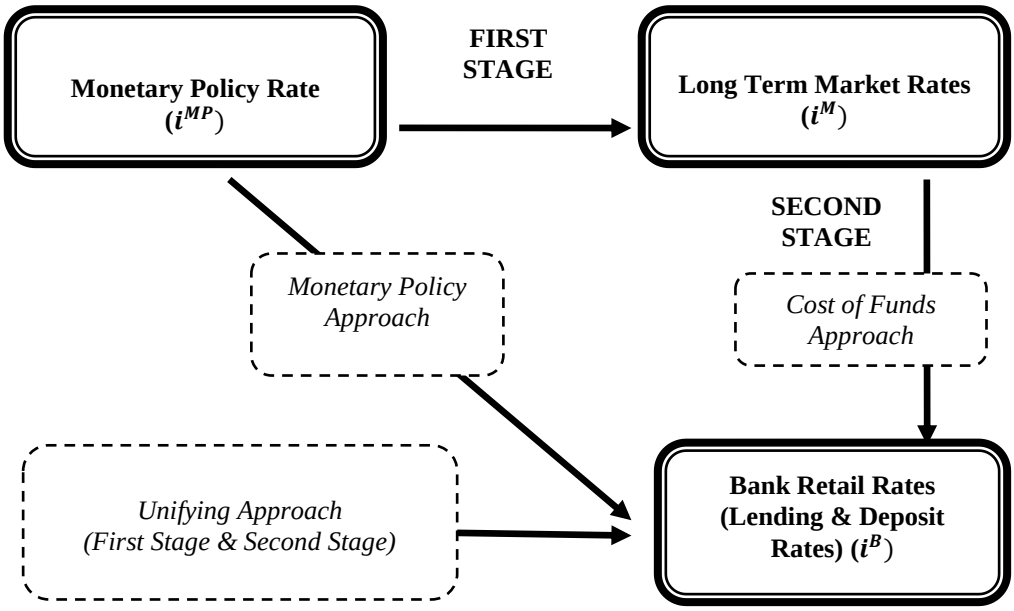

Figure 1. The Approaches Explaining Interest Rate Pass-Through
Source: Égert and MacDonald (2008).

The Monetary Policy Approach ($\boldsymbol{i^{MP} \rightarrow i^{B}}$) deals with the effect of monetary policy on bank's rates and does not include any other explanatory variables. This approach focuses only on the pass-through from the policy rates to the bank's retail rates (Samba and Yan, 2010: 32). It is

possible to look directly at the pass-through between policy rates and the bank's rates under the assumption of a stable yield curve. This assumption allows us to test the pass-through by taking a shortcut (Crespo-Cuaresma et al., 2006: 91).

The Cost of Funds Approach ($\boldsymbol{i^M \rightarrow i^B}$) comprises the second stage of the pass-through (Doojav and Kalirajan, 2016: 277). This approach is supported by the marginal cost pricing model developed by Rousseas (1985) and De Bondt (2005). The Cost of Funds Approach focuses on the decision of setting prices of the banks while revealing the impact of changes in market rates on deposit and lending rates. The cost of funds refers to two meanings for the banks in terms of deposits and loans. While the cost of funds indicates the financing costs for deposits, it indicates the opportunity costs for loans (Samba and Yan, 2010: 32). Short-run money market rates may directly affect long-run market rates according to this approach (Doojav and Kalirajan, 2016: 277).

The Unifying Approach [($\boldsymbol{i^{MP} \rightarrow i^M}$) & ($\boldsymbol{i^M \rightarrow i^B}$)] includes two stages. While the policy rate is transmitted to market rates in the first stage, there is a pass-through from market rates to bank's retail rates in the second stage as may be seen in Figure 1 (Égert and MacDonald, 2008: 10).

The speed and degree of pass-through may be influenced by many factors sorted as follows: macroeconomic conditions, monetary policy operations and the structure of the financial system.

Macroeconomic Conditions: Rapid economic growth has a positive impact on pass-through, however economic contraction has a negative impact. An increase in uncertainty in the economy negatively affects expectations and thus slows down the pass-through. High levels of public debt affect the pass-through negatively (Cavusoglu, 2010: 31-32).

Monetary Policy Operations: Expected and unexpected changes in the policy rates may affect the pass-through variously. Banks are adept at adapting to anticipated changes, but they are less agile when it comes to unforeseen changes. The speed and degree of pass-through also vary depending on whether the change of policy rate is permanent or temporary. Banks just want to adapt to permanent changes due to the adjustment costs (Bredin et al., 2002: 225-226).

Structure of the Financial System: The pass-through may be affected by various factors within the framework of the structure of the financial system, such as competition/concentration, asymmetric information, and adjustment costs. If *competitio*n is low in the banking market, banks may trade with high-profit margins and may adapt slowly and incompletely to changes in policy rates. The competition among banks is measured by the *concentration*. If the concentration of the banking market is high, competition among the banks decreases, and thus interest rate pass-through weakens, slows down, and becomes asymmetric (Égert and MacDonald, 2008: 10). *Asymmetric information* affects the pass-through negatively because the expansion of the cost of asymmetric information increases the funding costs for banks. Banks transmit this increase to their customers by increasing the lending rates. An increase in lending rates may lead to two problems: Adverse Selection and Moral Hazard. If banks increase the lending rates, they may have to choose high-risk and dishonest customers (Adverse Selection) or investors may invest in risky projects (Moral Hazard). Since these problems may increase the credit risk of banks, the expected return of banks may decrease. In this situation, banks adjust lending rates below market rates and ration loan supply.However, credit rationing causes upward rigidity for lending rates. On the other hand, if banks do not ration the supply of credit, upward rigidity may not be valid

for lending rates. It can be assumed that banks lend to two classes of borrowers: riskless borrowers and risky borrowers. Adverse selection and moral hazard cause an increase in lending rates for risky borrowers. In such a situation, transmission from policy rate to lending rates is complete for the riskless borrowers. However, for risky loans, banks need to increase the lending rates by a rate higher than the increase of policy rate to compensate for the probability of default (De Bondt, 2002: 8-10). If policy interest rates change too often, banks do not want to change interest rates often due to *adjustment costs*. In such economic conditions, banks prefer to change other elements of lending or deposit agreements instead of changing interest rates (Cavusoglu, 2010: 31-46).

In short, such conditions as follows support fast and symmetric pass-through: complete and symmetric information, high competition, suitable macroeconomic conditions, expected and permanent changes in the policy rates. If these conditions do not exist in the banking market and the economy as a whole, the policy rate may not adjust to the banks' rates in the same direction and at the same level. In such a situation defined as asymmetric pass-through, the bank's rates may be sticky for upward or downward changes in the policy rate (Uslu and Karahan, 2016: 672). The level of pass-through is so important for the success of monetary policies. An incomplete, asymmetric and slow pass-through may cause a failure of monetary policy and may affect negatively the decisions of economic units about investment, savings, and consumption. On the other hand, if the long-run pass-through is high, fast, and complete, the interest rate channel is effective. A fast, symmetrical and complete pass-through creates an efficient, and well-functioning financial system (Tai et al., 2012: 163-164).

The Central Bank of the Republic of Türkiye (CBRT) had implemented a monetary policy that included a single target (price stability) and a single instrument (short-run rates) until 2010. As the 2008 Global Crisis made it clear that financial stability should not be ignored, the CBRT turned to unconventional monetary policies. The CBRT adopted multiple targets, such as keeping credit volume at reasonable levels and preventing exchange rate volatility (financial stability), in addition to price stability (CBRT, 2024). Since short-run interest rates were not sufficient to achieve these targets, the CBRT started to use additional instruments such as the interest rate corridor, reserve requirements, liquidity management, reserve option mechanism, and the 1-week repo rate to diversify its instruments. For managing liquidity, the CBRT used the 1-week repo rate and the overnight lending rate, which is the upper band of the interest rate corridor, to fund the market. The using of these rates led to the emergence of a new concept known as the weighted average funding cost. The weighted average funding cost represents monetary policy and is expected to play an effective role in the monetary transmission mechanism (Buberkoku and Kizilder, 2019: 219-220).

Based on this, interest rate pass-through is an important research topic in terms of demonstrating the success or failure of monetary policy. The present study tests the pass-through in Türkiye within the framework of the Monetary Policy Approach by using Autoregressive Distributed Lag (ARDL) and Nonlinear ARDL (NARDL) models for two periods (2011:01-2016:12 and 2017:01-2023:10). Testing two periods and comparing the results of these periods with ARDL and NARDL models make this study different from other studies that analyze Türkiye. The weighted average funding cost is preferred as an independent variable. It is also preferable to use the commercial loan interest rate as a dependent variable since bank loans are crucial for both price stability and financial stability. This study tries to find answers to two questions: 1. Is there a one-to-one pass-through for Türkiye? If there is not, what can be said about the degree and speed of it? Is it complete or incomplete? Is it fast or slow? Is the pass-through

symmetric or asymmetric? 2. What are the differences/similarities between the empirical results of the first period and the second period? The study consists of three parts following the introduction section each aimed at answering specific questions. The second section provides the literature review while the third section introduces the model, dataset and methodology. Empirical findings are presented in the fourth section. The conclusion includes policy recommendations for complete and efficient pass-through.

2. Literature Review

The studies test interest rate pass-through are divided into three groups. The studies in the first group perform the analysis with a monetary policy approach, while those in the second group are based on the cost of fund approach. The studies in the last group are tested with the unifying approach. Although the pass-through between the policy rate and money market rate is mostly complete or close to complete according to the results of the studies, the pass-through from the policy rate/the money market rate to the bank's retail rates is usually incomplete. Empirical studies often test a single country, but it is also common to analyze multiple countries. The interest rate pass-through is an important topic for Türkiye as well as for all other countries. Just two of the studies evaluating Türkiye apply the ARDL model. Both studies are based on a single period. No study applying the NARDL model has tested Türkiye. The ARDL and NARDL models are applied in this study to examine the interest rate pass-through over two periods to see if there are any differences. This study differs from other research on Türkiye due to this circumstance. Table 1 provides a review of the empirical literature.

Table 1. Related Studies

Author	Country	Period	Variables	Method	Result
Bredin et al. (2002)	Ireland	1980:01-2001:03	Money Market Rate (MMR), Lending Rate (LR)(Mortgage, Consumer, Firm), Prime Rate	Johansen Cointegration Test, Error Correction Model (ECM)	Pass-through from MMR to LR is not complete. The highest speed of adjustment is valid for prime rates.
De Bondt (2002)	Euro Area	1996:01-2001:05	MMR, Government Bond Yield (GBY), Deposit Rate (DR), LR	Vector Autoregressive (VAR), Impulse Response, ECM	Pass-through within one month from MMR to LR/DR is incomplete. Pass-through of LR is almost complete for the long run.
Sander and Kleimeier (2003)	Euro Area	1993:01-2002:10	O/N MMR, Interbank Rate, GBY, LR, DR	VAR, Threshold Autoregressive (TAR)	Pass-through is high for the monetary policy rate.
Crespo-Cuaresma et al. (2004)	Czech Republic, Hungary, Poland	1994:01-2002:12	Interbank MMR, GBY, LR, DR	ARDL	Although the pass-through is complete for Poland, it is incomplete for the Czech Republic and Hungary.

Table 1. Continued

Horváth et al. (2004)	Hungary	1997:01-2004:04 2001:05-2004:04	MMR, LR (Hausehold and Corporate) DR	ECM, TAR, Panel Regression	Pass-through from MMR to corporate rate is complete and quick. The adjustment of DR and household rates is incomplete and sluggish.
Amarasekara (2005)	Sri Lanka	1996:06-2004:12	Repo & Reverse Repo Rates, Open Market Operation (OMO) Rates, Call MMR, LR, DR	Granger Causality Test, Simple Linear Regressions, Engle Granger (EG) and Johansen Cointegration Tests, ECM	Pass-through from PR to call MMR is almost complete. Pass-through from call MMR to LR and DR is sluggish and incomplete except for the prime rates. Commercial bank's rates adapt symmetrically.
Humala (2005)	Argentina	1993:06-2000:12	MMR, LR (Overdrafts, Bills, Personal Loans)	EG and Johansen Cointegration Test, VAR/VECM, Markov Switching (MS) VAR/VECM	There is a high stickiness for high-risk loans.
Kwapil and Scharler (2006)	Euro Area and United States	1995:01-2003:09	MMR, LR (Household, Mortgage, Business), DR	ARDL	Pass-through is less complete in the Euro Area than in the U.S. for DR and LR.
Sørensen and Werner (2006)	Euro Area	1999:01-2004:06	PR, LR (Corparate, Consumer, Mortgage), DR (Current Account, Time)	Pedroni Cointegration Test, ECM	Pass-through is the highest for mortgages and lowest for current account deposits.
Aydin (2007)	Türkiye	2001:06-2005:09	MMR, LR (Vehicle, Corporate, Consumer, Mortgages)	Westerlund Cointegration Test, Hausman Test	Pass-through of household loans is higher compared to corporate loans.
Von Borstel (2008)	Germany, Euro Area	2003:01-2007:09	MMR, LR (Household, Overdraft, Consumer, Hausing, Corparate), DR (Time, Savings)	VAR, Johansen Cointegration Test, VECM	Although pass-through from MMR to time DR, corporate rates and housing rates is fast, it is sluggish for the consumer rate and saving DR.
Maskay and Pandit (2010)	Nepal	1990:Q1-2009:Q4	PR, DR, LR, Saving Rate	EG and Johansen Cointegration Tests, ECM	PR is ineffective for the retail rates.
Cavusoglu (2010)	Türkiye	2002:01-2009:12	PR, LR (Vehicle, Commercial, Consumer, SME, Mortgages), DR	VAR, ECM	Although the degree of pass-through is high for LR, the speed of adjustment is high for DR. Pass-through of consumer loans is higher and faster compared to commercial loans.

Table 1. Continued

Belke et al. (2012)	European Monetary Union 12 Countries	2003:01-2011:09	MMR, LR	ARDL, Johansen Cointegration Test	Pass-through is incomplete.
Hanif and Khan (2012)	Pakistan	2001:07-2011:08	PR, MMR, DR, LR	ARDL	Pass-through from PR to MMR is swift. Pass-through from MMR to DR is sluggish and incomplete. LRs are more sensitive to changes in MMR compared to the DR.
Tai et al. (2012)	6 Asian Countries	1988:01-1997:06	MMR, DR, LR	Generalized Least Square (GLS), Ordinary Least Squares (OLS)	Pass-through from MMR to DR/LR is slow and sluggish.
Sahin et al. (2013)	Türkiye	2002:01-2012:08	PR, LR (Vehicle, Commercial, Consumer, Mortgages)	VAR, Variance Decomposition, Impulse Response, Granger Causality Test	Pass-through from PR to LR is incomplete.
Yuksel and Metin Ozcan (2013)	Türkiye	2001:12-2011:04	PR, LR (Cash, Vehicle, Housing, Commercial)	TAR, Momentum TAR (MTAR)	Pass-through is symmetric, complete and significant.
Doojav and Kalirajan (2016)	Mongolia	2002:12-2015:09	MMR, LR, DR	ARDL, NARDL	Pass-through of the DR is higher than LR. Adjustment of DR is slower compared to LR. Although the pass-through is negatively asymmetric for LR, it is positively asymmetric for DR.
Uslu and Karahan (2016)	Türkiye	2002:01-2014:12	BIST Interbank O/N Rate, LR (Vehicle, Commercial, Consumer, Mortgages)	ARDL, Kalman Filter	The highest pass-through is valid for consumer loans.
Grigoli and Mota (2017)	Dominican Republic	2006:06-2015:06	PR, DR, LR (Commercial, Mortgage, Consumer)	ARDL, TAR, MTAR	Pass-through of LR is faster compared to DR. Adjustments of short-run rates are asymmetric.
Ugur and Bingol (2018)	Türkiye	2002:01-2016:12	PR, LR (Vehicle, Commercial, Consumer, Mortgages)	Toda Yamamota and Frequency Domain Causality Tests	There is a causality from PR to LRs except for vehicle rate.
Buberkoku and Kizilder (2019)	Türkiye	2011:01-2017:09	The CBRT Average Funding Cost (AFC), BIST Interbank O/N Rate, DR, LR (Vehicle, Commercial, Consumer, Mortgages),	Gregory-Hansen Cointegration Tests	CBRT AFC is more influential than BIST Interbank O/N Rate on LR and DR.

Table 1. Continued

Sahin (2019)	Türkiye	2002:01-2018:04	The CBRT AFC, O/N Simple Rate, LR (Personal, Vehicle, Commercial, Consumer, Housing), DR	EG and Johansen Cointegration Test, VECM, Nonlinear VECM	Pass-through of DR is higher compared to LR. There is a symmetric relationship and correct transmission for all variables.
Bulut (2020)	Türkiye	2011:01-2019:06	BIST Interbank O/N Rate, LR (Consumer, Commercial)	Gregory-Hansen and Tsong Cointegration Tests	Pass-through is almost complete.
Guler (2021)	Türkiye	2013:01-2018:11	CBRT O/N Lending, One Week Repo Rates, CBRT AFC and BIST Interbank O/N Rate, LR, DR	GMM	LR and DR are more sensitive to CBRT AFC and BIST Interbank O/N Rate
Salihoglu and Hepsag (2021)	Türkiye	2011:01 01-2021:22 01	CBRT AFC, BIST Interbank O/N Rate, LR, DR	Residual Augmented Least Squares (RALS)	The Pass-through from BIST Interbank O/N rate to LR and DR is higher than the pass-through of CBRT AFC.
Ozsoy Calis et al. (2022)	Türkiye	2020-2021 weekly data	BIST O/N Repo Rate, LR (Vehicle, Commercial, Consumer, Mortgages)	Granger Causality Test	There is a causality relationship only between the BIST O/N Repo rate and vehicle loans.
Gunes (2022)	Türkiye	2012:06 01-2022:28 01	The CBRT AFC, LR (Vehicle, Commercial, Consumer, Mortgages), DR	VAR, Variance Decomposition, Impulse Response	Pass-through of DR is higher compared to LR.
Jorayev and Yildiz (2022)	Türkiye	2010:05-2021:03	PR, LR (Commercial), DR	ARDL	LR and DR adapt to changes in the PR slowly.
Ojaghlou and Kaya Soztanaci (2022)	Türkiye	2002:01-2021:03	CBRT Discount Rate, LR, DR, MMR, Treasury Bill Rate, GBY	Bayesian VAR	Pass-through between the CBRT discount rate and LR is complete.
Oyadeyi (2022)	Nigeria	2006:12-2020:12	PR, MMR, DR, LR	Mean Adjustment Lag, ECT	Although short run pass-through from PR to MMR is incomplete, the long run process over-shoots. Pass-through from MMR to LR and DR is weak and incomplete.
Herlambang et al. (2023)	Indonesia	1990:03-2017:02	MMR, LR	NARDL	There is an upward rigidity in the overall period.

3. Dataset, Model and Methodology

This study analyzes the interest rate pass-through for Türkiye with a monthly dataset and two periods (2011:01-2016:12 and 2017:01-2023:10). The analysis started with 2011:01 because the dataset of the independent variable was accessible by this year and month. The analysis was based on two periods to understand the pass-through better because the policy rate was relatively stable in the first period of the analysis, while fluctuation increased in the second period (see Figure 2). This situation may differentiate the degree and speed of pass-through. Therefore, it is useful to test these periods separately to prove the difference. Additionally, comparing two periods allows for an analysis of their symmetry/asymmetry, degree, and speed.

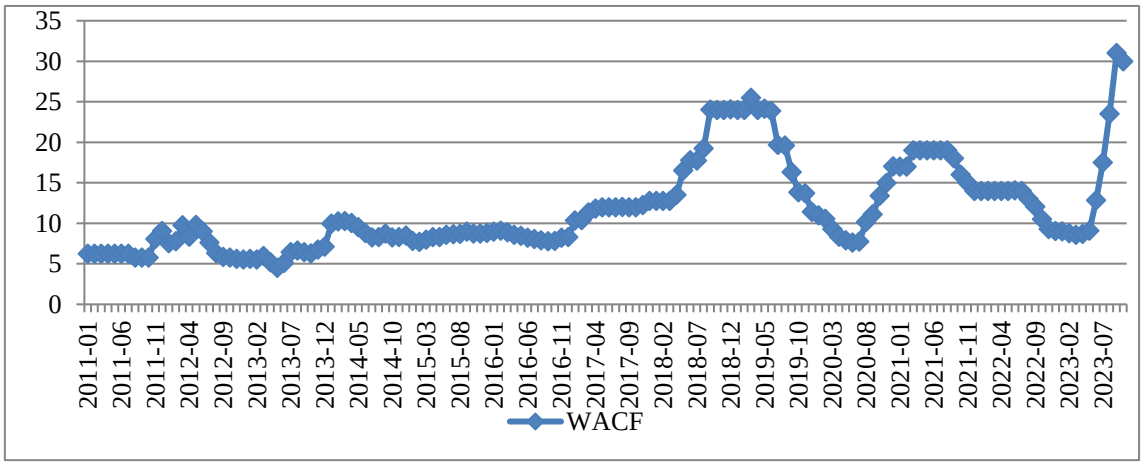

Figure 2. The Weighted Average Funding Cost of the CBRT

Since the policy rate may affect both the money market rate and bank's retail rate, this study prefers to look at the pass-through using a shortcut. Thus, the study focuses on the Monetary Policy Approach. This study represents the policy rate using the weighted average funding cost (WACF) of the CBRT as an independent variable similar to Buberkoku and Kizilder (2019), Sahin (2019), Guler (2021), Salihoglu and Hepsag (2021), and Gunes (2022). This study also adds the weighted average interest rate of banks' commercial loans (IRCL) as a dependent variable to represent the lending rate, or bank retail rate, similar to other studies such as Cavusoglu (2010), Sahin et al. (2013), Yuksel and Metin Ozcan (2013), Uslu and Karahan (2016), Grigoli and Mota (2017), Ugur and Bingol (2018), Buberkoku and Kizilder (2019), Sahin (2019), Bulut (2020), Ozsoy Calis et al. (2022), Gunes (2022), Jorayev and Yildiz (2022). The CBRT Electronic Data Delivery System is the source of the dataset (CBRT, 2023).

Equation (1) shows the model that tests the interest rate pass-through of Türkiye. The degree of the pass-through is indicated by β_1. The Monetary Policy Approach states that β_1 should theoretically have a positive sign.

$$IRCL_t = \beta_0 + \beta_1 WACF_t + \varepsilon_t \quad (1)$$

$(\beta_1 = 1) \rightarrow$ There is a complete, strong and symmetrical pass-through. The condition of commercial loan market is competitive.

$(\beta_1 < 1)$ → There is an incomplete and weak pass-through. The condition of commercial loan market is non-competitive. Weak competition may indicate that banks have some degree of market power. The other factor that can explain the incomplete pass-through is asymmetric information. If banks ration the amount of credit supply due to the asymmetric information, β_1 may take on a value less than 1. There are many factors that may cause incomplete pass-through except market power and asymmetric information. These factors are given as follows: economic contraction, an increase in uncertainty, a high level of public debt, temporary and unexpected changes in policy interest rates, and adjustment costs.

$(\beta_1 > 1)$ → If banks do not ration the supply of credit against asymmetric information problems and they prefer to increase lending rates, β_1 may take on the value higher than 1 (De Bondt, 2002: 8-10; Bulut, 2020: 20; Salihoglu and Hepsag, 2021: 46).

This study analyses the interest rate pass-through by applying ARDL and NARDL models. The ARDL model developed by Pesaran et al. (2001) has a better performance in testing for cointegration in small samples. Time series do not need to be cointegrated in the same order, unlike other traditional cointegration tests. In other words, the ARDL model makes it possible to test for cointegration with I(0) and I(1) variables. However, any variable should not definitely be I(2) (Doojav and Kalirajan, 2016: 277).

Firstly, cointegration between the variables is tested with the ARDL Bound Test and Equation 2 is estimated.

$$\Delta IRCL_t=\alpha_0+\theta_1 IRCL_{t-1} + \theta_2 WACF_{t-1} + \sum_{i=1}^{p} \beta_1 \Delta IRCL_{t-i}+ \sum_{i=0}^{p} \gamma_1 \Delta WACF_{t-i}+\varepsilon_t \quad (2)$$

It is necessary to determine the suitable lag length using Information Criterion such as Akaike (AIC), Schwarz (SC) or Hannan-Quinn (HQ) based on the VAR model for the estimation. ARDL model in Equation 3 is used for the estimation of long-run coefficients.

$$IRCL_t = \beta_0 + \sum_{i=1}^{p} \varphi_1 IRCL_{t-i} + \sum_{i=0}^{q} \gamma_1 WACF_{t-i}+ v_t \quad (3)$$

Error Correct Model (ECM) based on the ARDL is presented in Equation 4, and it is used to test short-run effects. EC_{t-1} refers to adaptation for long-run. The coefficient of EC_{t-1} is expected to be statistically significant and negative.

$$\Delta IRCL_t= \beta_0 + \sum_{i=1}^{p} \varphi_1 \Delta IRCL_{t-i}+ \sum_{i=0}^{q} \gamma_1 \Delta WACF_{t-i}+\rho(EC_{t-1})+\varepsilon_t \quad (4)$$

The NARDL model developed by Shin et al. (2013) has the same advantage as the ARDL model in capturing any cointegrating relation (Herlambang et al., 2023: 5). The NARDL model also allows to determine the nonlinear cointegration, linear cointegration or absence of cointegration (Doojav and Kalirajan, 2016: 277). Asymmetric cointegrating regression in Equation 5 is used for testing pass-through.

$$IRCL_t = \beta^+ WACF_t^+ + \beta^- WACF_t^- + u_t \quad (5)$$

β^+ and β^- represent long-run parameters. The partial sum processes of positive and negative changes in the WACF are separated as shown in Equation 6 and Equations 7.

$$IRCL_t^+ = \sum_{j=1}^{t} IRCL_j^+ = \sum_{j=1}^{t} \max(IRCL_j, 0) \quad (6)$$

$$IRCL_t^- = \sum_{j=1}^{t} IRCL_j^- = \sum_{j=1}^{t} \max(IRCL_j, 0) \quad (7)$$

Equation 5 is indicated in the asymmetric EC form in Equation 8.

$$IRCL_t = \alpha + \rho IRCL_{t-1} + \theta^+ WACF_{t-1}^+ + \theta^- WACF_{t-1}^- + \sum_{j=1}^{p-1} \gamma_j IRCL_{t-j} + \sum_{j=1}^{q-1} (\varphi_j^+ WACF_{t-j}^+ + \varphi_j^- WACF_{t-j}^-) + \varepsilon_t \quad (8)$$

The asymmetric long-run relationship is tested with $\rho = \theta^+ = \theta^- = 0$ based on Equation 8. If there is a long-run relationship, it is tested whether the asymmetric long-run parameters $(\beta^+, \beta^-) -\theta^+/\rho\ , -\theta^-/\rho$ are equal to each other. The asymmetric short-run relationship is tested in two ways: strong and weak form. The equality between the positive and negative short- run parameters that in the same lag length ($\varphi_j^+ = \varphi_j^-$) is tested with the Wald Test in order to determine the strong asymmetry. The equality between the sum of positive short-run parameters and the sum of negative short-run parameters ($\sum_{j=1}^{q-1} \varphi_j^+ = \sum_{j=1}^{q-1} \varphi_j^-$) is tested with the Wald Test for determining the weak asymmetry (Malik et al., 2020: 8; Icen, 2021: 9-11).

4. Empirical Results

4.1. Results of First Period: (2011:01-2016:12)

This study applied the Dickey-Fuller Unit Root Test (DF), Augmented Dickey-Fuller Unit Root Test (ADF), and Philips-Perron Unit Root Test (PP) to check the stationarity of the series (Dickey and Fuller, 1979; Dickey and Fuller, 1981; Phillips and Perron, 1988). The empirical results in Table 2 show that dependent and independent variables were I(1). Since none of the series were I(2), the study applied the ARDL and NARDL models.

Table 2. Unit Root Tests: (2011:01-2016:12)

Variable	DF		ADF		PP		Status
	Intercept	Intercept and Trend	Intercept	Intercept and Trend	Intercept	Intercept and Trend	
IRCL	(-1.26)	(-2.62)	(-2.88) [0.05]**	(-3.09) [0.12]	(-2.41) [0.14]	(-2.34) [0.41]	I(1)
ΔIRCL	(-5.41)*	(-5.47)*	(-5.39) [0.00]*	(-5.40) [0.00]*	(-5.15) [0.00]*	(-5.15) [0.00]*	
WACF	(-1.84)***	(-2.50)	(-2.23) [0.20]	(-2.47) [0.34]	(-2.34) [0.16]	(2.63) [0.27]	I(1)
ΔWACF	(-7.88)*	(-7.88)*	(-7.82) [0.00]*	(-7.77) [0.00]*	(-7.82) [0.00]*	(7.77) [0.00]*	

Note: Values in () and [] show t-statistics and probability respectively. *, **, *** show significance at 1%, 5% and 10% level respectively. Null Hypothesis of DF, ADF and PP: Variable has a unit root.

The Sequential Modified LR Test Statistic (LR), the Final Prediction Error (FPE), AIC, SC and HQ Information Criterion presented a lag length of 2 for the conducting cointegration. Lag-length selection according to the VAR model showed that all dots were within the circle at the polynomial graph. Table 3 presents the ARDL (2,2) and NARDL (2,0,0) models.

The ARDL (2,2) model included DUMMY1 (it is defined as 1 for 2014M08; as 0 for the other months) because of the instability of the CUSUM^2. Inclusion of DUMMY 1 ensures the stability for the overall model. In addition, other diagnostic test results [Jarque-Bera test for normality (X^2_{JB}), Breusch-Godfrey Serial Correlation LM test (X^2_{BG}), ARCH test for heteroscedasticity (X^2_{ARCH}), Ramsey's reset test for misspecification of model (X^2_R)] and statistics [$\mathrm{R}^2, \overline{\mathrm{R}}^2, \mathrm{F}$] of the model indicated that there was no problem statistically within the ARDL (2,2) model.

The finding of the Bound Test indicated that the estimated F-statistic value was statistically significant, and it was higher than the critical value of the upper bound of Narayan's (2005) table. WACF affected IRCL positively and significantly in the long and short run. The long-run findings indicated that a 1 % increase (decrease) in the WACF was able to lead to an increase (decrease) of 1.094 % in IRCL. Thus, commercial lending rates exhibited an overshooting reaction to the changes in the policy rates.

The short-run estimates were 0.242 and 0.257 respectively. This meant that the commercial lending rate pass-through was incomplete. The estimation of the EC was -0.167. When the CBRT changed the policy rate, the adjustment took around 6 months for the commercial lending rate to reach its long-run equilibrium value.

Table 3. ARDL and NARDL Models: (2011:01-2016:12)

	ARDL (2,2)			**NARDL (2,0,0)**		
Bound Test	**F statistic** 4.460**			**F statistic** 5.278*		
	Variable	**Coef**	**Prob**	**Variable**	**Coef**	**Prob**
Long Run	WACF	1.094	0.000*	WACF_POS	1.234	0.000*
	DUMMY1	-6.568	0.055**	WACF_NEG	1.249	0.000*
	C	5.123	0.018**	DUMMY1	-6.017	0.028**
				C	11.847	0.000*
Error Correction Model	D(IRCL(-1))	0.252	0.008*	D(IRCL(-1))	0.288	0.003*
	D(WACF)	0.242	0.007*	D(WACF_POS)	0.337	0.003*
	D(WACF(-1))	0.257	0.011**	D(WACF_NEG)	0.134	0.397
	D(DUMMY1)	-1.305	0.002*	D(DUMMY1)	-1.431	0.001*
	EC(-1)	-0.167	0.001*	EC(-1)	-0.211	0.000*
Wald Test				$\mathrm{W_L}$	0.037 (0.848)	*Symmetric*
				$\mathrm{W_S}$	(-)	
Model Statistics	R^2		0.501	R^2		0.386
	$\overline{\mathrm{R}}^2$		0.453	$\overline{\mathrm{R}}^2$		0.338
	F		10.541 (0.000)	F		8.038 (0.000)
Diagnostic Tests	$\mathrm{X}^2_{\mathrm{JB}}$		0.362(0.835)	$\mathrm{X}^2_{\mathrm{JB}}$		0.772(0.680)
	$\mathrm{X}^2_{\mathrm{BG}}$		0.097(0.907)	$\mathrm{X}^2_{\mathrm{BG}}$		0.221(0.802)
	$\mathrm{X}^2_{\mathrm{ARCH}}$		0.043(0.958)	$\mathrm{X}^2_{\mathrm{ARCH}}$		0.591(0.557)
	$\mathrm{X}^2_{\mathrm{R}}$		0.599(0.442)	$\mathrm{X}^2_{\mathrm{R}}$		1.065(0.306)
	CUSUM		Stable	CUSUM		Stable
	CUSUM^2		Stable	CUSUM^2		Stable

Note: *, **, *** show significance at 1%, 5% and 10% level respectively.

If there is an asymmetric relationship in the model, the ARDL model may not present correct results. For this reason, the NARDL model is also estimated to test asymmetry with the Wald test. The findings of NARDL showed that there was a positive and statistically significant relationship between WACF and IRCL in the long run. The short-run results indicated that while the increment of WACF increased IRCL, the decrease in WACF did not have a statistically significant effect on IRCL. However, the Wald test results did not support asymmetry in the long run. As a result, the pass-through from the policy rate to the commercial lending rate was symmetric between 2011:01 and 2016:12 for Türkiye. The findings of the NARDL Wald Test confirmed the robustness of the ARDL model.

4.2. Results of Second Period: (2017:01-2023:10)

Table 4 shows the results of the DF, ADF, and PP tests. The findings indicate that IRCL is I(1), while WACF is I(0). Since time series do not need to be cointegrated in the same order, this study applied the ARDL and NARDL models for the period of 2017:01-2023:10.

Table 4. Unit Root Tests: (2017:01-2023:10)

Variable	DF		ADF		PP		Status
	Intercept	Intercept and Trend	Intercept	Intercept and Trend	Intercept	Intercept and Trend	
IRCL	(-1.70)***	(-2.52)	(-1.97) [0.30]	(-2.07) [0.56]	(-1.26) [0.64]	(-1.30) [0.88]	I(1)
ΔIRCL	(-3.68)*	(-3.84)*	(-3.68) [0.01]*	(-3.83) [0.02]**	(-3.68) [0.01]*	(-3.83) [0.02]*	
WACF	(-2.84)*	(-3.45)**	(-3.37) [0.02]**	(-3.20) [0.09]***	(-1.75) [0.40]	(-1.69) [0.75]	I(0)
ΔWACF	(-4.36)*	(-4.45)*	(-4.33) [0.00]*	(-4.40) [0.00]*	(-4.46) [0.00]*	(-4.53) [0.00]*	

LR, FPE, and AIC presented a lag length of 4 for the conducting cointegration. Lag-length selection according to the VAR model indicates that all dots are within the circle at the polynomial graph. Table 5 presents the ARDL (2,2) and NARDL (2,4,0) models.

The ARDL (2,2) includes DUMMY2 (it is defined as 1 for 2021M12-2022M08; as 0 for the other months) to resolve the instability of CUSUM^2. The inclusion of DUMMY2 ensures the stability for the overall model. Thus, all diagnostic test results and statistics of the model show that there is no problem statistically within the model. The Bound test result of the ARDL (2,2) model showed that the calculated F-statistic value was statistically significant and there was a cointegration between WACF and IRCL.

WACF affected IRCL positively and significantly in the long and short run. The long-run results indicated that a 1 % increase (decrease) in the WACF was able to lead to an increase (decrease) of 0.898 % in IRCL. This means that the long-run pass-through is incomplete for the period of 2017:01-2023:10. The short-run estimates were 0.733 and 0.472 respectively. Thus, commercial lending rates exhibited a lower reaction. The estimate of the EC was -0.248 and statistically significant. The adjustment took around 4 months for the commercial lending rate to reach its long-run equilibrium value when CBRT changed the policy rate.

Although the NARDL model provided significant coefficients, the findings of the Wald test did not support asymmetry in the long run. Thus, the pass-through of the commercial lending rates was symmetric for the period of 2017:01-2023:10 in Türkiye. The findings of the NARDL Wald Test confirmed the robustness of the ARDL model.

Table 5. ARDL and NARDL Models: (2017:01-2023:10)

	ARDL (2,2)			**NARDL (2,4,0)**		
Bound Test	**F statistic**			**F statistic**		
	7.065*			8.706*		
	Variable	**Coef**	**Prob**	**Variable**	**Coef**	**Prob**
Long Run	WACF	0.898	0.000*	WACF_POS	0.739	0.000*
	DUMMY2	7.364	0.000*	WACF_NEG	0.751	0.000*
	C	5.222	0.008*	DUMMY2	8.256	0.000*
				C	13.409	0.000*
Error Correction Model	D(IRCL(-1))	0.253	0.009*	D(IRCL(-1))	0.304	0.002*
	D(WACF)	0.733	0.000*	D(WACF_POS)	0.850	0.000*
	D(WACF(-1))	0.472	0.001*	D(WACF_POS(-1))	0.518	0.009*
	D(DUMMY2)	3.129	0.002*	D(WACF_POS(-2))	-0.178	0.388
	EC(-1)	-0.248	0.000*	D(WACF_POS(-3))	0.506	0.010**
				D(WACF_NEG)	0.333	0.090***
				D(DUMMY2)	3.242	0.001*
				EC(-1)	-0.287	0.000*
Wald Test				W_L	0.046 (0.831)	*Symmetric*
				W_S		-
Model Statistics	R^2		0.736	R^2		0.761
	$\overline{R}^2$		0.714	$\overline{R}^2$		0.729
	F		33.846 (0.000)	F		23.754 (0.000)
Diagnostic Tests	X^2_{JB}		3.724(0.155)	X^2_{JB}		0.284(0.868)
	X^2_{BG}		0.667(0.617)	X^2_{BG}		0.721(0.581)
	X^2_{ARCH}		1.008(0.409)	X^2_{ARCH}		0.164(0.956)
	X^2_R		2.075(0.154)	X^2_R		0.325(0.571)
	CUSUM		Stable	CUSUM		Stable
	$CUSUM^2$		Stable	$CUSUM^2$		Stable

5. Conclusion and Policy Recommendations

Monetary policy has a crucial function for the CBRT's two important targets of price stability and financial stability. For central banks to achieve their purpose through the interest rate channel, banks' rates need to be directed in line with targets. Hence, interest rate pass-through is an important topic for the central banks. While an incomplete pass-through may cause a failure of monetary policies, a complete one ensures its success because the bank's deposit and lending rates determine the decisions of the economic units about investment, savings, and consumption. When the policy rate is lowered by applying an expansionary monetary policy aimed at stimulating economic activity and this decrease is reflected in the bank's lending rate completely, economic units increase consumption and investment expenditures. Thus, the aggregate demand and production also increase. On the other hand, when central banks increase the policy rate by applying the contractionary monetary policy in order to curb inflation, and this increase reflects bank's lending rate completely, total output decreases due to the decrement of the expenditures.

Hence, inflationary pressure decreases. As a result, interest rate pass-through should be symmetric and complete in a well-functioning macro-financial market.

This is exactly why the interest rate pass-through is an important research topic in terms of demonstrating the success or failure of monetary policy. This study aimed at testing the pass-through within the framework of the Monetary Policy Approach by using linear ARDL and NARDL models for two periods (2011:01-2016:12 and 2017:01-2023:10). Testing two periods and comparing the results of these periods with ARDL and NARDL makes this study different from other studies that have analyzed Türkiye.

NARDL Wald test results indicated that pass-through was symmetric for both periods. Symmetric pass-through made it possible to discuss and compare the findings of linear ARDL models. According to the long-run results, the coefficient of the pass-through was higher than 1 in the first period while it was lower than 1 in the second period. Short-run findings presented that the coefficient was lower in the first period compared to the second period. The speed of adjustment was faster in the second period.

The finding of the symmetry is in line with Yuksel and Metin Ozcan (2013) and Sahin (2019). The long-run results of the second period are similar to the studies conducted by Buberkoku and Kizilder (2019), Bulut (2020), Salihoglu and Hepsag (2021). Lastly, the speed of adjustment for the second period is similar to the study of Cavusoglu (2010). Symmetric pass-through for both periods is a very important advantage for the CBRT. CBRT may control overall the macroeconomy and reach its aims more easily due to the symmetry. Although the long-run findings are statistically significant for both periods, coefficients differ from each other. This difference indicates that different factors may have been effective for interest rate pass-through. The overshoot of commercial lending rates in the first period may be related to the reaction of banks against asymmetric information. Banks may not have rationed the amount of loan supply and may have chosen to increase lending rates to counter moral hazard and adverse selection problems in the first period. The incomplete pass-through in the second period could be caused by many different factors as weak competition or power market, rationing of credit supply, economic contraction, rising uncertainty, large amounts of public debt, temporary and unexpected changes in policy rates, and adjustment costs. Frequent changes in the policy rate in the second period may have caused weak pass-through due to adjustment costs. Thus, the stability of the policy rate is so important for a complete pass-through.

As a result, the interest rate pass-through of Türkiye is overshoots in the first period while it is incomplete in the second one. These findings require policy recommendations for strengthening interest rate pass-through. The stability of macroeconomic variables is important for the pass-through because the stability of policy rates depends on the stability of macroeconomic variables. The instability of the general level of prices may lead to frequent changes in policy interest rates. It is recommended to be patient and decisive for the contractionary monetary policies applied to reduce inflation for Türkiye. If inflation is permanently reduced, the policy rate can be stable and the stability of the interest rate will strengthen the interest rate pass-through. Since a high level of public debt negatively affects pass-through, it is recommended to pay special attention to fiscal discipline. If the CBRT avoids unexpected and temporary changes to the policy rate, pass-through will be complete or almost complete. Asymmetric information may cause both upward and downward rigidity for lending rates. For this reason, it will be useful to focus on the solution of asymmetric information

problems in commercial loan markets. A good way to solve these problems is for the supplier of the loans to have reliable and detailed information from a neutral institution. Finally, the speed of adjustment is so important for the decisions of central banks. CBRT should take into account the speed of adjustment determined in this study to timely adjust the policy rate and monetary policy decisions.

If these recommendations are put into practice, the interest rate pass-through may be complete. Achieving price stability will be easier and faster when the interest pass-through is complete or almost complete. Additionally, a complete pass-through will increase the resilience of the financial system against macro-financial risks and shocks from both internal and external sources.

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.

References

Amarasekara, C. (2005). Interest rate pass-through in Sri Lanka. *Staff Studies*, 35(1-2), 1-32. doi:10.4038/ss.v35i1.1232

Aydın, H.İ. (2007). *Interest rate pass-through in Turkey* (CBRT Research and Monetary Policy Department Working Paper No. 07/05). Retrieved from https://www.tcmb.gov.tr/wps/wcm/connect/EN/TCMB+EN/Main+Menu/Publications/Research/Working+Paperss/2007/07-05

Belke, A., Beckmann, J. and Verheyen, F. (2012). *Interest rate pass-through in the EMU new evidence from nonlinear cointegration techniques for fully harmonized data* (Ruhr Economic Papers No. 350). Retrieved from http://hdl.handle.net/10419/61431

Bredin, D., Fitzpatrick, T. and O Reilly, G. (2002). Retail interest rate pass-through: The Irish experience. *The Economic and Social Review*, 33(2), 223-246. Retrieved from http://www.tara.tcd.ie/

Büberkökü, Ö. and Kızılder, C. (2019). Examining the interest rate transmission mechanism in the Turkish period of unconventional monetary policy. *Van Yüzüncü Yıl University Journal of Economics and Administrative Sciences*, 4(8), 216-244. Retrieved from https://dergipark.org.tr/tr/pub/vanyyuiibfd

Bulut, Ü. (2020). Monetary policy pass-through to lending rates: The case of Turkey. *The Bank Association of Türkiye*, 114, 17-29. Retrieved from https://www.tbb.org.tr/en/home

CBRT. (2013). *Monetary transmission mechanism*. Retrieved from https://www.tcmb.gov.tr

CBRT. (2023). *Electronic data delivery system.* Retrieved from https://evds2.tcmb.gov.tr/

CBRT. (2024). Monetary policy. Retrieved from https://www.tcmb.gov.tr/wps/wcm/connect/tr

Crespo-Cuaresma, J., Égert, B. and Reininger, T. (2004). *Interest rate pass-through in new EU member states: The case of the Czech Republic, Hungary and Poland* (William Davidson Institute Working Paper No. 671). Retrieved from https://deepblue.lib.umich.edu/bitstream/handle/2027.42/40057/wp671.pdf;sequence=3

Crespo-Cuaresma, J., Egert, B. and Reininger, T. (2006). *Interest rate pass-through in Central and Eastern Europe: Reborn from ashes merely to pass away?* (Oesterreichische Nationalbank Focus No. 1/06). Retrieved from https://https://finanzbildung.oenb.at/dam/jcr:188e48da-34f1-45da-8e86-20896b29c6a5/feei_2006_1_special_focus_2_tcm16-43657.pdf

Çavuşoğlu, F. (2010). *Pass-through from monetary policy interest rates to deposit and loan interest rates: The case of Türkiye* (Unpublished doctoral dissertation). CBRT, Ankara.

De Bondt, G. (2002). *Retail bank interest rate pass-through: New evidence at the Euro Area level* (European Central Bank Working Paper No. 136). Retrieved from https://www.ecb.europa.eu/pub/pdf/scpwps/ecbwp136.pdf

De Bondt, G.J. (2005). Interest rate pass-through: Empirical results for the Euro Area. *German Economic Review*, 6(1), 37–78. https://doi.org/10.1111/j.1465-6485.2005.00121.x

Dickey, D.A. and Fuller, W.A. (1979). Distribution of the estimators for autoregressive time series with a Unit Root. *Journal of the American Statistical Association*, 74(366), 427–431. doi:10.2307/2286348

Dickey, D.A. and Fuller, W.A. (1981). Likelihood ratio statistics for autoregressive time series with unit root. *Econometrica*, 49(4), 1057-1072. doi:10.2307/1912517

Doojav, G. and Kalirajan, K. (2016). Interest rate pass-through in Mongolia. *The Developing Economies*, 54(4), 271–291. doi:10.1111/deve.12112

ECB. (2024). Transmission mechanism of monetary policy. Retrieved from https://www.ecb.europa.eu/mopo/intro/

Égert, B. and MacDonald, R. (2008). *Monetary transmission mechanism in Central and Eastern Europe: Surveying the surveyable* (OECD Economics Department Working Papers No. 654). Retrieved from https://www.oecd-ilibrary.org/docserver/230605773237.pdf?expires=17028 10765&id=id&accname=guest&checksum=4979C68557AE337A0A8C363924F777A2

Grigoli, F. and Mota, J.M. (2017). Interest rate pass-through in the Dominican Republic. *Latin American Economic Review*, 26(4), 1-25. doi:10.1007/s40503-017-0041-x

Güler, A. (2021). The pass-through of policy rates to retail bank rates: The case of Turkey. *EKEV Academy Journal,* 85, 15-38. Retrieved from https://dergipark.org.tr/tr/pub/sosekev

Güneş, H. (2022). The effect of CBRT weighted average funding cost on bank rates. *Research of Financial Economic and Social Studies,* 7(4), 565-574. https://doi.org/10.29106/fesa.1080807

Hanif, M.N. and Khan, M.U.H. (2012). *Pass-through of SBP policy rate to market interest rates: An empirical investigation* (Munich Personal RePEc Archive No. 39587). Retrieved from https://mpra.ub.uni-muenchen.de/39587/1/MPRA_paper_39587.pdf

Herlambang, R.D.B., Purwono, R. and Rumayya, R. (2023). Testing the consistency of asymmetric interest rate pass-through: The case of Indonesia. *Cogent Economics & Finance*, 11(1), 2178124. https://doi.org/10.1080/23322039.2023.2178124

Horváth, C., Krekó, J. and Naszódi, A. (2004). *Interest rate pass-through: The case of Hungary* (Magyar Nemzeti Bank Working Paper No. 2004/8). Retrieved from https://www.mnb.hu/letoltes/wp2004-8.pdf

Humala, A. (2005). Interest rate pass-through and financial crises: Do switching regimes matter? The case of Argentina. *Applied Financial Economics*, 15(2), 77-94. https://doi.org/10.1080/0960310042000297908

İçen, H. (2021). Asymmetric relationship between public expenditures and economic growth in Turkey. *Doğuş University Journal,* 22(2), 1-18. https://doi.org/10.31671/doujournal.972977

Jorayev, N. and Yıldız, E.B. (2022). Testing the existence of asymmetric information in the Turkish credit market: The marginal cost pricing model. *Karadeniz Technical University Institute of Social Sciences Journal of Social Sciences*, 12(24), 435-448. Retrieved from https://dergipark.org.tr/tr/pub/sbed

Kwapil, C. and Scharler, J. (2006) *Interest rate pass-through, monetary policy rules and macroeconomic stability* (Oesterreichische Nationalbank Working Paper No. 118). Retrieved from https://www.econstor.eu/bitstream/10419/264710/1/oenb-wp-118.pdf

Malik, M.Y., Latif, K., Khan, Z., Butt, H.D., Hussain, M. and Nadeem, M.A. (2020). Symmetric and asymmetric impact of oil price, FDI and economic growth on carbon emission in Pakistan: Evidence from ARDL and non-linear ARDL approach. *Science of the Total Environment*, 726, 138421. https://doi.org/10.1016/j.scitotenv.2020.138421

Maskay, N.M. and Pandit, R. (2010). Interest rate pass-through in Nepal (An examination over the period of FY 1990:1 - FY 2009:4). *Nepal Rastra Bank Economic Review*, 22(1), 1-18. Retrieved from https://www.nrb.org.np/

Narayan, P.K. (2005). The saving and investment nexus for China: Evidence from cointegration tests. *Applied Economics*, 37(17), 1979-1990. https://doi.org/10.1080/00036840500278103

Ojaghlou, M. and Kaya Söztanacı, B. (2022). Interest rate pass-through and monetary transmission mechanism in Turkey. *Journal of Business and Economics Studies*, 10(1), 46-54. Retrieved from https://dergipark.org.tr/tr/pub/iicder

Oyadeyi, O. (2022). Interest rate pass-through in Nigeria. *Journal of Economics and Development Studies*, 10(1), 49-62. doi:10.15640/jeds.v10n1a5

Özsoy Çalış, N., Babuşçu, Ş. and Hazar, A. (2022). Investigation of interest rate pass-through in Turkey by Granger causality analysis. *The Journal of Kesit Academy*, 8(32), 465-486. Retrieved from https://kesitakademi.com/

Pesaran, M.H., Shin, Y. and Smith, R.J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, 16(3), 289-326. Retrieved from https://doi.org/10.1002/jae.616

Phillips, P.C.B. and Perron, P. (1988). Testing for a unit root in time series regression. *Biometrika*, 75(2), 335-346. https://doi.org/10.1093/biomet/75.2.335

Rousseas, S. (1985). A markup theory of bank loan rates. *Journal of Post Keynesian Economics*, 8(1), 135-144. https://doi.org/10.1080/01603477.1985.11489549

Sahin, A. (2019). Loom of symmetric pass-through. *Economies,* 7(1), 11. https://doi.org/10.3390/economies7010011

Şahin, G., Canpolat, E. and Doğan, M. (2013). Econometric analysis of interest rate pass-through impact: An empirical study on Türkiye. *İnönü University International Journal of Social Sciences,* 2(1), 70-90. Retrieved from https://dergipark.org.tr/en/pub/inijoss

Salihoğlu, E. and Hepsağ, A. (2021). Banka faiz oranı geçişkenliği: RALS eşbütünleşmeyöntemiyle normal dağılmamayı dikkate alan bir yaklaşım. Bankacılar Dergisi, 117, 40-57. Retrieved from https://www.tbb.org.tr/tr/bankacilik/arastirma-ve-yayinlar/bankacilar-dergisi/43?year=2024

Samba, M.C. and Yan, Y. (2010). Interest rate pass-through in the Central African economic and monetary community (CAEMC) area: Evidence from an ARDL analysis. *International Journal of Business and Management,* 5(1), 31-41. doi:10.5539/ijbm.v5n1p31

Sander, H. and Kleimeier, S. (2004). Convergence in euro-zone retail banking? What interest rate pass-through tells us about monetary policy transmission, competition and integration. *Journal of International Money and Finance*, 23(3), 461-492. Retrieved from https://doi.org/10.1016/j.jimonfin.2004.02.001

Shin, Y., Yu, B. and Greenwood-Nimmo, M. (2014). Modelling asymmetric cointegration and dynamic multipliers in a nonlinear ARDL framework. In R. Sickles and W. Horrace (Eds.), *Festschrift in honor of Peter Schmidt* (pp. 281-314). New York: Springer.

Sørensen, C.K. and Werner, T. (2006). *Bank interest rate pass-through in the Euro Area a cross country comparison* (European Central Bank Working Paper No. 580). Retrieved from https://www.ecb.europa.eu/pub/pdf/scpwps/ecbwp580.pdf

Tai, P.N., Sek, S.K. and Har, W.M. (2012). Interest rate pass-through and monetary transmission in Asia. *International Journal of Economics and Finance,* 4(2), 163-174. doi:10.5539/ijef.v4n2p163

Uğur, A. and Bingöl, N. (2018). Pass-through between policy interest rate and banking loan rate comments with causality tests in Turkey. *Journal of Management and Economics Research,* 16(1), 258-274. https://doi.org/10.11611/yead.389715

Uslu, N.Ç. and Karahan, P. (2016). A dynamic analysis on pass-through of monetary policy to loan rates: The case of Turkey. *Journal of Management and Economics*, 23(3), 671-690. https://doi.org/10.18657/yonveek.281806

Von Borstel, J. (2008) *Interest rate pass-through in Germany and the Euro Area* (Research on Money in the Economy Discussion Paper No. 2008-05). Retrieved from http://hdl.handle.net/10419/88236

Yüksel, E. and Özcan, K.M. (2013). Interest rate pass-through in Turkey and impact of global financial crisis: Asymmetric threshold cointegration analysis. *Journal of Business Economics and Management*, 14(1), 98-113. https://doi.org/10.3846/16111699.2012.671189

Ekonomi, Politika & Finans Araştırmaları Dergisi, 2024, 9(2): 306-322
Journal of Research in Economics, Politics & Finance, 2024, 9(2): 306-322
Araştırma Makalesi / Research Article, https://doi.org/10.30784/epfad.1428412

THE RELATIONSHIP BETWEEN COMMERCIAL, TECHNOLOGICAL, RESEARCH (MULTIDIMENSIONAL) COMPLEXITY INDICES AND FINANCIAL DEVELOPMENT

Ticari, Teknolojik, Araştırma (Çok Boyutlu) Kompleksite Endekslerinin Finansal Gelişme ile İlişkisi

Tuba Esra BASKAK*

Abstract

The source of economic growth is the supply-demand balance. Demand refers to consumption and supply refers to production. Producing quality products plays an important role on the production side of this balance. The country, which has a wide range of qualified products called sophisticated products, continues to grow with financial development. The concept of economic complexity refers to product diversity. This concept has taken its place in the literature by being expanded into commercial, technological, and research complexity indices as the content of the multidimensional complexity index. In this study, the relationship between multidimensional complexity indices and financial development indicators of E7 (Emerging) countries (Brazil, China, India, Indonesia, Mexico, Russia, Turkey) is analyzed with Gengenbach, Urbain, and Westerlund Cointegration Test and Mean Group Estimator applied in case of cointegration. It has been determined that these variables are cointegrated, and this relationship between the commercial and technological complexity index and financial development is significant. As a result of the analysis with the mean group estimator, it was concluded that the technological complexity index has a greater impact on financial development than the commercial and research complexity indices.

Keywords:
Economic Growth, Financial Economics, Panel Data Models

JEL Codes:
O40, P34, C23

Öz

Ekonomik büyümenin kaynağı arz-talep dengesidir. Talep tüketimi, arz ise üretimi ifade eder. Bu dengenin üretim tarafında kaliteli ürün üretmek önemli rol oynuyor. Sofistike ürünler olarak adlandırılan geniş bir nitelikli ürün yelpazesine sahip olan ülke, finansal gelişmeyle birlikte büyümeye devam ediyor. Ekonomik karmaşıklık kavramı ürün çeşitliliğini ifade etmektedir. Bu kavram, çok boyutlu karmaşıklık indeksinin içeriği olarak ticari, teknolojik ve araştırma karmaşıklığı indeksleri olarak genişletilerek literatürdeki yerini almıştır. Bu çalışmada E7 (Gelişmekte olan) ülkelerin (Brezilya, Çin, Hindistan, Endonezya, Meksika, Rusya, Türkiye) çok boyutlu karmaşıklık endeksleri ile finansal gelişmişlik göstergeleri arasındaki ilişki Gengenbach, Urbain ve Westerlund Eşbütünleşme Testi ve eşbütünleşme bulunması durumunda uygulanan Ortalama Grup Tahmincisi ile analiz edilmiştir. Bu değişkenlerin eşbütünleşik olduğu ve ticari ve teknolojik karmaşıklık endeksi ile finansal gelişme arasındaki bu ilişkinin anlamlı olduğu tespit edilmiştir. Ortalama grup tahmincisi ile yapılan analiz sonucunda teknolojik kompleksite endeksi finansal gelişmede üzerinde ticari ve araştırma kompleksite endekslerinden ziyade daha büyük etkiye sahip olduğu sonucuna varılmıştır.

Anahtar Kelimeler:
Ekonomik Büyüme, Finansal Ekonomi, Panel Veri Modelleri

JEL Kodları:
O40, P34, C23

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1. Introduction

Economic growth is among the most important goals of every country. There are variables representing more than one macro indicator that mutually affects economic growth. It is a fact that macroeconomic indicators are used more in the literature. Macroeconomic variables are important for both countries and studies. In addition to these variables, new indicators have also emerged in the literature. Economic complexity and multidimensional economic complexity (trade, technological, and research complexity indices) are some of the new indicators.

The difference and quantity of products are considered rather than how many countries produce products. The diversity of products reveals the concept of complexity. Instead of producing more than one product of the same product, a country produces sophisticated products and sells them in the national and international markets, which contributes positively to the country's economy. The concept of complexity is measured by the economic complexity index. In the last year, this concept has taken its place in the literature under the name of multidimensional complexity index, including commercial, technological, and research complexity index. A country's product diversity depends on technological development, exports and imports, research and development expenditures, innovation, active use of knowledge, inclusion of skills, financial opportunities provided to economic decision-making units, and financial development.

When looking at the literature, it is noteworthy that studies mostly focus on economic complexity and growth variables for analysis. There are also analyses in the literature that include financial development. However, it has been divided into three different indices and started to be published on the website of The Observatory of Economic Complexity, affiliated with the Massachusetts Institute of Technology, since 2023. A study analyzing the commercial complexity index, technological complexity index, and research complexity index, which is called the multidimensional complexity index, has not been found in the literature. This study's contribution to the literature occurs here.

Following the introduction section, information about financial development and the multidimensional complexity index is given, and the analysis is started. In the study, the relationship between financial development and multidimensional complexity indices of E7 Countries (Brazil, China, India, Indonesia, Mexico, Russia, Türkiye), which are fast growing and have great importance in global trade, was analyzed. A model was established in which the dependent variable is financial development, and the independent variable is multidimensional complexity indices. There are 23 years and 7 units in the analysis, which covers the period between 1999 and 2021. The time dimension is larger than the unit dimension. For this reason, the Pesaran CD cross-sectional dependency test was used. Then, the Swamy S homogeneity test was used to determine homogeneity. Gengenbach, Urbain, and Westerlund’s Cointegration Test were conducted for cointegration between variables, and the significance of cointegration was estimated with the Weighted Group (MG) Estimator. In the conclusion section, the findings were interpreted, and suggestions were made.

2. Theoretical Frame and Literature Review

2.1. Theoretical Frame

The structural changes contribute to the growth of the country's economy. When a country focuses on the characteristics it has, increases its product diversity, and stands out from other countries in this diversity, it realizes structural changes. It is important for countries to use their characteristics in areas with high productivity. This situation reveals the concept of economic complexity. Economic complexity means using a country's output in productive areas and supporting it with knowledge and skills (Erkan and Yildirimci, 2015).

The concept of economic complexity emerged inspired by the products exported by countries. The diversity of products exported by a country reflects the concept of complexity, and the fact that exports increase the country's income reflects the concept of economic growth. Rather than whether a country produces more than one product and exports these products, it is more important which countries produce a product. The same product produced in two different countries differs depending on the country's knowledge and skills. The quality of the products is more important than the number of products produced in the country (Rodrik, 2006).

The knowledge and skills of countries show the quality of the products they produce and the products they will export in the future. For example, learning a foreign language is something that an individual can do by spreading his knowledge over time. If a football player has the ability to score goals, it means that he will be a good football player. This ability shows the skill of the football player (Can and Dogan, 2018). Countries should also attach importance to knowledge as well as skill in product production. The fact that countries have a very high level of skills and knowledge causes them to produce many products in qualitative and quantitative terms, and these products differ from other products (Hausmann and Hidalgo, 2011).

If the income level in a country is different, the skill level and active use of information in that country are not developed. Since countries with low levels produce fewer and unqualified products, they either cannot sell these products at all or very little. However, countries with high levels can produce more sophisticated products. The export of sophisticated products is high, and income levels are increasing rapidly (Hausmann and Hidalgo, 2010).

The development of countries in terms of knowledge and skills depends on the economic decision-making units in the country. The country's knowledge and skill levels are also improving with the combination of individuals' desire to learn, companies' desire to develop, and the support provided by the state to households and companies. The support of companies and the state is important in this regard (Can and Dogan, 2018).

Financial development is the transfer of capital from inefficient areas to productive areas with the support of technology. The development of the country's banking sector also leads to financial development. As the opportunities provided to companies and individuals in the banking sector increase, the number of products produced in the country also increases. Local producers, who easily obtain capital, increase their sophisticated products. Companies with increased capital are developing technologically as they enable easier purchase of machinery, tools, and equipment. Technologically developing companies' production speeds are increasing, and they are starting to produce more sophisticated products. The support of individuals and companies by banks and politicians causes the products produced and exported in the country to

increase both qualitatively and quantitatively. The quantitative and qualitative increase in products also increases the country's trade, technological structure and research, including its R&D structure. Commercial, technological and research complexity indices, which are three important distinctions of economic complexity, are also increasing. The increase in these three complexity indices, called multidimensional complexity indices, has an impact on the income levels of countries and the country's economy grows (Shahbaz et al., 2013). Financial development affects multidimensional complexity indices by increasing exports through capital, technology and banking channels. Likewise, a positive indicator in the indices means that the country's economy is moving in a positive direction, which means that exports, banking sector, technology and capital are improving. These situations also have a positive impact on financial development. In the form of a theoretical hypothesis, an increase in financial development increases multidimensional complexity indices. Increasing index values also increase financial development. Theoretically, a mutual positive effect is expected.

It has been seen as a deficiency in the literature that the concept of economic complexity is insufficient to measure its impact, especially on sustainable green growth, and that this measurement is made only through the trade indicator. Upon the request to evaluate this measurement in terms of innovation indicators, the concept of economic complexity started to be published with commercial, technological, and research data called multidimensional complexity indices (Stojkoski et al., 2023).

After the 1980s, with the adoption of Neoliberal Economic Policies, economic growth and foreign trade began to accelerate positively. The financial opportunities provided after the policies implemented have an impact on the increase in economic growth and the prevention of foreign trade deficit. Financial development is also the result of economic growth. Economic growth and financial development both affect and are affected by each other. This is the reason why financial development has not experienced much change since the 1980s. As seen in Figure 1, financial development in E7 countries remained within a certain band. However, Brazil has made very good progress in financial development after 2010.

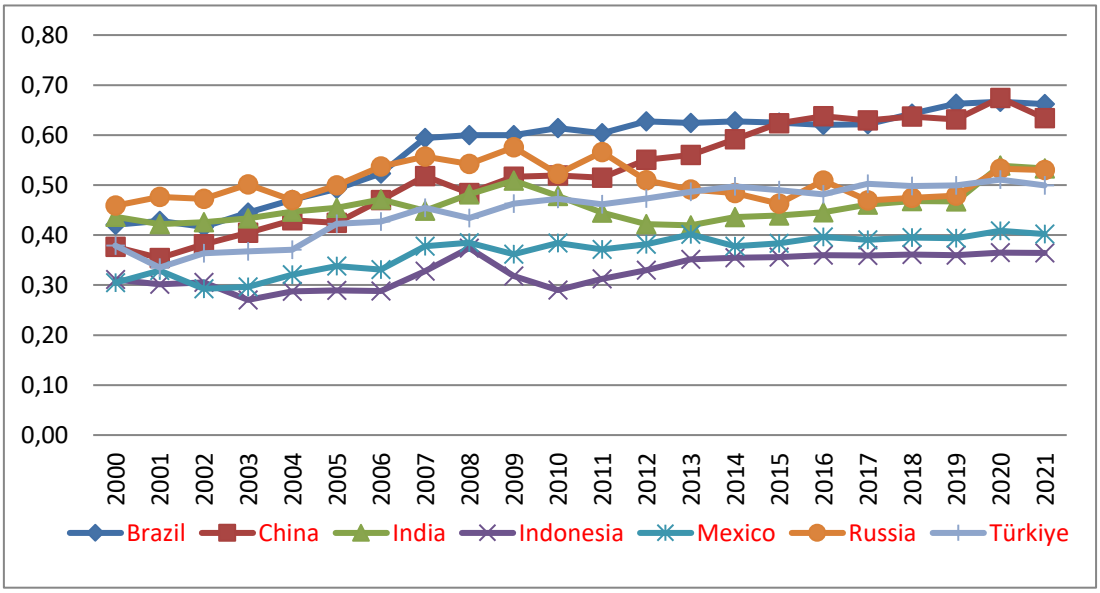

Figure 1. Financial Development of E7 Countries
Source: International Monetary Fund, 2024.

Figure 2 shows that India, which is among the E7 countries, increased its trade and the diversity of commercial products with a rapid acceleration between 2002 and 2003. However, there was a sudden decline between 2003 and 2004. Trade was also negatively affected as India slowed down in economic growth in the early 2000s. After 2005, E7 countries have generally experienced an increase in the diversity of commercial products. India came to the forefront in terms of exports and imports in 2021. As seen in Figure 2, its maximum commercial level is in 2021. Among these countries, Indonesia has the lowest trade complexity index. It can be said that the very high population of Indonesia compared to other countries causes domestic production to be consumed and exports to decrease.

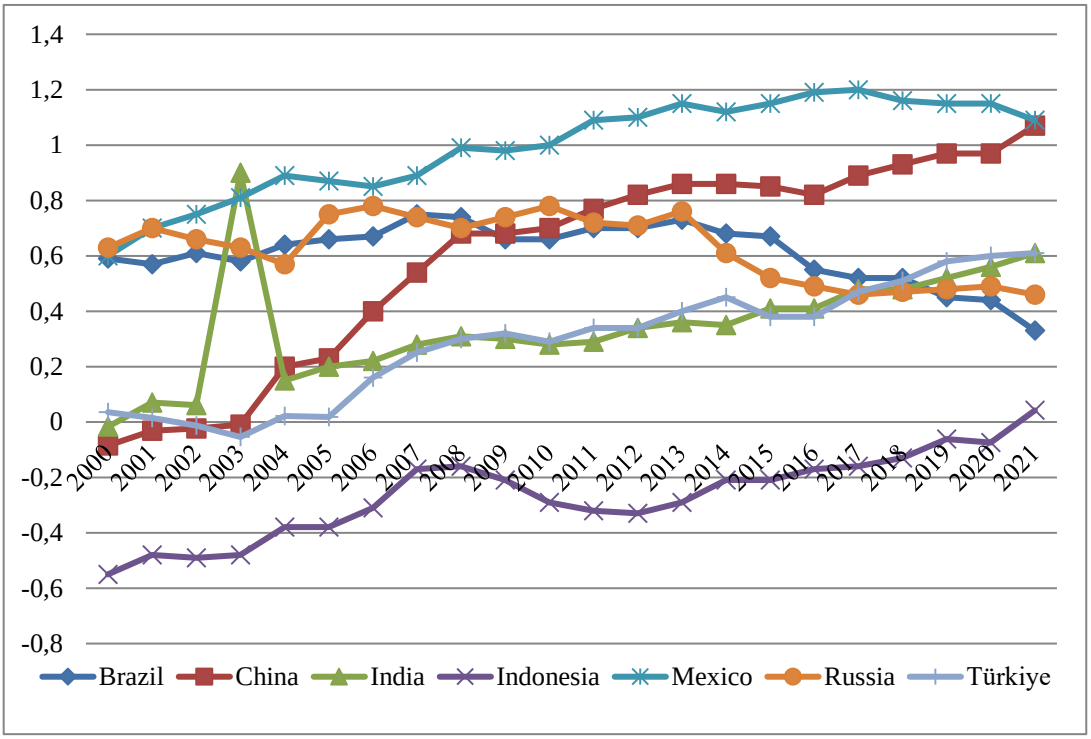

Figure 2. Trade Complexity Indexes of E7 Countries
Source: The Obsarvatory of Economic Complexity, 2024.

Mexico and China generally appear to have and export an increasing level of product diversity. However, the fact that China is at very good levels in e-commerce and foreign trade, especially in 2021, is also reflected in the figure. Türkiye has followed a general trend and even increased in recent years. However, the reason for the decrease after a certain increase in Russia can be attributed to the existence of regional income inequality despite being in a good position in terms of foreign trade. Political inactivity in fast-growing Brazil and protests within the country have hindered its development. The fact that Brazil is the largest coffee producer and has sophisticated products besides coffee has increased the commercial complexity index. However, like Russia, trade in Brazil has declined in recent years.

As seen in Figure 3, E7 countries have not been able to gain regular technological momentum. In Mexico and Indonesia, overpopulation and economic inequality lead to a situation where technological development and the production of sophisticated products based on technology are put on the back burner. Russia, Brazil and Türkiye have followed the same

path. Since India is the fastest growing economy after 2010, it has made technological progress in the years after 2010. In recent years, China has declined technologically and risen commercially. It is considered that this is due to decline and rise.

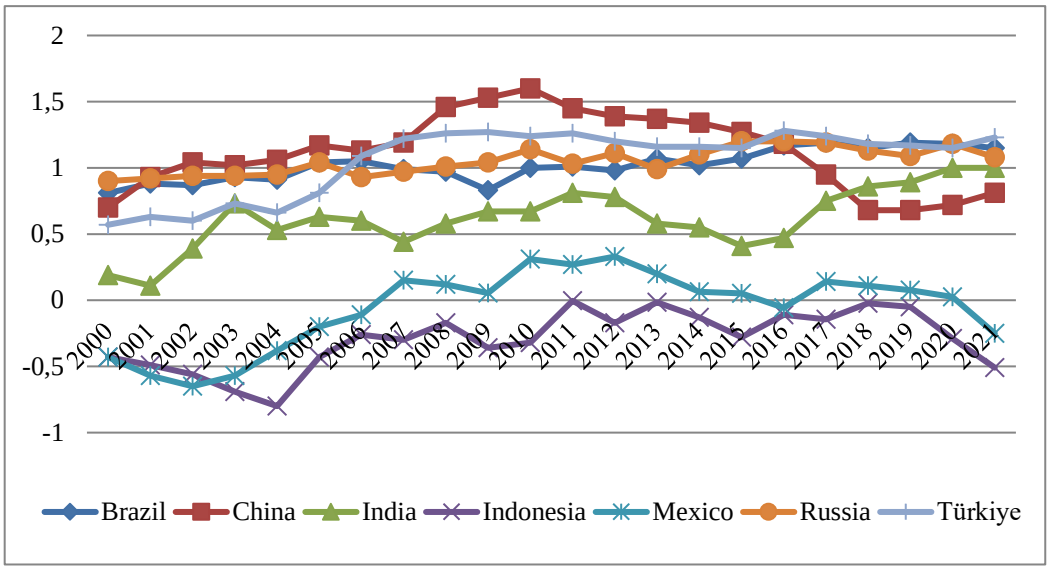

Figure 3. Technology Complexity Indexes of E7 Countries
Source: The Obsarvatory of Economic Complexity, 2024.

Looking at Figure 4, E7 countries increased their research-based sophisticated products between 2005 and 2017 but decreased in the remaining years. Since E7 Countries are among the fast-growing countries with a high share in global trade, they have given more importance to the production of trade and technology-oriented products. It is thought that the crises caused the decline in research and development activities in the 2000s. Countries that have experienced a decline in recent years have started to rise again in terms of innovation, research, and information technologies.

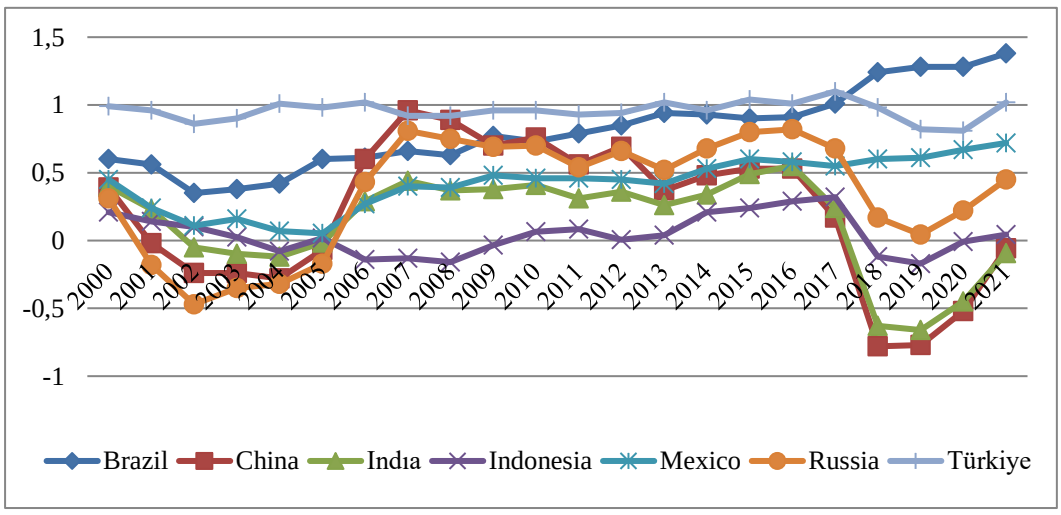

Figure 4. Research Complexity Indexes of E7 Countries
Source: The Obsarvatory of Economic Complexity, 2024.

2.2. Literature Review

Looking at the literature, the relationship of the economic complexity index with multiple variables has been analyzed. However, no study analyzing the commercial complexity index, technological complexity index and research complexity index, which is called the multidimensional complexity index, has been found in the literature. However, it is useful to analyze financial development and economic complexity.

Daude et al. (2015) analyzed the financial development and economic complexity index data of 103 countries between 1976 and 2010. It was found that financial development is a variable that determines economic complexity. Can and Dogan (2018) conducted a cointegration test in their study covering the years 1970 and 2013. It was seen that financial development positively affected economic complexity and the relationship between them was significant. Nguyen et al. (2020) analyzed financial development and economic complexity variables of 52 countries between 1995 and 2017. It has been determined that financial development affects the other variable positively in the short term. However, this effect is negative in the long term. Sahin and Durmus (2020) examined the relationship of the economic complexity index with capital investments, patent applications, and foreign direct capital investments, as well as the financial development variable. Newly industrializing countries were used in the research. Variables were found to be significant in Türkiye and Mexico. Another consequence is that financial development causes complexity.

Nguyen and Su (2021) analyzed the financial development and economic complexity variables of 86 countries covering the years 2002 and 2017. It has been determined that financial development has a positive impact on economic complexity. Njangang et al. (2021) examined the impact of financial development on economic complexity in 24 African countries between 1983 and 2017. In these countries, the relationship between financial development and economic complexity was positive. Efeoglu (2022) tested the relationship between financial development and complexity in N11 countries in his study covering the years 1995-2019. It has been concluded that increasing financial development also increases economic complexity. Kazemzadeh et al. (2023) conducted PVAR analysis in their study covering 49 countries. Financial development and economic complexity variables were also evaluated in the analysis. The variables that are positively related in the first period are found to be negatively effective in the third lag.

Can and Doğan (2018), Nguyen and Su (2021), Njangang et al. (2021), Efeoglu (2022) found that two variables positively affect each other. However, Nguyen et al. (2020) found a positive relationship only in the short term. They detected a negative relationship in the long term. Şahin and Durmuş (2020) concluded that there is a significant relationship between them, especially in Türkiye and Mexico. In the same studies, it was found that financial development affects complexity.

3. Data, Method and Results

3.1. Data

Using panel data analysis in data based on studies spanning time and countries is important for the accuracy of the results. Since there are 23 years and 7 countries, panel data analysis was performed. In the study where Brazil, China, India, Indonesia, Mexico, Russia and

Türkiye, known as E7 Countries, were discussed, the relationship between commercial, technology and research complexity indices, known as multidimensional complexity index, and financial development between 1999 and 2021 was examined.

For convenience in the study, the variables used are given abbreviated names. As shown in Table 1, FD represents financial development, TRADE represents business complexity index, TECHNOLOGY represents technology complexity index, and RESEARCH represents research complexity index.

Table 1. The Details of Variables

Variable Name	Description	Source
FD	Financial Development	International Monetary Fund (2024)
TRADE	Trade Complexity Index	Obsarvatory of Economic Complexity (2024)
TECHNOLOGY	Technology complexity Index	Obsarvatory of Economic Complexity (2024)
RESEARCH	Research complexity Index	Obsarvatory of Economic Complexity (2024)

In the model where financial development and commercial, technological and research complexity indices are examined, commercial, technological and research complexity indices are considered as independent variables. The established model is as follows;

$$FD = \beta_0 + \beta_1 TRADE + \beta_2 TECHNOLOGY + \beta_3 RESEARCH + \mu_{it} \quad (1)$$

FD in the model in equation 1 is the dependent variable defining financial development. Variables with β coefficients on the right side of the equation represent independent variables, and μit indicates the error term. Multidimensional complexity indices were taken from The Obsarvatory of Economic Complexity website, and financial development was taken from the International Monetary Fund website. In this study, the Stata program was used to perform the analysis. The purpose of building the model is to determine the relationship between the selected variables and to express the order in which they were selected in the stata program. At the same time, another purpose of specifying this model is to show that the relationship between the dependent variable of financial development and multidimensional complexity indices is analyzed. The relationship between the independent variables has not been determined.

As a result of the study by Stojkoski et al. (2023), the concept of economic complexity index started to be expressed as multidimensional complexity index. Their study proved that the multidimensional complexity index, which consists of commercial, technological and research complexity indices, has a great impact on the income distribution of countries (Stojkoski et al., 2023). The last purpose of the model is to show that the financial deepening relationship has been analyzed in addition to this study.

3.2. Method

When looking at the probability values of the tests, a significance level of 0.05 is taken into account. Comments are made at this level. If the resulting value is less than the 0.05 significance level, it will reject the null hypothesis, and if it is greater than it, it will be accepted. If it is greater, the null hypothesis of the test is accepted. The probability values resulting from all tests performed in this study were interpreted according to the 0.05 significance level.

In panel analysis, horizontal cross-section and homogeneity should be checked. Analysis should start with these tests first. Because, according to the results of these tests, it is decided which unit root test, cointegration test and causality test will be used. For this reason, Pesaran CD cross-sectional dependence test and Swamy S homogeneity test were used in this study.

The proposition of the null hypothesis is expressed as there is no cross-section, and the proposition of the alternative hypothesis is expressed as there is. In the homogeneity test, the null hypothesis includes the proposition that the model is homogeneous, and the alternative hypothesis includes the proposition that the model is heterogeneous (Swamy, 1970; Ozayturk and Alper, 2017).

The analysis continues with unit root tests. If the model turns out to be heterogeneous and there is cross-sectional dependence in the model, a unit root test from the 2nd group of second generation unit root tests should be preferred. Horizontal Section Extended Im, Pesaran and Shin Unit Root Test is one of this group of tests. The null hypothesis of this test indicates the absence of stationarity, and the alternative hypothesis indicates stationarity (Yerdelen Tatoglu, 2018). If the series do not turn out to be stationary, their differences should be taken. The differenced series become stationary.

Gengenbach, Urbain and Westerlund Panel Cointegration Test and Mean Group Estimator are used to look at cointegration between variables and test their significance. The null hypothesis of the cointegration test is the absence of cointegration, and the alternative hypothesis is the existence of cointegration. As a result of this test, the significance of the cointegrated variables is checked. For this purpose, cointegration estimator is made. This estimator shows the impact of variables on each other and the significance relationship between variables. The null hypothesis of the cointegration estimator includes the proposition that the long-term relationship is meaningless, and the alternative hypothesis is significant (Gengenbach et al., 2016).

3.3. Results

As seen in Table 2, the values are below 0.05. The test revealed the existence of cross-sectional dependence in the model.

Table 2. Pesaran CD Cross Section Dependency Test

Variables	Statistical Value	Probability Value
FD	13.49	0.0000
TRADE	5.27	0.0000
TECHNOLOGY	11.57	0.0000
RESEARCH	6.28	0.0000

Table 3 shows that the probability values are less than the 0.05 significance level. The null hypothesis containing the homogeneous proposition of the Swamy S test was rejected. It was concluded that the model was heterogeneous.

Table 3. Swamy S Homogeneity Test

Chi-Square Value	Statistical Value	Probability Value
Chi (24)	739.13	0.0000

As a result of the unit root test, it was found that the variables were not stationary. This situation can be seen in Table 4. After retesting the variables by taking their first differences, it was revealed that the variables became stationary at their first difference, as the probability values were less than 0.05 significance level. The letter D is added to the names of the variables to indicate that their first differences are taken.

Table 4. Cross Section Extended Im, Pesaran and Shin Unit Root Test

	I(0)			I(1)	
Variables	Statistical Value	Probability Value	Variables	Statistical Value	Probability Value
FD	-1.479	0.070	DFD	-6.220	0.000
TRADE	0.474	0.682	DTRADE	-3.002	0.001
TECHNOLOGY	-0.370	0.356	DTECHNOLOGY	-3.026	0.001
RESEARCH	1.946	0.974	DRESEARCH	-3885	0.000

In Table 5, the cointegration test's probability value is = 0.01, which reveals a cointegration relationship between the variables subject to analysis.

Table 5. Gengenbach, Urbain and Westerlund Cointegration Test

Variables	Coefficient	Statistical Value	Probability Value
FD - TRADE	-0.730	-3.232	<=0.01
FD - TECHNOLOGY	-0.775	-3.309	<=0.01
FD - RESEARCH	-0.728	-3.281	<=0.01

The results of the model estimated with the cointegration estimator in terms of financial development trade complexity index are shown in Table 6. Looking at the general coefficients, when the trade complexity index is increased by 1%, financial development increases by approximately 13%. According to the probability value, the long-term relationship between financial development and the trade complexity index is significant. The long-term relationship was insignificant in Brazil and India but significant in other countries. In Brazil, when the trade complexity index is increased by 1%, financial development decreases by approximately 0.13%.

Table 6. Mean Group Forecaster (FD-TRADE)

General Coefficients		
Coefficient	**Statistical Value**	**Probability Value**
0.1251	2.51	0.012
Unit-Specific Coefficients		
	Brazil	
Coefficient	Statistical Value	Probability Value
-0.1331	-0.72	0.472
	China	
Coefficient	Statistical Value	Probability Value
0.2285	12.01	0.000
	India	
Coefficient	Statistical Value	Probability Value
0.0582	1.90	0.057
	Indonesia	
Coefficient	Statistical Value	Probability Value
0.1402	5.29	0.000
	Mexico	
Coefficient	Statistical Value	Probability Value
0.1890	10.62	0.000
	Russia	
Coefficient	Statistical Value	Probability Value
0.1319	2.01	0.044
	Türkiye	
Coefficient	Statistical Value	Probability Value
0.2609	11.28	0.0000

When the general coefficients in Table 7 are examined, it has been determined that when the technology complexity index is increased by 1%, financial development increases by approximately 15%, and according to the probability value result, it has been determined that the dependent variable and the technological complexity index affect each other in the long term. When unit-specific coefficients are examined, it is seen that the cointegration relationship between the variables is significant in countries other than China and Russia. In China, when the technological complexity index is increased by 1%, financial development decreases by approximately 0.005%.

Table 7. Mean Group Forecaster (FD-TECHNOLOGY)

General Coefficients		
Coefficient	**Statistical Value**	**Probability Value**
0.1481	2.09	0.037
Unit-Specific Coefficients		
	Brazil	
Coefficient	Statistical Value	Probability Value
0.5549	5.60	0.000
	China	
Coefficient	Statistical Value	Probability Value
-0.0005	-0.01	0.994
	India	
Coefficient	Statistical Value	Probability Value
0.0584	3.13	0.002
	Indonesia	
Coefficient	Statistical Value	Probability Value
0.0935	3.85	0.000
	Mexico	
Coefficient	Statistical Value	Probability Value
0.1110	5.97	0.000
	Russia	
Coefficient	Statistical Value	Probability Value
0.0432	0.55	0.584
	Türkiye	
Coefficient	Statistical Value	Probability Value
0.1762	9.92	0.000

The dependent variable and research complexity index results of the estimator are shown in Table 8. Looking at the general coefficients, when the research complexity index is increased by 1%, financial development increases by approximately 7%, and according to the probability value result, It is seen that the dependent variable and the research complexity index are insignificant in cointegration. According to the units, cointegration is significant in Brazil and Mexico, but insignificant in the rest. In China and India, when the research complexity index is increased by 1%, financial development decreases by approximately 0.02% and 0.03%, respectively.

Table 8. Mean Group (MG) Forecaster (FD-RESEARCH)

General Coefficients		
Coefficient	**Statistical Value**	**Probability Value**
0.0753	1.87	0.062
Unit-Specific Coefficients		
	Brazil	
Coefficient	Statistical Value	Probability Value
0.2546	6.61	0.000
	China	
Coefficient	Statistical Value	Probability Value
-0.0258	-0.61	0.542
	India	
Coefficient	Statistical Value	Probability Value
-0.0336	-1.74	0.082
	Indonesia	
Coefficient	Statistical Value	Probability Value
0.0187	0.38	0.702
	Mexico	
Coefficient	Statistical Value	Probability Value
0.1573	4.69	0.000
	Russia	
Coefficient	Statistical Value	Probability Value
0.0327	1.77	0.076
	Türkiye	
Coefficient	Statistical Value	Probability Value
0.1237	0.64	0.519

4. Conclusion and Suggestions

This study analyzed the relationship between financial development and commercial, technological, and research complexity indices, called multidimensional complexity indices, of the developing E7 countries, which have a high share in global trade and are fast growing. Since panel data analysis was performed, cross-sectional dependency and whether the model was heterogeneous were examined first.

Pesaran CD cross-section dependence test was used to analyze cross-section dependence, and Swamy S homogeneity test was used to determine homogeneity. There is cross-sectional dependence, and the model was found to be heterogeneous. In cases where there is cross-sectional dependence, and the model is heterogeneous, one of the second generation second group unit root tests was chosen to determine the stationarity of the series. Horizontal Section Extended Im, Pesaran, and Shin Unit Root Test showed that the series became stationary after taking their first differences. Then, Gengenbach, Urbain, and Westerlund Cointegration Test was applied to detect cointegration. The variables were found to be cointegrated. After this test, which showed that the effects of the variables used in the analysis would continue in the long term, the model was estimated with the Mean Group Estimator to look at the significance levels.

No analysis using the multidimensional complexity index has been found in the literature. This situation has led to a focus on analyses made with economic complexity. Can and Doğan (2018), Nguyen and Su (2021), and Efeoglu (2022) reach the following conclusion: These two variables have a positive impact. Similar results emerged in this study. However, Nguyen et al. (2020) found positivity between the two variables in the short term. Negativity has been detected in the long term. This finding differs from the analysis conducted in this study.

Because the significance of the long-term relationship was determined in the study. Similarly, as a result of the study conducted by Şahin and Durmuş (2020), it was seen that the data for Türkiye and Mexico were meaningful. It was similar to the results of this study.

As a result, it was found that the change in the technological complexity index affected financial development more, followed by commercial and research complexity indices. While financial development is greater in countries where the economy is at a good level, there is also financial development in countries where economic growth is overflowing. Theoretically, since commercial, technological and research arguments have a positive effect on economic growth and this effect is significant, the positive and significant effect resulting from the analysis supports the theory.

The fact that domestic and foreign sales of sophisticated products provided by technological development are more effective in financial development shows that the technological momentum achieved by Brazil, China, India, Russia, and Türkiye in the E7 countries is in the right direction. However, Indonesia and Mexico need to attach importance to technological progress in terms of growth, foreign trade, and increasing product diversity.

Since there is no literature on the multidimensional complexity index, it is evaluated in the context of the economic complexity index. For this reason, the evaluation of this study, which is thought to contribute to the literature, in the context of the literature is limited. However, in general, the positive impact of the studies on economic complexity on growth and financial development is a theoretically expected result. Moreover, the majority of this study's mean group estimator results are also consistent with the theory. The theoretical hypothesis is that the multidimensional complexity index increases as financial development increases. This hypothesis is also valid in the reverse case. The majority of the results of the analysis also support this hypothesis. The negative effect of Brazil on the commercial complexity index, China on the technology complexity index, and China and India on the research complexity index is an indication that financial development is not in good condition in these countries. Because this is not the theoretically expected result. These countries need to follow policies towards financial development.

In contrast to the theoretical framework, the analysis reveals a negative and insignificant relationship between China's technological complexity index and financial sophistication. This suggests that the country has progressed more slowly in terms of technology due to its shift towards foreign trade and progress in e-commerce. Therefore, China's policymakers are advised to emphasize technological and trade progress. The effect of the trade complexity index on financial development is close to that of the technological complexity index. The trade complexity index is significant and positive in the E7 countries except Brazil and India due to the bad condition of Brazil's trade. While Brazil has made significant strides in technological advancement and innovation, commercial product diversity production remains in the background. For this reason, it is recommended that Brazil's policymakers pursue policies that increase foreign trade. When the research complexity index is examined from a theoretical perspective, it is seen to be less effective than the commercial and technological complexity index. The analysis result was the same as the theoretical result. However, since E7 countries are in the middle-income country group, In order to avoid being caught in the middle-income trap, which is a problem in the growth of the economy, and to get rid of this problem, research and development studies must accelerate.

They need to improve their knowledge and skills not only in commercial and technological development but also in research. The fact that the research complexity index was significant and positive only in Brazil and Mexico also supports theoretical information. Because, unlike other countries, the research complexity indices of these two countries have progressed in an increasing trend.

As a result, it is recommended that policy makers in E7 countries prepare policies that provide opportunities to support financial development in achieving innovation, technological progress and sustainable growth targets in the context of multidimensional complexity indices.

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.

References

Can, M. and Dogan, B. (2018). The relationship between economic complexity and financial development: An empirical analysis in the Turkish sample. *Finance, Political and Economic Comments*, 638, 5-16. Retrieved from https://dergipark.org.tr/tr/pub/fpeyd/

Daude, C., Nagengas, A. and Perea, J.R. (2015). Productive capabilities: An empirical analysis of their drives. *The Journal of International Trade & Economic Development*, 25(4), 504-535. https://doi.org/10.1080/09638199.2015.1073342

Efeoglu, R. (2022). Economic complexity and financial development in N11 countries. *Manisa Celal Bayar University Journal of Social Sciences*, 20(1), 185-196. https://doi.org/10.18026/cbayarsos.1016597

Erkan, B. and Yildirimci, E. (2015). Economic complexity and export competitiveness: The case of Türkiye. *Procedia-Social and Behavioral Sciences*, 195, 524-533. https://doi.org/10.1016/j.sbspro.2015.06.262

Gengenbach, C., Urbain, J-P. and Westerlund, J. (2016). Error correction testing in panels with common stochastic trends. *Journal of Applied Econometrics*, 31(6), 982-1004. https://doi.org/10.1002/jae.2475

Hausmann, R. and Hidalgo, C.A. (2010). *Country diversification, product ubiquity, and economic divergence* (Harvard Kennedy School Faculty Research Working Paper No. 201). Retrieved from https://dash.harvard.edu/bitstream/handle/1/4554740/RWP10-045_Hausmann_Hidalgo.pdf

Hausmann, R. and Hidalgo, C.A. (2011). The network structure of economic output. *Journal of Economic Growth*, 16(4), 309-342. https://doi.org/10.1007/s10887-011-9071-4

International Monetary Fund. (2024). *Financial development* [Dataset]. Retrieved from https://www.imf.org/en/Data

Kazemzadeh, E., Fuinhas, J.A., Koengkan, M. and Shadmehri, M.T.A. (2023). Relationship between the share of renewable electricity consumption, economic complexity, financial development and oil prices: A two-step club convergence and PVAR model approach. *International Economics*, 173, 260-275. https://doi.org/10.1016/j.inteco.2022.12.001

Nguyen, C.P. and Su, T.D. (2021). Financing the economy: The multidimensional influences of financial development on economic complexity. *Journal of International Development*, 141, 644-684. https://doi.org/10.1002/jid.3541

Nguyen, C.P., Schinckus, C. and Su, T.D. (2020). The drivers of economic complexity: International evidence from financial development and patents. *International Economics*, 164, 140–150. https://doi.org/10.1016/j.inteco.2020.09.004

Njangang, H., Asongu, S., Tadadjeu, S. and Nounamo, Y. (2021). *Is financial development shaping or shaking economic sophistication in African countries?* (European Xtramile Centre of African Studies WP. No. 21/018). http://dx.doi.org/10.2139/ssrn.3806772

The Obsarvatory of Economic Complexity. (2024). *Multidimensional complexity indices* [Dataset]. Retrieved from https://oec.world/en

Ozayturk, G. and Alper, A.E. (2017). The effect of oil imports on the current account deficit: An analysis of OECD countries. *Ankara University SBF Magazine*, 72(3), 513-524. https://doi.org/10.1501/SBFder_0000002457

Rodrik, D. (2006). What's so special about China's exports? *China & World Economy*, 14(5), 1-19. https://doi.org/10.1111/j.1749-124X.2006.00038.x

Sahin, D. and Durmus, S. (2020). Determinants of the level of economic complexity in newly industrializing countries. *ODU Journal of Social Sciences Research*, 10(2), 334-351. Retrieved from https://dergipark.org.tr/tr/pub/odusobiad/

Stojkoski, V., Koch, P. and Hidalgo, C.A. (2023). Multidimensional economic complexity and inclusive green growth. *Communications Earth & Envıronment*, 4, 130. https://doi.org/10.1038/s43247-023-00770-0

Swamy, P.A.V.B. (1970). Efficient inference in a random coefficient regression model. *Econometrica*, 38(2), 311. https://doi.org/10.2307/1913012

Yerdelen Tatoglu, F. (2018). *Panel time series analysis stata applied* (2. Ed.). Istanbul: Beta Publications.

Ekonomi, Politika & Finans Araştırmaları Dergisi, 2024, 9(2): 323-335
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TECHNOLOGY ORIENTED STRUGGLE AGAINST CLIMATE CHANGE IN TRANSPORTATION SECTOR: AN EMPIRICAL INVESTIGATION*

Taşımacılık Sektöründe İklim Değişikliğine Karşı Teknoloji Yönlü Mücadele: Ampirik Bir İnceleme

Nisa SEÇİLMİŞ** & **Pınar GÜMÜŞ AKAR*****

Keywords:
Transportation Sector, Climate Change Mitigation, Innovation, Patent

JEL Codes:
Q54, Q55, R40

Abstract

The transportation sector is one of the most important sectors in which greenhouse gas emissions (GHG) are the highest, thus causing the global warming problem to rise. One of the most effective and international solutions to this problem is considered to be a technology-oriented struggle, and the development of green technologies is encouraged by global authorities. The study aims to investigate the success of the technology-oriented struggle against global warming in the transport sector. In analyses, data on transportation-related greenhouse gas emissions, the number of patents (transport-related climate change mitigation technologies), trade openness, and GDP per capita of 12 OECD countries years between 1999-2017 were used. To identify the long-run and short-run relationship among variables, the Cross-Sectional Autoregressive Distributed Lags Estimator (CSARDL) and also the Mean Group (MG), Augmented Mean Group (AMG), and Common Correlated Effects Mean Group Estimators (CCE) were applied. According to the estimators' findings, no evidence was found that the number of patents and trade openness affected greenhouse gas emissions, but it was determined that GDP positively affected greenhouse gas emissions. As a result, it can be said that the technology-oriented struggle against climate change in the transportation sector alone isn't sufficient to reduce transportation-related GHG emissions.

Anahtar Kelimeler:
Ulaştırma Sektörü, İklim Değişikliğinin Azaltılması, Yenilik, Patent

JEL Kodları:
Q54, Q55, R40

Öz

Ulaştırma sektörü, sera gazı emisyonlarının (GHG) en yüksek olduğu ve dolayısıyla küresel ısınma sorununun büyümesine neden olan en önemli sektörlerden biridir. Bu sorunun en etkili ve küresel çözümünün teknoloji odaklı mücadele olduğu düşünülmekte ve yeşil teknolojilerin geliştirilmesi küresel otoriteler tarafından teşvik edilmektedir. Bu çalışma, ulaştırma sektöründe küresel ısınmaya karşı teknoloji odaklı mücadelenin başarısını ölçmeyi amaçlamaktadır. Analiz için 12 OECD ülkesinin 1999-2017 yılları arasındaki ulaştırma kaynaklı sera gazı emisyonları, patent sayısı (ulaşımla ilgili iklim değişikliğini azaltma teknolojileri), ticari açıklık ve kişi başına düşen GSYİH verilerinden yararlanılmıştır. Bu çerçevede değişkenler arasındaki uzun ve kısa dönemli ilişkinin belirlenmesi amacıyla yatay kesit otoregresif dağıtılmış gecikme tahmincisi (cross-sectionally augmented autoregressive distributed lag – CS ARDL) ve ek olarak Ortalama Grup (Mean Group MG), Artırılmış Ortalama Grup (Augmented Mean Group - AMG) ve Ortak İlişkili Etkiler Ortalama Grup Tahmin Edicileri (Common Correlated Effects-CCE) kullanılmıştır. Kullanılan tüm tahmin edicilerin bulgularına göre, patent sayıları ve ticari açıklığın sera gazı emisyonlarını etkilediğine dair herhangi bir kanıt bulunamamış, fakat GSYİH'nın sera gazı emisyonlarını olumlu yönde etkilediği tespit edilmiştir. Sonuç olarak, ulaştırma sektöründe iklim değişikliğine karşı teknoloji yönlü mücadelenin, ulaşım kaynaklı GHG emisyonlarını azaltmada tek başına yeterli olamadığı söylenebilir.

* The study is an expanded version of the paper "Technology Oriented Struggle Against Climate Change in Transportation Sector: An Empirical Investigation" at the congress "ECONEFE'23 in Istanbul, Turkey on 20-21 May 2023.

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1. Introduction

Sustainable development is a broad subject with its cultural, social, economic, spatial, and environmental dimensions interacting with each other (Kaypak, 2011: 22). However, the most critical focus lies on the challenges that stem from the inherent interplay between the economy and nature. Because the continuity of the economic organization depends on ensuring harmony between the environment and the economy, with policies that will not result in the detriment of the environment (Kılıç, 2012: 207). The transportation sector, which relies on the utilization of fossil fuels, is one of the sectors that play a leading role in this balance that needs to be established between the environment and the economy.

The transportation sector, which makes it possible to reach social or economic opportunities, is directly related to economic growth and development with the space and time benefit it creates, as well as human well-being, quality of life, social equity, and social inclusion (Bakker et al., 2014: 337, 338). In the global economic order, where the free movement of capital, people, services and goods is important, the transportation sector has a very critical place in terms of its role (Seçilmiş and Konu, 2021: 249). Years between 2006 and 2020, the value of transportation services in the world increased from US$ 717,20 bln to US$ 955,20 bln (33% increase) in terms of imports and from US$ 580,30 bln to US$ 819,20 bln (41% increase) in terms of exports (UN, 2021: 286). Increasing passenger and freight transport mobility causes an increase in transport-related energy demand, as it requires a faster and more flexible transport system (Intergovernmental Panel on Climate Change [IPCC], 1996: 22). As a result of the growth and development of the transportation industry, the adverse impact of the sector on energy use and the environment are also increasing.

Environmental issues stemming from transportation are closely tied to the strategies, policies, and programs implemented in the field of transport. These adverse effects unfold gradually over time, often leading to irreversible consequences (Fenley et al., 2007: 64). Achieving sustainable transportation involves managing the adverse environmental impacts while simultaneously meeting its economic, and social responsibilities (Longshurst et al., 1996: 199).

Sustainable transportation, which is defined differently in various institutions and research (Bakker et al., 2014: 343; Ahn and Park, 2022: 1171), in its most basic form; it is the ability to satisfy the existing transportation demand without the risk of depriving future generations of their needs, making it an integral part of sustainable development strategies. For transport to be sustainable, it must fulfill three fundamental criteria: first, the consumption of renewable resources must not exceed their natural replenishment rates; second, the use of non-renewable resources should be balanced with the development of sustainable renewable alternatives; and third, the emission of pollutants should stay within the environment's assimilative capacity. (Fenley et al., 2007: 64). GHGs, which constitute the most important part of the pollution emission mentioned in the last condition, trap some of the energy from the sun in the atmosphere and cause the planet to warm up. GHG gases emitted by the transportation industry include hydrofluorocarbons (HFCs), chlorofluorocarbons (CFCs), nitrous oxide (N2O) and carbon dioxide (CO_2). Nitrogen oxide (NOx) released from aircraft is another type of gas that creates a radiation effect on ozone (IPCC, 1996: 4). Figure 1 shows the sectoral distribution of emissions of GHG from energy use. After energy industries, the sector of transportation stands as the second-largest emitter of GHG emissions.

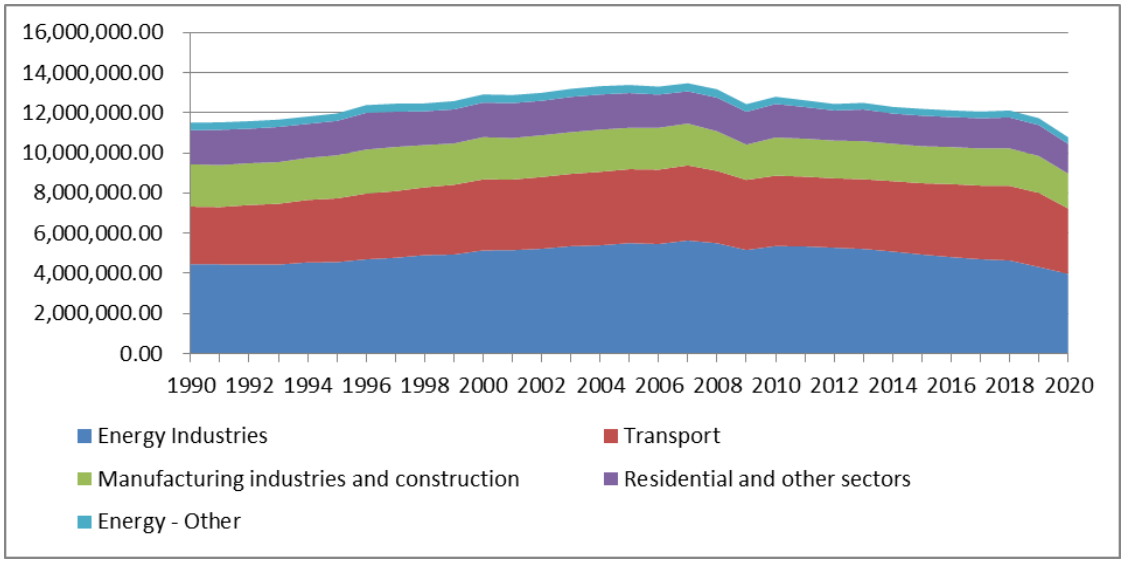

Figure 1. Sectoral Distribution of GHG Emissions from Energy in OECD Countries (1990-2020)
Source: OECD

According to the Second Assessment Report (SAR II) of the IPCC (1995), which emphasizes the relationship between the transportation sector and climate change and provides detailed information, it has been reported that, with the 1990 figures, the three sectors with the highest energy consumption are industry, housing/trade and transportation and the these sector's shares of CO_2 emissions are 45%, 29%, and 21%, respectively. Among these sectors, CO_2 emissions from transportation sector energy use have been reported to have recorded the fastest growth in the last two decades. In the SAR II, three technological developments that can be made to curtail the transport sector's GHG emissions are emphasized: alternative energy sources, infrastructure changes, and energy efficiency improvements. The cost-effectiveness of technological advances in these three areas may vary according to individual and national level accessibility to resources, know-how, institutional capacity, technology, and local market conditions. Energy efficiency improvements include the development of fuel-saving technologies in vehicles, new designs, techniques, and production lines for this purpose. Alternative energy sources include the advancement of technologies that enable the production of fuel from sources of renewable energy, and it is predicted that these fuels can reduce GHG by at least 80% in vehicle operations. Infrastructure changes include the development of technologies that will provide convenience in transportation infrastructure and transportation systems designs, such as traffic and fleet management, transitions between transportation modes, and thus create GHG-reducing effects (IPCC, 1996).

There are various studies suggested that the political support for the technology-oriented struggle against climate change has achieved its purpose and is quite effective in the development of new Technologies (Johnstone et al., 2010; Su and Moaniba, 2017; Dechezleprêtre et al., 2019; Panepinto et al., 2021). In this context, Figure 2 illustrates the number of patent applications made to the European Patent Office (EPO) between 1990 and 2022 (the data for 2022 reflect the last update date of October 19, and it is possible that the number of applications will increase further at the end of the year). According to Figure 2, it is noteworthy that the number of patent applications has an increasing trend, and the rate of increase has increased considerably, especially after the 2000s. Cumulatively, between 1990 and

2022, a total of 1,226,226 technology patent applications for efforts to mitigate climate change within the transportation sector were filed (the cumulative total number of patents for the same period for all sectors was 76,049,979).

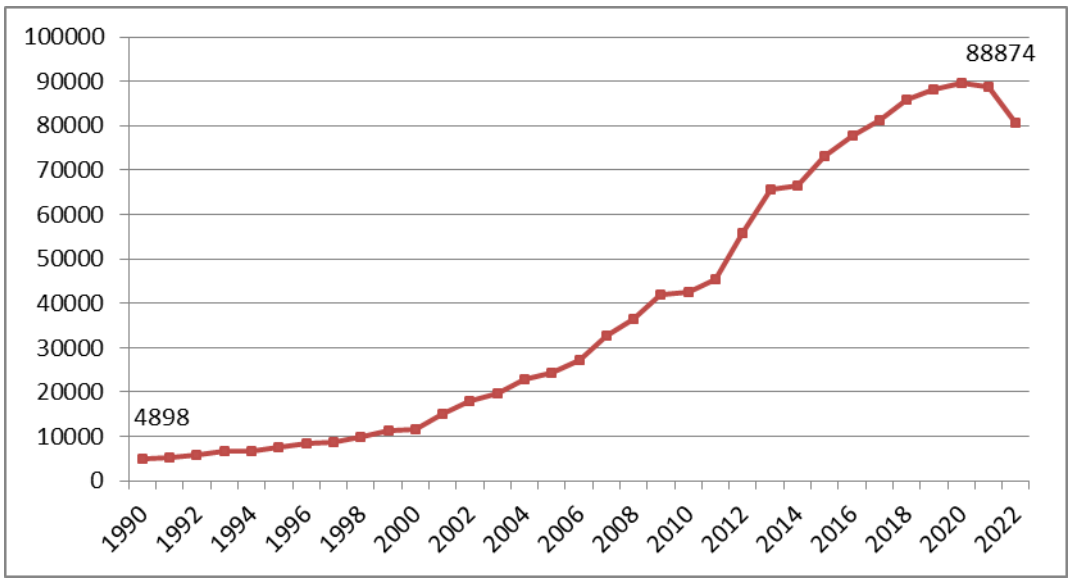

Figure 2. Quantity of Patents on Transportation CCMTs (Y02T)
Source: EPO

Many countries have agreed to implement the global common goals and measures Under the purview of the United Nations Framework Convention on Climate Change (UNFCCC) in the fight against global warming. The advancement, diffusion, and adoption of eco-friendly technologies are among the most important tools that can be used to achieve these common goals (Su and Moaniba, 2017; Ferreira et al., 2020). In line with the awareness created and policies developed in the national and international context, it can be said that innovative activities towards climate change are given importance at the global level and significant increases are experienced in the efforts to fight against technology.

As a result of the awareness created and policies developed in the national and international arena, it is cannot be ignored that innovative activities towards climate change are given importance at the global level and significant increases are experienced in the efforts to combat technology. However, the extent to which these innovative activities are successful in combating climate change bears a question mark. Based on this, the aim of this study is to explore whether the developed technologies have effectively reduced GHG emissions and to determine the success of the technology-oriented policy for combating transportation-induced global warming. More precisely, the aim is to examine the success of the technology-oriented struggle with climate change for sustainable transportation.

In the literature review, it was determined that there is no study that empirically measures the GHG emissions reducing effect of technologies developed for climate change directly in the transportation sector, based on existing data and, it is hoped that the study will contribute to this gap. For the purpose of the study, the long-term and short-term relationship between greenhouse gas emissions from transportation and the number of patents (transport-related CCMTs, trade

openness and GDP per capita were tested using the CSARLD estimator. Additionally, second-generation panel model estimators MG, AMG, and CCE were used to test the robustness of CSARDL results. Data from 12 OECD countries between 1999 and 2017 were used in the analysis.

The study is structured as follows: In the second part, previous academic studies on the subject will be included; In the third part, the data set and the method will be explained; In fourth part, the findings will be presented; In the fifth section, the results will be given.

2. Literature Review

The focus of this study is the technology-oriented struggle against climate change. There are many studies in the literature about technology and climate change. In general terms, it can be seen that the political support given to the technology-oriented fight against climate change has achieved its purpose and is quite effective in the development of new technologies, revealed by various studies in the literature. Dechezleprêtre et al. (2013) investigated the factors affecting technology transfer to reduce greenhouse gas emissions. In the study conducted on 96 countries between 1995 and 2007, it was stated that restrictions on international trade and foreign direct investments had a negative impact on the spread of local technological talents and climate-friendly technologies. In the study by Raiser et al. (2017), in which they examined patents, intellectual property rights, and innovation in reducing global warming, it was stated that patents, which economically encourage technology development, pose an obstacle in the fight against climate change by restricting global access to emission-reducing technologies. Princiotta (2021) emphasized that greenhouse gas emissions threaten the habitability of the planet in his review study, and emphasized that there is a need for mitigation actions covering all countries and sectors as soon as possible in order to limit global warming. R&D on up-and-coming clean energy and CO_2 Removal Technologies have been proposed as two important key actions. Caravella et al. (2021), based on the analysis of patent data on EU CCMTs, stated that there is a need for a mission-oriented technology policy with low-carbon and energy-reliable additional directed investments for the complete decarbonization model. Pasimeni et al. (2021) examined the economies of the US, Europe, Japan, and China in research seeking global evidence of what has been achieved so far in CCMTs. Among the findings of the study are the issues that these countries have made significant progress in the technology-oriented struggle, but that there is a need for more continuous and joint efforts in this struggle, and that international climate agreements should be supported more in order to encourage clean energy innovation, organize international cooperation, and increase positive competition.

There are very few studies on technology and combating climate change on the basis of the transportation sector. Wright and Fulton (2005) examined the scope and cost of reducing emissions from the transportation sector of developing countries using different options. Focusing particularly on fuel technology, the study concluded that a diversified package of measures for mode switching would be the most cost-effective tool in reducing greenhouse gas emissions. Chapman (2007) examined the effectiveness of technological and behavioral solutions in reducing GHG emissions from car use, road freight, and aviation. It was stated that a combination of behavior change and technology development policies could be countervailing. Feng et al. (2020) aimed to determine the CO2-blocking technology and efficiency factors related to transportation in China, and it was revealed that the factors that

make the biggest contribution to reducing CO_2 emissions are energy-saving technology, production technology, potential energy density, and production efficiency. Hussain (2022) analyzed the 2000-2020 data of 35 OECD countries in his study, in which he examined the effects of transportation-related technologies developed for climate change on the economy and the environment. According to the analysis, and findings made with CS-ARDL; CCMTs for transportation have a negative impact on transportation efficiency.

There are also many studies in the literature that develop scenarios to mitigate greenhouse gas or CO_2 emissions of the transportation sector (Rajan, 2006; Andres et al., 2011; Stanley et al., 2011; Dedinec et al., 2013; Miotti et al., 2016; Ülengin et al., 2018; Moreira and Pacca, 2020). In these studies, the importance of technological developments in the fight against climate change in the transportation sector, some predictions for the future with various alternative solutions, the effectiveness of existing policies and the fight against climate change in different transportation modes are discussed. Among these studies, empirical ones are mostly based on future scenarios and do not analyze the relationship between existing data.

Although there are many studies that test the effectiveness of the technology-oriented fight against climate change on a macroeconomic scale (Álvarez-Herránz, 2017; Jordaan et al., 2017; Su and Moaniba, 2017; Al Mamun et al., 2018; Ahmad et al., 2020; Ferreira et al., 2020) no study with similar content on the transportation sector was found in the literature review. It is thought that this study will contribute to the literature by measuring how successful innovative activities in the transportation sector are in combating climate change.

3. Data and Methodology

In this study, we investigated the relationship between greenhouse gas emissions and innovation in transportation, trade openness and GDP in selected OECD countries. OECD countries panel group includes Australia, Austria, the United States, Canada, the United Kingdom, Germany, Denmark, Finland, the Republic of Korea, Switzerland, Netherlands and Sweden for which data was available. The data used in the study covers the years between 1999 and 2017. Table 1 represent the used variables, symbols of variables and source of data.

Table 1. Used Variables and Data Source

Variable	Abbreviation	Data Source
Greenhouse gas emission (Tranportation related)	lnghg	OECD
Patent numbers (CCMTs related to transportation)	lnpt	OECD
Trade openess (The sum of a country's exports and imports as a share of that country's GDP)	lnto	Our World in Data
GDP Per Capita	lnpc	World Bank

To represent the environmental effect, greenhouse gas emissions have been used, while as an indicator of innovation, transport-related patent numbers were used. Trade openness and GDP per capita are also considered as they are directly linked to the transportation sector. Therefore, these two variables were included in the analysis as control variables.

Table 2. Descriptive Statistics

Variable	Obs.	Mean	Std.Dev.	Min	Max
lnghg	228	10,978	1,400	9,292	14,444
lnpt	228	3,614	1,484	0	7,095
lnto	228	4,276	0,431	3,098	5,061
lnpc	228	10,702	0,287	9,662	11,363

Descriptive statistics of mean, maximum, minimum, and standard deviation of variables used in this study are taken part in Table 2. Utilizing the logarithm of the series transforms the variables into a linear form, thereby minimizing variance. Consequently, employing logarithms in the analysis of series with diverse fluctuations and substantial numerical values yields more convenient outcomes for econometric analyses. Therefore all variables have been used in logarithmic form. In this framework, the model used in the paper is constructed as below:

$$lnghg = \alpha_0 + \beta_1 lnpt_{it} + \beta_2 lnto_{it} + \beta_3 lnpc_{it} + \varepsilon_{it} \quad (1)$$

In this model, lnghg is the dependent variable while lnpt, lntr, and lnpc are independent variables. β represents the partial slope coefficient, εit is error term and α is the intercept.

In this study, firstly the Pesaran (2015) cross-sectional dependence test was used. According to the results of the cross-sectional dependence analysis, the use of first-generation or second-generation unit root tests and panel estimators was specified. In line with cross-sectional dependency test results CIPS unit root test that the second-generation unit root test (Pesaran, 2007) was applied. To detect the heterogeneity of the series, Pesaran and Yamagata (2008) Slope Homogenity Test was applied. To identify the long-run and short-run relationship among variables, the cross-sectional autoregressive distributed lags (CSARDL) estimator (Chudik and Pesaran, 2015) which allows working with series that are stationary at different levels and cross-sectional dependency was used. Also, for the purpose of testing the robustness of the CSARDL results, the second-generation panel model estimators were used to analyze the relationship between the variables in the long run. In this framework, the Mean Group (Pesaran and Smith, 1995), Augmented Mean Group (Eberhardt and Bond, 2009), and Common Correlated Effects Mean Group (Pesaran, 2006) estimators were applied.

4. Findings

Pesaran's (2015) cross-sectional dependency test was appropriate to detect the presence of cross-sectional dependence between the variables. According to the test results in Table 3, the hypothesis that there is no cross-sectional dependence between the data analyzed at a significance level of 1% for all variables, was rejected. Therefore, for analyzing the stationarity of the series a second-generation panel unit root test that eliminates the cross-sectional dependency problem was used.

Table 3. Pesaran (2015) Cross-sectional Dependence Test

	lnghg	lnpt	lnto	lnpc
CD	3.269***	22.763***	18.792***	32.577***

Note: *** refers 1% significance level.

Table 4. CIPS Unit Root Test Results

Variables	Constant		Constant and Trend	
	Level	First Difference	Level	First Difference
lnghg	- 1.087	- 3.109***	- 1.763	- 3.514***
lnpt	- 3.598***		- 3.644***	
lnto	- 1.904	- 3.272***	1.962	- 3.361***
lnpc	- 1.315	- 2.449***	- 1.188	- 2.769*

Note: *** and * refer to a significance level of 1% and %10 respectively.

In this framework, the results of the applied CIPS unit root test (Pesaran 2015) are in Table 4. According to the results of the CIPS unit root test in Table 4, it was found that lnghg, lnto and lnpc series were stationary at first differences i.e. I(1) while lnpt series was stationary at level i.e. I(0).

Table 5. Pesaran and Yamagata 2008 Slope Homogenity

	t stat	p value
$\tilde{\Delta}$	11.225***	0.000
$\tilde{\Delta}$adj	13.076***	0.000

Note: *** refers to a significance level of 1%.

According to the Delta heterogeneity test findings in Table 5, the H_0 hypothesis can be rejected at 1% significance level and the series exhibit heterogeneous properties.

Table 6. CS ARDL Estimation Results

Variable	Dependent Variable: lnghg				
	Long Run			Short Run	
	Cofficient / (Prob.)	St.Errors / (T- Stat)	Variable	Cofficient / (Prob.)	St.Errors / (T- Stat)
lnpt	0.0002943	0.0061177	**Δlnpt**	0.0013331	0.0102236
	(0.962)	(0.05)		(0.896)	(0.13)
lntrd	0.0015757	0.0588444	**Δlntrd**	-0.0127137	0.0913343
	(0.979)	(0.03)		(0.889)	(-0.14)
lnpc	0.3736831***	0.0700457	**Δlnpc**	0.5790555***	0.1228687
	(0.000)	(5.33)		(0.000)	(4.71)
			Ect(-1)	-1.507113***	0.0627812
				(0.000)	(-24.01)

Note: *** refers to a significance level of 1%.

In Table 6, the results of CS-ARDL estimation results are given. According to the CS-ARDL test results, no significant relationship was found between GHG and the number of transportation-related patents and trade openness in the short term and long term. Analysis results show that there is a positive relationship between GDP per capita and GHG. According to the coefficient estimates, a 1% increase in GDP per capita causes an increase of 0.57% in the short term and 0.37% in the long term. According to the results, the ECT which show the stability of the model, is statistically significant at the %1 significance level and its coefficient is negative (-1.507113) as expected. The fact that the error term coefficient is negative, statistically significant, and between -1 and -2 indicates that the system has reached equilibrium

with gradually decreasing fluctuations in the long term (Alam and Quazi, 2003; Narayan and Smith, 2006; Karagöl et al. 2007; Hacıimamoğlu, 2023).

Table 7. Panel MG, AMG, CCEMG Estimation Results

Variables	MG Coefficients	AMG Coefficients	CCEMG Coefficients
lnpt	- 0.0018137	0.00645575	0.0015637
lntrd	- 0.0669059	0.0123082	0.0236089
lnpc	0.3826792 **	0.6672834 ***	0.5549773***

Note: *** and ** refers to a significance level of 1% and 5% respectively.

The results of Panel MG, AMG, and CCEMG estimation which made for the robustness check of CS-ARDL estimation results are included in Table 7. For all estimators, no significant relationship was found between GHG and trade openness and the number of transportation-related patents. According to MG, AMG and CCEMG coefficient estimates indicate 0,382%, 0.667%, and 0.554 positive correlation between GDP per capita and GHG, respectively. These test results which made for robustness correspond to CS-ARDL findings.

5. Conclusion

The transport sector is an important source of greenhouse gas emissions due to its energy consumption and fossil fuel use. These emissions, especially CO_2 emissions, contribute to global warming and climate change by increasing the greenhouse gas concentration in the atmosphere. The transportation sector, which consists of road, sea, air, and railway, is the second sector with the largest share in total GHG emissions with each component. Therefore, The transportation sector holds a significant role in addressing climate change.

Measures such as promoting sustainable and low-carbon transport systems, increasing energy efficiency, using alternative fuels, developing public transport networks and expanding green logistics practices help minimize the environmental footprint of the transport sector and be effective in combating climate change. With both global policy makers and academic studies, it is predicted that the most effective of these measures is technology-oriented struggle.

In the study, in order to investigate the reality of this prediction, the relationship between GHG (transport originating) and the number of patents (technology developed for climate change in the transport sector) was tested using 1999-2017 data of 12 selected OECD countries. Trade openness and per capita GDP, which are directly related to the transport sector, are other variables used in the analysis. According to the findings of all used estimators, no effect has been observed that transportation-related climate change mitigation patent numbers and trade openness affect GHG emissions. However, all estimators indicate that GDP positively impacts GHG emissions. This finding supports the studies of Mazzarino (2000), Fan and Lei (2016), Andrés and Padilla (2018), and Ghannouchi et al. (2023) who found a positive correlation between GDP growth and greenhouse gas emissions from transportation. As economies grow and develop, the volume of activities such as manufacturing, construction, tourism, and logistics increases, and accordingly, the need for both private and public transportation vehicles may increase. The result obtained from this study can similarly be interpreted as increasing economic growth in selected OECD countries causing an increase in transportation demand and, accordingly, increasing fuel consumption causing an increase in greenhouse gas emissions.

According to the result obtained from the study, technologies developed for combating climate do not have a mitigating effect on climate change. This result supports the study findings of Chapman (2007), Dechezleprêtre et al. (2013), and Raiser et al. (2017) in the literature. It can be thought that the use of patents has not become widespread, most of them have not yet started to be used in production methods, and therefore technology diffusion has not been fully realized. While green technologies are being produced on the one hand, and the demand for transportation is constantly increasing with the effect of globalization on the other, this may be the reason why the findings of the study are not compatible with the political predictions.

As a result, it has been revealed that it is insufficient to combat climate change by developing technology alone. In addition to the technology-oriented struggle, policy arrangements based on more holistic solutions are needed, such as encouraging the use of effective technologies, preventing the provision and use of environmentally harmful transportation services through taxation and other deterrent regulations, raising the awareness of society to use environmental technologies and encouraging the use of environmental technologies. Sustainable transportation will be able to achieve success with globally audited plans in which social solutions as well as technical solutions are adopted, cared for and sustained by all economic units.

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.

References

Ahmad, M., Jiang, P., Majeed, A., Umar, M., Khan, Z. and Muhammad, S. (2020). The dynamic impact of natural resources, technological innovations and economic growth on ecological footprint: An advanced panel data estimation. *Resources Policy*, 69, 101817. https://doi.org/10.1016/j.resourpol.2020.101817

Ahn, H. and Park, E. (2022). For sustainable development in the transportation sector: Determinants of acceptance of sustainable transportation using the innovation diffusion theory and technology acceptance model. *Sustainable Development*, 30(5), 1169-1183. https://doi.org/10.1002/sd.2309

Al Mamun, M., Sohag, K., Shahbaz, M. and Hammoudeh, S. (2018). Financial markets, innovations and cleaner energy production in OECD countries. *Energy Economics*, 72, 236-254. https://doi.org/10.1016/j.eneco.2018.04.011

Alam, I. and Quazi, R. (2003). Determinants of capital flight: An econometric case study of Bangladesh. *International Review of Applied Economics*, 17(1), 85-103. https://doi.org/10.1080/713673164

Álvarez-Herránz, A., Balsalobre, D., Cantos, J.M. and Shahbaz, M. (2017). Energy innovations-GHG emissions nexus: Fresh empirical evidence from OECD countries. *Energy Policy*, 101, 90-100. https://doi.org/10.1016/j.enpol.2016.11.030

Andrés, L. and Padilla, E. (2018). Driving factors of GHG emissions in the EU transport activity. *Transport Policy*, 61, 60-74. https://doi.org/10.1016/j.tranpol.2017.10.008

Andress, D., Nguyen, T.D. and Das, S. (2011). Reducing GHG emissions in the United States' transportation sector. *Energy for Sustainable Development*, 15(2), 117-136. https://doi.org/10.1016/j.esd.2011.03.002

Bakker, S., Zuidgeest, M., Coninck, H. and Huizenga, C. (2014). Transport, development and climate change mitigation: Towards an integrated approach. *Transport Reviews*, 34(3), 335–355. https://doi.org/10.1080/01441647.2014.903531

Caravella, S., Costantini, V. and Crespi, F. (2021). Mission-oriented policies and technological sovereignty: The case of climate mitigation technologies. *Energies*, 14(20), 6854. https://doi.org/10.3390/en14206854

Chapman, L. (2007). Transport and climate change: A review. *Journal of Transport Geography*, 15(5), 354-367. https://doi.org/10.1016/j.jtrangeo.2006.11.008

Chudik, A. and Pesaran, M.H. (2015). Common correlated effects estimation of heterogeneous dynamic panel data models with weakly exogenous regressors. *Journal of Econometrics*, 188(2), 393-420. https://doi.org/10.1016/j.jeconom.2015.03.007

Dechezleprêtre, A., Glachant, M. and Ménière, Y. (2013). What drives the international transfer of climate change mitigation technologies? Empirical evidence from patent data. *Environmental and Resource Economics*, 54, 161-178. https://doi.org/10.1007/s10640-012-9592-0

Dechezleprêtre, A., Martin, R. and Bassi, S. (2019). Climate change policy, innovation and growth. In R. Fouquet (Eds.), *Handbook on green growth* (pp. 217-239). UK: Edward Elgar Publishing.

Dedinec, A., Markovska, N., Taseska, V., Duic, N. and Kanevce, G. (2013). Assessment of climate change mitigation potential of the Macedonian transport sector. *Energy*, 57, 177-187. https://doi.org/10.1016/j.energy.2013.05.011

Eberhardt, M. and Bond, S. (2009). *Cross-section dependence in nonstationary panel models: A novel estimator* (MPRA Paper No. 17692). Retrieved from https://mpra.ub.uni-muenchen.de/17870/2/MPRA_paper_17870.pdf

EPO. (2022). *Searching for patents.* Retrieved from https://www.epo.org/searching-for-patents.html

Fan, F. and Lei, Y. (2016). Decomposition analysis of energy-related carbon emissions from the transportation sector in Beijing. *Transportation Research Part D: Transport and Environment*, 42, 135-145. https://doi.org/10.1016/j.trd.2015.11.001

Feng, C., Sun, L.X. and Xia, Y.S. (2020). Clarifying the "gains" and "losses" of transport climate mitigation in China from technology and efficiency perspectives. *Journal of Cleaner Production*, 263, 121545. https://doi.org/10.1016/j.jclepro.2020.121545

Fenley, C.A., Machado, W.V. and Fernandes, E. (2007). Air transport and sustainability: Lessons from Amazonas. *Applied Geography*, 27, 63-77. https://doi.org/10.1016/j.apgeog.2006.12.002

Ferreira, J.J.M., Fernandes, C.I. and Ferreira, F.A.F. (2020). Technology transfer, climate change mitigation, and environmental patent impact on sustainability and economic growth: A comparison of European countries. *Technological Forecasting & Social Change*, 150, 119770. https://doi.org/10.1016/j.techfore.2019.119770

Ghannouchi, I., Ouni, F. and Aloulou, F. (2023). Investigating the impact of transportation system and economic growth on carbon emissions: Application of GMM System for 33 european countries. *Environmental Science and Pollution Research*, 30(39), 90656-90674. https://doi.org/10.1007/s11356-023-28595-6

Hacıimamoğlu, T. (2023). Testing the environmental Phillips Curve hypothesis in MIKTA countries: CSARDL test approach. *Ordu Üniversitesi Sosyal Bilimler Enstitüsü Sosyal Bilimler Araştırmaları Dergisi*, 13(1), 301-316. https://doi.org/10.48146/odusobiad.1104588

Hussain, Z. (2022). Environmental and economic-oriented transport efficiency: The role of climate change mitigation technology. *Environmental Science and Pollution Research*, 29(19), 29165-29182. https://doi.org/10.1007/s11356-021-18392-4

IPCC. (1995). *Climate change 1995: IPCC second assessment report* (A Report of the Intergovermental Panel on Climate Change). Retrieved from https://digital.library.unt.edu/ark:/67531/metadc11834/m1/1/

IPCC. (1996). *Technologies, policies and measures for mitigating climate change* (IPCC Technical Paper I). Retrieved from https://www.ipcc.ch/site/assets/uploads/2018/03/paper-I-en.pdf

Johnstone, N., Haščič, I. and Popp, D. (2010). Renewable energy policies and technological innovation: Evidence based on patent counts. *Environmental and Resource Economics*, 45, 133–155. https://doi.org/10.1007/s10640-009-9309-1

Jordaan, S.M., Romo-Rabago, E., McLeary, R., Reidy, L., Nazari, J. and Herremans, I.M. (2017). The role of energy technology innovation in reducing greenhouse gas emissions: A case study of Canada. *Renewable and Sustainable Energy Reviews*, 78, 1397-1409. https://doi.org/10.1016/j.rser.2017.05.162

Karagöl, E., Erbaykal, E. and Ertuğrul, H.M. (2007). Economic growth and electricity consumption in Turkey: A bound test approach. *Doğuş Üniversitesi Dergisi*, 8(1), 72-80. Retrieved from https://dergipark.org.tr/en/pub/doujournal/

Kaypak, Ş. (2011). A sustainable environment for a sustainable development in the process of globalization. *KMÜ Sosyal ve Ekonomik Araştırmalar Dergisi*, 13(20), 19-33. Retrieved from https://dergipark.org.tr/en/pub/kmusekad/

Kılıç, S. (2012). An ecological approach to the economic dimension of sustainable development concept. İstanbul Üniversitesi *Siyasal Bilgiler Fakültesi Dergisi,* 47, 201-226. Retrieved from https://dergipark.org.tr/en/pub/iusiyasal

Longshurst, J., Gibbs, D.C., Raper, D.W. and Conlan, D.E. (1996). Towards sustainable airport development. *The Environmentalist*, 16, 197-202. https://doi.org/10.1007/BF01324760

Mazzarino, M. (2000). The economics of the greenhouse effect: Evaluating the climate change impact due to the transport sector in Italy. *Energy Policy*, 28(13), 957-966. https://doi.org/10.1016/S0301-4215(00)00078-1

Miotti, M., Supran, G.J., Kim, E.J. and Trancik, J.E. (2016). Personal vehicles evaluated against climate change mitigation targets. *Environmental Science & Technology*, 50(20), 10795-10804. https://doi.org/10.1021/acs.est.6b00177

Moreira, J.R. and Pacca, S.A. (2020). The climate change mitigation potential of sugarcane based technologies for automobiles; CO2 negative emissions in sight. *Transportation Research Part D: Transport and Environment*, 86, 102454. https://doi.org/10.1016/j.trd.2020.102454

Narayan, P.K. and Smyth, R. (2006). What determines migration flows from low-income to high-income countries? An empirical investigation of Fiji–Us migration 1972–2001. *Contemporary Economic Policy*, 24(2), 332-342. https://doi.org/10.1093/cep/byj019

OECD. (2023). *OECD data* [Database]. Retrieved from https://data.oecd.org/

Our World in Data. (2022). *Trade openness* [Database]. Retrieved from https://ourworldindata.org/

Panepinto, D., Riggio, V.A. and Zanetti, M. (2021). Analysis of the emergent climate change mitigation technologies. *International Journal of Environmental Research and Public Health*, 18(13), 6767. https://doi.org/10.3390/ijerph18136767

Pasimeni, F., Fiorini, A. and Georgakaki, A. (2021). International landscape of the inventive activity on climate change mitigation technologies. A patent analysis. *Energy Strategy Reviews*, 36, 100677. https://doi.org/10.1016/j.esr.2021.100677

Pesaran, M.H. (2006). Estimation and inference in large heterogeneous panels with a multifactor error structure. *Econometrica*, 74(4), 967-1012. https://doi.org/10.1111/j.1468-0262.2006 .00692.x

Pesaran, M.H. (2007). A simple panel unit root test in the presence of cross-section dependence. *Journal of Applied Econometrics*, 22(2), 265-312, https://doi.org/10.1002/jae.951

Pesaran, M.H. (2015). Testing weak cross-sectional dependence in large panels. *Econometric Reviews*, 34(6-10), 1089-1117. https://doi.org/10.1080/07474938.2014.956623

Pesaran, M.H. and Smith, R. (1995). Estimating long-run relationships from dynamic heterogeneous panels. *Journal of econometrics*, 68(1), 79-113. https://doi.org/10.1016/0304-4076(94)01644-F

Pesaran, M.H. and Yamagata, T. (2008). Testing slope homogeneity in large panels. *Journal of Econometrics*, 142(1), 50-93. https://doi.org/10.1016/j.jeconom.2007.05.010

Princiotta, F.T. (2021). The climate mitigation challenge - Where do we stand? *Journal of the Air & Waste Management Association*, 71(10), 1234-1250. https://doi.org/10.1080/10962247.2021.1948458

Raiser, K., Naims, H. and Bruhn, T. (2017). Corporatization of the climate? Innovation, intellectual property rights, and patents for climate change mitigation. *Energy Research & Social Science*, 27, 1-8. https://doi.org/10.1016/j.erss.2017.01.020

Rajan, S.C. (2006). Climate change dilemma: Technology, social change or both?: An examination of long-term transport policy choices in the United States. *Energy Policy*, 34(6), 664-679. https://doi.org/10.1016/j.enpol.2004.07.002

Seçilmiş, N. and Konu, A. (2021). Türkiye'de hava taşımacılığı altyapı yatırımlarının havacılık ekonomisi üzerindeki etkileri. D. Macit (Ed.), *Havacılık ekonomisi teori, politika ve güncel araştırmalar* içinde (s. 249-273). Ankara: Nobel Press.

Stanley, J.K., Hensher, D.A. and Loader, C. (2011). Road transport and climate change: Stepping off the greenhouse gas. *Transportation Research Part A: Policy and Practice*, 45(10), 1020-1030. https://doi.org/10.1016/j.tra.2009.04.005

Su, H.-N. and Moaniba, I.M. (2017). Does innovation respond to climate change? Empirical evidence from patents and greenhouse gas emissions. *Technological Forecasting and Social Change*, 122, 49–62. https://doi.org/10.1016/j.techfore.2017.04.017

Ülengin, F., Işık, M., Ekici, Ş.Ö., Özaydın, Ö., Kabak, Ö. and Topçu, Y.İ. (2018). Policy developments for the reduction of climate change impacts by the transportation sector. *Transport Policy*, 61, 36-50, https://doi.org/10.1016/j.tranpol.2017.09.008

UN. (2021). 2020 *international trade statistics yearbook* (United Nations ST/ESA/STAT/SER.G/69 (Vol.II)). Retrieved from https://comtradeapi.un.org/files/v1/app/publicationfiles/2020/VolII2020.pdf

World Bank. (2022). *World development indicators* [Database]. Retrieved from https://databank.worldbank.org/source/world-development-indicators

Wright, L. and Fulton, L. (2005). Climate change mitigation and transport in developing nations. *Transport Reviews*, 25(6), 691-7171464. https://doi.org/10.1080/01441640500360951

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THE EFFECT OF BUDGET DEFICITS ON STOCK MARKET RETURNS IN EMERGING MARKETS: A PANEL VAR ANALYSIS

Gelişmekte Olan Piyasalarda Bütçe Açıklarının Hisse Senedi Piyasası Getirileri Üzerindeki Etkisi: Panel VAR Analizi

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Keywords:
Budget Deficits, Stock Returns, Emerging Markets, COVID-19

JEL Codes:
E62, G15, H6

Abstract

This study examines the impact of fiscal deficits on stock returns. The sample covers emerging markets for the period 2016Q1-2021Q4. The analysis results using panel vector autoregression (PVAR) and Granger causality tests indicate that fiscal deficits cause stock returns. These results are confirmed for countries with low and medium levels of financial development and for European countries. However, in countries with high levels of financial development such as the BRICS and ASEAN countries, no effect is observed. It is also found that this effect disappears during the COVID-19 pandemic. The results of the study question the strong form of the efficient market hypothesis (EMH). According to the EMH, stock prices should fully reflect all available information. However, the impact of fiscal deficits on stock returns in low- and middle-income countries and European countries suggests that market participants may not fully reflect this information, addressing the existence possibility of markets that are not efficient in the strong form.

Anahtar Kelimeler:
Bütçe Açıkları, Borsalar, Gelişmekte Olan Ülkeler, COVID-19

JEL Kodları:
E62, G15, H6

Öz

Bu çalışma, bütçe açıklarının hisse senedi getirileri üzerindeki etkisini incelemektedir. Örneklem olarak 2016Q1'den 2021Q4' kadar olan döneme ait gelişmekte olan piyasa verileri kullanılmıştır. Panel vektör otoregresyon (PVAR) ve Granger nedensellik testleri ile uygulanan analiz sonucunda bütçe açıklarının hisse senedi getirileri üzerinde nedensel bir etkisinin olduğu tespit edilmiştir. Bu sonuçlar, finansal gelişmişlik düzeyi düşük ve orta olan ülkeler ile Avrupa ülkeleri için doğrulayıcıdır. Ancak, finansal gelişmişlik düzeyi yüksek, BRICS ve ASEAN ülkelerinde herhangi bir etki yoktur. Ayrıca, etkinin COVID-19 pandemi döneminde ortadan kalktığı gözlemlenmiştir. Çalışma sonuçları, Etkin Piyasa Hipotezi'nin (EMH) güçlü formunu sorgulamaktadır. EMH'ye göre, hisse senedi fiyatları tüm mevcut bilgileri tam olarak yansıtmalıdır. Ancak, finansal gelişmişlik düzeyi düşük ve orta olan ülkeler ile Avrupa ülkelerinde bütçe açıklarının hisse senedi getirilerini etkilemesi, piyasa katılımcılarının bu bilgileri tam olarak yansıtamadığını ve güçlü formda etkin olmayan piyasaların olabileceğini göstermektedir.

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1. Introduction

Budget deficits play a crucial role in determining the value of financial assets by distorting the optimal resource allocation. Adrangi and Allender (1998) concatenate the effects of budget deficits on stock prices using four channels. Firstly, a large budget deficit hurts economic growth in the short and long run, and it decreases stock prices by harming investor confidence. Secondly, an unsustainable budget deficit may affect stock prices through inflationary expectations. Thirdly, compensating the budget deficits by monetizing or increasing tax revenues affects the stock prices. Lastly, budget deficits adversely affect the competitiveness of domestic products in the international market, so stock prices decrease through the interest and exchange rates.

Darrat (1988) tests the impact of budget deficits on stock prices for Canada and reports that there is no impact in terms of available information on fiscal policy. Darrat and Brocato (1994) investigate the link between the efficiency of the US stock market and six other macro-finance factors and show that federal budget deficits have an impact on future stock returns. Adrangi and Allender (1998) scrutinize the effect of budget deficits on stock prices in the USA, Germany, France, and Japan and reveal that a reduction in budget deficits harms stock prices in the USA but not others. Tekeli (2007) investigated the effect of budget deficits on stock price movements (ISE 100). As a result of the study, it was determined that there is no long-term integration between stock prices and budget deficits and that there is no Granger causality relationship between these variables. Jansen et al. (2008) analyze the role of fiscal policy on stock and treasury bonds markets and find no direct link between fiscal policy and asset prices. Laopodis (2012) examines the relationship between federal budget deficits, interest rates, and the stock market in the USA and suggests that budget deficits negatively affect stock returns. Agnello and Sousa (2010) assess the role of fiscal policy on the stock market for ten industrialized countries and indicate that a positive budgetary shock hurts stock prices. Chatziantoniou et al. (2013) seek the effects of monetary and fiscal shocks on the stock market performance in Germany, the UK, and the USA. They highlight the coordination between monetary and fiscal policies for stock market performance. Stoian and Iorgulescu (2020) inquire whether stock market prices include fiscal policy information for Romania in the short and long run. They reveal that the long-term effect of fiscal policy on the stock market prices is statistically insignificant, but the short-term impact is significant. The study conducted by Kaya et al. (2013) examined the relationships between the IMKB-100 index and macroeconomic variables such as the exchange rate and money supply from 2002 to 2012. The findings indicate a negative relationship between the exchange rate and stock returns but a positive relationship with the money supply. On the other hand, Sevinc's (2014) study investigated the relationships between the BIST-30 index and various macroeconomic variables from 2003 to 2013. While a negative relationship was found between the money supply, interest rates, gold prices, and stock returns, a positive relationship was observed with the current account balance, inflation, and the export-to-import ratio. Additionally, no relationship was identified between exchange rate fluctuations, industrial production increases, and stock market returns. Koyuncu's (2018) study focused on the relationship between the BIST-100 index and the industrial production index, inflation, interest rates, and economic growth from 1988 to 2016 using EKK tests. The dynamic EKK findings suggest that industrial production and inflation positively affect the BIST-100 index, while real economic growth and interest rates have a negative impact. The results imply that increases in industrial production significantly boost the BIST-100 index. Guler and Haykir (2023) estimated the effects of budget deficits on the BIST-100 index for the 2003Q1-2019Q4 period using the ARDL model. The analysis results of the

study show that although the model is integrated in the long term, there is no statistically significant relationship between the budget balance and the stock market index. However, in the short term, a decrease in the budget deficit positively affects the stock market index. Although there is no statistically significant relationship between GDP, CPI, and exchange rate variables and the stock market index in the long term, there is a positive relationship between money supply and the stock market index. There is a negative relationship between interest rate and stock market index.

Budget deficits have a significant impact on stock market returns in emerging markets. Studies reveal that budget deficits can influence stock prices positively or negatively based on the short-term or long-term perspective. Budget expansion tends to boost stock market returns in the short run, while budget contraction can adversely affect stock performance (Lee et al., 2022; Khatab, 2022). Additionally, the relationship between budget deficits and stock market returns can vary across different periods within the same country, as seen in the case of Ghana, where the impact changed between two sub-samples (Nwakobi, 2020). Furthermore, the nature of the effect of fiscal policy on stock market development in emerging economies like Nigeria emphasizes the need for careful accommodation of fiscal policies to support stock market activities and overall economic growth (Abakah, 2016). Whereas some studies find a positive relationship between budget deficit and stock market prices (Van Aarle et al., 2003; Grobys, 2013), other studies find a negative relationship (Ewing, 1998; LAopodis, 2006).

Studies provide different results regarding the impact of budget deficits on stock prices. These differences may depend on various factors such as countries' economic structures, financial policies, and market dynamics. Studies explicitly conducted in Türkiye show that budget deficits do not significantly affect stock prices in the long term, but a positive effect is observed in the short term. This suggests that Türkiye's economic structure and financial policies may direct short-term market reactions. This paper investigates whether budget deficits affect stock market returns and contributes to the existing literature in four-folds. First, the study focuses on emerging markets rather than analyzing advanced economies or a single country. Second, we investigate the impact of financial development on the budget deficits and stock returns nexus. Third, this paper examines the sub-groups of emerging markets such as BRICS, Europe, and ASEAN. Finally, we study whether the relationship between budget deficits and stock returns differs during the COVID-19 pandemic.

2. Data and Methodology

We employ panel vector autoregression (PVAR) and panel-granger causality tests for 16 emerging markets using quarterly data of budget deficits to GDP, stock returns, GDP growth, money supply to GDP, and inflation from 2016Q1 to 2021Q4. This period encompasses critical years for emerging markets. Additionally, its coverage of the pandemic era is significant for examining the effects on budget deficits and stock returns, which holds importance in the literature. Panel Vector Autoregression (PVAR) is a statistical technique used to model the interactions of multiple variables over time. This technique is achieved by adapting the traditional vector autoregression (VAR) to cases involving panel data. Panel data includes time series data for individuals or cross-sections. For example, annual GDP, inflation, and investment rates for multiple countries are defined as panel data. PVAR analyzes the dynamic relationship between variables in such cases, considering the lagged effects between them. Panel Granger Causality

Test is a statistical test used in conjunction with PVAR. It is used to evaluate the causal relationship between two variables. This test measures one variable's past values' ability to predict another variable's future values. If one variable's past values significantly predict another variable's future values, Granger causality is said to exist. PVAR and Panel Granger Causality Tests do not prove causality but demonstrate a statistical relationship. Interpretation of causality should be done carefully, and other factors should also be considered. International Financial Statistics (IFS, 2024) is the primary data source for macro variables. If the data is missing in the IFS, we collect the data from each country's official government website. We obtain the stock market returns from Investing.com.

Table 1. Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min.	Max.
Stock Returns	512	8.645	1.608	6.038	11.848
Budget Deficits To GDP	512	-0.028	0.050	-0.418	0.238
GDP Growth	512	0.118	2.185	-0.885	48.612
Money Supply To GDP	512	1.320	3.450	0.0003	11.750
Inflation	512	4.886	0.196	4.625	5.629

Table 1 presents summary statistics for five economic variables, each based on 512 observations. Stock Returns have an average of 8.645 with a standard deviation of 1.608. The returns range from a minimum of 6.038 to a maximum of 11.848. Budget Deficits to GDP show an average deficit of -0.028 with a standard deviation of 0.050. The deficits range from -0.418 to 0.238. GDP Growth has an average growth rate of 0.118 with a standard deviation of 2.185. The growth rates vary widely, from a minimum of -0.885 to a maximum of 48.612. Money Supply to GDP has an average ratio of 1.320 with a standard deviation of 3.450. The ratios range from a minimum of 0.0003 to a maximum of 11.750. Inflation has an average rate of 4.886 with a standard deviation of 0.196. The inflation rates are tightly clustered, ranging from 4.625 to 5.629.

The analysis includes two sections; in the first section, we use the entire sample, and in the second section, we distinguish countries according to the Financial Development Index of 2018 (latest available data) constructed by IMF and strategic partnership groups, namely BRICS (Brazil, Russia, India, China, South Africa), Europe (Bulgaria, Croatia, Hungary, Poland, Romania, Serbia, Türkiye), and ASEAN (Philippines, Malaysia, Thailand, Indonesia).

To disentangle the impact of budget deficits on stock returns, we estimate the following PVAR:

$$X_{it} = A(L)X_{it-1} + \mu_i + \epsilon_{it} \quad (1)$$

where X_{it} is a vector of endogenous variables, $A(L)$ is a matrix of lag operators, μ_i is the country-specific effect, and ε_{it} is the error term. X_{it} consists of budget deficits to GDP, stock returns, GDP growth, money supply to GDP, and inflation.

We first investigate the stationary variables and cross-sectional dependency, which are reported in Table 2. The results indicate that cross-sectional dependency exists and variables are stationary at the level. Thus, we can employ PVAR analysis to identify the relationship between variables. LLC and IPS Tests: Both tests show that the null hypothesis of a unit root can be rejected at the 1% significance level for all variables (Stock Returns, Budget Deficits to GDP, GDP Growth, Money Supply to GDP, and Inflation). This implies that these variables are

stationary. The critical value at the 1% level is -2.38. All CIPS test statistics are more negative than this critical value, meaning the null hypothesis of a unit root can be rejected at the 1% level, indicating stationarity. High and significant CD-Test statistics indicate strong cross-sectional dependence for all variables. Overall, the results suggest that all tested variables are stationary, meaning they do not contain a unit root, and there is strong evidence of cross-sectional dependence among the variables.

Table 2. Panel Unit Root Tests

	LLC	IPS	CIPS	CD-Test
Stock Returns	-16.405***	-16.183***	-5.050***	33.05***
	(0.000)	(0.000)	Critical Value at 1% Level: -2.38	(0.000)
Budget Deficits to GDP	-12.398***	-14.467***	-4.339***	17.53***
	(0.000)	(0.000)	Critical Value at 1% Level: -2.38	(0.000)
GDP Growth	-29.697***	-28.219***	-5.757***	31.46***
	(0.000)	(0.000)	Critical Value at 1% Level: -2.38	(0.000)
Money Supply to GDP	-3.436***	-1.958**	-3.119***	40.74***
	(0.000)	(0.025)	Critical Value at 1% Level: -2.38	(0.000)
Inflation	-12.523***	-12.699***	-4.029***	5.76***
	(0.000)	(0.000)	Critical Value at 1% Level: -2.38	(0.000)

Notes: P-values are in the parenthesis. ** and *** show the statistical significance at the 5 and 1 percent levels, respectively.

3. Empirical Results

Table 3 presents the results of PVAR analysis and panel-granger causality tests. The first row (column) of Panel A indicates the dependent (independent) variables of PVAR analysis, and Panel B shows the Granger causality among variables. This paper focuses on analyzing the effect of budget deficits on stock returns and the effect of the COVID-19 pandemic on this relationship.

The results reveal that reducing budget deficits positively affects subsequent stock returns. Notably, a one percent decrease in budget deficits leads to a 1.78 percent increase in stock returns. Similarly, stock returns increase due to a rise in the GDP growth and money supply. On the contrary, a one percent increase in inflation lowers the stock returns. The insignificant interaction term indicates that the impact of budget deficits on stock returns disappears during the pandemic. Granger causality tests support the PVAR analysis, and all independent variables are Granger's cause for stock returns.

Table 3. Panel VAR Analysis

Panel A: PVAR Analysis					
	Stock Returns	**Budget Deficits to GDP**	**GDP Growth**	**Money Supply to GDP**	**Inflation**
L. Stock Returns	-0.233**	0.098**	0.361***	-0.438***	0.014
	(0.115)	(0.047)	(0.104)	(0.142)	(0.010)
L. Budget Deficits to GDP	1.785***	-0.013	1.739***	-2.336***	0.041
	(0.666)	(0.264)	(0.612)	(0.886)	(0.062)
L. GDP Growth	0.169**	-0.035	-0.143*	0.235*	0.006
	(0.084)	(0.034)	(0.077)	(0.128)	(0.007)
L. Money Supply to GDP	0.263**	-0.073	0.197*	0.845***	0.009
	(0.121)	(0.052)	(0.119)	(0.184)	(0.012)
L. Inflation	-3.327**	-0.048	-2.240	2.175	-0.147
	(1.607)	(0.454)	(1.440)	(1.812)	(0.251)
Covid*Budget Deficits to GDP	0.429	0.491**	-0.227	0.717	0.088
	(0.584)	(0.230)	(0.541)	(0.795)	(0.057)
Panel B: Granger Causality Test					
Stock Returns		4.184**	11.877***	9.456***	1.833
		(0.041)	(0.001)	(0.002)	(0.176)
Budget Deficits to GDP	7.175***		8.068***	6.946***	0.429
	(0.007)		(0.005)	(0.008)	(0.512)
GDP Growth	4.060**	1.016		3.378*	0.715
	(0.044)	(0.313)		(0.066)	(0.398)
Money Supply to GDP	4.700**	1.933	2.727*		0.628
	(0.030)	(0.164)	(0.099)		(0.428)
Inflation	4.284**	0.011	2.422	1.440	
	(0.038)	(0.915)	(0.120)	(0.230)	

Notes: COVID is a dummy variable equal to one when the sample period is between 2020Q1 and 2020Q4 and zero otherwise. Standard errors (in Panel A) and p-values (in Panel B) are in parenthesis. *, **, and *** show statistical significance at the 10, 5, and 1 percent levels, respectively.

Furthermore, we divide the countries into three groups according to the financial development index and strategic partnerships. The motivation behind the segmentation of the analysis by countries with different levels of financial development is essential for understanding how varying financial conditions may influence the relationship between budget deficits and stock returns. By categorizing countries based on their levels of financial development, the aim is to determine whether the impact of budget deficits on stock returns varies across these categories.

Table 4 demonstrates the results of sub-groups. Since we focus on the impact of budget deficits on stock returns, we only present the results accordingly. The results in the financial development sub-groups show that a decrease in budget deficits positively affects the stock returns for low and middle financial development groups. In other words, if the country has a strong financial system, the effect of budget deficits on stock returns disappears. In strategic partnership groups, a one percent decrease in budget deficits leads to a 1.39 percent increase in stock returns in European countries, whereas the BRICS and ASEAN countries do not exhibit significant relations. In addition, budget deficits do not significantly impact stock returns in any sub-groups during the pandemic.

Table 4. Sub-Groups Analysis

Dependent Variable: Stock Returns	Financial Development Groups			Country Groups		
	Low	Middle	High	BRICS	Europe	Asean
L. Stock Returns	-0.058	-0.153	-0.492***	-0.506***	-0.190	-0.307*
	(0.123)	(0.209)	(0.099)	(0.127)	(0.122)	(0.162)
L. Budget Deficits to GDP	1.737*	1.427**	-0.509	-0.766	1.397**	0.603
	(0.925)	(0.625)	(0.515)	(0.628)	(0.602)	(0.437)
L. GDP Growth	0.042	0.092	0.276	0.522***	0.025	0.305
	(0.103)	(0.148)	(0.209)	(0.183)	(0.082)	(0.274)
L. Money Supply to GDP	0.109	0.217*	0.267	0.498**	0.091	0.752
	(0.120)	(0.118)	(0.307)	(0.247)	(0.078)	(0.593)
L. Inflation	-0.682	-5.709**	2.033	1.987	-3.783*	-0.176
	(2.505)	(2.498)	(1.637)	(2.620)	(2.057)	(2.157)
Covid*Budget Deficits to GDP	-0.544	1.247	-0.117	0.003	0.057	1.823
	(0.848)	(1.237)	(0.588)	(0.535)	(0.845)	(2.014)
Granger Causality Test						
Budget Deficits to GDP	3.525*	5.200**	0.979	1.488	5.390**	1.904
	(0.060)	(0.023)	(0.323)	(0.223)	(0.020)	(0.168)
GDP Growth	0.164	0.386	1.744	8.105***	0.091	1.235
	(0.685)	(0.535)	(0.187)	(0.004)	(0.763)	(0.266)
Money Supply to GDP	0.832	3.353*	0.758	4.062**	1.366	1.608
	(0.362)	(0.067)	(0.384)	(0.044)	(0.242)	(0.205)
Inflation	0.074	5.220**	1.541	0.686	3.382*	0.007
	(0.785)	(0.022)	(0.214)	(0.448)	(0.066)	(0.935)

Notes: COVID is a dummy variable equal to one when the sample period is between 2020Q1 and 2020Q4 and zero otherwise. Standard errors (in Panel A) and p-values (in Panel B) are in parenthesis. *, **, and *** show statistical significance at the 10, 5, and 1 percent levels, respectively.

4. Conclusion

This paper explores the link between budget deficits and stock returns in emerging markets. The results show a positive and significant impact of a decline in budget deficits on stock returns, which is valid for the low and middle financial development groups and European countries. We also find no evidence for countries with high financial development, such as BRICS and ASEAN. Furthermore, the positive effect of a decline in budget deficits no longer exists in the COVID-19 pandemic period.

According to the Efficient Market Hypothesis (EMH), stock prices fully reflect all available information, implying that it is impossible to consistently outperform the market through informed trading strategies, as all relevant information is already incorporated into stock prices. However, the observation that budget deficits consistently influence stock returns in certain financial development groups or regions suggests that market participants may not be fully effective in incorporating this information into stock prices. Therefore, the results indicating a significant impact of budget deficits on stock returns call into question the strong form of the EMH, which posits that stock prices reflect all available information, including insider information. This raises the possibility of market inefficiencies in the affected regions or groups, where investors may be able to generate abnormal returns by exploiting the relationship between budget deficits and stock returns. Our study aligns with existing literature, showing that reducing budget deficits positively affects stock returns in countries with low and middle levels of financial development (Darrat, 1998; Darrat and Brocato, 1994). Additionally, Adrangi and Allender (1998) found that while reducing budget deficits negatively affected stock prices in the USA, no

such effect was observed in other countries. This finding is consistent with our study, which observes no significant impact in highly financially developed countries, as well as in BRICS and ASEAN countries. Tekeli (2007) found no long-term relationship between budget deficits and stock prices in Türkiye. Similarly, Güler and Haykır (2023) reported a positive short-term effect of budget deficits on stock prices in Türkiye but no statistically significant long-term relationship. Our study underscores the positive impact of budget deficit reductions in countries with low and middle levels of financial development, suggesting a similar dynamic may be present in emerging markets like Türkiye. The study also highlights the extensive impact of the pandemic on economic dynamics and the changing role of traditional fiscal policies on market responses during this period. The pandemic era should be considered an exceptional period that requires a re-evaluation of conventional economic relationships.

In conclusion, the impact of budget deficits on stock returns is a complex and multifaceted issue. Country-specific factors, financial development levels, and temporal conditions are crucial in this relationship. This study provides significant insights into emerging markets. It makes invaluable contributions to the existing literature and emphasizes the importance of financial development levels when assessing the influence of fiscal policy on stock markets. Overall, governments determine their priorities regarding budget deficits and stock returns nexus according to the level of financial development. Countries with lower financial development should employ austerity policies to decrease their budget deficits, whereas those with higher financial development should continue to support their financial systems since the stock returns include all publicly available information in these countries.

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.

References

Abakah, E.J.A. and Adusah-Poku, F. (2016). Budget deficits and stock market returns: Evidence from Ghana. *Journal of Finance and Economics*, 4(4), 113-117. doi:10.12691/jfe-4-4-3

Adrangi, B. and Allender, M. (1998). Budget deficits and stock prices: International evidence. *Journal of Economics and Finance*, 22(2), 57-66. https://doi.org/10.1007/BF02771476

Agnello, L. and Sousa, R.M. (2013). Fiscal policy and asset prices. *Bulletin of Economic Research*, 65(2), 154-177. https://doi.org/10.1111/j.0307-3378.2011.00420.x

Al Khatab, A. and Al Iraqi, B. (2022). The impact of the budget deficit on the performance of a sample of Arab financial markets. *Tanmıyat Al-Rafıdaın*, 41(133), 225-243. doi:10.33899/tanra.2021.131049.1116

Chatziantoniou, I., Duffy, D. and Filis, G. (2013). Stock market response to monetary and fiscal policy shocks: Multi-country evidence. *Economic Modelling*, 30, 754-769. https://doi.org/10.1016/j.econmod.2012.10.005

Darrat, A.F. (1988). On fiscal policy and the stock market. *Journal of Money, Credit, and Banking*, 20(3), 353-363. https://doi.org/10.2307/1992261

Darrat, A.F. and Brocato, J. (1994). Stock market efficiency and the federal budget deficit: Another anomaly? *Financial Review*, 29(1), 49-75. https://doi.org/10.1111/j.1540-6288.1994.tb00813.x

Ewing, B.T. (1998). The impact of federal budget deficits on movements in the stock market: Evidence from Australia and France. *Applied Economics Letters*, 5(10), 649-651. https://doi.org/10.1080/135048598354348

Fama, E. (1970). Efficient capital market: A review of theory and empirical work. *The Journal of Finance*, 25(2), 383-417. https://doi.org/10.7208/9780226426983-007

Grobys, K. (2013). An empirical analysis of changes of the impact of federal budget deficits on stock market returns: Evidence from the US economy. *Applied Economics Letters*, 20(9), 921-924. https://doi.org/10.1080/13504851.2013.765534

Güler, H. and Haykır, Ö. (2023). Türkiye'de bütçe açıklarının BIST-100 endeksi üzerindeki etkisi. *Çukurova Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, 32(3), 65-77. https://doi.org/10.35379/cusosbil.1252940

International Financial Statistics. (2024). *Statistics* [Dataset]. Retrieved from https://data.imf.org/?sk=4c514d48-b6ba-49ed-8ab9-52b0c1a0179b&sId=-1

Jansen, D.W., Li, Q., Wang, Z. and Yang, J. (2008). Fiscal policy and asset markets: A semiparametric analysis. *Journal of Econometrics*, 147(1), 141-150. https://doi.org/10.1016/j.jeconom.2008.09.007

Kaya, V., Çömlekçi, İ. and Kara, O. (2013). Hisse senedi getirilerini etkileyen makroekonomik değişkenler 2002–2012 Türkiye örneği. *Dumlupınar Üniversitesi Sosyal Bilimler Dergisi*, 35, 167-176. Retrieved from https://dergipark.org.tr/en/pub/dpusbe/

Koyuncu, T. (2018). BİST-100 endeksinin makroekonomik değişkenler ile ilişkisi: Ampirik bir çalışma. *Finans Ekonomi ve Sosyal Araştırmalar Dergisi,* 3(3), 615-624. https://doi.org/10.29106/fesa.423051

Laopodis, N.T. (2006). Dynamic interactions among the stock market, federal funds rate, inflation, and economic activity. *Financial Review*, 41(4), 513-545. https://doi.org/10.1111/j.1540-6288.2006.00155.x

Laopodis, N.T. (2012). Dynamic linkages among budget deficits, interest rates and the stock market. *Fiscal Studies*, 33(4), 547-570. https://doi.org/10.1111/j.1475-5890.2012.00172.x

Lee, C.L., Ng, C.P., Koh, C.M. and Ahmad, R. (2022). The asymmetric impact of fiscal policy on an emerging stock market. *Asian Economics Letters*, Advance online publication. https://doi.org/10.46557/001c.37049

Nwakobi, P.C., Ananwude, A.C. and Umezurike, C.M. (2020). Fiscal policy and stock market development in an emerging West African economy: The Case of Nigeria. *Finance & Economics Review*, 2(3), 52-68. https://doi.org/10.38157/finance-economics-review.v2i3.182

Sevinç, E. (2014). Makro ekonomik değişkenlerin BİST-30 endeksinde işlem gören hisse senedi getirileri üzerindeki etkilerinin arbitraj fiyatlama modeli kullanarak belirlenmesi. *İstanbul Üniversitesi İşletme Fakültesi Derg*isi, 43(2), 271-292. Retrieved from https://dergipark.org.tr/tr/pub/ibr

Stoian, A. and Iorgulescu, F. (2020). Fiscal policy and stock market efficiency: An ARDL bounds testing approach. *Economic Modelling*, 90, 406-416. https://doi.org/10.1016/j.econmod.2019.12.023

Tekeli, R. (2014). Bütçe açıklarının hisse senedi fiyat hareketlerine etkisi: Türkiye örneği. *Selçuk Üniversitesi Sosyal Bilimler Meslek Yüksekokulu Dergisi*, 10(1-2), 215-230. Retrieved from https://dergipark.org.tr/en/pub/selcuksbmyd

Van Aarle, B., Garretsen, H. and Gobbin, N. (2003). Monetary and fiscal policy transmission in the Euro-area: Evidence from a structural VAR analysis. *Journal of Economics and Business*, 55(5-6), 609-638. https://doi.org/10.1016/S0148-6195(03)00056-0

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THE IMPACT OF ECONOMIC FACTORS ON PUBLIC HEALTH EXPENDITURE IN TÜRKİYE: PRINCIPAL COMPONENT ANALYSIS EVALUATION FOR THE PERIOD 2002-2022

Türkiye'de Ekonomik Faktörlerin Kamu Sağlık Harcamaları Üzerine Etkileri: 2002-2022 Yılları Arası Dönemin Temel Bileşenler Analizi ile Değerlendirilmesi

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Keywords:
Principal Component Analysis,
Health Expenditure,
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JEL Codes:
H51, I15, C32

Abstract

This study analyzes the economic factors affecting public health expenditure in Türkiye from 2002 to 2022. The main objective is to identify the economic reasons for the decreasing share of public health expenditure in Gross Domestic Product (GDP). It examines macroeconomic variables such as GDP per capita, unemployment rate, labor force participation rate, consumer price index, tax revenue, and exchange rate using principal component analysis (PCA). The results show that GDP per capita, exchange rate, and tax revenue significantly impact public health expenditure, indicating a direct relationship between economic growth and health spending. The unemployment rate does not directly affect public health expenditure, while an increase in labor force participation rate can reduce it. This study underscores the importance of macroeconomic stability and effective economic policies for sustainable health financing in Türkiye. By using long-term data, it provides a comprehensive analysis of how economic factors impact health expenditure, distinguishing it from other studies in the literature. The findings emphasize that a healthy economy leads to increased public investment in health services.

Anahtar Kelimeler:
Temel Bileşenler Analizi,
Sağlık Harcamaları,
Ekonomik Faktörler

JEL Kodları:
H51, I15, C32

Öz

Bu çalışma, 2002-2022 yılları arasında Türkiye'de kamu sağlık harcamalarını etkileyen ekonomik faktörleri analiz etmektedir. Temel amaç, kamu sağlık harcamalarının Gayri Safi Yurt İçi Hasıla (GSYİH) içindeki payının azalmasının ekonomik nedenlerini belirlemektir. Temel bileşenler analizi (PCA) kullanılarak kişi başına GSYİH, işsizlik oranı, işgücüne katılım oranı, tüketici fiyat endeksi, vergi geliri ve döviz kuru gibi makroekonomik değişkenler incelenmiştir. Sonuçlar kişi başına düşen GSYİH, döviz kuru ve vergi gelirinin kamu sağlık harcamalarını önemli ölçüde etkilediğini ve ekonomik büyüme ile sağlık harcamaları arasında doğrudan bir ilişki olduğunu göstermektedir. İşsizlik oranı kamu sağlık harcamalarını doğrudan etkilemezken, işgücüne katılım oranındaki artış harcamaları azaltabilmektedir. Bu çalışma, Türkiye'de sürdürülebilir sağlık finansmanı için makroekonomik istikrarın ve etkili ekonomi politikalarının önemini vurgulamaktadır. Uzun vadeli verileri kullanarak, ekonomik faktörlerin sağlık harcamalarını nasıl etkilediğine dair kapsamlı bir analiz sunmakta ve literatürdeki diğer çalışmalardan ayrılmaktadır. Bulgular, sağlıklı bir ekonominin sağlık hizmetlerine yapılan kamu yatırımlarının artmasına yol açtığını vurgulamaktadır.

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1. Introduction

In recent years, understanding the dynamics of public health expenditure and the factors that influence it has become increasingly important for both policymakers and researchers. These expenditures are recognized as an indicator of how much governments invest in health services and directly impact overall public health, accessibility, and quality of health services (Yetim et al., 2021). Particularly in developing countries such as Türkiye, understanding the impact of economic factors on public health expenditure is crucial for developing and implementing effective health policies (Esen and Çelik Keçili, 2022).

Healthcare expenditure represents a large proportion of GDP in all Organisation for Economic Co-operation and Development (OECD) countries and has increased significantly in recent decades (OECD, 2024). For example, median health expenditure in the OECD increased from 3.8% in 1960 to 7.9% in 1990 (Anderson et al., 2000). OECD health data for the period 1975-2004 also show that growth in health expenditure per capita has consistently exceeded growth in GDP per capita (Nghiem and Connelly, 2017). Moreover, the growth in health expenditure is faster in wealthier countries, and the health sector accounts for a larger share of GDP in these countries. For example, in the United States, the richest country in the OECD, health expenditure as a proportion of GDP was 5.2% in 1960, 14.0% in 1998, and 17.3% in 2022 (Vankar, 2024).

Looking at current health indicators in Türkiye, the ratio of health expenditure to GDP increased from 4.6% in 2000 to 5.5% in 2009. After the 2008 social security reform, health expenditure started to decline steadily, finally falling below 5% in 2011 and reaching 4% in 2022, about half of the OECD average of 8.8% (TURKSTAT, 2023). The same pattern can be observed for out-of-pocket spending by households in Türkiye; while it was 28.6% in 2000, it started to decline rapidly after 2008, falling to 14.51% in 2009 (World Bank Open Data, 2023). In 2020 it was 16.43% and in 2022 18.5% (TURKSTAT, 2023). Although this situation points to the positive effects of universal health coverage, the share of out-of-pocket health expenditure by households in total expenditure on health services raises questions about the sustainability of financing (Sülkü and Caner, 2011; Kara, 2013; Yavuz et al., 2013; Aboubacar and Xu, 2017; Focacci, 2023). In Türkiye, which has the lowest ratio of health expenditure to national income among OECD countries (8.8 %), out of every 100 liras of general health expenditure, 78 liras are covered by the public sector and the remaining 22 liras by individuals (Euronews, 2022).

The reasons for the increase in health expenditure are complex and multidimensional in the literature. Studies on the factors influencing public health expenditure show that, contrary to common perception, the direct impact of population aging on health expenditure is rather limited (Bieszk-Stolorz and Dmytrów, 2023), while macroeconomic indicators such as GDP at (Peker Say and Yücel, 2006; Topcu and Atasayar, 2020; Boyacioğlu and Terzioğlu, 2022; Söyük, 2023), consumer price index (Erdogan and Erdogan, 2023), exchange rate (Esen and Çelik Keçili, 2022) and labour force participation rate (Coşkun Yılmaz, 2023) play an important role (Kurt, 2015; Atilgan et al., 2017; Piabuo and Tieguhong, 2017; Liu et al., 2019). However, in the existing literature, the effects of these factors are usually analyzed in isolation, and their complex interactions are not sufficiently addressed. This paper aims to fill this gap by comprehensively analyzing how these economic factors together affect public health expenditure in Türkiye.

To effectively analyze the multifaceted nature of health expenditures, PCA is widely used in the literature. PCA helps in reducing the dimensionality of complex data sets and identifying the main components that influence health expenditures. For example, Munsur et al. (2009) used PCA to analyze household out-of-pocket health expenditures in Bangladesh and found that drug expenditures constitute a larger component compared to other health expenditures. Chao and Wu (2017) utilized PCA loadings to weight variables from the Medical Expenditure Panel Survey data and created data-driven indices. Similarly, Guo et al. (2008) applied PCA to analyze drug expenditure and utilization trends in the US Medicaid programs, identifying expenditure and utilization patterns. Wanzala et al. (2019) assessed the performance of health systems in Kakamega County, Kenya, using PCA, and identified components that significantly impact health service delivery. Additionally, Getzen and Poullier (1992) demonstrated that the increase in health expenditures in OECD countries is largely related to policy and expenditure management rather than demographic factors, associating it with medical advancements. Reimers and Powell (2001) analyzed the relationship between health expenditures and GDP in OECD countries, showing that health expenditures are determined by income and medical progress. Zhang and Wan (2023) used grey correlation and PCA methods to analyze the factors affecting health expenditures in China and predict future trends. These studies show that PCA is a powerful tool in analyzing health expenditures and services, providing significant insights into the impacts of economic, social, and demographic factors.

By employing PCA in this study, I aim to provide a comprehensive understanding of how various economic factors collectively influence public health expenditure in Türkiye. This approach allows us to identify the primary components that significantly impact health expenditure and to analyze their interactions in a multidimensional framework. PCA helps address the complexity and multidimensionality of the factors influencing health expenditures, providing a more holistic view compared to traditional single-factor analyses.

The study is structured as follows. The second section consolidates the theoretical underpinnings of the study through a comprehensive review of the literature behind the study. Section 3 describes the data used, the data sources, the research questions, and the methodology. The empirical analysis is presented in the fourth section. This study uses PCA followed by regression analysis to understand the impact of economic factors on public health expenditure (PHE). PCA was chosen to reduce the original dataset's multidimensionality and address multicollinearity issues. This method simplifies the strong correlations between the variables in the dataset, creating a smaller number of independent components. These components are then used as independent variables in the regression analysis. Newey-West standard errors were used in the regression model because the assumptions of freedom from error (autocorrelation) and homoscedasticity (constant variance) were not fully met in the initial analyses. The Newey-West method provides robust standard errors against both autocorrelation and heteroskedasticity, making the model estimates more reliable. The fifth section summarizes the main findings and draws conclusions on the impact of economic factors on public health expenditure. In the last section, the limitations of the study and suggestions for future research are presented.

Considering the unique conditions of Türkiye and the impact of public investment in health services, this study provides an in-depth understanding of the relationship between health

expenditure and economic factors and helps policy makers to develop strategic recommendations for the sustainability of public health expenditure.

2. Background

The trends and determinants of health expenditure in OECD countries have been analysed extensively and the main determinants of health expenditure growth have been found to be: income growth (Panopoulou and Pantelidis, 2011; Wang, 2015), education (Yetim et al., 2021), population ageing (Pekkurnaz, 2015; Jakovljevic et al., 2020), technological progress (Nghiem and Connelly, 2017) and health insurance penetration (Lorenzoni et al., 2014).

This may indicate the positive impact of universal health coverage (Dorlach and Yeğen, 2023). A similar trend can be observed for voluntary health payment schemes in Türkiye, which fell from 0.4% of GDP in 2000 to 0.3% in 2009 and 0.2% between 2011 and 2019 (Ministry of Family, Labor and Social Services, 2020).

These percentages may not necessarily mean that individuals are paying more for healthcare. On the contrary, due to the 2008 Social Security reform and the expansion of universal health coverage, more people are gaining access to healthcare services, and out-of-pocket expenses for individuals are decreasing. The reduction in the ratio of health expenditure to GDP may indicate that the government is able to deliver healthcare services more efficiently, thereby reducing the financial burden on citizens. For low-income households, this can reduce health inequalities and improve overall health conditions. The increase in out-of-pocket health expenditures from 16.43% in 2020 to 18.5% in 2022 may indicate increased demand for and utilization of healthcare services due to the pandemic. Additionally, this increase might signal the need for more accessible and effectively managed health expenditures overall. The decrease in health expenditures as a percentage of GDP may be associated with the more efficient and preventive delivery of healthcare services, which is a positive development that enhances overall quality of life.

It is well known that Türkiye has a national health system; therefore, health expenditure is a significant part of the composition of government expenditure. Although researchers and health professionals occasionally question the efficiency of the health system and health spending, especially during periods of high workload such as epidemics and pandemics (Erdogan and Erdogan, 2023), there are very few studies that examine the impact of economic factors on health spending.

The literature indicates that the increase in real per capita income, technological innovations, the widespread use of insurance for medical treatment and the ageing of the population play an important role in the increase in health expenditure (Sülkü and Caner, 2011; Kara, 2013; Yavuz et al., 2013; Focacci, 2023). Şenol's (2021) study begins by highlighting that the economic crises of 1994, 2001 and 2009 significantly negatively impacted public health expenditures and health indicators. The economic difficulties experienced during these crises led to a decrease in public funding for health services, leading to decreased access to health services and general health indicators. The study shows that these negative effects were caused not only by economic conditions but also by the political preferences of the time.

Another important study by Atılgan et al. (2017) analyses the impact of health spending on economic growth in Türkiye. The results, which support the health-led growth hypothesis, show a positive relationship between health expenditures and economic growth. This suggests that investment in health services has a positive impact not only on human capital, but also on overall economic performance.

Sparkes et al. (2019) discussed how health financing reforms are a political process and how these reforms trigger political challenges by affecting the distribution of interest groups. In their study, they highlighted the importance of political economy analysis in addressing the political challenges encountered during the reform process. Specifically, the reforms in Türkiye have led to significant improvements in the financing of and access to health services, but have also created a number of political challenges. Similar findings have been observed in studies conducted in both Türkiye and other countries.

For instance, Akdağ (2011) examined the impact of the Health Transformation Program on the Turkish health system and noted that while the reforms improved access to health services, they also posed challenges for financing sustainability. Sayan and Yıldırım (2012) analyzed the distribution of health expenditures in Türkiye and assessed the social justice implications of the reforms. Another study by Erus and Hatipoğlu (2017) explored the political dimensions of health reforms in Türkiye, detailing the political and economic impacts of the reforms and discussing measures to address inequalities in access to health services.

Additionally, Wendt et al. (2010) examined the political effects of health system reforms in European countries, highlighting the role of interest groups. Yip and Hsiao (2008) discussed the health reforms in China, detailing the political and economic obstacles encountered during implementation. Roberts et al. (2008) emphasized the necessity of strong political support and stakeholder involvement for the successful implementation of health reforms.

Taking these studies together, the independent variables affecting public health expenditures have been analyzed taking into account Türkiye's economic structure. It has been frequently emphasized in the literature that macroeconomic variables such as GDP per capita, unemployment rate, labor force participation rate, consumer price index, tax revenue and exchange rate have significant effects on health expenditures (Esen and Çelik Keçili, 2022; Coşkun Yılmaz, 2023; Atılgan et al., 2017; Erdogan and Erdogan, 2023). In addition, GDP per capita is an important indicator for evaluating the impact of economic growth and welfare level on health expenditures in PCA analyses. This variable was used as income or GDP in the studies by Chao and Wu (2017), Getzen and Poullier (1992), Reimers and Powell (2001) and Zhang and Wan (2023). Tax revenues, which have a direct impact on health expenditures, have also been analysed in the context of health expenditure financing and budget in studies by Getzen and Poullier (1992) and Aboubacar and Xu (2017).

However, unlike the studies in the literature, this study allows policymakers and researchers to approach the issue from a more holistic perspective by evaluating the impact of multiple economic factors on health expenditures simultaneously. In this way, more informed decisions can be made in the development of health policies and management of public health expenditures.

3. Data and Methodology

3.1. Data and Data Sources

In this study, the effect of economic factors on public health expenditure in Türkiye in the period 2002-2022 is analyzed by performing PCA using STATA 18 program. The analysis was performed using annual data. The abbreviations, explanations and sources of the variables used in the study are shown in Table 1.

Table 1. **Study Variables**

Variables	Unit	Description	Source
Dependent Variable			
PHE	TL	Public health expenditures	Turkstat
Independent Variables			
GDP per capita	TL	GDP per capita	Turkstat
LFPR	%	Labor force participation rate	Turkstat
CPI	%	Consumer price index	Turkstat
FER	$	Foreign exchange rate	Turkstat
UNR	%	Unemployment rate	Turkstat
TAX	TL	Tax revenues	Ministry of Finance

3.2. Methodology

There are several reasons for using PCA as a method. The first is to reduce multicollinearity. Economic indicators are often highly correlated with each other. For example, GDP per capita and public health expenditure may have a linear relationship. PCA reduces this multicollinearity by allowing each principal component to carry independent information. PCA also helps identify the data set's main trends and patterns (Alan, 2021). It is important to see more clearly the impact of economic indicators on public health expenditure. The third reason is that PCA reduces the independent variables to a smaller number of principal components, making it easier to interpret which factors are more dominant and their potential impact on public health expenditure.

According to the analyses carried out in the paper, the formula of PCA can be explained as follows:

(i) For each economic indicator (e.g. GDP per capita, CPI, TAX), the values are averaged and divided by the standard deviation. This process eliminates scale differences between variables.

$$x_{ij}^{*} = \frac{x_{ij} - \bar{x}_j}{S_j} \tag{1}$$

where x_{ij} is the original value, $\bar{x}_j$ is the mean of the jth variable, s_j is the standard deviation of the jth variable and x_{ij}^{*} sis the standardized value.

(ii) The covariance matrix of the standardized data is calculated. This matrix contains variances and covariances between variables.

$$C = \frac{1}{n-1} X^T X \tag{2}$$

(iii) The eigenvalues and eigenvectors of the covariance matrix are calculated. Large eigenvalues represent the main sources of variance in the data set.

(iv) Principal components that explain a certain percentage of the total variance are selected. These components are a compressed form of the information in the original data set.

3.3. Research Hypotheses

The hypotheses that define the scope of the study and will help to understand in depth the relationship between public health expenditure and economic factors are as follows:

H_1: Between 2002 and 2022, certain economic factors significantly influence public health expenditure in Türkiye.

H_2: Macroeconomic variables such as GDP per capita, unemployment rate, labor force participation rate, consumer price index, tax revenue, and exchange rate have a significant impact on public health expenditure in Türkiye.

H_3: The unemployment and labor force participation rates directly and indirectly significantly affect public health expenditure in Türkiye.

H_4: Türkiye's public health expenditure is resilient to economic fluctuations, implying health financing sustainability.

4. Results

4.1. Descriptive Statistics

Before starting the analysis, descriptive statistics (such as mean, median, standard deviation, minimum, and maximum) were obtained for each variable to understand the general structure of the dataset (Table 2).

Table 2. Descriptive Statistics

	PHE	GDP per capita	LFPR	CPI	FER	UNR	TAX
Mean	9.73e+07	33998.05	48.81952	14.99095	3.878571	11.01429	5.21e+11
Std. dev.	1.07e+08	38537.99	3.103637	13.70628	4.414437	1.234215	6.06e+11
Minimum	1.33e+07	5486	43.5	6.16	1.16	9.2	5.96e+10
Maximum	4.64e+08	176651	53.2	64.27	18.7	14	2.71e+12
Variance	1.14e+16	1.49e+09	9.632565	187.862	19.48725	1.523286	3.67e+23
Skewness	2.241414	2.64008	-0.0215083	2.546138	2.323885	1.199488	2.470779
Kurtosis	7.820355	10.11822	1.76071	9.187042	7.695656	3.806551	9.238639

From the observed values, the variables PHE, GDP per capita, and TAX especially have rather high maximum values and large variances, suggesting that these variables may have heavy tails and potentially high skewness (Table 2). This could mean that the assumption of normal distribution is violated and should be considered in the analysis. Given the statistical characteristics of the data, histograms were plotted for each variable to understand the variables'

distribution better. These graphs show the shape of the distributions of the variables and possible outliers. The relationships between the variables were then analyzed using the correlation matrix.

The histogram of public health expenditure shows large values with very low frequencies, and most of the distribution is concentrated in low values. This indicates that in some periods (e.g., COVID-19), health expenditure can be exceptionally high (Figure 1).

The CPI histogram shows mostly low values, with the distribution narrowing at the other extreme for higher values. This suggests that low levels of inflation are more common overall but that there are also occasional periods of high inflation (Figure 2).

An analysis of the unemployment rate histogram shows that it is mainly concentrated between 10 and 11. This indicates that the share of the unemployed in the labour force is generally concentrated in a narrow range. This reflects the dynamics of the labor market, which may be influenced by macroeconomic stability or specific policy interventions (Figure 3).

The activity rate histogram shows that it is concentrated around a certain value (around 48) and that other values are less frequent. The participation rate can be assumed to be more homogeneously distributed in the data set, and the labor market has a relatively stable structure (Figure 4).

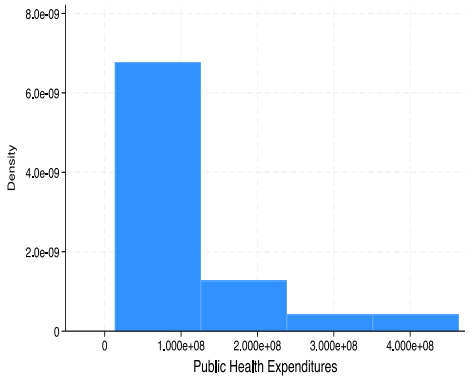

Figure 1. Public Health Expenditures

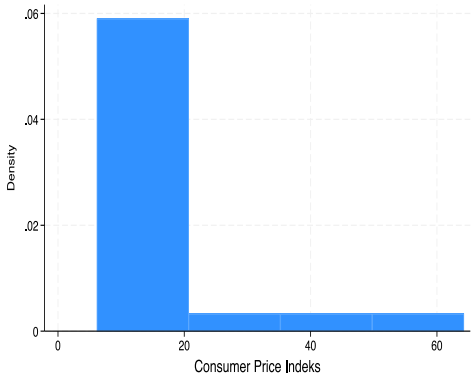

Figure 2. Consumer Price Index

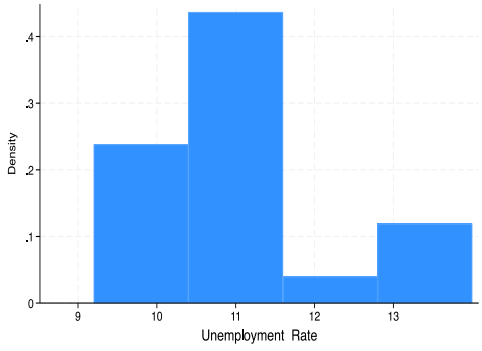

Figure 3. Unemployment Rate

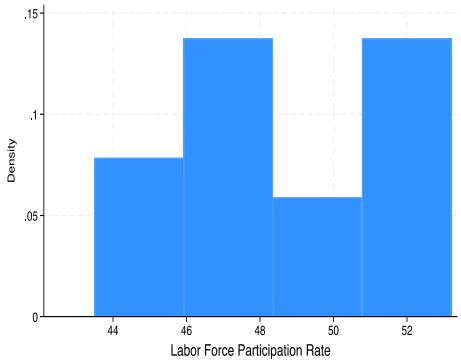

Figure 4. Labor Force Participation Rate

The exchange rate histogram shows that it has very low values at a low frequency, and a large part of the distribution is at higher values. This suggests that it tends to cluster around a particular value and may be a more volatile variable (Figure 5).

The histogram of tax revenue shows that there is a single class (the leftmost class) with a large value, and then the distribution drops rapidly. This shows that most tax revenues are low, but the distribution is characterized by a small number of high tax revenues (Figure 6).

The histogram of GDP per capita shows high values with a low frequency, which is usually characteristic of large economies. It also shows a higher frequency at lower values, indicating that the number of people with lower income levels is greater. This indicates a wide range of levels of economic activity and inequalities in income distribution (Figure 7).

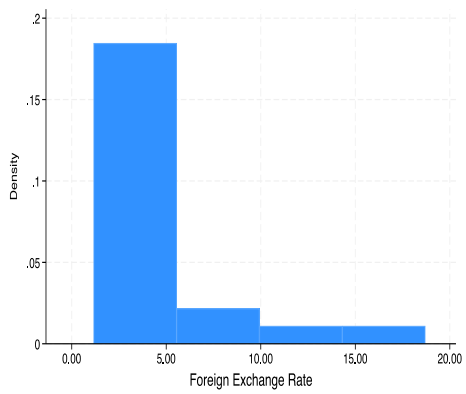

Figure 5. Foreign Exchange Rate

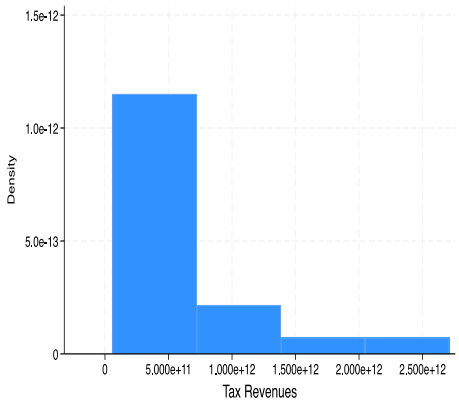

Figure 6. Tax Revenues

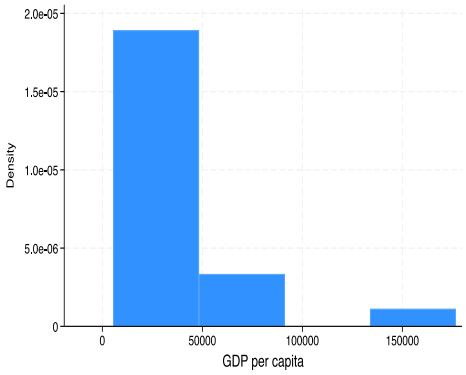

Figure 7. GDP per capita

4.2. Correlation

The pairwise correlations of the variables were calculated to understand the strength and direction of the relationship between each pair of variables. The correlation matrix calculates the Pearson correlation coefficients between each variable and presents them in a matrix format. Correlation coefficients take values between -1 and +1, where +1 indicates a fully positive

linear relationship, -1 indicates a fully negative linear relationship, and 0 indicates no relationship. High positive or negative values in the correlation matrix indicate a strong relationship between the relevant variables. If such a relationship is found, it is important to consider how to combine these variables in the PCA. Also, very high correlations (e.g. 0.8 or higher) may indicate multicollinearity problems, in which case PCA may be useful to address these problems.

Table 3. Pearson's Correlation Coefficients

Variables	PHE	GDP per capita	LFPR	CPI	FER	TAX	UNR
PHE	1.0000						
GDP per capita	0.9926	1.0000					
LFPR	0.6041	0.5988	1.0000				
CPI	0.8256	0.8463	0.4723	1.0000			
FER	0.9903	0.9795	0.5911	0.8722	1.0000		
TAX	0.9959	0.9992	0.6149	0.8378	0.9826	1.0000	
UNR	0.1587	0.1005	0.1362	-0.0908	0.1330	0.1126	1.0000

This correlation matrix shows the strength of the relationships between the variables in the dataset (Table 3). A very high correlation (0.9926) was found between PHE and GDP. This shows that health expenditure is generally closely related to the size of a country's economy. It suggests that, in general, the larger a country's economy, the more resources it can allocate to health services.

There is also a very high correlation (0.9903) between PHE and FER. This shows that changes in exchange rates can have a large impact on health expenditure. The high correlation may be because many medical supplies and pharmaceuticals are imported, and fluctuations in exchange rates directly affect the cost of these imports. As a result, when the local currency depreciates, the cost of imported medical goods increases, leading to higher public health expenditure.

The correlation between PHE and TAX is also very high (0.9959). This indicates that health expenditure is closely related to tax revenue, showing that health expenditure receives significant financing from the government budget when tax revenue increases. This relationship can be attributed to the structure of the government's budget allocation process, where increased tax revenue allows for more funds to be directed towards public services, including health. When the economy performs well, and tax revenues are high, the government has more financial resources to allocate to the health sector, enhancing the overall quality and accessibility of healthcare services.

The correlation between CPI and GDP per capita is also high (0.8463), indicating that there is a significant relationship between the size of the economy and consumer prices. On the other hand, the correlations between UNR and other variables are relatively low. This suggests that the unemployment rate may tend to move independently of other economic indicators, that unemployment may not be influenced by certain aspects of economic conditions, or that other factors may play a role in unemployment.

Given the high correlations in the data set, PCA was used to reduce its size and overcome the problems of multicollinearity. PCA simplifies the relationships between variables in the dataset by extracting independent principal components from highly correlated variables.

4.3. Principal Component Analysis

The first three principal components in the PCA analysis explain 96.95% of the total variance (Tables 4, 5, and 6). This is quite high and is generally considered sufficient for analysis. This means that they reflect most of the information in the data set. The first component alone explains 73.59% of the variance, indicating that it is a very strong component.

Table 4. **Summary of Principal Components Analysis**

Principal Components/Correlation		Number of obs	21
		Number of comp.	7
		Trace	7
Rotation:	(unrotated = principal)	Rho	1.0000

The eigenvectors (weights of the principal components) show the relationship of each principal component to the original variables. For Comp1, PHE, GDP, FER, and TAX have high positive weights, indicating that these four variables largely explain this component. This could represent the economic size and financial position. Comp2 is particularly dominated by the variable UNR. This suggests that the unemployment rate may move independently of the other variables and that this component may capture the impact of unemployment on economic factors. Comp3 is dominated by LFPR and is a component that captures labor market dynamics.

To calculate the scores of the components in the analysis, principal component scores are generated for each observation, and then regression analyses are performed using these scores. This analysis is important for understanding which economic factors influence public health expenditure. In this way, 'pc1', 'pc2', and 'pc3' variables were created. This means that most of the variance between the variables in the dataset is explained by the first four principal components.

Table 5. **Eigenvalue and Cumulative Variance Table**

Component	**Eigenvalue**	**Difference**	**Proportion**	**Cumulative**
Comp1	5.15117	4.10204	0.7359	0.7359
Comp2	1.04914	0.462684	0.1499	0.8858
Comp3	0.586452	0.394502	0.0838	0.9695
Comp4	0.191949	0.17173	0.0274	0.9970
Comp5	0.0202194	0.0192176	0.0029	0.9998
Comp6	0.00100179	0.000931681	0.0001	1.0000
Comp7	0.0000701121		0.0000	1.0000

When the loadings (eigenvectors) of the principal components are analyzed, the effects of each variable on the first four principal components are observed. For example, the variables 'PHE,' 'GDP,' 'FER', and 'TAX' have very high loadings on the first principal component (Comp1). This indicates that the first component is largely explained by these variables and that these variables represent economic size or financial condition.

Table 6. Load Vectors of Principal Components

Variable	Comp1	Comp2	Comp3	Comp4	Comp5	Comp6	Comp7
PHE	0.4350	0.0343	-0.1179	-0.2766	-0.1785	-0.7784	-0.2853
GDP per capita	0.4350	-0.0248	-0.1100	-0.2522	0.5064	0.4304	-0.5411
LFPR	0.2984	0.1614	0.9339	0.1110	-0.0098	0.0016	-0.0171
CPI	0.3874	-0.2555	-0.1792	0.8517	0.1298	-0.1013	0.0035
FER	0.4352	-0.0023	-0.1398	-0.0584	-0.7665	0.4453	0.0425
TAX	0.4359	-0.0092	-0.0874	-0.2730	0.3223	-0.0099	0.7897
UNR	0.0542	0.9523	-0.2062	0.2103	0.0574	0.0128	0.0077

In the next step, a regression model was constructed to understand the impact of economic factors on public health expenditure using these principal component values.

$$PHE = \beta_0 + \beta_1 PC1 + \beta_2 PC2 + \beta_3 PC3 + \in \quad (3)$$

Here PHE is public health expenditure. $PC1, PC2, PC3$ are the principal components obtained by PCA. $\beta_0, \beta_1, \beta_2, \beta_3$ are regression coefficients, and $\in$ is the error term.

Table 7. Principal Components Regression Analysis Results

Source	SS	df	MS	Number of obs	21	
				F(3, 17)	349.82	
Model	2.2480e+17	3	7.4935e+16	Prob > F	0.0000	
Residual	3.6416e+15	17	2.1421e+14	R-squared	0.9841	
				Adj R-squared	0.9812	
Total	2.2845e+17	20	1.1422e+16	Root MSE	1.5e+07	
PHE	**Coefficient**	**Std. Err.**	**t**	**P>|t|**	**[95% conf. interval]**	
pc1	4.65e+07	1441963	32.24	0.000	4.34e+0	4.95e+07
pc2	3669434	3195150	1.15	0.267	-3071744	1.04e+07
pc3	-1.26e+07	4273572	-2.95	0.009	-2.16e+07	-3582652
cons	9.73e+07	3193835	30.47	0.000	9.06e+07	1.04e+08

Note: The p-values indicate statistical significance: $p < 0.05$

According to the results of the regression analysis carried out in the study (Table 7), The model explains 98.41% of the observed variance (R-squared = 0.9841), which is very high and indicates that the model represents the data well. The F-test (Prob > F = 0.0000) indicates that the model is statistically significant, which means that at least one of the independent variables in the model has a significant effect on PHE. The coefficient of 'pc1' is approximately 46.5 million, indicating that the first principal component positively and strongly affects PHE. The p-value of this component is 0.000, which is highly statistically significant. The first principal component (PC1) obtained from the analysis is identified as the main factor influencing a large proportion of health expenditure. High positive loadings indicate that the variables PHE, GDP

per capita, FER and TAX strongly relate to this component. In other words, the larger and healthier the economy, the higher the public expenditure on health. The coefficient of 'pc2' is about 3.67 million, but the p-value of this component is 0.267, which is not statistically significant. UNR has a high weight on this component. This suggests that this factor does not have a direct effect on health expenditure or that its effect is masked by other factors. The coefficient of 'pc3' is about -12.6 million and the p-value is 0.009, which means that this component has a negative and statistically significant effect on the GHE. The LFPR has a significant impact on this component and tends to reduce public health expenditure. The fact that the LFPR has a high impact on this component indicates that the participation of people of working age in the labor force can have a significant impact on economic activity.

4.4. Diagnostic Tests

A homoscedasticity test was performed to test the assumptions of the regression model. The Breusch-Pagan/Cook-Weisberg test is used to test for heteroskedasticity (non-constant variance) (Table 8).

Table 8. Breusch–Pagan/Cook–Weisberg Test for Heteroskedasticity

Assumption	Normal error terms
Variable	Fitted values of PHE
H0	Constant variance
chi2(1)	0.62
Prob > chi2	0.4314

According to the results of the test, since the P-value is 0.4314, we do not have sufficient evidence to reject the null hypothesis. In this case, the data are considered to have a constant variance (homoscedasticity). This means that the errors of the regression model have a constant variance and there is no problem of heteroskedasticity. This result indicates that the model accurately reflects the characteristics and relationships and that the standard error estimates are reliable. This means that the model successfully satisfies one of the econometric assumptions and increases the robustness of the analysis.

Looking at the distribution of the points in the graph, the errors are mostly randomly distributed along a horizontal line (Figure 8). However, a slight upward trend, especially towards larger predicted values, indicates homoscedastic errors. The p-value (0.4314) obtained earlier with the Breusch-Pagan test provides strong evidence that the errors of the model have a constant variance and that there is no problem of heteroskedasticity. This graph also supports this conclusion, as it shows no evidence of an increase or decrease in the variance of the errors. However, before commenting on any irregularities or significant deviations in the graph, the Durbin-Watson test was performed to further examine the actual values of these points and their relationship with other variables in the model.

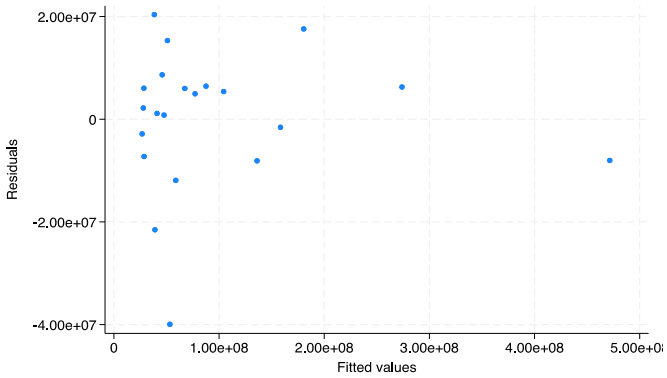

Figure 8. Distribution of Residuals

The Durbin-Watson (DW) d-statistic tests regression analysis's independence of error terms (residuals). This statistic is used to detect serial correlation (autocorrelation) between errors. The Durbin-Watson statistic usually takes a value between 0 and 4. If DW ≈ 2, it is assumed that there is no serial correlation between the errors (i.e. the errors are independent). If DW < 2, there may be a positive serial correlation. If DW > 2, there may be a negative serial correlation.

The result of the Durbin-Watson statistic is 0.6037619. This result is significantly less than 2. This may indicate positive serial correlation, i.e. one error term is positively correlated with the previous error term. Serial correlation is a common problem with time series data, and it is necessary to assess whether time is a factor in the data. If there is a positive serial correlation, it should be recognized that the standard errors of the regression model may be underestimated, making some variables appear statistically significant. This can affect the reliability of the model estimates and the accuracy of the interpretations.

The Breusch-Godfrey LM test was used to determine whether autocorrelation exists in the error terms (Table 9). If the test's p-value is below the significance level (usually 0.05 or 0.01), this is taken as evidence of autocorrelation in the model. The Breusch-Godfrey LM test results show that the chi-squared value for one lag is approximately 5.387, which is associated with 1 degree of freedom. As the p-value of this test is 0.0203, it indicates that there is a serial correlation (autocorrelation) between the errors at the 5% significance level. This indicates that there is first-order autocorrelation in the error terms in the regression model. Robust regression was performed using Newey-West standard errors to correct for autocorrelation in the model. This accounts for autocorrelation and heteroskedasticity and provides more reliable standard errors and test statistics.

Table 9. **Breusch–Godfrey LM Test for Autocorrelation**

lags(p)	**chi2**	**df**	**Prob > chi2**
1	5.387	1	0.0203

Note: H_0: No serial correlation

According to the regression results with Newey-West standard errors (Table 10), The main component pc1 has a positive and statistically significant effect on public health

expenditure (PHE). The coefficient is about 46.5 million, and its standard error is 1,016,406. The t-statistic is 45.74, and the p-value is 0.000, indicating that pc1 has a strong and significant effect on PHE. The effect of component pc2 on PHE is not statistically significant ($p > 0.05$). The coefficient is approximately 3.669.434, and its standard error is 3.573.710. The t-statistic is 1.03, and the p-value is 0.319, so we cannot say anything definite about the effect of pc2 on PHE. The main component, pc3, has a negative and statistically significant effect on PHE. The coefficient is about -12.6 million, and its standard error is 3.261.126. The t-statistic is -3.86, and the p-value is 0.001, indicating that pc3 has a significant and negative effect on PHE. The constant term represents the expected value of PHE when all other independent variables are zero and is estimated to be around 97.3 million. Its standard error is 3,872,670, and the t-statistic is 25.13, indicating that the constant is statistically significant.

Table 10. Regression with Newey–West Standard Errors

				Number of obs		21
				Maximum lag		1
					F(3, 17)	994.83
					Prob > F	0.0000
PHE	**Coefficient**	**Std. Err.**	**t**	**P>|t|**	**[95% conf.**	**interval]**
pc1	4.65e+07	1016406	45.74	0.000	4.43e+07	4.86e+07
pc2	3669434	3573710	1.03	0.319	-3870435	1.12e+07
pc3	-1.26e+07	3261126	-3.86	0.001	-1.95e+07	-5718727
cons	9.73e+07	3872670	25.13	0.000	8.92e+07	1.05e+08

As a result, pc1 and pc3 have significant effects on PHE in the model, while the effect of pc2 is not significant. According to the results of the diagnostic tests for the regression model, we can say that the model is generally in good condition. In addition, the results obtained without logarithmic transformation of the variables seem to have successfully revealed an important part in explaining the effect of economic indicators on health expenditure.

5. Conclusion

This study aims to analyze the economic factors affecting public health expenditures in Türkiye from 2002 to 2022. In the context of Türkiye, key determinants of public health expenditures are GDP per capita, tax revenues, and exchange rates. According to the PCA, the first principal component shows that GDP per capita, exchange rate, and tax revenues positively and strongly impact public health expenditures. This component generally represents the country's economic size and financial condition. As economic development increases, public health expenditures also rise. This means that the state can allocate more resources, and economic growth positively reflects on health expenditures (Ataklı-Yavuz and Yılmaztürk, 2023). A healthy economy facilitates more investment in public health services (Esen and Çelik Keçili, 2022). However, during economic downturns, health expenditures are constrained. Income levels determine individuals' access to health services and their spending on these services. Higher-income levels lead to higher health expenditures, while lower income levels restrict access to health services (Boyacıoğlu and Terzioğlu, 2022; Gerdtham and Jönsson, 2000).

Fiscal policies also play a critical role in determining health expenditures. Government funding for health expenditures largely depends on tax revenues; increases in tax revenues boost the budget allocated to health expenditures while decreases constrain them (Okunade and Suraratdecha, 2000). Increased tax revenues enable the government to invest more in health services. Sayan and Yıldırım's (2012) study also highlights the critical importance of tax policy for financing health services.

Another significant factor is exchange rates. An increase in exchange rates raises the cost of imported medical supplies and drugs, thus increasing public health expenditures. Since Türkiye's health sector heavily relies on imports, fluctuations in exchange rates directly affect health expenditures (Esen and Çelik Keçili, 2022).

According to the PCA, the unemployment rate dominates the second principal component. This component indicates that the unemployment rate moves independently of other economic variables and does not directly impact public health expenditures. This finding shows that the indirect effects of unemployment on health expenditures are limited (Coşkun Yılmaz, 2023).

Finally, the labor force participation rate dominates the third principal component. This component represents labor market dynamics. An increase in the labor force participation rate suggests more individuals are employed and tends to reduce public health expenditures. As the labor force participation rate increases, access to employer-provided health insurance improves, reducing the demand for public health services. Yetim et al. (2021) found similar results in their study on OECD countries. They showed that individuals actively participating in the workforce have fewer health problems compared to the unemployed, thus reducing public health expenditures. Atılgan et al. (2017) also highlight the reducing effect of the labor force participation rate on health expenditures.

Health expenditures cannot be easily reduced like other budget items. Firstly, health is considered a fundamental human right, and states must provide health services to their citizens (WHO, 2024). Restricting access to health services results in significant individual and societal costs. Untreated illnesses, early deaths, and productivity losses lead to negative outcomes that affect the entire society. Therefore, cuts or inadequacies in health expenditures result in irreparable damage (Human Rights Watch, 2023).

Secondly, health expenditures significantly involve externalities. One person's health directly affects the health and well-being of others. Control of infectious diseases and vaccination are good examples of this. Hence, investments in health benefit the entire society and have positive externalities (Özen and Köse, 2022).

Thirdly, health expenditures arise largely from mandatory and urgent needs. Unlike other goods and services, health is often non-deferrable or indispensable. Ensuring the continuity of financing models is essential rather than cutting expenditures (Topcu and Atasayar, 2020).

Fourthly, health forms the basis of human capital, and healthy individuals drive economic and social development. Good health increases productivity, enhances educational success, and reduces poverty. Thus, health expenditures are also an investment in the future, determining the country's development potential. Short-term savings at the expense of health expenditures can lead to heavy costs in the long term.

For these reasons, sustainable models for financing health expenditures are critical. Flexible financing methods that balance public resources, social health insurance, and personal contributions according to needs must be implemented. Ensuring fair, accessible, and quality health services is a fundamental duty of the state (Altınöz and Aslan, 2019).

In conclusion, this article highlights the multidimensional nature of economic factors affecting public health expenditures in Türkiye. Therefore, policymakers must consider the factors influencing health expenditures and establish well-designed financing mechanisms to create a resilient and inclusive health service network.

6. Limitations and Future Research

Although this study provides a comprehensive analysis of the economic factors affecting public health expenditure in Türkiye, there are some shortcomings and potential areas for future research. One of these is the limited time frame. Although the period 2002-2022 covers significant economic changes, the analysis of trends and cyclical effects over a longer period could contribute to a deeper understanding of the relationship between economic factors and health expenditure. In addition, the inclusion of different macroeconomic variables and social factors (e.g. education level, lifestyle, health awareness) could provide a more comprehensive understanding. As a suggestion for future research, Türkiye's economic and health expenditure data were not compared with those of other countries with similar economic structures or different health systems. Such comparisons would allow Türkiye's situation to be assessed from a broader perspective.

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 are no potential conflicts of interest in this study.

References

Aboubacar, B. and Xu, D. (2017). The impact of health expenditure on the economic growth in sub-Saharan Africa. *Theoretical Economics Letters,* 7(3), 615–622. https://doi.org/10.4236/tel.2017.73046

Akdağ, R. (2011). *Sağlıkta dönüşüm programı değerlendirme raporu (2003-2010).* Ankara: TC Sağlık Bakanlığı Yayınları.

Altınöz, B. and Aslan, A. (2019). Eğitim ve sağlık faktörleri bağlamında beşeri sermayenin ekonomik büyümeye katkısı: N-11 ülkeleri için bir uygulama. In A. Umut (Ed.), *3. International economic research and financial markets congress proceeding book* (pp. 183-194). Paper presented at the International Economics Research and Financial Markets Congress, Gaziantep, Türkiye.

Anderson, G.F., Hurst, J., Hussey, P.S. and Jee-Hughes, M. (2000). Health spending and outcomes: Trends in OECD Countries, 1960–1998. *Health Affairs,* 19(3), 150–157. https://doi.org/10.1377/hlthaff.19.3.150

Ataklı-Yavuz, R. and Yılmaztürk, R. G. (2023). Sağlık harcamalarının ekonomik etkileri: Türkiye örneği. *Yönetim ve Ekonomi Araştırmaları Dergisi,* 21(3), 163-175. https://doi.org/10.11611/yead.1344037

Atilgan, E., Kiliç, D. and Ertuğrul, H. M. (2017). The dynamic relationship between health expenditure and economic growth: Is the health-led growth hypothesis valid for Türkiye? *The European Journal of Health Economics,* 18(5), 567–574. https://doi.org/10.1007/s10198-016-0810-5

Bieszk-Stolorz, B. and Dmytrów, K. (2023). The well-being-related living conditions of elderly people in the European Union - Selected aspects. *Sustainability,* 15(24), 16823. https://doi.org/10.3390/su152416823

Boyacioğlu, E.Z. and Terzioğlu, M.K. (2022). Do health spending and economic growth matter in development? Evidence from Türkiye. *Ekonomi Politika ve Finans Araştırmaları Dergisi,* 7(Özel Sayı), 19-32. https://doi.org/10.30784/epfad.1147618

Chao, Y. and Wu, C.-J. (2017). Principal component-based weighted indices and a framework to evaluate indices: Results from the Medical Expenditure Panel Survey 1996 to 2011. *PLoS ONE,* 12(8), e0183997. https://doi.org/ 10.1371/journal.pone.0183997

Coşkun Yılmaz, S. (2023). The effect of health and education expenditures on the employment: Empirical evidence from Türkiye. *Journal of Economics and Research,* 4(2). https://doi.org/10.53280/jer.1357586

Dorlach, T. and Yeğen, O. (2023). Universal health coverage with private options: The politics of Türkiye's 2008 health reform. *Studies in Comparative International Development,* 58(3), 430–456. https://doi.org/10.1007/s12116-023-09402-2

Erdogan, S. and Erdogan, E.S. (2023). Analyzing the asymmetric effect of disaggregated health expenditures on economic growth. *Quality & Quantity,* 57(3), 2673–2686. https://doi.org/10.1007/s11135-022-01487-6

Erus, B. and Hatipoğlu, O. (2017). Health policy and redistribution: Türkiye's health transformation program in perspective. *Health Policy and Planning,* 32(8), 1120-1127. https://doi.org/10.1093/heapol/czx062

Esen, E. and Çelik Keçili, M. (2022). Economic growth and health expenditure analysis for Türkiye: Evidence from time series. *Journal of the Knowledge Economy,* 13, 1786–1800. https://doi.org/10.1007/s13132-021-00789-8.

Euronews. (2022). *Sağlık harcamalarının milli gelire oranı.* Retrieved from https://tr.euronews.com/saglik/2022/04/05/sagl-k-harcamalar-n-n-milli-gelire-oran-oecd-ve-ab-de-sagl-ga-en-az-pay-ay-ran-ulke-turkiy /(18/3/2024)

Focacci, C.N. (2023). Old versus young: How much do countries spend on social benefits? Deterministic modeling for government expenditure. *Quality & Quantity*, 57, 363-377. https://doi.org/10.1007/s11135-022-01371-3

Gerdtham, U.G. and Jönsson, B. (2000). International comparisons of health expenditure: Theory, data and econometric analysis. In A.J. Culyer and J.P. Newhouse (Eds.), *Handbook of health economics* (pp. 11-53), https://doi.org/10.1016/S1574-0064(00)80160-2

Gerdtham, U.-G., Søgaard, J., Andersson, F. and Jönsson, B. (1992). An econometric analysis of health care expenditure: A cross-section study of the OECD countries. *Journal of Health Economics*, 11(1), 63–84. https://doi.org/10.1016/0167-6296(92)90025-V

Getzen, T.E. and Poullier, J.P. (1992). International health spending forecasts: Concepts and evaluation. *Social Science & Medicine*, 34(9), 1057-1068. https://doi.org/10.1016/0277-9536(92)90106-M

Guo, J., Jing, Y., Nguyen, K., Fan, H., Li, X. and Kelton, C. (2008). Principal components analysis of drug expenditure and utilisation trends for major therapeutic classes in US Medicaid programmes. *Journal of Medical Economics*, 11(4), 671-694. https://doi.org/10.3111/13696990802596095

Human Rights Watch. (2023). Governments should step up public health care spending. Retrieved from https://www.hrw.org/news/2023/09/21/governments-should-step-public-health-care-spending

Jakovljevic, M., Sugahara, T., Timofeyev, Y. and Rancic, N. (2020). Predictors of (in)efficiencies of healthcare expenditure among the leading Asian economies – Comparison of OECD and non-OECD nations. *Risk Management and Healthcare Policy*, 13, 2261–2280. https://doi.org/10.2147/RMHP.S266386

Kara, A. (2013). A low quality–high cost–low satisfaction trap in public health care: A model and an efficiency-quality-welfare improving stochastic resolution. *Quality & Quantity*, 47(4), 2081–2093. https://doi.org/10.1007/s11135-011-9643-6

Kurt, S. (2015). Government health expenditures and economic growth: A Feder-Ram approach for the case of Türkiye. *International Journal of Economics and Financial Issues*, 5(2), 441–447. Retrieved from https://dergipark.org.tr/en/pub/ijefi/

Liu, Y.-H., Chang, W.-S. and Chen, W.-Y. (2019). Health progress and economic growth in the United States: The mixed frequency VAR analyses. *Quality & Quantity*, 53, 1895-1911. https://doi.org/10.1007/s11135-019-00847-z

Lorenzoni, L., Belloni, A. and Sassi, F. (2014). Health-care expenditure and health policy in the USA versus other high-spending OECD countries. *The Lancet*, 384(9937), 83–92. https://doi.org/10.1016/S0140-6736(14)60571-7

Ministry of Family, Labor and Social Services. (2020). *OECD ve AB ülkelerinde sağlık ve geri ödeme sistemleri*. Ankara: Sosyal Güvenlik Kurumu.

Munsur, A.M., Atia, A., Koffi, A.K. and Kawahara, K. (2009). Household out-of-pocket expenditures on health care in Bangladesh according to principal component analysis (PCA). *Bioscience Trends*, 3(1), 25-31. https://doi.org/10.5582/bst.3.25

Nghiem, S.H. and Connelly, L.B. (2017). Convergence and determinants of health expenditures in OECD countries. *Health Economics Review*, 7(1), 29. https://doi.org/10.1186/s13561-017-0164-4

OECD. (2024). *Health expenditure and financing* [Dataset]. Retrieved from https://stats.oecd.org/index.aspx?DataSetCode=SHA

Okunade, A.A. and Suraratdecha, C. (2000). Health care expenditure inertia in the OECD countries: A heterogeneous analysis. *Health Care Management Science*, 3(1), 31–42. https://doi.org/10.1023/a:1019020802989

Özen, A. and Köse, C.B. (2022). Türkiye'de kamu harcaması bileşenlerinin ekonomik büyümeye etkisi. *Ekonomi Politika ve Finans Araştırmaları Dergisi,* 7(1), 32-52. https://doi.org/10.30784/epfad.1006124

Panopoulou, E. and Pantelidis, T. (2011). Convergence in per capita health expenditures and health outcomes in the OECD countries. *Applied Economics*, 44(30), 3909–3920. https://doi.org/10.1080/00036846.2011.583222

Peker Say, N. and Yücel, M. (2006). Energy consumption and CO2 emissions in Türkiye: Empirical analysis and future projection based on an economic growth. *Energy Policy*, 34(18), 3870–3876. https://doi.org/10.1016/j.enpol.2005.08.024

Pekkurnaz, D. (2015). Convergence of health expenditure in OECD countries: Evidence from a nonlinear asymmetric heterogeneous panel unit root test. *Journal of Reviews on Global Economics*, 4, 76–86. https://doi.org/10.6000/1929-7092.2015.04.07

Piabuo, S.M. and Tieguhong, J.C. (2017). Health expenditure and economic growth - A review of the literature and an analysis between the economic community for central African states (CEMAC) and selected African countries. *Health Economics Review*, 7(1), 23. https://doi.org/10.1186/s13561-017-0159-1

Reimers, C.W. and Powell, L.M. (2001). Health care spending in OECD countries: A convergence analysis. *Journal of Health Economics*, 20(6), 1271-1282. https://doi.org/10.1016/S0167-6296(01)00110-2

Roberts, M.J., Hsiao, W., Berman, P. and Reich, M.R. (2008). *Getting health reform right: A guide to improving performance and equity*. Oxford: Oxford University Press.

Sayan, S. and Yıldırım, J. (2012). Inequities in health care financing in Türkiye: Redistributive effect of health care payments by households. *The European Journal of Health Economics*, 13(3), 351-364. https://doi.org/10.1007/s10198-011-0306-2

Söyük, S. (2023). The impact of public health expenditure and gross domestic product per capita on the risk of catastrophic health expenditures for OECD countries. *Frontiers in Public Health*, 11, 1122424. https://doi.org/10.3389/fpubh.2023.1122424

Sparkes, S.P., Bump, J.B., Özçelik, E.A., Kutzin, J. and Reich, M.R. (2019). Political economy analysis for health financing reform. *Health Systems and Reform*, 5(3), 183–194. https://doi.org/10.1080/23288604.2019.1633874

Sülkü, S.N. and Caner, A. (2011). Health care expenditures and gross domestic product: The Turkish case. *The European Journal of Health Economics*, 12(1), 29–38. https://doi.org/10.1007/s10198-010-0221-y

Şenol, O., Gökkaya, D. and Çirakli, Ü. (2021). The effects of economic variables on health expenditure per capita and life expectancy at birth: Panel data analysis for middle top income countries. *Mehmet Akif Ersoy Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi,* 8(3), 1499–1515. https://doi.org/10.30798/makuiibf.909994

Topcu, E. and Atasayar, Y. (2020). Sağlık harcamaları, sermaye birikimi ve ekonomik büyüme arasındaki nedensel ilişki: Gelişmiş ve gelişmekte olan ülkeler üzerine bir inceleme. *Ekonomi Politika ve Finans Araştırmaları Dergisi,* 5(2), 276-291. https://doi.org/10.30784/epfad.734004

TURKSTAT. (2023). Public health expenditures. Retrieved from https://data.tuik.gov.tr/Bulten/Index?p=49676&dil=2#

Vankar, P. (2024). *U.S. national health expenditure as percent of GDP from 1960 to 2022* [Dataset]. Retrieved from https://www.statista.com/statistics/184968/us-health-expenditure-as-percent-of-gdp-since-1960/#:~:text=In%202022%2C%20U.S.%20national%20health,GDP%20share%20among%20developed%20countries

Wang, F. (2015). More health expenditure, better economic performance? Empirical evidence from OECD countries. *INQUIRY: The Journal of Health Care Organization, Provision, and Financing*, 52, 0046958015602666. https://doi.org/10.1177/0046958015602666

Wanzala, M., Were, V., Oloo, J. and Nguka, G. (2019). Assessing capacity and performance of health systems using principal component analysis: Results from cross sectional survey in Kakamega County, Western Kenya. *Journal of Health, Medicine and Nursing*, 59, 33-40. https://doi.org/10.7176/JHMN/59-05

Wendt, C., Frisina, L. and Rothgang, H. (2010). Healthcare system types: A conceptual framework for comparison. *Social Policy & Administration*, 43(1), 70-90. https://doi.org/10.1111/j.1467-9515.2008.00647.x

WHO (1946). Constitution of the World Health Organization (WHO). Retrieved from https://www.globalhealthrights.org/instrument/constitution-of-the-world-health-organization-who/

World Bank Open Data. (2023). *Open data* [Dataset]. Retrieved from https://data.worldbank.org/indicator/SH.XPD.OOPC.CH.ZS?locations=TR

Yavuz, N.C., Yilanci, V. and Ozturk, Z.A. (2013). Is health care a luxury or a necessity or both? Evidence from Türkiye. *The European Journal of Health Economics*, 14(1), 5–10. https://doi.org/10.1007/s10198-011-0339-6

Yetim, B., İlgün, G., Çilhoroz, Y., Demirci, Ş. and Konca, M. (2021). The socioeconomic determinants of health expenditure in OECD: An examination on panel data. *International Journal of Healthcare Management*, 14(4), 1265–1269. https://doi.org/10.1080/20479700.2020.1756112

Yip, W. and Hsiao, W. (2008). The Chinese health system at a crossroads. *Health Affairs*, 27(2), 460-468. https://doi.org/10.1377/hlthaff.27.2.460

Zhang, X. and Wan, X. (2023). Research and prediction of health expenditure factors in China based on machine learning methods. In K. Li, Q. Li, P. Fournier-Viger., W-Ch. Hong., X. Liang., L. Wang and X. Xu (Eds.), *Atlantis highlights in computer sciences* (pp. 737-744). https://doi.org/10.2991/978-94-6463-040-4_112

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FİNANSAL PERFORMANSIN ÖLÇÜLMESİNDE PİOTROSKİ F-SKORU BİLEŞENLERİ VE ÇKKV YÖNTEMLERİNİN BAĞLANTISI: MEREC TABANLI MARCOS UYGULAMASI

The Nexus of Piotroski F-score Components and MCDM Methods in Measuring Financial Performance: An Application of MEREC-Based MARCOS

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Anahtar Kelimeler:
Finansal Performans,
Bilişim Sektörü,
Piotroski F-skoru
MEREC,
MARCOS

JEL Kodları:
C44, G11, G17

Öz

Bu çalışmanın amacı, Borsa İstanbul bilişim sektöründe yer alan firmaların finansal performanslarının analiz edilmesidir. 2023:Q1-2023:Q4 arasındaki dört çeyreklik dönemi kapsayan çalışmada kriterlerin ağırlıklandırılmasında MEREC yöntemi kullanılmıştır. Kriter ağırlıkları belirlendikten sonra firmaların finansal performans sıralamaları MARCOS yöntemi ile belirlenmiştir. Ayrıca çalışmada iki farklı senaryoya dayalı olarak duyarlılık analizleri yapılmış ve analiz sonucunda elde edilen bulgular karşılaştırmalı olarak incelenmiştir. Literatürdeki diğer çalışmalardan farklı olarak kriter seçiminde Piotroski F-skoru bileşenlerinden yararlanılmıştır. MEREC yöntemine göre elde edilen kriter ağırlıklarında dönemler itibariyle farklılaşma olmakla birlikte, en yüksek ağırlığa sahip kriterlerin aktif devir hızı ve aktif karlılık oranı olduğu tespit edilmiştir. Buna karşın, en düşük kriter ağırlığına cari oranın sahip olduğu görülmüştür. Çalışma sonucunda en iyi ve en düşük performansa sahip firmaların incelenen dönemler itibariyle dalgalanma gösterdiği belirlenmiştir. Bununla birlikte, sonuçlar genel olarak incelendiğinde, en iyi performansa sahip firmalar SMART ve PAPIL olmuştur. En düşük performansa sahip firmaların ise genel olarak KAREL ve OBASE olduğu tespit edilmiştir.

Keywords:
Financial Performance,
IT Sector,
Piotroski F-score,
MEREC,
MARCOS

JEL Codes:
C44, G11, G17

Abstract

The aim of this study is to analyze the financial performance of firms in the Borsa Istanbul IT sector. In the study over the period 2023:Q1-2023:Q4, the MEREC method was used to weight the criteria. After the criteria weights are determined, the financial performance rankings of the firms are determined by the MARCOS method. In addition, sensitivity analyses based on two different scenarios are conducted in the study and the findings obtained are examined comparatively. Unlike other studies in the literature, Piotroski F-score components were utilized in criteria selection. Although there is a difference in the criteria weights obtained by the MEREC method in terms of periods, it is determined that the criteria with the highest weights are asset turnover ratio and return on assets ratio. On the other hand, it was concluded that the lowest criterion weight was the current ratio. As a result of the study, it was determined that the firms with the best and the lowest performance fluctuated over the analysis periods. However, when the results are evaluated in general, the firms with the best performance are SMART and PAPIL. The firms with the lowest performance were found to be KAREL and OBASE.

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1. Giriş

Bilginin ortaya çıkması ile yayılması arasındaki farkın zamansal ve mekânsal boyutta giderek küçüldüğü günümüzde firmalar bir yandan yoğun rekabet koşulları altında varlığını devam ettirmeye çalışırken diğer taraftan ortaya atılan yenilikçi ürünlerle fark yaratmaya çalışmaktadır. Teknoloji ve inovasyonu merkezine alarak gelişim gösteren sektörlerin en önemlilerden birisi de bilişim sektörüdür. Bilişim sektöründe yaşanan hızlı değişim ve gelişmelerin sadece kendi içerisinde sınırlı kalmaması ve diğer sektördeki firmaların da iş modeli veya iş süreçleri yönüyle etkilemesi sektörün önemini daha fazla artıran unsurlar arasında yer almaktadır.

Yapay zeka, bulut teknolojileri, büyük veri çözümlemeleri ve endüstri 4.0 gibi bilişim firmalarının odağındaki yenilikçi süreçler yalnızca diğer firmaları değil insanlığı da yakından etkileyen gelişmelerdendir (Atalay ve Altın, 2020: 206). Bilişim sektöründe meydana gelen büyüme sadece sektörün değil aynı zamanda faaliyette bulunulan ülkenin ekonomik büyümesine de katkı sağlamaktadır. Firmaların bilançolarında bu büyümenin etkisiyle hızla yükselen gelirler ve karlar pek çok yatırımcının dikkatini çekmiştir (Inani ve Gupta, 2017: 127).

Bilişim sektörünün yalnızca yatırımcıların değil araştırmacıların da dikkatini çekmesiyle sektördeki firmaların finansal performansını incelemeye yönelik çok sayıda çalışma yapılmıştır. Firmaların geleceğe yönelik vereceği kararları şekillendirerek stratejik hedeflerini gerçekleştirmelerinde önemli bir yere sahip olan performans değerleme çalışmaları aynı zamanda mevcut durumun incelenmesine olanak tanımaktadır (Yılmaz Türkmen ve Çağıl, 2012: 60). Bu yönüyle yapılan çalışmalar sektörün önemini göstermesinin yanında, bu sektördeki firmaların finansal performanslarının incelenerek, geleceğe yönelik politikaların ortaya konulması açısından da önem kazanmaktadır.

Firmalarının finansal performansını inceleyen çalışmalarda değerlendirme yapılacak kriterlerin seçimi elde edilecek sonuçların üzerinde etkiye sahiptir. Bu nedenle değerlendirme kriterlerinin seçimi büyük önem kazanmaktadır. Yapılan çalışmalarda kriter seçiminde uzman görüşünden yararlanmanın yanında literatürden yararlanılarak seçilen kriterler ağırlık kazanmıştır. Bunun yanında firmanın finansal gücünün göstergesi niteliğindeki bir yaklaşım olan Piotroski F-skoru yönteminin de kriterlerin oluşturulması bağlamında öneme sahip olduğu düşünülmektedir.

Piotroski F-skoru, bir muhasebe profesörü olan Joseph Piotroski (2000) tarafından önerilen ve geliştirilen bir stratejidir. Piotroski, F-skoru yöntemini 2000 yılında özsermaye yatırım stratejisini tanıtan ve etkinliğini araştırma sonuçlarıyla kanıtlayan "Değer Yatırımı: Kazananları ve Kaybedenleri Ayırmak için Tarihsel Mali Tablo Bilgilerini Kullanmak" başlıklı makalesi ile ortaya koymuştur. F-skoru stratejisi, borsada kazanç sağlamak için temel analiz unsurlarının uygulanmasına dayanmaktadır. Yatırımcılar, mali tablolardaki verileri kullanarak hangi firmaların "kazanan", hangi firmaların "kaybeden" olduğunu belirleyebilirler. Piotroski, finansal analiz unsurlarının bir firmanın hisselerinin çekiciliğini gösterebileceğini, bunun bilinen ve kullanılan değerli yatırımlarda ek bir aşama olarak kullanılması gerektiğini belirtmiştir (Kusowska, 2021: 48).

Piotroski (2000) tarafından önerilen strateji firmaların finansal tablolarındaki verilerinin belirli ölçütlere dayalı olarak değerlendirilmesi ve nihai olarak da bu ölçütlerin puanlanmasına dayanmaktadır. Kârlılık, kaldıraç-likidite ve operasyonel verimlilik olmak üzere üç kategoriye

ayrılan dokuz finansal sinyalin analizi incelenecek her bir firma için yapılmaktadır. Firmaların finansal tablolarından elde edilen verileri önceden belirlenen ölçütlere göre incelenerek her sinyal için ikili bir derecelendirme puanı atanmaktadır. Buna göre, bir sinyal uygulaması "iyi" olarak değerlendirilirse 1, "zayıf" olarak algılanırsa 0 olarak puanlanır. Daha sonra elde edilen puanlar toplanarak firmalar için Piotroski F skoru belirlenir (Piotroski, 2000: 7). F skoruna göre, 0 ile 9 arasında değişen değer ne kadar düşük olursa firmanın iyi sinyalleri de o kadar az olacaktır. Aksine bu göstergenin değeri ne kadar yüksek olursa firmanın hisseleri yatırımcılar için o kadar cazip olacaktır (Piotroski, 2005: 181; Piotroski ve So, 2012: 2845).

Bu çalışmanın amacı, bilişim sektöründe faaliyet gösteren firmaların finansal performansını güncel ÇKKV (çok kriterli karar verme) yöntemlerinden MEREC (MEthod based on the Removal Effects of Criteria) ve MARCOS (Measurement of Alternatives and Ranking according to COmpromise Solution) yöntemleriyle değerlendirmektir. 2023:Q1-2023:Q4 arasındaki dört çeyreklik dönemi kapsayan çalışmada performans kriterleri olarak Piotroski F-skoru bileşenlerinden yararlanılmıştır. Literatür incelendiğinde, Piotroski F-skoru bileşenlerine dayalı ÇKKV yöntemleriyle performans analize yönelik bir çalışmaya rastlanılmamıştır. Bununla birlikte, ÇKKV yöntemlerinin güncel örneklerinden MEREC ve MARCOS yöntemlerini kullanarak bilişim sektöründe yapılmış bir çalışma olmaması da çalışmayı mevcut literatürden farklı kılarak özgün yanını ortaya koymaktadır.

Çalışma beş bölümden oluşmaktadır. Giriş bölümünü takiben ilgili literatüre yer verilmektedir. Üçüncü bölümde çalışmada kullanılacak yöntem tanıtılmaktadır. Dördüncü bölüm uygulamaya ayrılmışken, beşinci bölümde ise elde edilen bulgulara dayalı olarak sonuç ortaya konulmakta ve geleceğe yönelik politika önerilerinde bulunulmaktadır.

2. Literatür İncelemesi

Literatür incelendiğinde Borsa İstanbul'da (BİST) işlem gören firmaların performanslarını ÇKKV yöntemleri kullanılarak inceleyen çok sayıda çalışma yer almaktadır. Çalışmanın odağını bilişim sektörü oluşturduğundan bu sektördeki firmaların finansal performansını inceleyen çalışmalara öncelikle yer verilmiştir.

Yılmaz Türkmen ve Çağıl (2012), 2007-2010 yılları arasında BİST Bilişim sektöründe faaliyet gösteren 12 firmanın finansal performansını TOPSIS yöntemiyle incelemiştir. Finansal tablolardan elde edilen sekiz adet oran kullanılarak yapılan çalışmada firmaların finansal performansları yıllar itibariyle karşılaştırmalı olarak incelenmiştir. Ayrıca çalışmada bilişim sektöründeki firmaların yüksek tutarlı yatırımlarının geri dönüşünün uzun bir dönemde olabileceği veya beklenen seviyenin altında kalabileceğine vurgu yapılmıştır.

Inani ve Gupta (2017), 2011'den 2015'e kadar olan 5 yıllık bir dönem için Hindistan Borsasına kote bilişim sektörü firmalarının performansını analiz etmiştir. TOPSIS yöntemini kullanarak yapılan çalışmada on adet finansal rasyo üzerinden firmaların finansal performansları karşılaştırmalı olarak incelenmiştir. Çalışma sonucunda, düşük performans gösteren firmaların daha yüksek performans gösterenlerin izlediği politikaları analiz ederek stratejilerini revize etmeleri önerisinde bulunulmuştur.

Gök Kısa ve Perçin (2018), çalışmalarında 2015 yılı için Forbes Dergisinin açıkladığı Global 2000 listesinde yer alan 11 bilişim sektörü firmasının performansını ENTROPİ-VIKOR bütünleşik yöntemiyle incelemiştir. En yüksek finansal performansı gösteren firmaların sırasıyla

Apple, Hewlett-Packard ve Lenovo Group şeklinde gerçekleştiği ve yüksek performans gösteren firmalarda elde edilen sonuçların Forbes dergisi tarafından yayımlanan sıralamayla paralellik gösterdiği tespit edilmiştir.

Doğan ve Calp (2019), BİST bilişim sektöründe faaliyet gösteren firmaların 2018 yılının 12 aylık dönemini kapsayan verilerini kullanarak finansal performansını analiz etmiştir. Gri İlişkisel Analiz yöntemi kullanılarak yapılan çalışmada on altı finansal oran üzerinden yapılan analiz sonucunda, en iyi finansal performansa sahip firmanın KFEİN, en düşük finansal performansa sahip olan firmanın ise ARENA olduğu sonucuna ulaşılmıştır.

Atalay ve Altın (2020), 2014-2018 döneminde BİST'te işlem gören bilişim sektörü firmalarının performans değerlemesinin yanında, performansa göre oluşturulan portföylerin getirileri ile performans sonuçları arasındaki ilişkiyi incelemiştir. TOPSIS yönteminin kullanıldığı çalışmada on bir finansal oran üzerinde yapılan analiz sonucunda, yüksek performans gösteren ESCOM ve LINK firmalarının yıllar itibariyle üst sıralardaki yerlerini koruduğu tespit edilmiştir. Çalışmada ortaya konulan bir diğer önemli bulgu ise, yüksek performans değerine sahip firmalardan oluşan portföyde diğer firmalara göre daha yüksek portföy getirisi elde edilmesi ve bu doğrultuda performans değerleri ile portföy getirileri arasında bir uyumun tespit edilmesidir.

Turhan ve Aydemir (2021), BİST bilişim sektöründe faaliyet gösteren firmaların 2020 yılındaki verileri ile finansal performansını incelemiştir. AHP ağırlıklı Gri İlişkisel Analiz bütünleşik yöntemi kullanılarak yapılan çalışmada firmaların on iki finansal oran üzerinden finansal performansı değerlendirilmiştir.

Öndeş ve Özkan (2021), 2020 yılının ilk üç çeyreklik verilerinden yararlanarak hesaplanan sekiz finansal oran üzerinden BİST bilişim sektöründeki firmaları bütünleşik CRITIC-EDAS yöntemiyle incelemiş ve finansal performans üzerinde Covid-19 pandemisinin olası etkilerini araştırmıştır. Çalışma sonucunda, ilk çeyrek için en yüksek performans gösteren firmalar sırasıyla ARDYZ, PAPIL ve LINK iken, ikinci çeyrek için sıralamalar PAPIL, INDES ve DESPEC olarak gerçekleşmiştir. Üçüncü çeyrek sıralamaları ise INDES, PAPIL ve LINK şeklinde ortaya konulmuştur. Ayrıca, Covid-19 pandemisinin sektörü olumlu yönde etkilediğine vurgu yapılmıştır.

Gürkan ve Aldoury (2021) 2017-2019 arasında üç yıllık bir dönem için BİST'te işlem gören on beş teknoloji firmasının finansal performansını TOPSIS yöntemiyle incelemiştir. Finansal tablolardan elde edilen sekiz oran kullanılarak yapılan çalışmada firmaların yıllar itibariyle performansları incelenmiş ve tüm dönemler dikkate alınarak en başarılı firmaların LINK, DGATE ve INDES olduğu tespit edilmiştir. Ayrıca çalışmada, başarılı kabul edilen firmaların nasıl bir finansal yapıya sahip olduğuna yönelik analiz yapılarak, başarılı firmalardaki finansal yapı için optimal değerler elde edilmiştir.

Sakarya ve İlkdoğan (2022), çalışmalarında BİST'te işlem gören bilişim sektörü firmalarının finansal performanslarını nakit akışı temelli finansal oranlara dayalı olarak CRITIC-TOPSIS bütünleşik yaklaşımıyla değerlendirmişlerdir. 2017- 2021 dönemini kapsayan çalışma sonuçlarına göre yıllar itibariyle en başarılı firmalar sırasıyla KRONT, LINK, LINK, INDES ve LINK olarak gerçekleşmiştir. Buna karşın en başarısız firmalar yıllar itibariyle DESPC, NETAS, DGATE, DESPC ve NETAS şeklinde gerçekleşmiştir.

Aktaş (2022), BİST bilişim sektöründe faaliyet gösteren firmaların 2019-2020 yıllarında pandemi öncesi ve sırasındaki finansal performansını karşılaştırmalı olarak incelemiştir. PROMETHEE yönteminin kullanıldığı çalışmada performans değerlendirmede yedi farklı oran ile inceleme yapılmış ve her iki dönem için en yüksek performans gösteren firmaların ARDYZ, LİNK ve FONET olduğu, buna karşın en düşük performansın ARMDA ve NETAŞ firmalarında gerçekleştiği sonucuna varılmıştır. Pandemi döneminde öncesine göre bilişim firmalarındaki karlılık oranlarda yükseliş olduğu çalışmada elde edilen bir diğer önemli bulgudur.

Tüminçin vd. (2022), 2016-2021 yılları arasında BİST bilişim sektöründeki on altı firmanın finansal performansı ile Covid-19 pandemisi ilişkisini on üç finansal rasyo verisine dayalı olarak incelemiştir. ENTROPİ-PROMOTHEE bütünleşik yaklaşımının kullanıldığı çalışmada firmaların finansal performansları karşılaştırmalı olarak incelenmiş ve covid-19 etkisinin bilişim sektörü açısından olumlu olduğuna dikkat çekilmiştir.

Sakarya ve Erayman (2022), 2017-2020 yılları arasında BİST bilişim sektöründeki firmaların finansal performansını nakit akış tablosuna dayalı finansal oranları kullanarak analiz etmiştir. PROMETHEE yönteminin kullanıldığı çalışma sonucunda firmaların finansal performanslarının incelenen dönem için dalgalanma gösterdiği ve her dönem için istikrarlı olarak üst sıralamalarda yer alan bir firmanın olmadığı ortaya konulmuştur.

Ergül ve Kondak (2023), çalışmalarında BİST bilişim sektörü firmalarının 2016-2021 dönemindeki verilerinden yararlanarak on dört farklı finansal rasyo hesaplamış ve finansal performansı COPRAS ve TOPSIS yöntemleriyle karşılaştırmalı olarak incelemiştir. Çalışma sonucunda her iki yönteme göre elde edilen finansal performans sıralamalarının birbiriyle önemli ölçüde uyumlu olduğu tespit edilmiştir.

Pala (2023), BİST teknoloji ve bilişim sektöründe faaliyet gösteren firmaların 2010-2021 yılları arasındaki finansal performansını hesaplanan on beş finansal oran yardımıyla incelemiştir. CRITIC yöntemiyle elde edilen ağırlıklandırmanın ardından GİA ve WASPAS yöntemleriyle firmaların finansal performansları karşılaştırmalı olarak incelenmiştir. WASPAS yöntemine göre en iyi performans gösteren firmaların KRONT ve LINK olduğu, GİA yönteminde ise KRONT firmasının genel olarak üst sıralarda yer almasıyla birlikte sonuçların daha fazla dalgalanma gösterdiği sonucuna ulaşılmıştır. Ayrıca çalışmada, WASPAS yönteminin dönemler itibariyle daha tutarlı sonuçlar ortaya koyduğu gösterilmiştir.

Baysal vd. (2023), BİST bilişim sektöründeki firmaların 2022 yılındaki finansal performansını TOPSIS yöntemiyle incelemiştir. Çalışma sonucunda en yüksek performansı ARDYZ firmasının sergilediği ve bunu sırasıyla LOGO ve KFEIN firmalarının izlediği tespit edilmiştir.

Yenilmezel Alıcı ve Ertuğrul (2023), 2021 yılında BİST bilişim sektöründe faaliyet gösteren firmaların finansal performanslarını finansal tablolardan hesaplanan sekiz finansal oran kullanarak incelemiştir. CILOS-CoCoSo bütünleşik yöntemi kullanılarak yapılan çalışmada, en iyi performansı FONET firmasının sergilediği sonucuna ulaşmıştır.

Daha az sayıdaki çalışmaların bilişim sektörüne odaklanmakla birlikte, MEREC-MARCOS bütünleşik yaklaşımını kullanarak yapılan bir çalışmaya rastlanılmamıştır. Tablo 1'de MARCOS ve MEREC yöntemlerini kullanarak yapılmış güncel çalışmalardan örnekler incelenmiştir.

Tablo 1. MARCOS ve MEREC ÇKKV Teknikleri ile Yapılmış Çalışmalar

Yazar	Yöntem	Çalışmanın Amacı
Ayçin ve Arsu (2022)	MARCOS ve MEREC	Sosyal Gelişme Endeksine göre ülkelerin performansının değerlendirilmesi
Gençtürk vd. (2021)	CRITIC ve MARCOS	Covid-19 pandemisinin katılım bankaları üzerindeki etkisinin araştırılması
Çınaroğlu (2021)	CRITIC ve MARCOS	Türkiye'deki üniversitelerin yenilikçilik ve girişimcilik performansının analizi
Altıntaş (2022)	MABAC ve MARCOS	Avrupa ülkelerindeki enerji inovasyon puanlarına göre performans analizi
Stević vd. (2020)	MARCOS	Sağlık sektöründe en uygun tedarikçi seçimi
Kara vd. (2024)	MEREC ve AROMAN	Türkiye'nin sınır komşuları karşısındaki sürdürülebilir rekabetçilik durumunun değerlendirilmesi
Turanboy vd. (2024)	MEREC ve MAIRCA	Şehir hastanelerinin kapasite performanslarının değerlendirilmesi
Sümerli Sarıgül vd. (2023)	MEREC, MARCOS ve CoCoSo	Havaalanlarının hizmet kalitesinin değerlendirilmesi
Arman ve Organ (2023)	MEREC ve CoCoSo	Avrupa Birliğine üye ve aday ülkelerdeki lojistik performansların değerlendirilmesi
Yalman vd. (2023)	MEREC, LOPCOW ve MARCOS	Türkiye ekonomisinin makroekonomik performansının değerlendirilmesi
Mastilo vd. (2024)	MEREC ve MARCOS	Bosna Hersek'te bankacılık sektörünün performansının değerlendirilmesi

3. Metodoloji

Çalışma kapsamında BİST bilişim sektöründeki firmaların 2023:Q1-2023:Q4 dönemindeki dört çeyreklik performansları analiz edilmiştir. Firmaların performans analizinin yapılmasında MEREC tabanlı MARCOS yöntemi kullanılmıştır. Ayrıca, kriter ağırlıklandırmada MEREC yönteminin yanında iki farklı senaryo oluşturularak duyarlılık analizleri yapılmış ve sonuçlar karşılaştırmalı olarak incelenmiştir. Çalışmada incelenen dönem için sürekli endeks kapsamındaki Tablo 2'de gösterilen 29 bilişim sektörü firması yer almaktadır.

Tablo 2. BİST Bilişim Sektörü Firmaları

No	Kod	Firma Adı	No	Kod	Firma Adı
1	ALCTL	Alcatel Lucent Teletaş	16	KRONT	Kron Teknoloji
2	ARDYZ	ARD Bilişim Teknolojileri	17	LINK	Link Bilgisayar
3	ARENA	Arena Bilgisayar	18	LOGO	Logo Yazılım
4	ATATP	ATP Yazılım	19	MANAS	Manas Enerji Yönetimi
5	AZTEK	Aztek Teknoloji	20	MIATK	Mia Teknoloji
6	DESPC	Despec Bilgisayar	21	MOBTL	Mobiltel İletişim
7	DGATE	Datagate Bilgisayar	22	MTRKS	Matriks Bilgi Dağıtım
8	EDATA	E-Data Teknoloji	23	NETAS	Netaş Telekom.
9	ESCOM	Escort Teknoloji	24	OBASE	Obase Bilgisayar
10	FONET	Fonet Bilgi Teknolojileri	25	PAPIL	Papilon Savunma
11	HTTBT	Hitit Bilgisayar	26	PENTA	Penta Teknoloji Ürünleri Dağıtım
12	INDES	İndeks Bilgisayar	27	PKART	Plastikkart
13	INGRM	Ingram Bilişim	28	SMART	Smartiks Yazılım
14	KAREL	Karel Elektronik	29	VBTYZ	VBT Yazılım
15	KFEIN	Kafein Yazılım			

Kaynak: Finnet Hisse Expert

Çalışmada finansal performans incelemesinde kullanılacak kriterlerin seçiminde Piotroski F-skoru bileşenlerinden yararlanılmıştır. Piotroski F-skorunu hesaplamak için toplam 9 kriter kullanılır ve bunlar ayrıca 3 gruba ayrılır (Rangapriya ve Meenakumari, 2021: 118-119; He ve Tan, 2022: 92-93):

Karlılık;

1. Aktif Karlılığı (ROA-Return on Assets) (ROA pozitif olduğunda F-skoru 1, aksi durumda 0)

2. Faaliyetlerden elde edilen nakit akışı (CFO-Cash Flow from Operating Activities) (CFO pozitifse F-skoru 1, aksi halde 0)

3. Aktif Karlılığındaki Değişim (ROA) (ΔROA sıfırdan büyükse F-skoru 1, aksi takdirde 0)

4. Tahakkuk (CFO, ROA'dan büyükse F-skoru 1 değerine sahiptir, aksi takdirde 0)

Kaldıraç, Likidite ve Yeni Hisse İhracı;

5. Kaldıraç (uzun vadeli) oranındaki değişiklik (oran bir önceki yıla göre düşerse F-skoru 1, aynı kalırsa veya artarsa 0)

6. Cari orandaki değişim (bir önceki yıla göre azalmışsa F-skoru 1, aynı kaldıysa veya arttıysa 0)

7. Hisse sayısındaki değişiklik (ilave hisse ihraç edilmemesi durumunda F-skoru 1, aksi takdirde 0)

Operasyonel Verimlilik;

8. Brüt kar marjındaki değişim (cari yılın oranı ile önceki yılın oranı arasındaki fark sıfırdan büyükse F-skoru 1, aksi takdirde 0)

9. Aktif devir hızındaki değişiklikler (cari yılın oranı ile önceki yılın oranı arasındaki fark sıfırdan büyükse F-skoru 1, aksi takdirde 0)

Çalışmada bilişim sektörü firmalarının finansal performansının incelenmesinde kullanılacak kriterlerin seçiminde hisse sayısındaki değişiklik bileşeni dışındaki 8 ayrı Piotroski F-skoru bileşeninden yararlanılmıştır. Finnet veri tabanı kullanılarak elde edilen kriterler Tablo 3'de yer almaktadır.

Tablo 3. Finansal Performans Kriterleri

Kriter No/Kod	Oran	Oran Yönü
K1	Net Kar Büyüme (%)	Maks.
K2	İşletme Faaliyetlerinden Elde Edilen Nakit Akışlarındaki Büyüme Oranı (%)	Maks.
K3	Aktif Karlılık Oranı (%)	Maks.
K4	Esas Faaliyet Karı Büyüme Oranı (%)	Maks.
K5	Finansal Kaldıraç Oranı (%)	Min.
K6	Cari Oran (%)	Maks.
K7	Brüt Kar Marjı (%)	Maks.
K8	Aktif Devir Hızı (%)	Maks.

3.1. MEREC Yöntemi

ÇKKV yöntemlerinden biri olan MEREC yöntemi, kriterlerin objektif ağırlıklarının elde edilmesinde kullanılmakta olup, Keshavarz-Ghorabaee vd. (2021) tarafından literatüre kazandırılmıştır. MEREC yöntemine göre her bir kriterin eksiltilmesiyle alternatiflerin performansı üzerindeki etkisi dikkate alınarak objektif kriter ağırlıkları belirlenir. Başka bir ifadeyle, kriterlere önem ağırlığı saptanmasında o kriterin ortadan kaldırılması durumundaki toplam kriter ağırlığındaki değişiklik dikkate alınır. Nihai olarak, alternatiflerin performansı üzerinde daha yüksek etkiye sahip kriterlere daha büyük önem ağırlıkları atanmaktadır (Keshavarz-Ghorabaee vd. 2021: 7; Ayçin ve Arsu, 2022: 78). MEREC yönteminin uygulanmasında izlenen altı aşamaya aşağıda yer verilmektedir (Keshavarz-Ghorabaee vd. 2021: 7-9; Ayçin ve Arsu, 2022: 78; Yalman vd. 2023: 67).

Aşama 1: Karar matrisi *m* sayıda alternatif ve *n* sayıda kriter dikkate alınarak oluşturulur.

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \quad (1)$$

Eşitlik (1)'de yer alan x_{ij} değeri, *j*. kritere göre (*j*=1,2, …, n) *i* alternatifinin (*i*= 1,2, ….m) aldığı değeri göstermektedir. MEREC yönteminin uygulanmasında karar matrisi içerisinde yer alan değerlerin pozitif olması gerekmektedir. Pozitif olmayan değerler sonraki aşamalardaki logaritmik hesapların yapılmasında engel oluşturmaktadır. Bu nedenle, karar matrisi elemanlarının içerisindeki pozitif olmayan değerlerin dönüştürülmesi gerekmektedir. Bu çalışmada karar matrisindeki pozitif olmayan değerlerin dönüştürülmesinde Zhang vd. (2014) tarafından ortaya konulan Z skoru tekniğinden yararlanılmıştır. Bu tekniğin uygulama aşamaları Eşitlik (2) ve (3)'te gösterilmiştir (Zhang vd. 2014: 3; Ersoy, 2022: 1007).

$$Z_{ij} = \frac{x_{ij} + \bar{x}_i}{s_i} \quad (2)$$

Eşitlik (2)'deki x_{ij} *i*. alternatifin *j*. kritere göre aldığı değeri, $\bar{x}_i$ ve s_i değerleri ise sırasıyla ortalama ve standart sapmayı göstermektedir. Z_{ij} ise *i*. indekse ait *j*. bölgede yer alan standartlaştırılmış veriyi göstermektedir. Ardından Eşitlik (3) yardımıyla karar matrisi elemanları pozitif hale getirilir.

$$Z'_{ij} = Z_{ij} + A \qquad A > \left|\min Z_{ij}\right| \quad (3)$$

Z'_{ij} dönüşümden sonraki standartlaştırılmış değeri ifade etmektedir. Dönüşüm yapıldıktan sonra tüm değerler sıfırdan büyük olmalıdır. Burada A öteleme değerini ifade etmektedir. Dönüşüm için belirlenen A değerinin $\left|\min Z_{ij}\right|$ değerine yakın olması değerlendirme sonucunun daha anlamlı olmasını sağlamaktadır (Demir ve Arslan, 2022: 1033). Bu nedenle matrislere Z skoru tekniği uygulanırken $A > \left|\min Z_{ij}\right|$ koşulunu sağlayacak en yakın pozitif değerin seçilmesine dikkat edilmiştir.

Aşama 2: Fayda ve Maliyet yönlü kriterlere göre karar matrisinin normalize edilir.

$$n_{ij}^{x} = \begin{cases} \dfrac{\min\limits_{k} x_{kj}}{x_{ij}} & j \in F \\ \dfrac{x_{ij}}{\max\limits_{k} x_{kj}} & j \in M \end{cases} \tag{4}$$

Bu aşamada matristeki her bir kriterin fayda veya maliyet yönlü olmasına göre Eşitlik (4)'te verilen işlemler uygulanılarak normalize edilir. Eşitlik (4)'teki n_{ij}^{x} değeri i alternatifinin j kriterine göre normalize edilmiş değerini ifade eder. F ve M ise sırasıyla fayda ve maliyet yönlü kriterleri ifade etmektedir.

Aşama 3: Alternatiflerin genel performans değerleri (S_i) tüm kriterler dikkate alınarak hesaplanır.

$$S_i = \ln\left(1 + \left(\frac{1}{n}\sum_{j}\left|ln\left(n_{ij}^{x}\right)\right|\right)\right) \tag{5}$$

Her bir alternatif için oluşan performans değerleri (S_i), Eşitlik (5)'deki formüle göre hesaplanır. Hesaplama yapılırken ele alınan kriterlere eşit önem ağırlığı verilmektedir.

Aşama 4: Her bir kriter değerinin ayrı ayrı çıkartılmasıyla alternatiflerin performans değerleri (S'_{ij}) elde edilir.

$$S'_{ij} = \ln\left(1 + \left(\frac{1}{n}\sum_{k,k\neq j}\left|ln\left(n_{ij}^{x}\right)\right|\right)\right) \tag{6}$$

Bu aşamada bir önceki aşamadan farklı olarak alternatiflerin performans değerlerinin elde edilmesinde her bir alternatif için sırayla her bir kriter eksiltilir ve S'_{ij} değeri hesaplanır.

Aşama 5: Mutlak farkların toplamı (E_J) hesaplanır.

$$E_j = \sum_{i}\left|S'_{ij} - S_i\right| \tag{7}$$

Eşitlikte yer alan E_j değeri *j*. kriterin çıkarılma etkisini göstermektedir.

Aşama 6: Her bir kriterin objektif önem ağırlığı (w_j) hesaplanır.

$$W_j = \frac{E_j}{\sum_{\mathrm{k}} \mathrm{E_k}} \tag{8}$$

Eşitlik (8)'in uygulanmasıyla elde edilen W_j değeri *j*. kriterin önem ağırlığını ifade etmektedir.

3.2. MARCOS Yöntemi

Alternatifler ve referans değerleri arasındaki ilişkiye dayanan MARCOS yöntemi, alternatiflerin sıralanmasında kullanılan ve Stevic vd. (2020) tarafından öne sürülen bir yaklaşımdır. Bir alternatifin ideal ve ideal olmayan çözüme göre durumunu ifade eden fayda

fonksiyonları kullanılarak çözüme ulaşılır. Bu yaklaşıma göre en iyi çözüm ideal duruma en yakın ve aynı zamanda ideal olmayan duruma en uzak konumdaki çözümdür (Stevic vd. 2020: 3-4; Ayçin ve Arsu, 2022: 79).

MARCOS yönteminin uygulanmasında izlenen aşamalar aşağıdaki gibidir (Stevic vd. 2020: 4-5; Ayçin ve Arsu, 2022: 79-80).

Aşama 1: Karar matrisi *m* sayıda alternatif ve *n* sayıda kritere göre oluşturulması

$$X = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_m \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \cdots & C_n \end{array} \\ \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \end{array} \tag{9}$$

Aşama 2: Genişletilmiş karar matrisi oluşturulması

$$X = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_m \\ A_{AAI} \\ A_{AI} \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \cdots & C_n \end{array} \\ \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \\ x_{aai1} & x_{aai2} & \cdots & x_{aain} \\ x_{ai1} & x_{ai2} & \cdots & x_{ain} \end{bmatrix} \end{array} \tag{10}$$

Genişletilmiş karar matrisindeki ideal ve ideal olmayan değerler Eşitlik (11) ve (12)'den yararlanılarak hesaplanır.

$$AI = mak\ x_{ij}\ eğer\ j \in F\ \ ve\ \ min\ x_{ij}\ eğer\ j \in M \tag{11}$$

$$AAI = min\ x_{ij}\ eğer\ j \in F\ \ ve\ \ mak\ x_{ij}\ eğer\ j \in M \tag{12}$$

Bu aşamada, ilk aşamada elde edilen karar matrisine ideal ve ideal olmayan değerler eklenmektedir. Eşitlik (11)'deki AI ideal çözüm değerlerini, F ve M değerleri ise sırasıyla Fayda ve Maliyet yönlü kriterleri ifade etmektedir. Eşitlik (12)'deki AAI ideal olmayan çözüm değerlerini, F ve M değerleri ise sırasıyla Fayda ve Maliyet yönlü kriterleri ifade etmektedir.

Aşama 3: Genişletilmiş karar matrisinin normalizasyonu

$$X = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_m \\ A_{AAI} \\ A_{AI} \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \cdots & C_n \end{array} \\ \begin{bmatrix} n_{11} & n_{12} & \cdots & n_{1n} \\ n_{21} & n_{22} & \cdots & n_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ n_{m1} & n_{m2} & \cdots & n_{mn} \\ n_{aai1} & n_{aai2} & \cdots & n_{aain} \\ n_{ai1} & n_{ai2} & \cdots & n_{ain} \end{bmatrix} \end{array} \tag{13}$$

Normalize karar matrisinin elemanları fayda veya maliyet yönlü olmasına göre Eşitlik (14) ve (15)'den yararlanılarak hesaplanır.

$$n_{ij} = \frac{x_{ij}}{x_{ai}}\ eğer\ j\ \in F \tag{14}$$

$$n_{ij} = \frac{x_{ai}}{x_{ij}} \; eğer \; j \in M \tag{15}$$

Eşitliklerde yer alan n_{ij} $i.$ alternatifin $j.$ kritere göre normalize edilmiş değerini temsil etmektedir.

Aşama 4: Kriter ağırlığına göre Genişletilmiş karar matrisinin ağırlıklandırılması

$$v_{ij} = n_{ij} \times w_j \tag{16}$$

$$V = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_m \\ A_{AAI} \\ A_{AI} \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \cdots & C_n \end{array} \\ \begin{bmatrix} v_{11} & v_{12} & \cdots & v_{1n} \\ v_{21} & v_{22} & \cdots & v_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ v_{m1} & v_{m2} & \cdots & v_{mn} \\ v_{aai1} & v_{aai2} & \cdots & v_{aain} \\ v_{ai1} & v_{ai2} & \cdots & v_{ain} \end{bmatrix} \end{array} \tag{17}$$

Her bir kriterin ağırlık değerine göre bir önceki aşamada elde edilen matris değerleri ağırlıklandırılır. Burada v_{ij} , normalize edilmiş karar matrisi elemanlarının kriter ağırlıkları ile çarpılmasıyla elde edilen değeri ifade etmektedir.

Aşama 5: Alternatiflerin fayda derecelerinin ölçülmesi

Ağırlıklandırılmış karar matrisi elemanlarının toplamından elde edilen S_i değeri hesaplanır.

$$S_i = \sum_{i=1}^{n} v_{ij} \tag{18}$$

Alternatiflerin ideal ve anti ideal çözüme göre fayda dereceleri sırasıyla Eşitlik (19) ve Eşitlik (20)'den yararlanılarak hesaplanır.

$$K_i^+ = \frac{S_i}{S_{ai}} \tag{19}$$

$$K_i^- = \frac{S_i}{S_{aai}} \tag{20}$$

Eşitlik (19) ve (20)'de yer alan K_i^+ve K_i^-değerleri sırasıyla alternatiflerin ideal ve ideal olmayan çözüme göre fayda derecelerini ifade etmektedir.

Aşama 6: Alternatiflerin fayda fonksiyonlarının belirlenmesi $f(K_i)$ ve sıralanması

$$f(K_i^+) = \frac{K_i^-}{K_i^+ + K_i^-} \tag{21}$$

$$f(K_i^-) = \frac{K_i^+}{K_i^+ + K_i^-} \tag{22}$$

İdeal ve ideal olmayan çözüme göre elde edilen fayda fonksiyonları sırasıyla Eşitlik (21) ve Eşitlik (22)'den yararlanılarak hesaplanır. Bu değerler Eşitlik (23)'de kullanılmakta ve nihai çözüm elde edilmektedir.

$$f(K_i) = \frac{K_i^+ + K_i^-}{1 + \frac{1-f(K_i^+)}{f(K_i^+)} + \frac{1-f(K_i^-)}{f(K_i^-)}} \quad (23)$$

Eşitlik (21)'de yer alan $f(K_i^+)$ ideal çözüme göre fayda fonksiyonunu ifade etmektedir. Eşitlik (22)'de yer alan $f(K_i^-)$ ise, ideal olmayan çözüme göre fayda fonksiyonunu ifade etmektedir. $f(K_i)$ değeri alternatiflerin fayda fonksiyonunu ifade etmekte ve elde edilen en yüksek değer en iyi alternatif olmak üzere performans sıralamasında kullanılmaktadır.

4. Bulgular

Çalışmanın bu bölümünde kriter ağırlıklandırmada kullanılan MEREC yöntemi ve alternatiflerin sıralamasında kullanılan MARCOS yöntemine ilişkin örnek uygulamaya yer verildikten sonra yöntemlerin uygulanmasıyla elde edilen bulgulara ve bu bulgulara ilişkin değerlendirmelere yer verilecektir.

4.1. Kriter Ağırlıklarının Hesaplanmasında MEREC Yöntemi Uygulaması

BİST bilişim sektörü firmaları üzerinde Piotroski F-skoru bileşenlerine dayalı kriterlerin ağırlıklandırılmasında 2023 yılının üçüncü çeyreğine ait örnek uygulama adımlarına Tablo 4-8 aralığında yer verilmiştir. MEREC yönteminin uygulanmasında karar matrisi içerisinde negatif değerin yer alması, sonraki aşamalardaki logaritmik matematiksel hesaplamalara engel oluşturmaktadır. Tablo 10'da yer alan 2023 yılının üçüncü çeyreğine ait karar matrisi elemanlarında negatif değer yer aldığından Eşitlik (2) ve (3)'te yer alan adımlar uygulanmış ve veriler pozitife dönüştürülmüştür. Bu doğrultuda Eşitlik (3)'te yer alan A değeri 2023 üçüncü çeyrek için A= 1.80 alınmıştır. Zhang vd. (2014) tarafından öne sürülen Z skoru tekniği uygulanarak, pozitife dönüştürülmüş karar matrisi Tablo 4'te yer almaktadır.

Tablo 4. Karar Matrisi

Kriter Yönü	Maks.	Maks.	Maks.	Maks.	Min.	Maks.	Maks.	Maks.
	K1	K2	K3	K4	K5	K6	K7	K8
ALCTL	1.14	1.02	0.99	0.39	0.98	1.88	1.03	1.22
ARDYZ	2.03	5.75	3.12	2.42	1.08	1.47	3.28	0.98
ARENA	1.26	1.33	0.76	2.03	3.20	1.32	0.72	2.89
ATATP	1.69	2.52	2.27	3.31	1.01	1.56	2.00	1.31
AZTEK	1.63	1.33	2.39	2.16	2.10	1.42	1.32	3.41
DESPC	1.51	1.55	0.88	1.71	3.04	1.33	0.74	2.86
DGATE	1.00	1.83	0.71	1.64	2.93	1.34	0.75	2.95
EDATA	2.02	1.33	2.75	0.86	1.54	1.50	0.89	1.63
ESCOM	1.26	0.43	0.65	0.85	0.04	1.23	3.68	0.18
FONET	1.95	2.11	1.75	1.00	1.18	1.33	1.89	0.75
HTTBT	2.06	1.95	1.14	1.73	0.40	1.94	2.04	0.57
INDES	1.49	1.33	1.05	1.91	3.10	1.33	0.74	3.16
INGRM	1.71	0.43	0.75	1.35	2.95	1.36	0.70	2.29
KAREL	1.26	1.33	0.41	1.72	2.91	1.30	1.08	1.49
KFEIN	1.83	3.42	2.01	1.98	1.08	1.66	1.33	1.73
KRONT	1.08	2.57	1.66	0.89	1.71	1.42	3.28	0.95
LINK	1.29	1.33	2.89	1.32	0.26	4.64	3.24	0.62

Tablo 4. Devamı

LOGO	1.30	1.39	1.73	0.97	1.96	1.25	3.01	0.89
MANAS	0.97	1.33	0.93	3.69	2.28	1.34	3.01	0.80
MIATK	1.79	1.46	3.22	1.90	0.87	1.63	2.65	1.59
MOBTL	1.40	1.33	0.97	1.44	1.17	1.36	0.90	1.28
MTRKS	1.71	2.00	3.50	1.38	1.22	1.36	1.50	2.42
NETAS	1.26	1.33	0.67	2.05	3.63	1.26	0.79	1.44
OBASE	1.41	0.50	1.23	0.85	0.97	1.47	0.89	1.03
PAPIL	1.50	1.81	3.95	0.85	0.45	5.90	1.62	0.40
PENTA	1.40	1.33	0.79	1.51	2.45	1.38	0.77	2.85
PKART	2.49	1.33	0.93	1.05	2.67	1.33	0.70	2.86
SMART	6.65	2.64	2.79	5.38	0.90	1.39	3.29	0.94
VBTYZ	1.20	1.33	2.40	0.94	1.25	1.60	1.44	3.82

Karar matrisi oluşturulduktan sonra Eşitlik (4)'te yer alan hesaplamalar yapılmış ve normalize karar matrisi Tablo 5'deki gibi oluşturulmuştur.

Tablo 5. Normalize Karar Matrisi

Kriter Yönü	**Maks.**	**Maks.**	**Maks.**	**Maks.**	**Min.**	**Maks.**	**Maks.**	**Maks.**
	K1	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**
ALCTL	0.85	0.42	0.41	1.00	0.27	0.66	0.68	0.15
ARDYZ	0.48	0.07	0.13	0.16	0.30	0.84	0.21	0.19
ARENA	0.76	0.32	0.54	0.19	0.88	0.93	0.96	0.06
ATATP	0.57	0.17	0.18	0.12	0.28	0.79	0.35	0.14
AZTEK	0.59	0.32	0.17	0.18	0.58	0.87	0.53	0.05
DESPC	0.64	0.28	0.47	0.23	0.84	0.93	0.94	0.06
DGATE	0.96	0.23	0.58	0.24	0.81	0.92	0.93	0.06
EDATA	0.48	0.32	0.15	0.45	0.42	0.82	0.78	0.11
ESCOM	0.76	0.99	0.63	0.46	0.01	1.00	0.19	1.00
FONET	0.50	0.20	0.23	0.39	0.33	0.93	0.37	0.24
HTTBT	0.47	0.22	0.36	0.22	0.11	0.63	0.34	0.32
INDES	0.65	0.32	0.39	0.20	0.85	0.93	0.94	0.06
INGRM	0.57	1.00	0.54	0.29	0.81	0.91	1.00	0.08
KAREL	0.76	0.32	1.00	0.22	0.80	0.95	0.65	0.12
KFEIN	0.53	0.12	0.20	0.20	0.30	0.74	0.52	0.11
KRONT	0.90	0.17	0.25	0.44	0.47	0.87	0.21	0.19
LINK	0.75	0.32	0.14	0.29	0.07	0.27	0.22	0.29
LOGO	0.74	0.31	0.24	0.40	0.54	0.99	0.23	0.21
MANAS	1.00	0.32	0.44	0.10	0.63	0.92	0.23	0.23
MIATK	0.54	0.29	0.13	0.20	0.24	0.76	0.26	0.12
MOBTL	0.69	0.32	0.42	0.27	0.32	0.91	0.77	0.14
MTRKS	0.56	0.21	0.12	0.28	0.34	0.91	0.46	0.08
NETAS	0.76	0.32	0.61	0.19	1.00	0.98	0.88	0.13
OBASE	0.69	0.86	0.33	0.46	0.27	0.84	0.79	0.18
PAPIL	0.65	0.24	0.10	0.46	0.13	0.21	0.43	0.46
PENTA	0.69	0.32	0.52	0.26	0.67	0.90	0.91	0.06
PKART	0.39	0.32	0.44	0.37	0.74	0.93	0.99	0.06
SMART	0.15	0.16	0.15	0.07	0.25	0.89	0.21	0.19
VBTYZ	0.81	0.32	0.17	0.41	0.34	0.77	0.48	0.05

Tablo 6'da ise, alternatiflerin genel performans değeri Eşitlik (5) kullanılarak hesaplanmıştır.

Tablo 6. Firmaların Genel Performans Değerlerinin (S_i) Hesaplanması

	Si		Si		Si
ALCTL	0.55	HTTBT	0.79	MOBTL	0.64
ARDYZ	0.91	INDES	0.64	MTRKS	0.81
ARENA	0.61	INGRM	0.50	NETAS	0.54
ATATP	0.85	KAREL	0.54	OBASE	0.55
AZTEK	0.78	KFEIN	0.83	PAPIL	0.82
DESPC	0.63	KRONT	0.71	PENTA	0.62
DGATE	0.60	LINK	0.88	PKART	0.63
EDATA	0.70	LOGO	0.66	SMART	0.97
ESCOM	0.67	MANAS	0.67	VBTYZ	0.76
FONET	0.71	MIATK	0.85		

Firmaların performans değerleri Eşitlik (6) kullanılarak hesaplanmış Tablo 7'de sunulmuştur.

Tablo 7. Firmaların Performans Değerlerinin (S'_{ij}) Hesaplanması

	K1	K2	K3	K4	K5	K6	K7	K8
ALCTL	0.54	0.49	0.49	0.55	0.46	0.52	0.53	0.41
ARDYZ	0.87	0.77	0.80	0.81	0.84	0.90	0.83	0.82
ARENA	0.59	0.53	0.56	0.49	0.60	0.60	0.60	0.40
ATATP	0.82	0.75	0.75	0.73	0.78	0.84	0.79	0.74
AZTEK	0.75	0.71	0.67	0.67	0.74	0.77	0.74	0.59
DESPC	0.60	0.54	0.58	0.53	0.62	0.63	0.63	0.43
DGATE	0.60	0.50	0.57	0.50	0.59	0.60	0.60	0.39
EDATA	0.65	0.62	0.57	0.65	0.64	0.68	0.68	0.55
ESCOM	0.65	0.67	0.64	0.62	0.34	0.67	0.56	0.67
FONET	0.67	0.61	0.62	0.65	0.64	0.71	0.65	0.62
HTTBT	0.75	0.70	0.73	0.70	0.66	0.77	0.73	0.73
INDES	0.62	0.57	0.58	0.53	0.63	0.64	0.64	0.44
INGRM	0.46	0.50	0.46	0.41	0.49	0.50	0.50	0.29
KAREL	0.52	0.45	0.54	0.42	0.52	0.53	0.51	0.37
KFEIN	0.79	0.71	0.74	0.74	0.76	0.81	0.79	0.70
KRONT	0.70	0.59	0.62	0.65	0.66	0.70	0.61	0.60
LINK	0.87	0.82	0.77	0.81	0.73	0.81	0.80	0.81
LOGO	0.64	0.58	0.56	0.60	0.62	0.66	0.56	0.55
MANAS	0.67	0.60	0.62	0.52	0.64	0.67	0.58	0.57
MIATK	0.82	0.78	0.73	0.76	0.77	0.83	0.78	0.73
MOBTL	0.61	0.56	0.58	0.54	0.56	0.63	0.62	0.50
MTRKS	0.78	0.73	0.69	0.74	0.75	0.81	0.77	0.66
NETAS	0.52	0.46	0.51	0.41	0.54	0.54	0.53	0.38
OBASE	0.52	0.54	0.47	0.49	0.45	0.54	0.53	0.42
PAPIL	0.80	0.74	0.69	0.78	0.70	0.73	0.77	0.78
PENTA	0.59	0.54	0.57	0.52	0.59	0.61	0.61	0.41
PKART	0.57	0.55	0.58	0.56	0.61	0.63	0.63	0.43
SMART	0.87	0.87	0.87	0.83	0.90	0.96	0.89	0.88
VBTYZ	0.75	0.69	0.65	0.71	0.70	0.74	0.72	0.56

MEREC yönteminin son aşamasında mutlak farklar toplamı elde edildikten sonra kriter ağırlıkları sırasıyla Eşitlik (7) ve (8) uygulanarak elde edilmiştir. Elde edilen sonuçlar Tablo 8'de gösterilmiştir.

Tablo 8. Mutlak Fark Toplamlarının (E_J) ve Kriter Ağırlıklarının (w_j) Hesaplanması

	K1	K2	K3	K4	K5	K6	K7	K8
(E_J)	0.84	2.26	2.23	2.49	1.89	0.40	1.26	3.98
(w_j)	0.05	0.15	0.15	0.16	0.12	0.03	0.08	0.26

4.2. MEREC Yöntemine İlişkin Bulgular

Çalışmanın bu kısmında kriterlerin ağırlıklandırılmasında kullanılan MEREC yönteminin uygulanması sonucunda elde edilen bulgular yer almaktadır. Tablo 9'da çalışmanın tüm dönemleri için kriter ağırlıklarına yer verilmiştir. MEREC yöntemine göre kriter ağırlıklarının incelenen dönemlere göre değişkenlik gösterdiği görülmektedir. Bununla birlikte, MEREC yöntemine göre en önemli kriterin ağırlıklı olarak K8 (Aktif Devir Hızı) olduğu görülmektedir. Bu kriterden sonraki genel olarak en yüksek ağırlığa sahip olan kriter, K3 (Aktif Karlılık Oranı) kriteridir. En düşük önem ağırlığına sahip kriterin ise K6 (Cari Oran) olduğu görülmektedir.

Tablo 9. Tüm Dönemler İçin Kriter Ağırlıkları

Dönem	Yöntem	K1	K2	K3	K4	K5	K6	K7	K8
2023:12	MEREC	0.07	0.05	0.51	0.03	0.11	0.04	0.08	0.11
2023:09	MEREC	0.05	0.15	0.15	0.16	0.12	0.03	0.08	0.26
2023:06	MEREC	0.03	0.44	0.09	0.09	0.10	0.03	0.07	0.15
2023:03	MEREC	0.03	0.10	0.14	0.13	0.19	0.04	0.11	0.26

4.3. Performans Sıralamasında MARCOS Yöntemi Uygulaması

BİST bilişim sektörü firmaları üzerinde Piotroski F-skoru bileşenlerine dayalı kriterlerin ağırlıklandırılmasından sonra performans sıralamalarını elde etmek için MARCOS yöntemi uygulanmıştır. Yönteme göre izlenen 2023 yılının üçüncü çeyreğine ait örnek uygulama adımlarına Tablo 10-14 aralığında yer verilmektedir. Tablo 10'da MARCOS yönteminin ilk aşamasındaki karar matrisi oluşturulmaktadır. Yöntemin uygulanmasında kullanılacak karar matrisi 8 farklı kriter ve 29 alternatife göre düzenlenmiştir.

Tablo 10. Karar Matrisi

Kriter Yönü	Maks.	Maks.	Maks.	Maks.	Min.	Maks.	Maks.	Maks.
	K1	K2	K3	K4	K5	K6	K7	K8
ALCTL	-36.9	-33.3	4.7	-49.9	28.2	4.3	15.6	1.1
ARDYZ	218.9	477.8	37.3	169.2	30.9	2.0	87.2	0.9
ARENA	0.0	0.0	1.1	126.7	88.3	1.1	6.0	2.9
ATATP	120.6	128.7	24.2	264.2	29.0	2.5	46.5	1.2
AZTEK	106.0	0.0	26.0	141.3	58.6	1.7	25.1	3.5
DESPC	70.6	24.3	2.9	92.6	84.1	1.2	6.6	2.9
DGATE	-75.2	54.9	0.3	85.3	81.0	1.2	6.9	3.0
EDATA	217.7	0.0	31.5	0.6	43.5	2.1	11.3	1.6
ESCOM	0.0	-96.4	-0.7	0.0	2.9	0.6	100.0	0.0
FONET	196.1	85.0	16.3	16.4	33.8	1.2	43.0	0.6
HTTBT	227.3	66.8	6.9	94.9	12.5	4.7	47.9	0.4
INDES	65.5	0.0	5.5	114.3	85.7	1.1	6.7	3.2
INGRM	127.2	-97.1	1.0	53.5	81.6	1.3	5.2	2.3
KAREL	0.0	0.0	-4.3	93.7	80.6	1.0	17.3	1.4
KFEIN	163.0	226.3	20.2	121.0	31.0	3.1	25.4	1.7

Tablo 10. Devamı

KRONT	-53.3	134.1	14.8	3.7	48.2	1.7	87.2	0.8
LINK	6.6	0.0	33.7	50.0	8.9	20.3	85.8	0.5
LOGO	10.8	6.8	16.0	12.8	54.9	0.7	78.6	0.8
MANAS	-85.3	0.0	3.6	305.9	63.4	1.2	78.5	0.7
MIATK	150.0	14.7	38.8	112.4	25.2	2.9	67.3	1.5
MOBTL	38.9	0.0	4.2	63.7	33.4	1.3	11.7	1.2
MTRKS	128.2	72.3	43.0	57.3	34.7	1.3	30.7	2.4
NETAS	0.0	0.0	-0.3	129.5	100.0	0.7	8.1	1.4
OBASE	40.3	-89.3	8.3	0.0	28.0	2.0	11.2	0.9
PAPIL	66.2	52.1	50.0	0.0	14.1	27.6	34.6	0.2
PENTA	37.7	0.0	1.5	70.5	68.0	1.4	7.4	2.9
PKART	350.4	0.0	3.7	21.8	74.1	1.2	5.4	2.9
SMART	1542.9	141.8	32.2	487.9	26.2	1.5	87.5	0.8
VBTYZ	-18.7	0.0	26.3	10.0	35.6	2.7	28.8	3.9

Tablo 11'de karar matrisine Eşitlik (11) ve (12)'de hesaplanan ideal (AI) ve ideal olmayan çözüm (AAI) değerleri eklenerek Eşitlik (10)'a göre düzenlenen genişletilmiş karar matrisi oluşturulmuştur.

Tablo 11. Genişletilmiş Karar Matrisi

Kriter Yönü	**Maks.**	**Maks.**	**Maks.**	**Maks.**	**Min.**	**Maks.**	**Maks.**	**Maks.**
	K1	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**
AAI	-85.3	-97.1	-4.3	-49.9	100.0	0.6	5.2	0.0
ALCTL	-36.9	-33.3	4.7	-49.9	28.2	4.3	15.6	1.1
ARDYZ	218.9	477.8	37.3	169.2	30.9	2.0	87.2	0.9
ARENA	0.0	0.0	1.1	126.7	88.3	1.1	6.0	2.9
ATATP	120.6	128.7	24.2	264.2	29.0	2.5	46.5	1.2
AZTEK	106.0	0.0	26.0	141.3	58.6	1.7	25.1	3.5
DESPC	70.6	24.3	2.9	92.6	84.1	1.2	6.6	2.9
DGATE	-75.2	54.9	0.3	85.3	81.0	1.2	6.9	3.0
EDATA	217.7	0.0	31.5	0.6	43.5	2.1	11.3	1.6
ESCOM	0.0	-96.4	-0.7	0.0	2.9	0.6	100.0	0.0
FONET	196.1	85.0	16.3	16.4	33.8	1.2	43.0	0.6
HTTBT	227.3	66.8	6.9	94.9	12.5	4.7	47.9	0.4
INDES	65.5	0.0	5.5	114.3	85.7	1.1	6.7	3.2
INGRM	127.2	-97.1	1.0	53.5	81.6	1.3	5.2	2.3
KAREL	0.0	0.0	-4.3	93.7	80.6	1.0	17.3	1.4
KFEIN	163.0	226.3	20.2	121.0	31.0	3.1	25.4	1.7
KRONT	-53.3	134.1	14.8	3.7	48.2	1.7	87.2	0.8
LINK	6.6	0.0	33.7	50.0	8.9	20.3	85.8	0.5
LOGO	10.8	6.8	16.0	12.8	54.9	0.7	78.6	0.8
MANAS	-85.3	0.0	3.6	305.9	63.4	1.2	78.5	0.7
MIATK	150.0	14.7	38.8	112.4	25.2	2.9	67.3	1.5
MOBTL	38.9	0.0	4.2	63.7	33.4	1.3	11.7	1.2
MTRKS	128.2	72.3	43.0	57.3	34.7	1.3	30.7	2.4
NETAS	0.0	0.0	-0.3	129.5	100.0	0.7	8.1	1.4
OBASE	40.3	-89.3	8.3	0.0	28.0	2.0	11.2	0.9
PAPIL	66.2	52.1	50.0	0.0	14.1	27.6	34.6	0.2
PENTA	37.7	0.0	1.5	70.5	68.0	1.4	7.4	2.9
PKART	350.4	0.0	3.7	21.8	74.1	1.2	5.4	2.9
SMART	1542.9	141.8	32.2	487.9	26.2	1.5	87.5	0.8
VBTYZ	-18.7	0.0	26.3	10.0	35.6	2.7	28.8	3.9
AI	1542.9	477.8	50.0	487.9	2.9	27.6	100.0	3.9

Sonraki aşamada karar matrisi elemanlarını normalize etmek için Eşitlik (14) ve (15)'te yer alan hesaplamalar yapılarak Eşitlik (13)'e göre normalize karar matrisi oluşturulmuştur (Tablo 12).

Tablo 12. Normalize Karar Matrisi

Kriter Yönü	Maks.	Maks.	Maks.	Maks.	Min.	Maks.	Maks.	Maks.
	K1	K2	K3	K4	K5	K6	K7	K8
AAI	-0.06	-0.20	-0.09	-0.10	0.03	0.02	0.05	0.00
ALCTL	-0.02	-0.07	0.09	-0.10	0.10	0.16	0.16	0.29
ARDYZ	0.14	1.00	0.75	0.35	0.09	0.07	0.87	0.22
ARENA	0.00	0.00	0.02	0.26	0.03	0.04	0.06	0.74
ATATP	0.08	0.27	0.48	0.54	0.10	0.09	0.47	0.31
AZTEK	0.07	0.00	0.52	0.29	0.05	0.06	0.25	0.89
DESPC	0.05	0.05	0.06	0.19	0.03	0.04	0.07	0.73
DGATE	-0.05	0.11	0.01	0.17	0.04	0.04	0.07	0.76
EDATA	0.14	0.00	0.63	0.00	0.07	0.08	0.11	0.40
ESCOM	0.00	-0.20	-0.01	0.00	1.00	0.02	1.00	0.00
FONET	0.13	0.18	0.33	0.03	0.09	0.04	0.43	0.16
HTTBT	0.15	0.14	0.14	0.19	0.23	0.17	0.48	0.11
INDES	0.04	0.00	0.11	0.23	0.03	0.04	0.07	0.82
INGRM	0.08	-0.20	0.02	0.11	0.04	0.05	0.05	0.58
KAREL	0.00	0.00	-0.09	0.19	0.04	0.04	0.17	0.36
KFEIN	0.11	0.47	0.40	0.25	0.09	0.11	0.25	0.43
KRONT	-0.03	0.28	0.30	0.01	0.06	0.06	0.87	0.21
LINK	0.00	0.00	0.67	0.10	0.32	0.74	0.86	0.12
LOGO	0.01	0.01	0.32	0.03	0.05	0.03	0.79	0.19
MANAS	-0.06	0.00	0.07	0.63	0.05	0.05	0.79	0.17
MIATK	0.10	0.03	0.78	0.23	0.11	0.11	0.67	0.39
MOBTL	0.03	0.00	0.08	0.13	0.09	0.05	0.12	0.30
MTRKS	0.08	0.15	0.86	0.12	0.08	0.05	0.31	0.61
NETAS	0.00	0.00	-0.01	0.27	0.03	0.03	0.08	0.34
OBASE	0.03	-0.19	0.17	0.00	0.10	0.07	0.11	0.23
PAPIL	0.04	0.11	1.00	0.00	0.21	1.00	0.35	0.06
PENTA	0.02	0.00	0.03	0.14	0.04	0.05	0.07	0.73
PKART	0.23	0.00	0.07	0.04	0.04	0.04	0.05	0.74
SMART	1.00	0.30	0.64	1.00	0.11	0.05	0.88	0.21
VBTYZ	-0.01	0.00	0.53	0.02	0.08	0.10	0.29	1.00
AI	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Tablo 13'te yer alan ağırlıklı normalize karar matrisi Eşitlik (16) ve (17) kullanılarak oluşturulmuştur.

Tablo 13. Ağırlıklı Normalize Karar Matrisi

Kriter Yönü	**Maks.**	**Maks.**	**Maks.**	**Maks.**	**Min.**	**Maks.**	**Maks.**	**Maks.**
Ağırlık	0.05	0.15	0.15	0.16	0.12	0.03	0.08	0.26
	K1	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**
AAI	0.00	-0.03	-0.01	-0.02	0.00	0.00	0.00	0.00
ALCTL	0.00	-0.01	0.01	-0.02	0.01	0.00	0.01	0.07
ARDYZ	0.01	0.15	0.11	0.06	0.01	0.00	0.07	0.06
ARENA	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.19
ATATP	0.00	0.04	0.07	0.09	0.01	0.00	0.04	0.08
AZTEK	0.00	0.00	0.08	0.05	0.01	0.00	0.02	0.23
DESPC	0.00	0.01	0.01	0.03	0.00	0.00	0.01	0.19
DGATE	0.00	0.02	0.00	0.03	0.00	0.00	0.01	0.20
EDATA	0.01	0.00	0.09	0.00	0.01	0.00	0.01	0.10
ESCOM	0.00	-0.03	0.00	0.00	0.12	0.00	0.08	0.00
FONET	0.01	0.03	0.05	0.01	0.01	0.00	0.04	0.04
HTTBT	0.01	0.02	0.02	0.03	0.03	0.00	0.04	0.03
INDES	0.00	0.00	0.02	0.04	0.00	0.00	0.01	0.21
INGRM	0.00	-0.03	0.00	0.02	0.00	0.00	0.00	0.15
KAREL	0.00	0.00	-0.01	0.03	0.00	0.00	0.01	0.09
KFEIN	0.01	0.07	0.06	0.04	0.01	0.00	0.02	0.11
KRONT	0.00	0.04	0.04	0.00	0.01	0.00	0.07	0.05
LINK	0.00	0.00	0.10	0.02	0.04	0.02	0.07	0.03
LOGO	0.00	0.00	0.05	0.00	0.01	0.00	0.06	0.05
MANAS	0.00	0.00	0.01	0.10	0.01	0.00	0.06	0.04
MIATK	0.01	0.00	0.11	0.04	0.01	0.00	0.06	0.10
MOBTL	0.00	0.00	0.01	0.02	0.01	0.00	0.01	0.08
MTRKS	0.00	0.02	0.12	0.02	0.01	0.00	0.03	0.16
NETAS	0.00	0.00	0.00	0.04	0.00	0.00	0.01	0.09
OBASE	0.00	-0.03	0.02	0.00	0.01	0.00	0.01	0.06
PAPIL	0.00	0.02	0.15	0.00	0.03	0.03	0.03	0.02
PENTA	0.00	0.00	0.00	0.02	0.01	0.00	0.01	0.19
PKART	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.19
SMART	0.05	0.04	0.09	0.16	0.01	0.00	0.07	0.05
VBTYZ	0.00	0.00	0.08	0.00	0.01	0.00	0.02	0.26
AI	0.05	0.15	0.15	0.16	0.12	0.03	0.08	0.26

Tablo 14'te yer alan değerlerin hesaplanması için Eşitlik (18), (19), (20), (21), (22) ve (23)'den yararlanılmış ve MARCOS yöntemine göre performans sıralamaları elde edilmiştir.

Tablo 14. $S_i, K_i^+, K_i^-, f(K_i^+), f(K_i^-), f(K_i)$ Değerlerinin ve Sıralamaların Hesaplanması

	S_i	K_i^+	K_i^-	$f(K_i^+)$	$f(K_i^-)$	$f(K_i)$	Sıralama
AAI	-0.05		1				
ALCTL	0.09	-1.66	0.09	1.057	-0.057	0.459	28
ARDYZ	0.46	-8.61	0.46	1.057	-0.057	0.248	2
ARENA	0.25	-4.64	0.25	1.057	-0.057	0.334	14
ATATP	0.34	-6.26	0.34	1.057	-0.057	0.383	6
AZTEK	0.38	-7.19	0.38	1.057	-0.057	0.250	3
DESPC	0.25	-4.68	0.25	1.057	-0.057	0.251	13
DGATE	0.25	-4.70	0.25	1.057	-0.057	0.221	12
EDATA	0.22	-4.15	0.22	1.057	-0.057	0.174	18
ESCOM	0.17	-3.25	0.17	1.057	-0.057	0.173	22
FONET	0.17	-3.23	0.17	1.057	-0.057	0.180	23
HTTBT	0.18	-3.37	0.18	1.057	-0.057	0.278	20
INDES	0.28	-5.22	0.28	1.057	-0.057	0.155	9
INGRM	0.16	-2.90	0.16	1.057	-0.057	0.131	24
KAREL	0.13	-2.45	0.13	1.057	-0.057	0.319	27
KFEIN	0.32	-5.98	0.32	1.057	-0.057	0.218	8
KRONT	0.22	-4.09	0.22	1.057	-0.057	0.275	19
LINK	0.28	-5.15	0.28	1.057	-0.057	0.175	10
LOGO	0.18	-3.27	0.18	1.057	-0.057	0.223	21
MANAS	0.22	-4.19	0.22	1.057	-0.057	0.331	17
MIATK	0.33	-6.20	0.33	1.057	-0.057	0.135	7
MOBTL	0.13	-2.52	0.13	1.057	-0.057	0.365	26
MTRKS	0.37	-6.85	0.37	1.057	-0.057	0.142	5
NETAS	0.14	-2.66	0.14	1.057	-0.057	0.082	25
OBASE	0.08	-1.54	0.08	1.057	-0.057	0.258	29
PAPIL	0.26	-4.83	0.26	1.057	-0.057	0.231	11
PENTA	0.23	-4.33	0.23	1.057	-0.057	0.231	16
PKART	0.23	-4.33	0.23	1.057	-0.057	0.494	15
SMART	0.50	-9.26	0.50	1.057	-0.057	0.373	1
VBTYZ	0.37	-7.00	0.37	1.057	-0.057	0.089	4
AI	1	1					

4.4. MARCOS Yöntemine İlişkin Bulgular

Çalışmanın bu kısmında MEREC yöntemiyle elde edilen kriter ağırlıkları kullanılarak MARCOS yöntemine göre elde edilen performans sıralamalarına ilişkin bulgular yer almaktadır. Tablo 15'de MARCOS yöntemine göre BİST bilişim sektörü firmalarının dönemler itibariyle performans sıralamaları yer almaktadır.

Tablo 15. MARCOS Yöntemine Göre Performans Sıralamaları

Dönem	2023:Q1	2023:Q2	2023:Q3	2023:Q4
Firmalar	**Sıralama**	**Sıralama**	**Sıralama**	**Sıralama**
ALCTL	24	27	28	4
ARDYZ	9	28	2	26
ARENA	11	16	14	10
ATATP	18	1	6	18
AZTEK	1	8	3	19
DESPC	15	20	13	3
DGATE	17	19	12	2
EDATA	7	17	18	17
ESCOM	4	29	22	29
FONET	25	6	23	23
HTTBT	19	21	20	21
INDES	14	14	9	8
INGRM	20	4	24	6
KAREL	27	24	27	11
KFEIN	16	15	8	20
KRONT	23	9	19	22
LINK	10	12	10	13
LOGO	22	13	21	12
MANAS	8	26	17	15
MIATK	3	7	7	27
MOBTL	26	25	26	16
MTRKS	6	3	5	28
NETAS	29	5	25	14
OBASE	28	22	29	5
PAPIL	2	11	11	24
PENTA	12	18	16	9
PKART	21	23	15	7
SMART	13	2	1	25
VBTYZ	5	10	4	1

2023 yılının ilk çeyreğine ilişkin sonuçlar değerlendirildiğinde, MEREC tabanlı MARCOS yöntemine göre en iyi performans gösteren firmalar sırasıyla AZTEK ve PAPIL olarak gerçekleşmiştir. En düşük performansı gösteren firmaların ise sırasıyla NETAS ve OBASE olduğu görülmektedir. 2023 yılının ikinci çeyreğine ilişkin sonuçlar incelendiğinde, en iyi performansı gösteren firmalar sırasıyla ATATP ve SMART firmaları iken, en düşük performans gösteren firmalar sırasıyla ESCOM ve ARDYZ firmaları olarak gerçekleşmiştir. 2023 yılının üçüncü çeyreğine ilişkin sonuçlar incelendiğinde, en iyi performansı sırasıyla SMART ve ARDYZ firmalarının gösterdiği saptanmıştır. En düşük performans gösteren firmalar ise sırasıyla OBASE ve KAREL olduğu tespit edilmiştir. 2023 yılının son çeyreğine ilişkin sonuçlar incelendiğinde en iyi performansı sırasıyla VBTYZ ve DGATE firmaları sergilerken, en düşük performansı ESCOM ve MTRKS firmaları göstermiştir.

4.5. Duyarlılık Analizi Sonuçları

Araştırmada yer alan alternatiflerin performans sıralamalarında, kriter ağırlıklarının farklılaşmasıyla meydana gelebilecek değişiminin incelenmesi duyarlılık analizi ile gerçekleştirilmektedir (Pala, 2023: 135). Bu çalışmada Pala (2023) tarafından gerçekleştirilen duyarlılık analizindeki 2 farklı senaryo benimsenerek duyarlılık analizi gerçekleştirilmiştir. Bu

doğrultuda çalışmada MEREC yöntemiyle elde edilen ve mevcut durumu gösteren kriter ağırlıklarının (M) yanında, tüm kriterlere eşit ağırlık verilerek oluşturulmuş eşit ağırlıklı senaryo (S1) ve MEREC tabanlı yöntemde elde edilen en yüksek ve en düşük kriter ağırlıklarının yer değiştirilmesiyle oluşturulmuş senaryo (S2) için analizler yapılmıştır. Çalışmada kriter ağırlıklarının farklı senaryolara göre değişiminin görülmesi açısından 2023:Q3 dönemine ilişkin bir örneğe Tablo 16'da yer verilmiştir.

Tablo 16. Duyarlılık Analizi Kriter Ağırlıkları (2023:Q3)

Senaryolar	K1	K2	K3	K4	K5	K6	K7	K8
M	0.055	0.147	0.145	0.162	0.123	0.026	0.082	0.259
S1	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
S2	0.055	0.147	0.145	0.162	0.123	0.259	0.082	0.026

MEREC tabanlı kriterler ağırlıklarının yanında yukarıda bahsedilen Senoryo 1 (S1) ve Senoryo 2 (S2)'nin uygulanmasıyla elde edilen performans sıralama sonuçları Tablo 17'de verilmiştir.

Tablo 17. Tüm Dönemler için Duyarlılık Analizi Sonuçları

Dönem	2023:Q1			2023:Q2			2023:Q3			2023:Q4		
Firmalar	M	S1	S2	M	S1	S2	M	S1	S2	M	S1	S2
ALCTL	24	24	19	27	29	29	28	28	26	4	26	29
ARDYZ	9	9	8	28	12	11	2	2	3	26	5	10
ARENA	11	16	20	16	20	13	14	21	21	10	16	4
ATATP	18	14	13	1	4	8	6	6	5	18	14	14
AZTEK	1	3	10	8	6	4	3	8	11	19	19	7
DESPC	15	19	21	20	25	24	13	19	19	3	25	15
DGATE	17	21	25	19	23	21	12	22	20	2	27	18
EDATA	7	8	12	17	19	17	18	15	15	17	21	26
ESCOM	4	7	3	29	13	14	22	11	13	29	1	2
FONET	25	23	18	6	11	16	23	17	16	23	17	27
HTTBT	19	12	9	21	17	22	20	14	10	21	12	16
INDES	14	20	23	14	18	12	9	18	18	8	22	11
INGRM	20	22	22	4	16	20	24	26	29	6	24	22
KAREL	27	27	27	24	24	26	27	27	27	11	9	17
KFEIN	16	15	14	15	14	15	8	9	7	20	13	8
KRONT	23	18	16	9	5	2	19	12	12	22	6	6
LINK	10	4	6	12	3	7	10	3	4	13	8	12
LOGO	22	17	15	13	15	18	21	16	17	12	15	25
MANAS	8	5	4	26	28	28	17	13	9	15	18	24
MIATK	3	2	5	7	7	10	7	5	6	27	10	19
MOBTL	26	26	24	25	27	27	26	24	22	16	11	20
MTRKS	6	11	11	3	8	9	5	7	8	28	4	9
NETAS	29	29	29	5	21	23	25	25	25	14	7	3
OBASE	28	28	26	22	10	3	29	29	28	5	28	28
PAPIL	2	1	1	11	2	6	11	4	1	24	3	13
PENTA	12	6	2	18	22	19	16	23	23	9	20	5
PKART	21	25	28	23	26	25	15	20	24	7	23	23
SMART	13	10	7	2	1	1	1	1	2	25	2	1
VBTYZ	5	13	17	10	9	5	4	10	14	1	29	21

Tablo 17'deki 2023 yılının ilk çeyreğindeki duyarlılık analizi sonuçları incelendiğinde her üç senaryo için NETAS ve KAREL firmalarının sıralamalarının değişmediği görülmektedir. Diğer firmaların ise performans sıralamaları senaryolara göre değişkenlik göstermektedir. Mevcut durumu ifade eden (M) MEREC yöntemine göre ilk sırada yer alan AZTEK firmasının, senaryo 1 (S1) ve senaryo 2 (S2) sonucuna göre performans sıralamasında düşüş meydana gelmiştir. S1 ve S2 sonucuna göre en iyi performansı gösteren firma PAPIL olmuştur. Bu dönemde en düşük performansın her üç senaryoya göre değişmeyerek NETAS firmasına ait olduğu görülmektedir. 2023 yılının ikinci çeyreğine ilişkin duyarlılık analizi sonuçlarına göre her üç senaryo için ortak sıralamaya sahip firmanın olmadığı ve tüm senaryolar için firma sıralamalarının değişkenlik gösterdiği görülmektedir. Bu dönemde en iyi performansı (M) sonuçlarına göre ATATP firması sergilemiştir. S1 ve S2 için ise en iyi performansı SMART firması sergilemiştir. En düşük performansı ise M senaryosunda ESCOM firması, S1 ve S2 senaryosunda ise ortak olarak ALCTL firması sergilemiştir.

2023 yılının üçüncü çeyreğine ilişkin duyarlılık analizi sonuçlarına göre her üç senaryo için KAREL ve NETAS firmalarının sıralamalarının değişmediği görülmektedir. Diğer firmaların ise performans sıralamaları senaryolara göre değişkenlik göstermektedir. Bu dönemde en iyi performansın M ve S1 senaryosuna göre ortak olarak SMART firmasının sergilediği, S2 senaryosuna göre ise en iyi performansın PAPIL firmasın ait olduğu görülmektedir. En düşük performansın ise M ve S1 senaryosunda ortak olarak OBASE firması sergilemiştir. S2 senaryosuna göre ise INGRM firmasının en düşük performansa sahip olduğu bulgusuna ulaşılmıştır. 2023 yılının dördüncü çeyreğine ilişkin duyarlılık analizi sonuçlarına göre her üç senaryo için ortak sıralamaya sahip firmanın olmadığı ve tüm senaryolar için firma sıralamalarının değişkenlik gösterdiği görülmektedir. Bunula birlikte en iyi performansı M, S1 ve S2 senaryolarına göre sırasıyla VBTYZ, ESCOM ve SMART firmalarının sergilediği tespit edilmiştir. En düşük performansın ise sırasıyla, ESCOM VBTYZ ve ALCTL firmalarının sergilediği görülmektedir.

Duyarlılık analizi sonuçlarına göre tüm senaryolar için sürekli aynı sıralamada yer alan az sayıda firma bulunduğu tespit edilmiştir. Bununla birlikte farklı senaryolar için elde edilen sonuçlarda 2023:Q4 dönemi hariç diğer dönemlerde performans sıralamasında üst sıralarda ve alt sıralarda yer alan firmalar açısından aynı veya birbirine oldukça yakın sonuçlar elde edildiği görülmektedir.

5. Sonuç

Firmaların içerisinde bulunduğu rekabet ortamını her geçen gün daha da etkisini artırmakta ve firmaların bu süreçteki performansları başarı veya başarısızlığı doğrudan etkilemektedir. Firmalar arasındaki rekabetin en yoğun olarak yaşandığı sektörlerden birisi de bilişim sektörüdür. Rekabet gücünü sermayeden alan geleneksel sektörlerin aksine, bilişim sektörünün ARGE ve inovasyona dayanan özelliği sektördeki rekabeti daha açık bir hale getirmektedir. Firmaların faaliyetlerini sürdürülebilmeleri ise, yaptıkları planlamalara ve oluşturdukları stratejilere bağlıdır. Hiç şüphesiz, yapılan planlama ve stratejilerin dönemler içerisinde değerlendirilerek geri bildirim alınması başarıyı etkileyen bir faktördür. Bu noktada, firmaların finansal performanslarının değerlendirilmesi hem mevcut durumu değerlendirmede hem de geleceğe yönelik stratejik planlamadaki hedeflere ulaşılması açısından önemlidir.

Bu çalışmanın amacı, BİST bilişim sektörü firmalarının finansal performansını değerlendirmektir. Firmaların finansal performansının değerlendirilmesinde MEREC-MARCOS bütünleşik yaklaşımı kullanılmıştır. Ayrıca değerlendirme kriterlerinin ağırlıklandırmada iki farklı senaryo oluşturularak duyarlılık analizleri yapılmış ve elde edilen sonuçlar, MEREC yöntemine göre elde edilen sonuçlar ile karşılaştırmalı olarak incelenmiştir. Bu çalışma iki yönüyle mevcut literatürden ayrılmaktadır. İlk olarak, ÇKKV yöntemlerinin yeni yöntemlerinden MEREC ve MARCOS ile bilişim sektörü finansal performansının incelenmemiş olması çalışmayı mevcut literatürden ayırmaktadır. İkincisi ise, kriter seçiminde Piotroski F-skoru bileşenlerinin kullanıldığı bir başka çalışmaya rastlanılmamış olması yönüyle de çalışma mevcut literatürden farklılaşmaktadır.

Çalışma kapsamında kullanılan kriter ağırlıklandırmada kullanılan MEREC yöntemi sonuçlarına göre, incelenen her bir dönemde kriter ağırlıklarında farklılaşma olduğu görülmektedir. Bununla birlikte, elde edilen sonuçlara göre bir genelleme yapıldığında en yüksek kriter ağırlığına sahip Piotroski F-skoru bileşenlerinin aktif devir hızı (K8) ve aktif karlılık oranı (K3) olarak sıralandığı, buna karşın en düşük kriter ağırlığının cari oran (K6) bileşenine ait olduğu sonucuna varılmıştır.

MEREC tabanlı MARCOS yaklaşımına göre elde edilen performans sıralamaları incelediğinde, 2023:Q1 döneminde en iyi performans gösteren firmalar sırasıyla AZTEK, PAPIL ve MIATK iken, en düşük performans gösteren firmalar NETAS, OBASE ve KAREL olarak gerçekleşmiştir. 2023:Q2 sonuçları incelendiğinde sırasıyla ATATP, SMART ve MTRKS firmalarının en iyi performans gösterdiği, buna karşın ESCOM, ARDYZ ve ALCTL firmalarının en düşük performansı gösterdiği tespit edilmiştir. 2023:Q3 sonuçlarına göre en iyi performansı SMART, ARDYZ ve AZTEK firmaları sergilemiştir. En düşük performansa sahip firmalar ise sırasıyla OBASE, ALCTL ve KAREL firmaları olmuştur. 2023:Q4 döneminde en iyi performansa sahip firmalar sırasıyla AZTEK, PAPIL ve MIATK iken, en düşük performans sahip firmaların sırasıyla NETAS, OBASE ve KAREL olduğu tespit edilmiştir. Kriter ağırlıklandırmada MEREC yönteminin yanında iki farklı senaryo oluşturularak duyarlılık analizleri gerçekleştirilmiştir. Duyarlılık analizi sonuçlarına göre, her iki senaryo için de 2023:Q4 dönemi haricinde en iyi ve en düşük performans sıralamalarında birbirinin aynısı veya yakın sonuçların elde edildiği tespit edilmiştir.

Çalışmada MEREC tabanlı MARCOS yönteminden elde edilen sonuçlara göre, en iyi performansın genel olarak SMART ve PAPIL firmalarına ait olduğu tespit edilmiştir. Ayrıca, en düşük performansa sahip firmaların ise genel olarak KAREL ve OBASE firmalarına olduğu sonucuna ulaşılmıştır. Bununla birlikte, incelenen bilişim sektörü firmalarında sürekli olarak en iyi performans ile en düşük performans gösteren bir firmanın tam olarak belirlenmesinin güç olduğu görülmektedir. Bu yönüyle elde edilen bulgular incelenen dönemler itibariyle dalgalanmalar göstermektedir. Bu bağlamda elde edilen sonuçlar, Sakarya ve Ermayan (2022) ve Pala (2023) tarafından yapılan çalışmaların sonuçlarıyla benzerlik göstermektedir. Bu durumunun temel nedenlerinden birisi olarak çalışmaları farklı dönemler, farklı performans değerlendirme kriterleri ve farklı yöntemlerle analiz edilmesi gösterilebilir. Ayrıca, bilişim sektörünün dinamik yapısı dikkate alındığında finansal performansların dönemler itibariyle değişkenlik göstermesi normal bir durum olarak görülebilir.

Finansal performans analizi sonuçlarına göre düşük performans gösteren firmaların Piotroski F-skoru bileşenlerine dayalı olarak değerlendirme yapıldığında karlılık bileşenlerini

artırmaları, uygun bir mali yapıya sahip olmaları ve operasyonel faaliyetlerindeki verimlilik düzeylerini iyileştirmeleri gerekmektedir.

Bundan sonraki çalışmalarda Piotroski F-skoru bileşenleri daha geniş bir zaman diliminde kullanılarak analiz yapılabileceği gibi farklı sektörler için de finansal performans analizi gerçekleştirilebilir. Ayrıca, kriter ağırlıklandırmada farklı yöntemler uygulanarak Piotroski F-skoru kriterlerinin önem düzeylerinin karşılaştırmalı olarak incelendiği çalışmalarında literatürdeki boşluğu dolduracağı düşünülmektedir.

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
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Kaynakça

Aktaş, Ö. (2022). BİST'de işlem gören bilişim sektörü şirketlerinin pandemi öncesi ve pandemi dönemi finansal performanslarının Promethee yöntemi ile ölçülmesi. *İşletme*, 3(2), 15-31. Erişim adresi: https://dergipark.org.tr/tr/pub/isletme

Altıntaş, F.F. (2022). Avrupa ülkelerinin enerji inovasyonu performanslarının analizi: MABAC ve MARCOS yöntemleri ile bir uygulama. *İşletme Akademisi Dergisi*, 3(2), 188–216. https://doi.org/10.26677/TR1010.2022.1027

Arman, K. ve Organ, A. (2023). AB'ye üye ve aday ülkelerin lojistik performanslarının MEREC ve COCOSO yöntemleri ile değerlendirilmesi. *Uluslararası Ticaret ve Ekonomi Araştırmaları Dergisi*, 7(2), 36-46. https://doi.org/10.30711/utead.1360959

Atalay, M.Ö. ve Altın, M. (2020). TOPSIS çok kriterli karar verme yöntemi ile finansal performansın ölçülmesi: Bilgi teknolojileri sektörü üzerinde bir uygulama. *International Journal of Social and Humanities Sciences*, 4(2), 205-228. Erişim adresi: https://dergipark.org.tr/tr/pub/ijshs

Ayçin, E. ve Arsu, T. (2022). Sosyal gelişme endeksine göre ülkelerin değerlendirilmesi: MEREC ve MARCOS yöntemleri ile bir uygulama. *İzmir Yönetim Dergisi*, 2(2), 75-88. https://doi.org/10.56203/iyd.1084310

Baysal, G., Sönmez, F. ve Anık Baysal, İ. (2023). BİST100'te işlem gören bilişim şirketlerinin TOPSIS yöntemiyle finansal performanslarının belirlenmesi. U. Özkaya (Ed.), *1. Uluslararası Bilimsel Araştırmalar ve İnovasyon Konferansı Bildiriler Kitabı* içinde (s. 230-238). 1. Uluslararası Bilimsel Araştırmalar ve İnovasyon Konferansı'nda sunulan bildiri, Konya. Türkiye. https://doi.org/10.59287/icsis.606

Çınaroğlu, E. (2021). CRITIC temelli MARCOS yöntemi ile yenilikçi ve girişimci üniversite analizi. *Journal of Entrepreneurship and Innovation Management*, 10(1), 111-133. Erişim Adresi: https://dergipark.org.tr/tr/pub/jeim

Demir, G. ve Arslan, R. (2022). Sensitivity analysis in multi-criterion decision-making problems. *Ankara Hacı Bayram Veli Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, 24(3), 1025-1056. https://doi.org/10.26745/ahbvuibfd.1103531

Doğan, A ve Calp, M.H. (2019). Borsa İstanbul'da işlem gören bilişim şirketlerinin performans ölçümü. G. Gürçay (Ed.), *Karadeniz Zirvesi 2. Uluslararası Sosyal Bilimler Kongresi Bildiriler Kitabı* içinde (s. 401-413). 2. Uluslararası Sosyal Bilimler Kongresi'nde sunulan bildiri, Rize. Erişim Adresi: https://www.karadenizkongresi.org/

Ergül, N. ve Kondak, G.N. (2023). Bilişim sektöründeki şirketlerinin mali performanslarını analizi. *İstanbul Journal of Social Sciences*, 37, 27-47. Erişim adresi: http://www.istjss.org

Ersoy, N. (2022). Türk inşaat firmalarının finansal performansının SECA yöntemi ile değerlendirilmesi. *İzmir İktisat Dergisi*, 37(4), 1003-1021. https://doi.org/10.24988/ije.1065282

Finnet Veri Tabanı. (2024). *Finnet* [Veri Seti]. Erişim adresi: https://www.finnet.com.tr/

Gençtürk, M., Senal, S. ve Aksoy, E. (2021). COVID-19 pandemisinin katılım bankaları üzerine etkilerinin bütünleşik CRITIC-MARCOS yöntemi ile incelenmesi. *Muhasebe ve Finansman Dergisi*, 92, 139-160. https://doi.org/10.25095/mufad.937185

Gök Kısa, A.C. ve Perçin, S. (2018). Bütünleşik Entropi ağırlık-VIKOR yöntemi ile bilişim teknolojisi sektöründe performans ölçümü. *Ekonomik ve Sosyal Araştırmalar Dergisi*, 14(1), 1-13. Erişim adresi: https://dergipark.org.tr/tr/pub/esad

Gürkan, S. ve Aldoury, N. (2021). TOPSIS çok kriterli karar verme yöntemi ile karşılaştırmalı finansal performans analizi: Teknoloji şirketleri üzerine bir araştırma. *Finans Ekonomi ve Sosyal Araştırmalar Dergisi*, 6(2), 225-239. https://doi.org/10.29106/fesa.868905

He, T. and Tan, B. (2022). *The Application of Piotroski's F-score in selecting the company's stock market*. Paper presented at 7th International Industrial Informatics and Computer Engineering Conference. Dubai, The United Arab Emirates. https://doi.org/10.25236/iiiece.2022.018

Inani, S.K. and Gupta, R. (2017). Evaluating financial performance of Indian IT firms: An application of a multi-criteria decision-making technique. *International Journal of Behavioural Accounting and Finance,* 6(2), 126-139. https://doi.org/10.1504/ijbaf.2017.10007498

Kara, K., Yalçın, G.C., Acar, A. Z., Simic, V., Konya, S. and Pamucar, D. (2024). The MEREC-AROMAN method for determining sustainable competitiveness levels: A case study for Turkey. *Socio-Economic Planning Sciences,* 91, 101762. https://doi.org/10.1016/j.seps.2023.101762

Keshavarz-Ghorabaee, M., Amiri, M., Zavadskas, E.K., Turskis, Z. and Antucheviciene, J. (2021). Determination of objective weights using a new method based on the removal effects of criteria (MEREC). *Symmetry*, 13(4), 525. https://doi.org/10.3390/sym13040525

Kusowska, M. (2021). Assessment of efficiency of Piotroski F-Score strategy in the Warsaw Stock Exchange. *Research on Enterprise in Modern Economy Theory and Practice*, 1(32), 47-59. https://doi.org/10.19253/reme.2021.01.004

Mastilo, Z., Štilić, A., Gligović, D. and Puška, A. (2024). Assessing the banking sector of Bosnia and Herzegovina: An analysis of financial indicators through the MEREC and MARCOS methods. *Journal of Central Banking Theory and Practice*, 13(1), 167-197. https://doi.org/10.2478/jcbtp-2024-0008

Öndeş, T. ve Özkan, T. (2021). Bütünleşik CRITIC-EDAS yaklaşımıyla Covid-19 pandemisinin bilişim sektörü üzerindeki finansal performans etkisi. *Gümüşhane Üniversitesi Sosyal Bilimler Dergisi*, 12(2), 506-522. https://doi.org/10.36362/gumus.878926

Pala, F. (2023). BİST teknoloji ve bilişim sektöründe işlem gören şirketlerin finansal performanslarının çok kriterli karar verme yöntemleri ile ölçülmesi ve yöntemlerin karşılaştırılması. *Finans Ekonomi ve Sosyal Araştırmalar Dergisi*, 8(1), 121-155. https://doi.org/10.29106/fesa.1220327

Piotroski, J.D. (2000). Value investing: The use of historical financial statement information to separate winners from losers. *Journal of Accounting Research*, 38, 1–41. https://doi.org/10.2307/2672906

Piotroski, J.D. (2005). Discussion of "separating winners from losers among low book-to-market stocks using financial statement analysis*". Review of Accounting Studies*, 10(2-3), 171-184. https://doi.org/10.1007/s11142-005-1527-3

Piotroski, J.D. and So, E.C. (2012). Identifying expectation errors in value/glamour strategies: A fundamental analysis approach. *Review of Financial Studies*, 25(9), 2841-2875. Retrieved from https://www.jstor.org/

Rangapriya, S. and Meenakumari, J. (2021). Using Piotroski F-Score for assessing financial health: Evidence from leading Indian private banks. *Management Science*, 8(1), 117-132. https://doi.org/10.34293/management.v8iS1-Feb.3765

Sakarya, Ş. ve Erayman, Ç. (2022). Nakit akış tablosuna dayalı finansal oranlar ve PROMETHEE yöntemi ile finansal performans analizi: BİST bilişim sektöründe bir uygulama. *Aksaray Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, 6(1), 51-78. https://doi.org/10.38122/ased.1016352

Sakarya, Ş. ve İlkdoğan, S. (2022). BIST Bilişim sektöründe faaliyet gösteren işletmelerin finansal performanslarının nakit akış oranları kapsamında CRITIC Temelli TOPSIS yöntemi ile değerlendirilmesi. *Pamukkale Üniversitesi İşletme Araştırmaları Dergisi*, 9(2), 421-445. https://doi.org/10.47097/piar.1173015

Stević, Ž., Pamučar, D., Puška, A. and Chatterjee, P. (2020). Sustainable supplier selection in healthcare industries using a new MCDM method: Measurement of alternatives and ranking according to COmpromise solution (MARCOS). *Computers & Industrial Engineering*, 140, 106231. https://doi.org/10.1016/j.cie.2019.106231

Sümerli Sarıgül, S., Ünlü, M. ve Yaşar, E. (2023). A new MCDM approach in evaluating airport service quality: MEREC-based MARCOS and CoCoSo methods. *Uluslararası Yönetim Akademisi Dergisi*, 6(1), 90-108. https://doi.org/10.33712/mana.1250335

Tüminçin, K., Öztel, A. ve Korkmaz, K. (2022). Entropi tabanlı PROMETHEE yöntemi ile Covid-19 pandemisinin finansal performans üzerindeki etkisinin araştırılması: Bilişim sektörü örneği. *Yönetim*

Ekonomi Edebiyat İslami ve Politik Bilimler Dergisi, 7(2), 49-92. https://doi.org/10.24013/jomelips.1204098

Turanboy, C., Sarıkaya, B. ve Arsu, T. (2024). Şehir hastanelerinin kapasite performansının MEREC ve MAIRCA yöntemleri ile değerlendirilmesi. *İşletme*, 5(1), 81-103. https://doi.org/10.57116/isletme.1436489

Turhan, T. and Aydemir, E. (2021). A financial ratio analysis on BIST information and technology index (XUTEK) using AHP-weighted Grey Relational Analysis. *Düzce Üniversitesi Bilim ve Teknoloji Dergisi*, 9(6), 195-209. https://doi.org/10.29130/dubited.1011252

Yalman, İ.N., Koşaroğlu, Ş.M. ve Işık, Ö. (2023). 2000-2020 döneminde Türkiye ekonomisinin makroekonomik performansının MEREC-LOPCOW-MARCOS modeliyle değerlendirilmesi. *Finans Politik & Ekonomik Yorumlar*, 664, 57-86. Erişim Adresi: http://www.ekonomikyorumlar.com.tr/

Yenilmezel Alıcı, S. ve Ertuğrul, İ. (2023). Evaluation of the financial performances of BIST IT sector by CILOS based CoCoSo method. *Pamukkale Üniversitesi İşletme Araştırmaları Dergisi*, 10(3), 745-759. https://doi.org/10.47097/piar.1359342

Yerdelen Kaygın, C. (2020). BİST bilişim sektöründe işlem gören şirketlerin finansal performanslarının MULTIMOORA yöntemleri ile ölçümü. *Muhasebe Bilim Dünyası Dergisi*, 22(3), 529-546. https://doi.org/10.31460/mbdd.680579

Yılmaz Türkmen, S. ve Çağıl, G. (2012). İMKB'ye kote bilişim sektörü şirketlerinin finansal performanslarının TOPSIS yöntemi ile değerlendirilmesi. *Maliye Finans Yazıları*, 1(95), 59–78. Erişim Adresi: https://dergipark.org.tr/tr/pub/mfy

Zhang, X., Wang, C., Li, E. and Xu, C. (2014). Assessment model of ecoenvironmental vulnerability based on improved entropy weight method. *The Scientific World Journal*, 2014, 797814. https://doi.org/10.1155/2014/797814

THE NEXUS OF PIOTROSKI F-SCORE COMPONENTS AND MCDM METHODS IN MEASURING FINANCIAL PERFORMANCE: AN APPLICATION OF MEREC-BASED MARCOS

EXTENDED SUMMARY

Objective of Study

Today's world has seen a significant increase in the speed at which information is disseminated, and this has led to a similar intensification of rivalry between businesses. The IT sector, which shows rapid development with R&D and innovation processes, is also in an intense competitive environment. The performance of firms under competitive conditions is the most important factor affecting success or failure. For this reason, analyzing the financial performance of firms is of great importance in examining their sustainability. The aim of this study is to evaluate the financial performance of 29 firms in the BIST IT sector for the period 2023:Q1-2023:Q4 using multi-criteria decision-making methods.

Literature Review

In the literature, there are many national and international studies analyzing the financial performance of firms in the IT sector. In this section, some of these studies will be briefly summarised. Inanı and Gupta (2017) analyzed the performance of IT sector firms listed on the Indian Stock Exchange for the period 2011-2015. Gök Kısa and Perçin (2018) examined the performance of 11 IT sector firms in the Global 2000 list announced by Forbes Magazine for 2015. Atalay and Altın (2020) analyzed the relationship between the performance results and the returns of the portfolios formed according to the performance, as well as the performance evaluation of the IT sector companies operating in BIST in the 2014-2018 period. Aktaş (2022) comparatively examined the financial performance of companies operating in the BIST IT sector before and during the pandemic in 2019-2020. Sakarya and İlkdoğan (2022) evaluated the financial performance of IT sector firms traded on BIST based on cash flow-based financial ratios. Tüminçin et al. (2022) examined the relationship between the financial performance of sixteen firms in the BIST IT sector and the Covid-19 pandemic between 2016-2021 based on thirteen financial ratio data.

Methodology

MEREC-based MARCOS method is applied to analyze the performance of the companies. In addition to the MEREC method for criteria weighting, sensitivity analyses were performed by creating two different scenarios and the results were examined comparatively. After selecting the components within the scope of Piotroski F-score to evaluate the performance of the companies in the IT sector, the MEREC method was used for weighting each criterion. After determining the criteria weights, the MARCOS method was used to determine the financial performance rankings. The study differs from the existing literature in two aspects. Firstly, there is no study that uses MEREC and MARCOS methods, which are among the current multi-criteria decision-

making techniques, to analyze the performance of the BIST IT sector. In addition, the fact that there is no study using Piotroski F score components as a performance evaluation criterion distinguishes the study from the existing literature and reveals its originality.

Findings

Based on the results of the MEREC method used in the criteria weighting within the scope of the study, it is seen that there is a differentiation in the criteria weights in each period examined. However, when a generalization is made based on the results obtained, it is concluded that the Piotroski F-score components with the highest criterion weights are listed as asset turnover (K8) and return on assets ratio (K3), while the lowest criterion weight belongs to the current ratio (K6) component. The results based on the criteria weights determined by the MEREC method show that the best-performing firms for the period 2023:Q1-2023:Q4 are AZTEK, ATATP, SMART, and VBTYZ, while the lowest-performing firms are NETAS, ESCOM, OBASE, and ESCOM. In addition, two different scenarios were created for the sensitivity analysis conducted in the study. According to the results of the sensitivity analysis, it was determined that for both scenarios, identical or close results were obtained in the best and worst performance rankings, except for the 2023:Q4 period.

Conclusion

The results obtained from the MEREC-based MARCOS method in the study show that the best performance belongs to SMART and PAPIL companies in general. In addition, it is concluded that the firms with the lowest performance are generally KAREL and OBASE. However, it is seen that it is difficult to identify a firm that consistently shows the best performance and the worst performance in the firms operated in the IT sector. In this respect, the findings obtained show fluctuations in the periods. Considering the Piotroski F-score components, firms with low performance should increase their profitability components, have a strong financial structure, and improve their efficiency levels in their operational activities when evaluated based on Piotroski components.

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DİJİTALEŞME ÇAĞINDA ROBOTLARIN VE ROBOTİK SÜREÇ OTOMASYONUNUN EKONOMİK ETKİLERİ

Economic Impacts of Robots and Robotic Process Automation in the Age of Digitalization

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Anahtar Kelimeler: Robotlar, Robotik Süreç Otomasyonu, İnovasyon, Ekonomik Büyüme, Yapısal Dönüşüm

JEL Kodları: O14, O32, O40

Öz

Teknolojik değişme, ekonomik büyüme sürecinin arkasındaki temel güçtür. Robotik süreç otomasyonu ve robotlar, daha önce ortaya çıkan buhar teknolojisinin ve elektrik enerjisinin yarattığı etkiler kadar ekonomik büyüme sürecine önemli katkı yapabilecek yeniliklerdir. Bu çalışmanın amacı, robotların ve robotik süreç otomasyonun ekonomide yarattığı değişimleri açıklamak ve ileride sahip olacakları potansiyeli tartışmaktır. Bu çalışmada, ilk olarak, robotların ve robotik süreç otomasyonun ekonomide yarattığı değişimler açıklanmaya çalışılmıştır. Bu çerçevede, robotların ve robotik süreç otomasyonun emek üretkenliği, istihdam, işlerin niteliği, yatırımlar, hizmetler sektörü gibi alanlarda yarattığı dönüşümler ve gelecek dönemde yaratabilecekleri etkiler incelenmiştir. Çalışmada ikinci olarak, robotik süreç otomasyonun yarattığı etkiler, örnek bankanın ticari kredi tahsis ve fatura ödeme süreçleri üzerinden gösterilmiştir. Her iki süreçte de robotik süreç otomasyonu kullanılması, üretkenlik artışına neden olmuştur. Bu süreçlerde robotik süreç otomasyonundan faydalanılması, istihdam kaybına sebep olmamıştır. Ticari kredi tahsis ve fatura ödeme süreçlerinde robotik süreç otomasyonundan yararlanılması sonucunda çalışanlar, rutin manuel ve tekrarlı işleri yapmayı bırakmışlar, katma değeri daha yüksek olan faaliyetlere daha fazla zaman ayırma imkanına kavuşmuşlardır. Robotik süreç otomasyonu, bütün bu kazanımları diğer bankacılık uygulamaları ile karşılaştırıldığında oldukça düşük yatırım maliyeti ile gerçekleştirmiştir. Yarattığı bütün bu etkiler sayesinde robotik süreç otomasyonu, örnek bankada önemli değişim yaratmıştır.

Keywords: Robots, Robotic Process Automation, Innovation, Economic Growth, Structural Change

JEL Codes: 014, O32, O4

Abstract

Technological change is the fundamental force behind the process of economic growth. Robotic process automation and robots are innovations that can make a significant contribution to the economic growth process, such as previously emerged steam technology and electrical energy. The aim of this study is to explain the changes that are created by robots and robotic process automation in the economy and to discuss the potential they will have in the future. In this study, firstly, the changes created by robots and robotic process automation in the economy have been attempted to be explained. Within this framework, the transformations and potential future impacts of robots and robotic process automation on labor productivity, employment, the nature of jobs, investments, and the services sector have been examined. Secondly, the effects of robotic process automation are demonstrated through the commercial loan allocation and bill payment processes of the sample bank. The use of robotic process automation in both processes has caused productivity increase. Using robotic process automation in these processes did not cause employment loss. As a result of utilizing robotic process automation in commercial loan allocation and bill payment processes, employees stopped doing routine, manual, and repetitive tasks and had the opportunity to spend more time on activities with higher added value. Robotic process automation has achieved all these gains with a very low investment cost compared to other banking applications. Thanks to all these effects, robotic process automation has created a significant change in the sample bank.

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1. Giriş

On sekizinci yüzyılın sonunda ortaya çıkan bir dizi icat ve yenilik, İngiltere'de pamuk üretimi başta olmak üzere, imalat sanayinde büyük değişimler yaratmıştır. Sanayi devriminin meydana gelmesine neden olan bu yenilik ve icatlar, toplumun bütün alanlarında derin dönüşümlere sebep olmuşlardır. İngiltere'de emek üretkenliği ve kişi başına düşen gelir, sanayi devriminin sonucu olarak hızlı şekilde artmıştır. Tarihte daha önce görülmeyen kendi kendine devam eden büyüme süreci, ilk defa İngiltere'de sanayi devriminin neticesinde ortaya çıkmıştır. Ekonomi ve bilgi, daha önce hiç rastlanmayan bir şekilde hızlı büyüme sürecine girmiştir. Bu hızlı büyüme süreci, sanayileşen ülkeler ile sanayileşme sürecinde geç kalan ülkeler arasında gelir farklılıklarının hızla artmasına neden olmuştur (Landes, 2017).

Teknolojik değişim süreci, sanayi devriminin arkasındaki temel itici güçtür. İngiltere'de on sekizinci yüzyılda ücretler, hem diğer Avrupa ülkelerindeki ücretlere göre, hem de sermayenin getirisine göre daha yüksektir. İngiltere, aynı zamanda, geniş kömür yataklarına da sahiptir. Bu durum, kömürün İngiltere'de oldukça bol ve ucuz olması sonucunu doğurmaktadır. İngiltere'nin on sekizinci yüzyılda sahip olduğu bu özel koşullar, sanayi devrimi tetikleyen esas faktörlerdir. Sermaye ve enerji kaynaklarının emeğe göre daha ucuz ve bol olması, emek tasarrufu ve verimlilik artışı sağlayacak yeniliklerin önünü açmıştır. Özellikle buhar teknolojisi, sanayinin çok farklı alanlarında kullanım imkânına sahip olduğu için, sanayi devrimine yol açan en önemli teknolojik yeniliktir (Allen, 2022).

Buhar teknolojisi gibi ekonomik büyüme sürecinde ölçeğe göre artan getiriye neden olan ve ekonomilerin kendi içsel dinamikleri ile gelişmesine sebep olan yenilikler, genel amaçlı teknolojiler olarak adlandırılmaktadırlar (Moser ve Nicholas, 2004). Genel amaçlı teknolojiler hem iş dünyasını hem de insan hayatını değiştirerek, toplumun bütün alanlarında önemli dönüşümlere neden olmaktadırlar. Buhar teknolojisi, elektrik enerjisi, içten yanmalı motorlar ve bilgi işlem teknolojileri, genel amaçlı teknolojiler olarak sınıflandırılmaktadırlar (Jovanovic ve Rousseau, 2005). Genel amaçlı teknolojilerin sahip olduğu üç önemli özellik, ekonomilerin büyüme sürecinde önemli rol oynamalarına neden olmaktadır. Bu özelliklerden ilki, genel amaçlı teknolojilerin çok farklı alanlarda kullanılabilmesidir. Genel amaçlı teknolojiler, ortaya çıktıkları sanayiler dışında da geniş kullanım alanına sahiptirler. Genel amaçlı teknolojilerin ekonomide büyük dönüşüm yaratmasına neden olan ikinci özellik, yeni ürünlerin ve hizmetlerin ortaya çıkmasını kolaylaştırmalarıdır. Bu durumun sonucu olarak, genel amaçlı teknolojiler, başka yeniliklerin de önünü açmaktadırlar. Genel amaçlı teknolojilerin sahip olduğu üçüncü önemli özellik, zaman içinde geliştirilmeye açık olmalarıdır. Bu sayede, maliyetleri zamanla önemli ölçüde azalmaktadır (Bresnahan ve Trajenberg: 1995; Javanovic ve Rousseau, 2005).

Robotlar, daha önce ortaya çıkan buhar teknolojisi, elektrik enerjisi, içten yanmalı motorlar ve bilgi işlem teknolojileri gibi genel amaçlı teknolojilerin özelliklerini taşımaktadırlar. İmalat sanayinde 1970'li yılların başından beri kullanılan robotların etkinliği, 1980 yıllardan itibaren artmıştır. Dünya üzerinde işlevsel olan robotların tahmin edilen sayısı, 1973 yılında 3000'dir. Bu sayı 1990 yılında 454.000'e çıkmıştır (Fırat ve Fırat, 2017). Robotlar, 2000'li yıllar ile birlikte hizmetler sektöründe de kullanılmaya başlamışlardır. Gelecek dönemde daha önce ortaya çıkan genel amaçlı teknolojiler gibi büyük dönüşümler yaratacak potansiyele sahiptirler.

Endüstri 4.0 süreci ve dayandığı teknolojiler, son dönemde hem imalat sanayini hem de hizmetler sektörünü dönüştürmektedirler. Özellikle hizmetler sektöründe geniş uygulama alanı bulan robotik süreç otomasyonu, bu Endüstri 4.0 teknolojileri arasında yer almaktadır. Robotik

süreç otomasyonu, çalışanların gerçekleştirdiği görevleri taklit eden ve onların yerine yapabilen bir bilgisayar yazılımı olarak tanımlanmaktadır. Robotik süreç otomasyonu, rutin, manuel ve tekrarlı işleri başarı ile gerçekleştirebilmektedir. Robotik süreç otomasyonu, firmalara, hem işleri daha hızlı ve daha düşük maliyet ile gerçekleştirme imkânı sunmakta, hem de yeni ürün ve hizmetlerin ortaya çıkmasına neden olmaktadır. Bu durum, robotik süreç otomasyonun, ekonomide, robotlar ile benzer değişimi yaratacak potansiyele sahip olduğunu göstermektedir.

Bu çalışmanın amacı, robotların ve robotik süreç otomasyonun ekonomide yarattığı değişimleri açıklamak ve ileride sahip olacakları potansiyeli tartışmaktadır. Çalışma, örnek bankanın uygulamaları üzerinden robotik süreç otomasyonun etkilerini göstererek ve robotlar ile robotik süreç otomasyonun ekonomide yarattığı değişimleri detaylı açıklamaya çalışarak diğer araştırmalardan farklılaşmaktadır. Çalışmada ilk olarak, robotların emek üretkenliği, istihdam, işlerin niteliği, yatırımlar, hizmetler sektörü gibi alanlarda yarattığı dönüşümler ve gelecek dönemde yaratabilecekleri etkiler incelenecektir. Robot üretimi, ayrıca bir endüstridir ve bu şekilde de ekonomiyi değiştirmektedirler. Bu nedenle, çalışmada, robot endüstrisinin genel özelliklerinden de bahsedilecektir. Robotik süreç otomasyonun emek üretkenliği, istihdam, işlerin niteliği, yatırımlar ve hizmetler sektöründeki etkileri, robotların aynı alanlarda yarattığı değişimler dikkate alınarak, çalışmanın bir sonraki kısmında tartışılacaktır. Özellikle hizmetler sektöründe önemli dönüşümler yaratma potansiyeline sahip olan robotik süreç otomasyonun yarattığı etkiler, örnek bir bankanın uygulamaları üzerinden, çalışmanın üçüncü bölümünde açıklanacaktır. Sonuç bölümünde ise, robotların ve robotik süreç otomasyonun geleceği tartışılacak, daha önceki bölümlerde ulaşılan sonuçlar özetlenecektir.

2. Robotların ve Robotik Süreç Otomasyonun Ekonomide Yarattığı Dönüşümler

Robotlar ve robotik süreç otomasyonu, ekonomide büyük değişimler yaratabilecek potansiyele sahip teknolojilerdir. Çalışmanın bu bölümünün amacı, robotların ve robotik süreç otomasyonun sahip olduğu bu potansiyeli tartışmak, ekonomide yarattıkları dönüşümleri açıklamaktır. Bu çerçevede bu bölüm, iki alt bölüme ayrılmıştır. İlk alt bölüm robotları, ikinci alt bölüm ise robotik süreç otomasyonunun anlatmaktadır. Her bir alt bölüm, robotların ve robotik süreç otomasyonun üretkenlik, istihdam, işlerin niteliği, hizmetler sektörü, yatırımlar ve üretim ağları üzerindeki etkilerini açıklamaktadır.

2.1. Robotların Ekonomide Yarattığı Dönüşümler

Robotlar, insan müdahalesi olmadan belirli görevleri yerine getiren, farklı yönlerde hareket yeteneğine sahip, otomatik makineler olarak tanımlanmaktadırlar (Benmelech ve Zator, 2022). Emek üretkenliğine yaptıkları katkı açısından genel amaçlı teknoloji özelliği gösteren robotlar, ekonomik ve sosyal değişimler yaratabilecek potansiyele sahiptirler. Bu nedenle, diğer genel amaçlı teknolojiler gibi, toplumun bütün alanlarında gelecek dönemlerde değişimler yaratabilirler (Cséfalvay, 2019; Jungmittag, 2021).

Robotlar ile buhar teknolojisinin emek üretkenliği açısından karşılaştırılması, robotların sahip olduğu genel amaçlı teknoloji potansiyelini anlamak için yol göstericidir. Buhar teknolojisi, sanayi devrimini takip eden dönemde, İngiltere'de, emek üretkenliği artışına önemli katkı yapmıştır. Buhar teknolojisinin İngiltere'de emek üretkenliği artışına yıllık katkısı, 1760 ile 1800 yılları arasındaki dönemde, %0,01'dir. Bu oran, 1850 ile 1870 yılları arasındaki

dönemde %0,41'e çıkmıştır. Bu durum, genel amaçlı teknolojilerin ekonomik büyüme sürecine katkılarının ilk kullanılmaya başladıkları zamanda değil; gecikmeli olarak gerçekleştiğini göstermektedir (Crafts, 2004). Robotlar, emek üretkenliği artışına, buhar teknolojisi kadar katkı yapmaktadırlar. Fakat bu etki, sanayide kullanılmaya başladıkları 1970'li yıllarda değil, 1990'lı yıllardan itibaren görülmeye başlamıştır. Dolayısıyla, robotların da emek üretkenliği artışına katkısı, buhar teknolojisinde olduğu gibi, gecikmeli olarak ortaya çıkmıştır. Graetz ve Michaels (2018), 1993 ile 2007 yılları arasındaki dönemde, Fransa, İtalya, İngiltere, ABD, Almanya ve İsviçre için ortalama yıllık emek üretkenliği artışını, 0,36 olarak hesaplamıştır. Bu oran, İngiltere'de 1850 ile 1870 yılındaki arasındaki dönemde, buhar teknolojisinin emek üretkenliğine katkısı olan %0,41'e yakındır.

İmalat sanayi, robotların ekonomide yarattığı etkinin en net görüldüğü alanların başında gelmektedir. Robotlar, 1970'li yılların başından itibaren, imalat sanayinde kullanılmaktadırlar. Robotların imalat sanayinde kullanımları, 1980'li yıllardan beri önemli ölçüde artmıştır (Zamalloa vd., 2017). Robotlar, başta otomotiv olmak üzere imalat sanayiinin farklı alanlarında otomasyona neden olmaktadırlar. Robotlar, imalat sanayinde genellikle montaj hattında yapılan faaliyetler gibi, rutin, tekrarlı ve manuel işleri yapmaktadırlar (Baldwin ve Forslid, 2020). Robotik alanında yapılan yenilikler, 2000'li yıllardan itibaren, hizmetler sektöründe daha çok yoğunlaşmaya başlamıştır. Hizmetler sektöründe robotların kullanımının, özellikle yapay zeka alanındaki gelişmelerin etkisi ile gelecek dönemde daha da çok artması beklenmektedir (Zamalloa vd., 2017). Bilgisayarların hesaplama kapasitesinin büyümesi, sayısal kontrollü alet teknolojilerinde meydana gelen gelişmeler, elektrik enerji depolama kapasitesinde ortaya çıkan artış, elektronik güç etkinliğinin önemli ölçüde yükselmesi, yerel düzeyde dijital iletişimin kapasitesinin büyümesi, internet kullanımının bütün dünyaya yayılması, dünya çapında veri depolama kapasitesinin önemli ölçüde gelişmesi gibi son yıllarda meydana teknolojik yenilikler, robotların ekonomide büyük dönüşümler yaratma potansiyelini önemli ölçüde artmıştır (Pratt, 2015).

Robotlar, daha önce görülen genel amaçlı teknolojiler gibi ekonomide büyük değişim yaratacak potansiyele sahiptirler. Robotların ekonomide değişim yaratacağı alanların başında, emek üretkenliği, istihdam, işlerin niteliği, yatırımlar ve hizmetler sektörünün yapısı gelmektedir. Robot üretim zinciri de yarattığı istihdam ve katma değer ile ülke ekonomilerinin gelişmesine önemli etki yapmaktadır. Çalışmanın bu bölümünde, robotların ekonominin bu alanlarında yarattığı değişimler açıklanmaya çalışılacaktır.

2.1.1. Robotların İstihdam Üzerindeki Etkileri

İstihdam, robotların ekonomide en önemli dönüşümü yaratması beklenen alandır. Firmaların robotları üretim süreçlerinde kullanmalarının iş piyasasında yarattığı değişim, iki etkinin sonucunda ortaya çıkmaktadır. Bu faktörlerden ilki, yer değişim etkisidir. Robotlar, insanların yaptığı işlerin azalmasına sebep olmakta; dolayısıyla istihdamın düşmesine yol açmaktadırlar. İkinci faktör ise, üretkenlik etkisidir. Robotların yarattığı üretkenlik artışı, başka alanlarda yeni işlerin ortaya çıkması sonucunu doğurmakta; bu sayede, yer değişim etkisinin olumsuz sonuçları ortadan kalkmaktadır (Acemoğlu ve Restrepo, 2020; Dauth vd., 2021). Robotların toplam istihdama etkisi, bu iki faktörün sonucu ortaya çıkarken; robotların kullanımı, firma düzeyinde istihdamı ve çıktıyı arttırmaktadır. Fakat aynı durum, robot kullanan firmaların robot kullanmayan rakipleri için söz konusu değildir. Robot kullanmayan firmalar, robot

kullanan rakipleri lehine istihdam ve çıktı kaybına uğramaktadırlar (Acemoğlu vd., 2020; Koch vd., 2021; Acemoğlu vd., 2023). Acemoğlu vd. (2020) çalışması, bu durumu, 2010 ile 2015 yılları arasındaki dönemde Fransa için göstermektedir. Bu çalışmanın ulaştığı sonuçlara göre, robot kullanmayan firmalar, rakipleri robot kullandığı durumda, istihdam da yüzde 2,5, çıktı da ise yüzde 2,1 kayba uğramaktadırlar. Robot kullanımının toplam istihdam üzerindeki etkisinin negatif olduğu, ABD, Fransa, İspanya ve Hollanda için yapılan farklı araştırmalarda da gösterilmiştir (Acemoğlu vd., 2020; Acemoğlu ve Restrepo, 2020; Koch vd., 2021; Acemoğlu vd., 2023). Almanya için ise durum farklıdır. Dauth vd. (2021), Almanya'da 1994 ile 2004 yılları arasındaki dönemde, robotların toplam istihdama etkisini incelemiştir. Bu çalışmada, robot kullanımı, toplam istihdam üzerinde negatif etki yaratmamaktadır. Almanya'da robot kullanımı, imalat sanayinde istihdamın azalmasına neden olmuştur; fakat bu etki, hizmetler sektöründe istihdam artışı ile dengelenmiştir. İmalat sanayiinde işlerini kaybedenler, hizmetler sektöründe yeni işler bulabilmişlerdir. Dolayısıyla, Almanya'da yer değişim etkisinin üretkenlik etkisi ile dengelendiği iddia edilebilmektedir. Bu nedenle, robotların toplam istihdam etkisini değerlendirirken, ülkelere özgü dinamikleri dikkate almak önemlidir.

2.1.2. Robotların İşlerin Niteliği Üzerindeki Etkileri

Robotların ekonomide dönüşüm yarattığı en önemli alanlardan biri işlerin niteliğidir. De Vries vd. (2020), 2005 ile 2015 yılları arası dönem için, 37 farklı ülkedeki 19 endüstride, robotların rutin ve manuel işlere olan etkisini incelemiştir. Firmaların robot kullanımı, bu çalışmanın ulaştığı sonuçlara göre, rutin ve manuel işlerde azalmaya sebep olmaktadır. Bu etki, özellikle, işçi ücretlerinin yüksek olduğu gelişmiş ülkelerde daha net olarak görülmektedir. Rutin olmayan görevler, yaratıcılık ve problem çözme gibi yetenekler gerektirmektedirler. Bu işlerde otomasyon zor olduğu gibi, robotlar ve insanlar beraber hareket etmek zorunda kalmaktadırlar. Robotların üretim süreçlerinde kullanımı, programlama ve tasarım gibi rutin olmayan yeni işlerin ortaya çıkması sonucunu da doğurmaktadır. Bu nedenlerle, üretim süreçlerinde robotlardan daha çok faydalanılması, rutin olmayan işleri arttırmaktadır. Robot kullanımının rutin olmayan işleri arttırıp, rutin işleri azaltması; düşük nitelikli çalışanları, orta ve yüksek nitelikli çalışanlara göre daha fazla etkilemektedir (Graetz ve Michaels, 2018). Ağırlıklı olarak rutin ve manuel işlerde çalışan düşük nitelikli çalışanlar, robotların üretim süreçlerinde kullanılmasından olumsuz etkilenirken; rutin olmayan işlerde çalışan yüksek nitelikli çalışanlar için aynı durum söz konusu değildir. Onlar bu süreçten olumlu etkilenmektedirler. Robot alımından sonra firmalar, yüksek eğitimli ve yüksek nitelikli çalışanları istihdam etmeyi daha çok tercih etmektedirler (Tang vd, 2021).

2.1.3. Robotların Üretkenlik Üzerindeki Etkileri

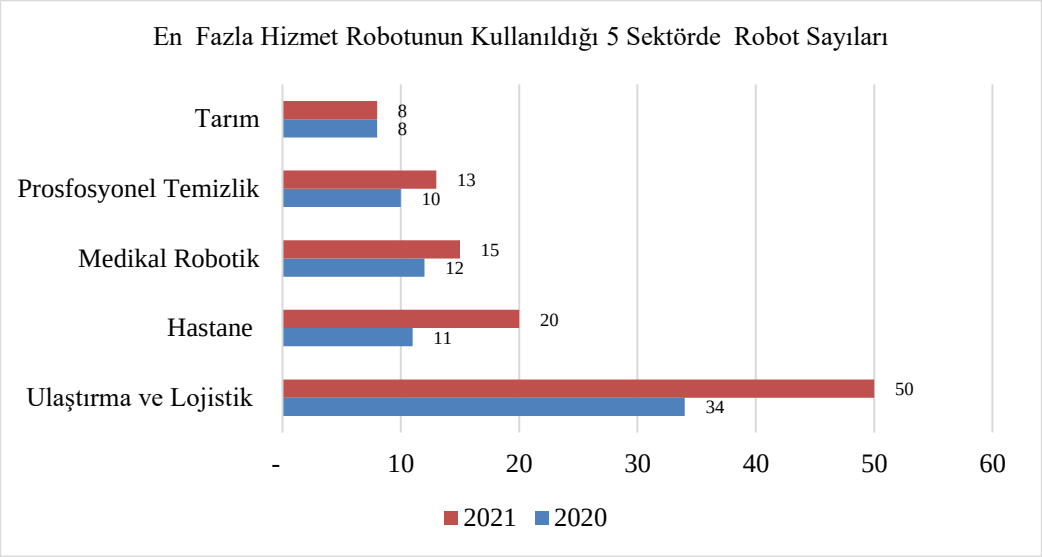
Yaşam standartlarının yükselmesi, üretkenlik artışı olmadan mümkün değildir. Fakat, küresel ekonomi, kalıcı hale gelmiş üretkenlik düşüşleri ile karşı karşıyadır. Bu eğilim, özellikle gelişmiş ülkelerde daha belirgindir. Robotlar, kalıcı hale gelmiş bu üretkenlik azalışlarını tersine çevirebilecek teknolojilerin başında gelmektedirler (Atkinson, 2018). Robotlar, giriş bölümde de ifade edildiği gibi, üretkenlik artışına daha önceki genel amaçlı teknolojiler gibi önemli katkı yapmaktadırlar. Dolayısıyla, robotların ekonomide önemli değişimler yarattığı alanların başında üretkenlik gelmektedir.

Robotların üretkenlik artışına yaptığı katkılar, farklı araştırmalarda gösterilmiştir. Bu çalışmaların başında, Graetz ve Michaels (2018) gelmektedir. Bu çalışma, 1993 ile 2007 yılları arasındaki dönemde, 17 ülkede, robot kullanımının emek üretkenliğine etkisini incelemektedir. Çalışmanın ulaştığı sonuca göre, artan endüstriyel robot kullanımı, emek üretkenliğine kalıcı ve anlamlı katkı yapmaktadır. Graetz ve Michaels (2018) tarafından ortaya konulan sonuçların benzerine, Kromann vd. (2020) tarafından da ulaşılmıştır. Bu çalışma, 2004 ve 2007 yılları için, 9 ülkede, 10 farklı imalat sanayi alt sektöründe, robot kullanımının emek üretkenliğine etkisini araştırmaktadır. Robot kullanımının artması, emek üretkenliğinin yükselmesine neden olmaktadır. Robotlardan en fazla faydalanmaya çalışan ülkeler, düşük ücretlerde karşılaştırmalı üstünlüğe sahip olan ülkeler karşısında dış ticaret açığı verenlerdir. Bu çalışmada, robot yatırımlarını en çok arttırmaya çalışan ülkeler, en fazla Çin rekabetine maruz kalanlardır. Jungmittag ve Pesole (2019), Avrupa Birliği'ne üye olan 12 ülkede, 9 imalat sanayi alt sektöründe, 2008 ile 2015 yılları arasındaki dönem için, robot kullanımının emek üretkenliğine etkisini incelemiştir. Bu çalışmanın ulaştığı sonuçlar da, diğer çalışmalar ile uyumludur. Robot kullanımı, emek üretkenliği üzerinde anlamlı etkiye sahiptir. Ulaştırma ekipmanları, bu çalışmada bulunan 12 ülkede, robot kullanımının emek üretkenliği artışına en fazla katkı yaptığı sektördür. Ulaştırma ekipmanları sektöründen sonra robot kullanımının emek üretkenliği artışına en fazla katkı yaptığı sektörler, plastik ve plastik ürünleri sektörü ile metal ve metal ürünleridir. Robotların emek üretkenliği artışına en az katkı yaptığı sektör ise, kimyasal ürünlerdir. Almanya, Fransa gibi Avrupa Birliği üyesi gelişmiş ülkelerin Doğu ve Orta Avrupa ülkelerinde, özellikle de otomotiv sektöründe robot yatırımı yapmaları, bu ülkelerdeki emek üretkenliği artışına olumlu katkı yapmaktadır. 2006 ile 2019 yılları arasında Orta ve Doğu Avrupa ülkelerine gelişmiş ülkeler tarafından otomotiv sektöründe yapılan robot yatırımları, Slovakya, Çek Cumhuriyeti, Slovenya, Macaristan'da emek üretkenliği artışı üzerinde oldukça olumlu etki yaratmıştır (Cette vd., 2021).

2.1.4. Robotların Hizmetler Sektörü Üzerindeki Etkileri

Genel amaçlı teknolojilerin en önemli özelliklerinden biri, ortaya çıktıkları sektörler dışında da dönüşümlere neden olmalarıdır. Genel amaçlı teknoloji özellikleri gösteren robotlar da giriş bölümünde ifade edildiği gibi, bu özelliğe sahiptirler. Hizmetler sektörü, bu durumun en net görüldüğü alanların başında gelmektedir. Robotlar, hizmetler sektöründe önemli etkiler yaratmaya başlamışlardır. Robotik alanında gelişmeler ve inovasyonlar, 1960 ile 2000 yılları arasında, sanayi sektöründe yoğunlaşmıştır. Bu durum, 2000'li yıllardan sonra değişmiştir. Robotik alanındaki geliştirmeler ve inovasyonlar, hizmetler sektöründe, sanayi sektörüne göre daha yoğun görülmeye başlamıştır. Daha yüksek hesaplama kapasitesine sahip, yapay zekâ algoritmaları kullanan, karmaşık sensör sistemleri içeren robotlar ortaya çıkmıştır. Bu robotlar, endüstriyel robotların aksine, insanlar ile ortak hareket edebilme kabiliyetine de sahiptirler (Zamalloa vd., 2017). Robotlar, hizmetler sektöründe önemli dönüşüm yaratacak potansiyele sahiptirler; ama bu sektördeki kullanımları henüz başlangıç aşamasındadır. Bu durum, aşağıda bulunan Şekil 1'de görülmektedir. Şekil 1, hizmet robotlarının en yoğun olduğu 5 sektördeki toplam kullanımlarını 2020 ve 2021 yılları için göstermektedir. Hizmetler sektöründe robot kullanımı, Şekil 2'de görülen sanayi sektöründeki robot kullanımının çok gerisindedir. Bu duruma neden olan temel faktör, hizmetler sektöründe robot kullanımı için gerekli olan yatırımların yetersiz olmasıdır. Bunun yanında, hizmetler sektöründe iş süreçlerini yeniden

tasarlamak ve yapılandırmak gerekmektedir. İşçilerin de yeniden eğitilmesi, yeni teknolojilere uyum sağlayabilmeleri için büyük önemdedir (Cséfalvay ve Gkotsis, 2022).



Şekil 1. En Fazla Hizmet Robotunun Kullanıldığı 5 Sektörde 2020 ve 2021 Yılları için Robot Sayıları (Sayılar 1000 olarak ifade edilmiştir).
Kaynak: Bill vd. 2022.

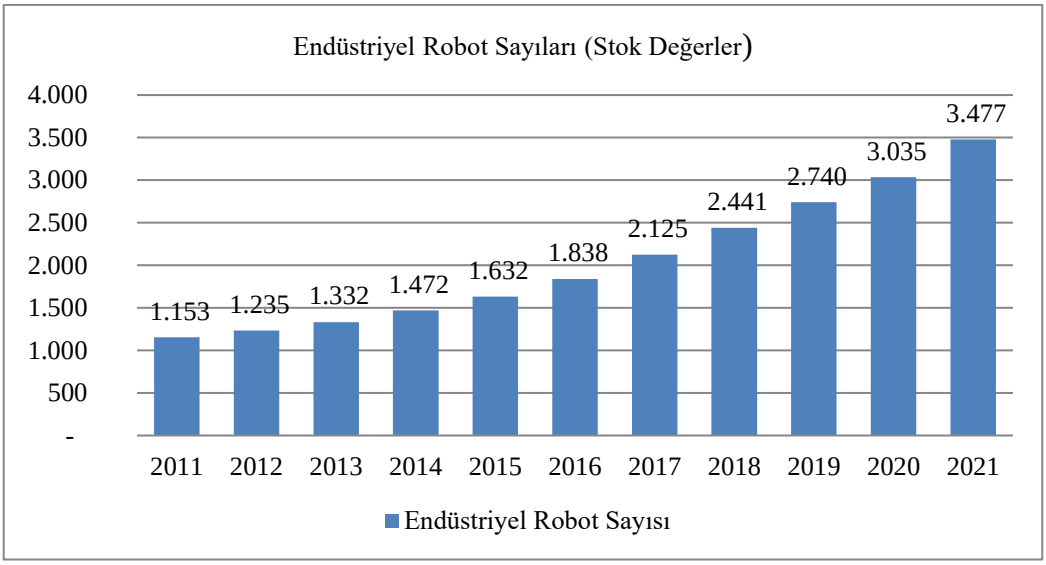
Robotlar, hizmetler sektöründe şu aşamada çok sınırlı olarak kullanılmaktadırlar; fakat perakende ve toptan ticaret, lojistik, eğitim, sağlık ve güvenlik alanları başta olmak üzere, hizmetler sektörünün çok farklı alanlarında geniş kullanım olanağına sahiptirler. Özellikle Japonya, hizmetler sektöründe robot kullanımında öncü konumdadır. Japonya, toplumun bütün alanlarına robotları entegre etmeye çalışan ilk ülkedir (Macrorie vd., 2019). Bu durum, Japonya'da çok farklı alanlarda robotların kullanılmaya çalışılmasına neden olmaktadır. Japonya'da hizmetler sektöründe robotların kullanıldığı alanların başında sağlık sektörü gelmektedir. Japon hükûmeti, özellikle hasta bakımı alanında hem robot kullanımını hem de robotların geliştirilmesini desteklemektedir. Yerel düzeydeki hükûmetler de bakımevlerinde robot kullanımını arttırmak için önemli teşvikler sağlamaktadırlar. Bakımevlerinde kullanılan robotlar, hasta bakıcıların ve hemşirelerin üzerindeki yükü önemli ölçüde azaltmaktadırlar. Fakat robotların, bu alanda çalışan hemşirelerin ve hasta bakıcıların yerini tamamen alması şu aşamada mümkün değildir. Sağlık çalışanları ve robotlar, işleri paylaşmakta ve birbirlerini tamamlamaktadırlar. Robotlar, Japonya'da yalnızca bakımevlerinde işleri azaltmakla kalmamakta, aynı zamanda kaza sayılarında da önemli azalışa sebep olmaktadırlar (Eggleston vd., 2021). Lojistik, robotların hizmetler sektöründe kullanılmaya başladığı diğer bir alandır. Amazon, elektronik ticaretin artmasının da etkisiyle, depolarında ve ulaştırma işlemlerinde robotlardan faydalanmaktadır. Tüketicilerin değişen eğilimleri, Amazon gibi lojistik sektöründe faaliyet gösteren firmaları, robot kullanmaya zorlamaktadır. Depo yönetimi ve lojistik alanlarında robot kullanımı, maliyetlerin düşmesine ve üretkenlik kazanımlarına neden olduğu gibi; karşılaşılan sorunlara esnek, uyumlu ve akıllı çözümler sunmaktadır. Depo yönetimi ve lojistik alanlarında robotların kullanımı, hataların da azalmasına neden olmaktadır (Estolatan

vd., 2018). Robotların, yakın dönemde, sağlık ve lojistik sektöründe olduğu gibi hizmetler sektörünün birçok alanında önemli rol oynaması oldukça muhtemeldir.

2.1.5. Robotların Yatırımlar Üzerindeki Etkileri

Robotların ekonomide dönüşüm yarattığı diğer bir alan yatırımlardır. Robot yatırımları, küresel rekabetin arttığı son dönemde epey önemli hale gelmiştir. Belli faktörler, ülkelerin ve firmaların robot yatırımı yapmasında etkili olmaktadırlar. Fernandez-Macias vd. (2021), Avrupa'da sanayi sektöründe faaliyet gösteren firmaların robot yatırımı yapmalarının nedenlerini incelemiştir. Üç faktör, bu çalışmada, firmaların robot yatırımı yapma kararı almasında önemli rol oynamaktadır. Bu etmenlerden ilki, rutin işlerin yoğunluğudur. Rutin işlerin artması, firmaların robotlara yatırım yapma eğilimini olumlu etkilemektedir. İkinci etmen, robotların kullanıldığı sektörün teknoloji rejimidir. Ölçek yoğun endüstriler, robot yatırımı yapmaya diğer endüstrilere göre daha çok meyillidirler. Üçüncü faktör, firmaların uluslararası pazarlarda maruz kaldığı rekabetin düzeyidir. İhracat yapan firmalar, küresel pazarlarda rekabet güçlerini korumak için robot yatırımı yapmaya daha fazla eğilimlidirler (Fernandez-Macias vd., 2021). Bu üç faktör, robot yatırımı yapılmasında önemli rol oynasa da en önemli etmen işçi ücretleridir. İşçilerin yerine robotların kullanılması ile elde edilecek maliyet tasarrufu, robot yatırımı kararlarının en önemli belirleyicisidir. İşçi ücretlerinin yüksek, emeğin kıt olduğu durumlarda, robot yatırımları artmaktadır (Atkinson, 2018; Graetz ve Michaels, 2018; Cheng vd., 2019; Fan vd., 2021). Yüksek işçi ücretleri, Sanayi devriminde yüksek emek maliyetlerinin İngiltere'de emek tasarrufuna neden olan inovasyonları tetiklemesi gibi, firmaların robot yatırımı kararı almasına önemli etki yapmaktadır. Robot yoğunluğunun en yüksek olduğu üç Avrupa ülkesi olan Almanya, İsveç ve Danimarka'da, imalat sanayinde saatlik işçi ücretleri, 40 euro'nun üzerindedir. Robot yoğunluğunun en az olduğu üç Avrupa ülkesi olan Romanya, Polonya ve Portekiz de ise imalat sanayinde saatlik işçi ücreti 12 euro'nun altındadır. Bu durum, robot yatırımlarında, ülkelerdeki işçi ücretlerinin önemine işaret etmektedir (Cséfalvay, 2023).

Dünyada kullanılan endüstriyel robot sayısı, son dönemde artmıştır. Bu durum, aşağıda bulunan Şekil 2'de görülmektedir. Dünyada sanayi sektöründe kullanılan robot sayısı, son on yılda, 1,15 milyondan 3,47 milyona çıkmıştır. Bu yükseliş eğilimine rağmen; dünyada yapılan robot yatırımlarının toplam yatırımlar içindeki payı hâlen çok düşüktür. Robot yatırımları, 2015 yılında, 1995 yılana göre önemli ölçüde artsa da toplam ekipman yatırımları içinde oldukça küçük bir paya sahiptir. 2015 yılında robotlara yapılan yatırımın toplam yatırımlar içindeki payı, yüzde 0,3 civarındadır. Robotların toplam sermaye oluşumu içindeki oranı ise daha düşüktür. 2015 yılında bu oran, yüzde 0,1'e ancak ulaşmıştır. 1995 ile 2015 yılları arasında yapılan robot yatırımları, en çok imalat sanayi alanında yoğunlaşmaktadır. İmalat sanayi dışındaki alanlarda yapılan robot yatırımları ihmal edilebilir düzeydedir. Tarım, madencilik, hizmetler sektörlerinde robotlar kullanılmaktadır; ama ekonominin tamamına bakıldığında robotlardan faydalanma oranı epey düşüktür. Robot yatırımları, imalat sanayi içinde, otomotiv sektörü, metal sanayi gibi belli alanlarda yoğunlaşmaktadır. Robotlar, tekstil, yiyecek içecek sektörleri gibi hafif sanayilerde çok az kullanılmaktadırlar (Benmelech ve Zator, 2022). Robot yatırımları, günümüzde, belli alanlarda yoğunlaşmalarına ve toplam içinde küçük bir paya sahip olmalarına rağmen; gelecek dönemlerde daha çok artması beklenmektedir.



Şekil 2. Kullanılan Toplam Endüstriyel Robot Sayısı (Sayılar 1000 olarak ifade edilmiştir).
Kaynak: Bill vd. 2022.

2.1.6. Robotların Üretim Ağları Üzerindeki Etkileri

Son dönemde Endüstri 4.0 süreci ile ilişkili teknolojilerin kullanımının yayılması, yeni üretim ağlarının ortaya çıkmasına neden olduğu gibi; mevcut üretim ağlarının yapısında da önemli değişimlere yol açmaktadır. Robotlar da bu Endüstri 4.0 teknolojilerinin arasında bulunmaktadırlar. Robotların üretimi, dağıtımı ve satışı, yeni bir üretim ağının ortaya çıkmasına neden olmaktadır (Fu ve Cheng, 2022). Robot üretimi ağı, yeni istihdam olanakları yaratmasının yanında; yatırımların ve yeniliklerin de meydana gelmesine sebep olarak, ekonomide önemli dönüşümler yaratmaktadır (Cséfalvay, 2023). Robot üretim ağı dört bölümden oluşmaktadır. Bu aşamalardan ilki, robotların geliştirilmesidir. Firmalar, üniversiteler ve araştırma kuruluşları, robotik alanındaki son teknolojileri geliştirmektedirler. Bu aşamada faaliyet gösteren firmaların temel etkinliği, araştırma ve geliştirmedir. İkinci aşama, robot imalatıdır. Robot imalatçılarının temel faaliyeti robotların üretilmesidir. Robot üreticisi firmalar geniş ölçekte robot imalatı yapmakta ve satış faaliyetleri gerçekleştirmektedirler. Bu temel faaliyetlerinin yanında, araştırma ve geliştirme faaliyetlerinde de bulunabilmektedirler. Robot üretim ağının üçüncü aşaması, robotların kullanıcıların üretim sistemlerine entegre edilmesidir. Sistem entegratörleri, son tüketici ile robot üreticileri arasında bulunmaktadırlar. Robotik sistemlerin karmaşık bir doğası vardır. Robot sistemleri, robot kullanan son tüketicilerin ihtiyaçlarına göre önemli farklılıklar göstermektedirler. Bu nedenle, robot sistemlerinin bu değişiklikleri dikkate alarak düzenlenmesi gerekmektedir. Sistem entegratörleri, son kullanıcıların robotları üretim süreçlerine adapte etmelerine yardımcı olmaktadırlar. Robot üretim ağının son aşaması ise, robotların üretim süreçlerinde kullanılmasıdır. Tüketiciler, üretim süreçlerinde, robotları üretim faktörü olarak kullanan firmalardır (Cséfalvay ve Gkotsis, 2022; Fu ve Cheng, 2022; Leigh ve Kraft, 2017).

Robot üretim ağının ilk aşaması, robotik alanında yapılan araştırma ve geliştirme süreçlerini kapsamaktadır. Robotik araştırmaları, makine ve elektrik mühendisliği, bilgisayar ve bilişsel bilimler, biyoloji ile ilgili alanlar gibi çok farklı disiplinleri içermektedir. Özellikle yazılım geliştirmesi, robotik araştırmalarında oldukça önemlidir (Leigh ve Kraft, 2017). Çok

farklı sektörlerde kullanılabilecek robotlar, bu alanlarda yapılan araştırmaların sonucunda ortaya çıkmaktadırlar. ABD, robotik araştırmalarında öncü ülke konumundadır. Japonya, Çin, Almanya, Güney Kore gibi gelişmiş ülkeler de, robotik araştırmalarına önemli yatırımlar yapmaktadırlar (Ghiasi ve Lariviere, 2015). Robot üretim ağının ikinci aşaması olan robot imalatı, robot geliştirme aşamasında olduğu gibi, az sayıda ülkede yoğunlaşmaktadır. Özellikle Almanya ve Japonya, robot imalatında lider ülkelerdir. İki faktör, bu durumun ortaya çıkmasında önemli rol oynamaktadır. Güçlü imalat sanayi tabanına sahip ülkeler, diğer ülkelere göre robot üretiminde daha çok öne çıkmaktadırlar. İmalat bilgisi, bu ülkeleri, robot üretim sürecinde rakiplerine göre daha avantajlı duruma getirmektedir. İkinci faktör, robot kullanan son tüketicilere olan yakınlıktır. Güçlü otomotiv ve elektronik sektörlerine sahip ülkeler, bu sektörlerin daha az geliştiği ülkelere göre daha fazla robot üretmektedirler (Cséfalvay ve Gkotsis, 2022). Robot üretim ağının ilk iki aşaması, belli başlı ülkelerde yoğunlaşırken; son iki aşaması olan entegrasyon ve robotların son tüketiciler tarafından kullanımı, daha fazla ülkeyi kapsamaktadır. Özellikle, robotik alanında rekabetçi olmak isteyen gelişmekte olan ülkelerin, robotik alanında araştırma ve geliştirme ile robot üretimine gereken önemi vermeleri gerekmektedir.

2.2. Robotik Süreç Otomasyonun Ekonomide Yarattığı Dönüşümler

Almanya imalat sanayi, artan küresel rekabet, iktisadi krizler, değişen tüketici alışkanlıkları, enerji tedariğinde yaşanan sorunlar gibi nedenlerle değişime zorlanmaktadır (Bartodziej, 2017). Almanya, imalat sanayinin karşı karşıya kaldığı bu zorlukların üstesinden gelmek için Endüstri 4.0 sürecini başlatmıştır. Endüstri 4.0, 2013 yılında, Almanya imalat sanayini dijital teknolojiler yardımıyla değiştirmeyi ve küresel pazarlardaki rekabet gücünü arttırmayı hedefleyen Alman stratejik girişimi olarak açıklanmıştır. Endüstri 4.0, en geniş tanımı ile, firmaların üretim ve hizmet süreçlerinde kullandıkları teknolojileri ve içerikleri ifade etmektedir. Siber fiziksel sistemler, akıllı fabrikalarda, fiziksel süreçleri takip edecekler, gerçek sistemlerin sanal kopyalarını üretecekler ve merkezi kontrol olmadan yerel kararlar vereceklerdir. Siber fiziksel sistemler, kendi aralarında olduğu gibi, insanlarla da nesnelerin interneti yardımıyla iletişim kuracaklar ve beraber hareket edeceklerdir. Endüstri 4.0, üretim ve hizmet süreçlerinde bu değişimi yaratırken, sekiz temel teknolojiye dayanmaktadır. Bu teknolojiler, eklemeli imalat, siber fiziksel sistemler, simülasyon teknolojileri, robot teknolojisi, veri analitiği ve yapay zekâ, görselleştirme teknolojileri, bulut teknolojisi ve nesnelerin internetidir. (Börü ve Tahsin, 2023).

Endüstri 4.0 sürecinin dayandığı teknolojiler, imalat sanayini yeni bir aşamaya taşımakta ve Dördüncü Sanayi Devrimi'ni başlamasına neden olmaktadırlar (Börü ve Tahsin, 2023). Endüstri 4.0 sürecinin dayandığı teknolojiler, firmalara, karmaşık üretim ve hizmet süreçlerini daha hızlı tamamlama, üretilen malların ve hizmetlerin kalitesini arttırma, maliyetleri düşürme gibi fırsatlar sunmaktadırlar. Endüstri 4.0 teknolojileri, aynı zamanda hem firmaların hem de ülkelerin karşı karşıya olduğu dijital dönüşüm sürecinin de temelini oluşturmaktadırlar (Ribeiro vd., 2021). Robotik süreç otomasyonu, firmalara bu imkanları sağlayan Endüstri 4.0 teknolojileri arasında bulunmaktadır. Robotik süreç otomasyonu, firmaların iş süreçlerini yeniden düzenlenmesine yardımcı olduğu gibi; şirketlerin yeni ürün ve hizmetleri ortaya çıkarmasına da destek olmaktadır (Siderska, 2020).

Endüstri 5.0 kavramı, temel olarak, insanlar ve makineler arasındaki iş birliğine dayanmaktadır. Endüstri 5.0, sürdürülebilir ürünler ve hizmetler yaratmayı hedeflemektedir. Bu çerçevede Endüstri 5.0 üç temel unsuru kapsamaktadır. Bu unsurlar, insan merkezlilik, sürdürebilirlik ve esnekliktir. Kapitalist üretim sürecinin gezegenimizin sahip olduğu kapasiteyi zorlamaya başlaması, Endüstri 5.0'ın gündeme gelmesinde önemli rol oynamaktadır. Sadece kara odaklanan bir üretim, gezegenimizin karşı karşıya olduğu çevresel ve toplumsal problemleri çözmek için yeterli değildir. Bu nedenle üretim süreci, çevresel ve toplumsal maliyetleri de hesaba katmak durumundadır. Toplumsal ve çevresel maliyetleri dikkate alan ve işçilerin refahına önem veren Endüstri 5.0 teknolojileri arasında ileri robotik uygulamalar da bulunmaktadır.Robotik süreç otomasyonu insanlar ile ortak hareket ederek, iş süreçlerinin daha etkin hale getirilmesine önemli katkı yapmaktadırlar (Fırat, 2023).

Endüstri 4.0 sürecinin dayandığı teknolojiler hem firmaların hem de ülkelerin uluslararası rekabet gücüne önemli katkılar sağlamaktadırlar. Endüstri 5.0 sürecinin dayandığı teknolojiler ise, sosyal ve çevresel maliyetleri dikkate alarak, bireysel ve toplumsal refahı arttırmayı hedeflemektedirler. Robotik süreç otomasyonu, bu iki sürecin özelliklere sahip olan teknolojiler arasında bulunmaktadır. İngiltere'de faaliyet gösteren Telefonica 02 firmasının arka ofis işlerinde robotik süreç otomasyonunu kullanması, bu duruma önemli bir örnektir. Telekomünikasyon sektöründe faaliyet gösteren firma, 2004 yılının başında, rekabet gücünü arttırmak için arka ofis işlerinin bir bölümünü Hindistan'da bulunan taşeron firmasına devretmiştir. Hindistan'da ücretler, İngiltere'ye göre daha düşüktür. Bu sayede, Telefonica 02, maliyetlerini azaltmayı hedeflemektedir. Fakat Telefonica 02'nin Hindistan'da bulunan taşeron firmasına devredeceği işlerin bir sınırı olduğu gibi, orada da çalışanların ücretleri yükselmektedir. Telefonica 02, bu sebeplerle, robotik süreç otomasyonunu iş süreçlerinde kullanmaya başlamıştır. Böylece hem maliyetlerini aşağıya çekmiş hem de küresel rekabet gücünü önemli ölçüde arttırmıştır (Lacity vd., 2015).

Firmalara ve ülkelere rekabet avantajı sağlayan robotik süreç otomasyonu, en genel tanımı ile, çalışanların yaptığı işleri taklit eden ve onların yerine yapabilen bir bilgisayar yazılımı olarak ifade edilebilmektedir. Çalışanlar tarafından yapılan belli görevler, robotik süreç otomasyonu tarafından daha hızlı ve daha düşük maliyet ile gerçekleştirilebilmektedir. Robotik süreç otomasyonu, özellikle tekrarlı, rutin ve manuel işleri başarı ile yerine getirebilmektedir. Robotik süreç otomasyonu, bir yazılım olduğundan dolayı, herhangi bir donanıma veya mekanik kısma sahip değildir (Jovanović vd., 2018).

Robotik süreç otomasyonu, otomasyon teknolojilerinin gelişim sürecinde önemli bir aşamadır. Son 70 yılda bilgisayar alanında meydana gelen yenilikler, otomasyon teknolojilerinin ilerlemesinde önemli rol oynamıştır (Taulli, 2020). Bilgisayar yazılımı kullanarak iş süreçleri otomatize etme fikri, ilk defa 1935 yılında Alan Turing tarafından ortaya atılmıştır. Alan Turing, algoritmalar yardımıyla iş süreçlerinin nasıl daha etkin ve hızlı hale getirilebileceğini göstermiştir (Doguc, 2022). Bütün otomasyon teknolojilerini önemli ölçüde etkileyen yenilikler, robotik otomasyon sürecinin de ortaya çıkmasında önemli rol oynamıştır. Arthur Samuel tarafından 1959 yılında IBM için geliştirilen makine öğrenmesi, bu yeniliklerin başında gelmektedir. Makine öğrenmesi, bilgisayarların çeviri ve metin özetleme gibi karmaşık işleri yapabilmesini sağlamıştır. Çeviri ve metin özetleme konusunda yaşanan sorunlar, doğal dil işleme alanındaki gelişmelerin önünü açmıştır. 1960'lı yıllardan itibaren önemli ilerlemeler kaydeden doğal dil işleme yazılımları, bilgisayarların insan dilini anlamasını hedeflemektedirler. Makine öğrenmesi ve doğal dil işleme alanında meydana gelen yenilikler,

ekran kazıma teknolojisi ile birlikte, 2000'li yılların başında basit robotik süreç otomasyonu uygulamalarının ortaya çıkmasında oldukça etkili olmuşlardır (Yetiz vd., 2021). Robotik süreç otomasyonu, özellikle, 2016 yılından itibaren hizmetler sektörü olmak üzere birçok alanda kullanılmaya başlamıştır (Madakam vd., 2019).

Özellikle veri, süreç ve entegrasyon ile ilgili alanlardaki işlerde, robotik süreç otomasyonu yaygın olarak kullanılmaktadır. Bu durum, aşağıda bulanan Tablo 1'de görülmektedir. Robotik süreç otomasyonu, veri transferi, dosya işleme, veri analizi, akış kontrol, olay tetikleme, bulut ve benzeri uygulamalara erişim gibi görevleri başarı ile yerine getirebilmektedir (Hofman vd., 2020). Robotik süreç otomasyonun hangi özelliklere sahip işler için uygun olduğu, Tablo 1'de görülen robotik süreç otomasyonun kullanıldığı alanlar incelendiğinde ortaya çıkmaktadır. Robotik süreç otomasyonu, her şeyden önce belirli kurallar çerçevesinde çok fazla sayıda yapılan, manuel, çok tekrarlı, standart işler için uygundur. Çok fazla sistemle entegre çalışan, az karmaşık, iyi belgelenmiş, veri girişlerinin dijital ortamdan olduğu süreçlerde robotik süreç otomasyonu kullanılması, başarılı sonuçlar vermektedir (Syed vd., 2020).

Tablo 1. Robotik Süreç Otomasyonunda Görev Sınıfları

Görev	Görevler Sınıfı	Açıklama	Örnekler
Veri ile ilgili	Veri transferi	Veri aktarımı ile İlgili işlevler	Veri şifreleme, dosya yükleme
	Dosya işleme	Dosya biçimlerini değiştirmek, şifrelemek, kodlamak	Dosyaları şifreleme ve kodlama, dosya biçim değişimi
	Veri analizi	Verilerin analiz edilmesi	Konuşmayı metne dönüştürme, optik karakter tanıma
	Uygulama operatörü	Diğer uygulamalara erişme ve çalıştırma	Başka uygulamalarda değerleri değiştirmek
Entegrasyon ile ilgili	Bulut hizmet operatörü	Bulut hizmetlerine erişme ve çalıştırma	Sosyal medya platformlarında bilgi yayınlama
	Girdi aracı operatörü	Girdi araçları kullanımında insanın taklit edilmesi	Tıklama, sürükleme, genişletme, kapatma
Süreç ile ilgili	Olay tetikleyicisi	Belli bir olayı, daha ileri etkinlikleri başlatması için bekleten fonksiyonlar	Dosya değişikliklerini algılama, görüntü ortaya çıkması ile tetikleme
	Akış kontrol operatörü	Belli bir koreografiye öğelerin bağlanması	Döngüler, kullanıcı etkileşimleri

Kaynak: Hofmann vd. 2020.

Robotik süreç otomasyonu, doğru şekilde uygulandığında, firmalara çok önemli kazanımlar sağlamaktadır. Robotik süreç otomasyonun operasyon etkinliğini arttırması, bu faydaların başında gelmektedir. Robotik süreç otomasyonun kullanılması hem iş kapasitesini arttırmakta hem de görevlerin daha hızlı tamamlanmasına neden olmaktadır. Robotik süreç otomasyonu, operasyon etkinliğini arttırmasının yanında, işlerin daha doğru yapılmasına da sebep olmaktadır. Özellikle manuel müdahale gerekliliğin fazla olduğu işlerde robotik süreç otomasyonun kullanılması, hata yapma olasılığını önemli ölçüde azaltmaktadır. İşlerde hata yapma riskinin robotik süreç otomasyonu yardımıyla önemli ölçüde azalması, üretilen ürün ve hizmetlerin kalitesinin artmasına neden olmaktadır. Robotik süreç otomasyonu, 24 saat aralıksız çalışabilmektedir. Bu durum, yukarıda ifade edilen özellikler ile birlikte, iş gücü tasarrufuna neden olmaktadır. Tekrarlı ve sıkıcı işlerin robotik süreç otomasyonu tarafından yapılması, çalışanların katma değeri daha yüksek olan faaliyetlere daha fazla zaman ayırabilmesine imkân

vermektedir. Bu sayede hem çalışan hem de müşteri memnuniyeti artmaktadır. İş süreçlerinde robotik süreç otomasyonu kullanılmasının sağladığı bütün bu faydalar dikkate alındığında; firmalarda robotik süreç otosmasyonu kullanımının önemli verimlilik kazanımlarını beraberinde getireceği rahatlıkla iddia edilebilmektedir (Doguc, 2022; Santos vd., 2020; Syed vd., 2020).

Firmalara önemli faydalar sağlayan robotik süreç otomasyonu, robotlar ile benzer şekilde, ekonominin tamamında önemli değişimler yaratacak potansiyele sahiptir. Robotlar, bir önceki bölümde açıklandığı gibi, emek üretkenliği, istihdam, işlerin niteliği, yatırımlar ve hizmetler sektöründe önemli değişimler yaratmaktadırlar. Robotik süreç otomasyonun bu alanlarda yaratacağı değişimler, Çalışmanın bu bölümünde, robotların bu ilgili alanlarda yarattığı dönüşümler temel alınarak incelenecektir. Robotik süreç otomasyonunun üretim zinciri de robot üretim zinciri gibi, gelecek dönemlerde ülke ekonomilerinin gelişmesine önemli katkılar sağlayacak özelliklere sahiptir. Bu çerçevede, çalışmanın bu bölümünde, robotik süreç otomasyonun üretim zincirinin özelliklerinden de bahsedilecektir.

2.2.1. Robotik Süreç Otomasyonun İstihdam Üzerindeki Etkileri

İstihdam, robotların ekonomide en büyük dönüşümleri yarattığı alanların başında gelmektedir. Robotik süreç otomasyonunun da gelecek dönemde, bu alanda benzer etkileri yaratması beklenmektedir. Robotların istihdamda nasıl bir dönüşüme yol açacağı, yer değişim etkisi ile üretkenlik etkisinin sonucu olarak ortaya çıkmaktadır. Robotik süreç otomasyonunun istihdamda yaratacağı değişimin de bu iki etkinin sonucu olarak meydana gelmesi oldukça olasıdır. Robotik süreç otomasyonunun yarattığı yer değişim etkisi, firma düzeyinde, Madakam vd. (2019) çalışması tarafından gösterilmiştir. Bu çalışmada, O2 firmasının robotik süreç otomasyonunu kullanmasının istihdam üzerinde yarattığı etkiler incelenmiştir. İngiltere'de bulunan O2 firması, robotik süreç otomasyonunu iş süreçlerinde kullanan ilk firmalar arasındadır. Firma, İngiltere'nin en büyük telekomünikasyon şirketlerinden biridir ve yaklaşık 25 milyon müşterisi bulunmaktadır. O2 firması, 2012 ile 2015 yılları arasında, robotik süreç otomasyonunu iş süreçlerinde kullanmıştır. Firma tarafından kullanılan tek bir robotik süreç otomasyonu yazılımı, bu dönemde, 150 çalışan tarafından yapılan bir işi tek başına yapmayı başarmıştır. Bu sayede, O2 firması hem verimliliğini arttırmış hem de maliyetlerini aşağıya çekmiştir (Madakam vd., 2019). Fakat robotik süreç otomasyonunun kullanımı iş kaybına neden olarak, toplam istihdam üzerinde olumsuz etki yaratmıştır. Üretkenlik etkisi, robotik süreç otomasyonunun istihdamda yarattığı değişimde, istihdam etkisi kadar önemli rol oynamaktadır. Robotik süreç otomasyonu ile firma çalışanlarının gelecek dönemde birçok alanda beraber hareket etmesi beklenmektedir. Bu durumun sonucu olarak, yeni işler ortaya çıkacaktır (Siderska, 2020). Fakat bu işler, yaratıcılık ve problem çözme gibi yeteneklere gereksinim duyacaklardır. Dolayısıyla, yüksek niteliklere sahip olan iş gücüne olan talep artacaktır. Üretkenlik etkisi, çalışanların ortaya çıkacak bu yeni alanlarda iş bulabilmesi durumunda, yer değişim etkisini dengeleyecek; yer değişim etkisinin istihdam üzerinde yarattığı negatif etkileri ortadan kaldıracaktır.

2.2.2. Robotik Süreç Otomasyonun İşleri Niteliği Üzerindeki Etkileri

İşlerin niteliği, robotların ekonomide önemli değişimler yarattığı alanlardan biridir. Robotlar, rutin ve manuel işleri yapmaktadırlar. Bu nedenle, özellikle imalat sanayinde, düşük

nitelikli işlerde, istihdam kaybına neden olmaktadırlar. Benzer bir etkiyi, robotik süreç otomasyonunun da yaratması oldukça olasıdır. Robotik süreç otomasyonu, yukarıda da açıklandığı gibi, rutin, tekrarlı ve manuel işleri başarı ile gerçekleştirmektedir. Bu durumun sonucu olarak, robotik süreç otomasyonu, daha çok rutin ve manuel işlerde istihdam olanaklarına sahip olan düşük nitelikli çalışanların yerini almaktadır. Yüksek nitelikli çalışanlar ise robotik süreç otomasyonunun iş süreçlerinde kullanılmasından olumlu etkilenmektedirler. Robotik süreç otomasyonu yazılımları ile firma çalışanlarının beraber hareket edeceği çalışma gruplarının ortaya çıkması beklenmektedir. Hem robotik süreç otomasyonu yazılımları hem de çalışanlar, bu çalışma gruplarında, kendilerine en uygun olan işleri yapacaklardır. Çalışanlar, problem çözmeye odaklı, yaratıcı işler ile ilgilenirken; robotik süreç otomasyonu yazılımları, rutin ve sıkıcı görevleri yerine getireceklerdir (Lacity ve Willcocks, 2016). Bu çalışma ortamı için gerekli donanıma sahip olan yüksek nitelikli çalışanlara olan talep artarken; robotik süreç otomasyonun gerçekleştirdiği işleri yapan düşük nitelikli çalışanlara olan talep ise azalacaktır. Olası istihdam kayıplarının önlenmesinde hükûmetlere önemli görevler düşmektedir. Hükûmetlerin, çalışanların yeniden eğitimine ağırlık vermesi; eğitim programlarını yaratıcılık ve problem çözme gibi yetenekleri geliştirecek şekilde yeniden düzenlemesi oldukça önemlidir.

2.2.3. Robotik Süreç Otomasyonun Üretkenlik Üzerindeki Etkileri

Robotların üretim süreçlerinde kullanımı, önemli üretkenlik kazanımlarına neden olmaktadır. Bu eğilim, sektör ve ülke düzeyleri için farklı çalışmalarda gösterilmiştir. Robotik süreç otomasyonu, 24 saat aralıksız çalışabilmekte; tekdüze ve sıkıcı işleri çalışanların yerine hızlı ve hatasız bir şekilde yapabilmektedir. Robotik süreç otomasyonu sayesinde sıkıcı ve tekdüze işleri yapmayı bırakan çalışanlar, katma değeri yüksek olan faaliyetlere daha fazla vakit ayırabilmektedirler. Robotik süreç otomasyonu, sahip olduğu bu özellikler nedeniyle hem firma hem de sektör düzeylerinde, önemli üretkenlik kazanımı yaratacak potansiyele sahiptir (Syed vd., 2020). Firma düzeyinde yapılan araştırmalar da robotik süreç otomasyonun yarattığı bu etkiyi ortaya koymaktadırlar. Aguirre ve Rodriguez, (2017), bu çalışmalardan biridir. Bu çalışmada, Kolombiya'da faaliyet gösteren bir firmanın ödeme belgesi oluşturma sürecinde robotik süreç otomasyonu kullanmasının üretkenlik üzerinde yarattığı etkiler incelenmiştir. Çalışanlar, bu çalışmada, iki gruba ayrılmıştır. Robotik süreç otomasyonu ilk grupta kullanılmaktadır. Arka ofis işleri, bu grupta, robotik süreç otomasyonu tarafından yapılırken; robotik süreç otomasyonu ve çalışanlar ön ofis işlerini yapmak için beraber hareket etmektedirler. İkinci grupta ise, işleri yapmak için robotik süreç otomasyonu kullanılmamaktadır. Hem ön ofis hem de arka ofis işleri, çalışanlar tarafından yapılmaktadır. İki grubun performans sonuçları, aşağıda bulunan Tablo 2'de gösterilmektedir. Tablo 2'deki sonuçlar, bir haftalık süreci kapsamaktadır. Robotik süreç otomasyonu kullanılmadığı durumda, çalışan başına düşen iş sayısı 270'dir. Robotik süreç otomasyonu kullanıldığında ise, bu sayı, 326'ya çıkmaktadır. Dolayısıyla, robotik süreç otomasyonu kullanımının, robotik süreç otomasyonunun kullanılmadığı duruma göre verimliliği, %20 civarı arttırdığı iddia edilebilmektedir (Aguirre ve Rodriguez, 2017). Bu durum, robotik süreç otomasyonunun üretkenlik artışında oynadığı önemli rolü göstermektedir.

Tablo 2. Robotik Süreç Otomasyonu Uygulama Sonuçları

Robotik süreç otomasyonu kullanan grup	Çalışan sayısı	22
	Ortalam iş süresi	431
	Toplam iş sayısı	7163
	Çalışan başına düşen iş sayısı	326
Robotik süreç otomasyonu kullanmayan grup	Çalışan sayısı	13
	Ortalam iş süresi	440
	Toplam iş sayısı	3505
	Çalışan başına düşen iş sayısı	270

Kaynak: Aguirre ve Rodriguez, 2017.

2.2.4. Robotik Süreç Otomasyonun Hizmetler Sektörü Üzerindeki Etkileri

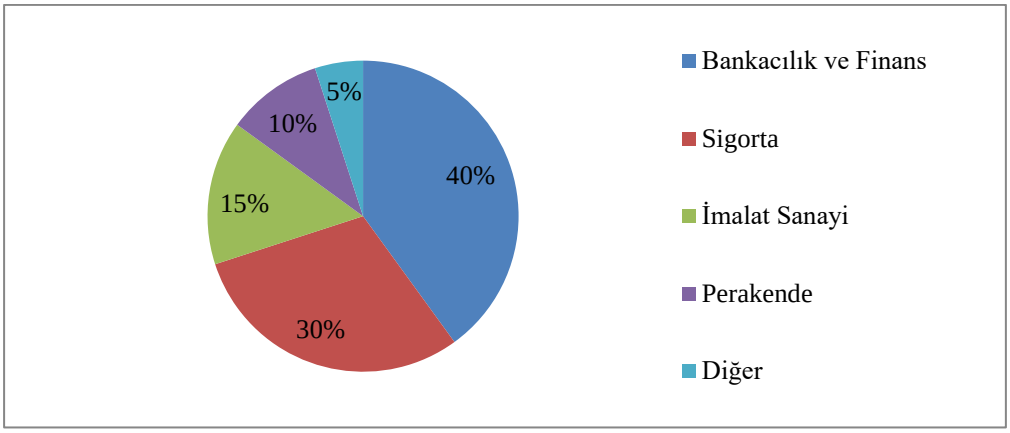
Robotların hizmetler sektöründe yarattığı dönüşümün etkisi sınırlıdır. Robotlar, esas olarak imalat sanayinde yoğun olarak kullanılmaktadırlar. Fakat benzer bir durum, robotik süreç otomasyonu için söz konusu değildir. Hizmetler sektörü, robotik süreç otomasyonunun en çok kullanıldığı alandır. Robotik süreç otomasyonundan bankacılık ve finans sektörü başta olmak üzere, hizmetler sektörünün çok farklı alanlarında, üretkenlik ve çıktı artışı sağlaması nedeniyle faydalanılmaktadır. Havacılık sektörü, robotik süreç otomasyonunun hizmetler sektöründe önemli etkiler yarattığı alanlardan biridir. Havacılık hizmetleri alanında, manuel, rutin ve tekrarlı çok fazla iş bulunmaktadır. Bu işler, zaman kaybına neden olduğu gibi, önemli hata risklerine de sahiptirler. Seyahat acenteleri tarafından düzenlenen biletlerin kontrol edilmesi, bu işlerin en önemlilerinden biridir. Uçuş iptalleri ve yenilenen rezervasyonları yönetmek için de robotik süreç otomasyonundan havacılık sektöründe faydalanılmaktadır. Havacılık sektöründeki bu tip işlerde robotik süreç otomasyonun kullanılması, üretkenliği arttırdığı gibi, insan kaynaklı hataların da önüne geçmektedir. Robotik süreç otomasyonunun kullanımı, uluslararası rekabetin çok yoğun olduğu havacılık sektöründe, firmaların rekabet gücüne de önemli katkı sağlamaktadır (Seçkiner vd., 2021).

Sigorta sektörü, hizmetler sektöründe robotik süreç otomasyonun sık kullanıldığı başka bir alandır. Rutin, manuel ve tekrarlı işlerin sayısı, sigorta sektöründe de havacılık sektöründe olduğu gibi fazladır. Müşterilere standart poliçelerin email yolu iletilmesi, bu poliçelerin kontrolü gibi işler, robotik süreç otomasyonu ile yapılmaya uygundurlar. Bu iş süreçlerinde robotik süreç otomasyonunun kullanılması, önemli üretkenlik kazanımlarını da beraberinde getirmektedir. Xchanginging firması, şirketlere robotik süreç otomasyonu alanında uygulama ve danışmanlık hizmeti vermektedir. Şirket, sigorta sektöründe faaliyet gösteren bir müşterisine, manuel ve tekrarlı işlerinde robotik süreç otomasyonu kullanması için uygulama ve danışmanlık hizmeti vermiştir. Bu sayede, çalışanlardan oluşan bir ekibin birkaç günde yaptığı bir iş, tek bir robotik süreç otomasyonu yazılımı ile 30 dakikada yapılmıştır (Lacity ve Willcocks, 2016). Robotik süreç otomasyonu, sigortacılık ve havacılık sektörlerinin dışında da hizmetler sektörünün birçok alanında uygulama imkanına sahiptir. Bu durum, aşağıda bulunan Tablo 3'de görülmektedir. Türkiye'de de robotik süreç otomasyonu uygulamaları, dünyada olduğu gibi, hizmetler sektöründe yoğunlaşmaktadır. Bu eğilimin gelecek dönemlerde artarak devam etmesi beklenmektedir.

2.2.5. Robotik Süreç Otomasyonun Yatırımlar Üzerindeki Etkileri

Yatırımlar, robotik süreç otomasyonunun, robotlar gibi, ekonomide önemli dönüşüm yaratma potansiyelinin olduğu alanlardan biridir. Çalışanların yerine robotların kullanılması ile elde edilecek maliyet tasarrufu, bir önceki bölümde ifade edildiği gibi, robot yatırımlarının en önemli nedenidir. Benzer bir durum, robotik süreç otomasyonu için de söz konusudur. Robotik süreç otomasyonunun yıllık lisans ücreti, 3000 EUR ile 8000 EUR arasında değişmektedir. Avrupa Birliği'nde bulunan ülkelerde çalışanların ortalama yıllık maaşı ise, 30000 EUR civarındadır. Tek bir çalışanın ortalama yıllık maaşı, robotik süreç otomasyonunun maliyetinin yaklaşık üç katıdır. Robotik süreç otomasyonu, çalışanların ortalama yıllık maaşından daha düşük maliyete sahip olmasının yanında; 24 saat kesintisiz çalışabilmektedir. Robotik süreç otomasyonu, bütün bu etkilerin sonucunda firmalara önemli maliyet tasarrufu sağlamaktadır (Anagnoste, 2017). Bu maliyet tasarrufu, firmaları robotik süreç otomasyonu yatırımı yapmaya teşvik eden faktörlerin başında gelmektedir. Rutin işlerin sıklığı, endüstri ölçeği, şirketlerin faaliyet gösterdiği sektördeki uluslararası rekabetin yoğunluğu gibi faktörler de firmaların robot yatırımı yapmasında etkili olmaktadır. Robotik süreç otomasyonu yatırımları için de benzer durum söz konusudur. Robotik süreç otomasyonu, rutin işler için uygundur. Robotik süreç otomasyonu ile yapılacak işlerin çok tekrarlı ve manuel olması gerekmektedir. Bu tür işler, ölçek yoğun endüstrilerde daha çok bulunmaktadır. Küresel rekabet, firmaların robotik süreç otomasyonu yapmasında önemli rol oynamaktadır. Üretkenlik artışına neden olan robotik süreç otomasyonu, şirketlerin küresel rekabet güçlerini hem korumasına hem de arttırmasına önemli katkı yapmaktadır. İngiltere'de bulunan Telefonica 02 firmasının robotik süreç otomasyonuna önemli yatırımlar yapmasının temel nedeni, küresel rekabet gücünü korumaktadır (Lacity vd., 2015). Dolayısıyla, bu üç faktör de robotlar da olduğu gibi, firmaları robotik süreç otomasyonu yatırımı yapmaya teşvik etmektedir.

Robot yatırımlarının toplam yatırımlar içindeki payı düşüktür. Robotik süreç otomasyonu alanında yapılan yatırımların gelecek dönemlerde daha çok artması beklenmektedir. Fakat benzer bir eğilimin robotik süreç otomasyonu yatırımları için de söz konusu olması, oldukça muhtemeldir. Robotik süreç otomasyonu temel olarak bir yazılım lisansıdır (Aguirre ve Rodriguez, 2017). Bu sebeple, robotik süreç otomasyonu kullanımı için büyük miktarda donanım yatırımına ihtiyaç bulunmamaktadır. Dolayısıyla, robotik süreç otomasyonunun yatırım maliyeti, diğer bilgi işlem teknolojilerine göre daha düşüktür (Suri vd., 2017). Bu nedenlerle, robotik süreç otomasyonu yatırımlarının toplam yatırımlar içindeki payı, gelecek dönemlerde büyük olasılıkla düşük olacaktır. Robot yatırımları temel olarak imalat sanayi alanında yoğunlaşmaktadır. İmalat sanayi alanı dışında robot kullanımı çok azdır. Fakat benzer bir durum, robotik süreç otomasyonu için söz konusu değildir. Hizmetler sektörü, robotik süreç otomasyonu yatırımlarının ve kullanımın en çok yoğunlaştığı alandır. Bankacılık ve sigortacılık, Dünyada 2022 yılında robotik süreç otomasyonunun en yoğun olarak kullanıldığı sektörlerdir. Bu iki sektörü, bilgi işlem teknolojileri ve lojistik sektörleri takip etmektedir. İmalat sanayinde robotik süreç otomasyonu kullanımı, bu dört sektörün gerisinde bulunmaktadır (Grand View Research, 2023). Benzer bir durum Türkiye içinde söz konusudur. Özdem ve Bora, (2022) çalışmasına göre, bankacılık ve finans sektörü, Türkiye'de robotik süreç otomasyonun en çok kullanıldığı alandır. Bankacılık ve finans sektörünün ardından sigorta sektörü gelmektedir. İmalat sanayi, bu iki sektörün gerisinde bulunmaktadır. Bu durumu aşağıda bulanan Şekil 3 göstermektedir. Hem Dünya'da hem Türkiye'de hizmetler sektörü, robotik süreç otomasyonu yatırımlarının yoğunlaştığı en önemli alandır.



Şekil 3. Türkiye'de Robotik Süreç Otomasyonun Sektörlerde Kullanım Oranları.
Kaynak: Özdem ve Bora, 2022

2.2.6. Robotik Süreç Otomasyonun Üretim Ağları Üzerindeki Etkileri

Robotik süreç otomasyonu, robotlar gibi yeni bir üretim ağının ortaya çıkmasına neden olmaktadır. Fakat bu üretim ağı, son dönemde meydana gelmiştir. Bu nedenle, ekonomi üzerinde robotlar kadar önemli etkiler yaratamamaktadır. Robotik süreç otomasyonu üretim ağı, robot üretim ağından farklı olarak, imalat aşamasına sahip değildir. İmalat süreci, istihdam ve yatırım gibi alanlarda önemli artış yaratmaktadır. Robotik süreç otomasyonu temel olarak bir bilgisayar yazılımıdır ve üretim sürecinde imalat aşaması bulunmamaktadır. Dolayısıyla, robotik süreç otomasyonu üretim ağı, robot üretim ağının imalat sürecinin ekonomi üzerinde yarattığı etkiyi yapamamaktadır. Robotik süreç otomasyonu üretim ağı, robot üretim ağına göre küçük olmasına rağmen; pazar büyüklüğü 2022 yılında 2,3 milyar dolara ulaşmıştır. Bu rakamın gelecek dönemlerde daha çok artması beklenmektedir (Grand View Research, 2023).

Robotik süreç otomasyonu üretim ağı, üç aşamadan oluşmaktadır. Robotik süreç otomasyonu üretim ağının ilk aşaması, robotlarda olduğu gibi araştırma geliştirmedir. Bu aşamada üniversiteler, firmalar ve araştırma kuruluşları, robotik süreç otomasyonu ile ilgili en son teknolojileri geliştirmektedirler. Robotik süreç otomasyonu ile ilgili araştırmalar henüz başlangıç aşamasındadır. Bu durum, aşağıda bulunan Tablo 3'te görülmektedir. Tablo 3, 1990 ile 2018 yılları arasındaki dönemde Web of Science ve Scopus veri tabanında robotik süreç otomasyonu anahtar kelimesinin arama sonuçlarını göstermektedir. Tablo 3'ten de görülebileceği gibi, robotik süreç otomasyonu alanında yapılan araştırmalar çok azdır. Bu durum, robotik süreç otomasyonu alanında araştırmaların henüz başlangıç aşamasında olduğuna işaret etmektedir. Robotik süreç otomasyonu alanında yapılan araştırmalar, 2015 ile 2018 arasındaki dönemde daha çok yoğunlaşmaktadır. Yapılan çalışmaların çok büyük çoğunluğu, bilgisayar ve yönetim bilimleri alanındadır (Sliż, 2019) Robotik süreç otomasyonu üretim ağının ikinci kısmı, firmaların ihtiyaçları dikkate alınarak geliştirilen yazılımların, firmaların kullanımına hazır hale getirilmesidir. Bu aşamada, yazılım geliştirme, entegrasyon ve satış, robot üretim ağından farklı olarak aynı firmalar tarafından yapılmaktadır. En önemli robotik süreç otomasyonu tedarikçileri arasında, Automation Anywhere (ABD), BluePrim (İngiltere), UiPatch (Romanya), Redwood (Hollanda), Workfusion (ABD) ve Openspan (ABD) bulunmaktadır (Anagnoste, 2017). Bu firmalar, şirketlerin ihtiyaçlarına uygun robotik süreç otomasyonu yazılımlarını geliştirip; onların süreçlerine entegre etmelerinin yanında, robotik süreç otomasyonu ile ilgili eğitim ve danışmanlık hizmetleri de vermektedirler (Lacity ve

Willcocks, 2016). Robotik süreç otomasyonu üretim ağının üçüncü kısımı tüketicilerdir. Son kullanıcılar olan tüketiciler, iş süreçlerini daha etkin hale getirmek için robotik süreç otomasyonunu kullanmaktadırlar. Walwart, American Express, gibi çok uluslu büyük şirketler başta olmak üzere farklı sektörlerden firmalar, robotik süreç otomasyonundan iş süreçlerinde faydalanmaktadırlar (Jovanović vd., 2018).

Tablo 3. Web of Science ve Scopus Veri Tabanlarında Robotik Süreç Otomasyonu Aramasının Sonuçları

Veritabanı	Anahtar Kelime	Yapılan Yayın Sayısı (1990-2018)	
		Hepsi	Bilimsel Makaleler
Web of Science	Robotik süreç otomasyonu	12	3
		1	0
Scopus		29	8
		20	6

Kaynak: Sliż, 2019.

Gelişmiş ülkelerde faaliyet gösteren firmalar, robot üretim ağında olduğu gibi, robotik süreç otomasyonu üretim ağında da araştırma geliştirme ile yazılım ve satış aşamalarına hâkim durumdadırlar. Robotik süreç otomasyonu gibi üretkenlik kazanımına neden olan ve çıktıyı arttıran teknolojiler, ekonomik kalkınma sürecinde son derece önemli rol oynamaktadırlar. Gelişmekte olan ülkelerin gelişmiş ülkeleri yakalamaları için robotik süreç otomasyonu gibi teknolojilere yatırım yapması, önem taşır. Gelişmekte olan ülkelerin, robotik süreç otomasyonu ağının araştırma geliştirme ile yazılım ve satış aşamalarında dünya ile rekabet edebilir konuma gelmeleri gerekmektedir. Bunun için gelişmekte olan ülkelerde bulunan hükûmetlere önemli görevler düşmektedir. Hükûmetler, firmalara gerekli olan destegi sağlamalı, özellikle araştırma ve geliştirme alanına yatırım yapmalıdırlar.

3. Robotik Süreç Otomasyonu Uygulamaları

Robotik süreç otomasyonu, robotlar gibi, ekonomide büyük dönüşümler yaratacak potansiyele sahiptir. Fakat robotik süreç otomasyonu, robotlardan farklı olarak, en çok hizmetler sektöründe kullanılmaktadır. Bankacılık ve sigortacılık sektörü, robotik süreç otomasyonunun hizmetler sektöründe en çok kullanıldığı alanların başında gelmektedir. Bu nedenle, robotik süreç otomasyonunun yarattığı etkiler, çalışmanın bu bölümde, örnek bankanın iş süreçlerinde kullandığı iki uygulama üzerinden tartışılacaktır. Bu çerçevede, ticari kredi tahsis ve fatura ödeme süreçlerinde robotik süreç otomasyonu kullanmanın emek üretkenliği, istihdam, işlerin niteliği, yatırımlar gibi alanlarda yarattığı etkiler incelenecektir. Ayrıca, bu uygulamalarda robotik süreç otomasyonu kullanmanın hizmetler sektöründe neden olduğu dönüşümler de açıklanmaya çalışılacaktır. Bu bölümün son kısmında ise, iki uygulamadan elde edilen faydalar özetlenecektir.

Çalışmada kullanılan veriler, örnek bankanın 2 farklı genel müdürlük birimi tarafından kullanılan robotik süreç otomasyonu uygulamalarından elde edilmiştir. Nakit yönetimi pazarlama müdürlüğü ve ticari kredi tahsis birimleri tarafından kullanılan robotik süreç otomasyonu uygulamaları, kullanıldıkları süre boyunca bankanın bilgi işlem ekipleri tarafından incelenmekte, analiz edilmekte ve raporlanmaktadırlar. Bu çalışmada kullanılan veriler örnek bankanın bilgi işlem ekiplerinden alınmıştır. Her iki uygulama da tam olarak ayrıntılı bir

biçimde öğrenilmiştir. Ayrıca, banka içerisinde ilgili robotik süreç otomasyonunu kullanan iş birimleri ile uygulama süreci tartışılmış, verilerin doğruluğu teyit edilmiştir.

3.1. Uygulama 1: Ticari Kredi Tahsis Birimleri Tarafından Kullanılan Robotik Süreç Otomasyonu Uygulaması

Çalışmanın bu bölümde açıklanacak ilk robotik süreç otomasyonu uygulaması, örnek bankanın ticari kredi tahsis birimleri tarafından kullanılmaktadır. Kredi talepleri, bölge ve genel müdürlük ticari kredi tahsis birimlerine değerlendirmeleri için gelmektedir. Bölge ve genel müdürlük birimlerinde çalışanlar, bu talepleri değerlendirmek için 17 farklı ekrandan kredi başvurusunda bulunan kişilerin istihbarat, kredi limiti, aksama durumu gibi bilgilerini toplamakta; ardından da bir dosya oluşturmaktadırlar. Başvuruda bulunan kişilere kredi verilip verilmeyeceğine, hazırlanan bu dosyada bulunan bilgilere göre karar verilmektedir. Ticari kredi tahsis sürecinin operasyonel kısmını oluşturan dosya oluşturma işi, banka tarafından geliştirilen robotik süreç otomasyonu sayesinde otomatik hale getirilmiştir. Robotik süreç otomasyonu, gerekli olan bilgileri toplamakta ve dosyayı oluşturmaktadır. Robotik süreç otomasyonu, daha sonra bu dosyayı, hem çalışanların rahatlıkla ulaşabileceği bir klasöre bırakmakta, hem de e-posta ile isteyen kişilere iletmektedir. Bu sayede, bölge ve genel müdürlük birimlerinde çalışanlar, dosya oluşturma süreci gibi operasyonel yükü fazla olan işler ile uğraşmayı bırakmakta, katma değeri daha yüksek olan işlere daha fazla ağırlık verebilmektedirler.

Ticari kredi tahsis süreçlerinde robotik süreç otomasyonu kullanılmasının değişim yarattığı en önemli alan üretkenliktir. Banka, 2021 yılının Eylül ayının başından itibaren, ticari kredi tahsis süreçlerinde dosya oluşturmak için robotik süreç otomasyonu kullanmaktadır. Robotik süreç otomasyonu, Eylül 2021 ile Ekim 2023 arasındaki dönemde, 90.877 talebi değerlendirmiş ve dosya oluşturmuştur. Robotik süreç otomasyonu, her bir talebi, ortalama 30 dakikada içinde tamamlamaktadır. Bu süre, aynı işi bir çalışanın yaptığı duruma göre oldukça kısadır. Bir çalışan günde 480 dakika çalışmaktadır. Robotik süreç otomasyonu, bu süre göz önüne alındığında, ilgili dönemde 5.679 adam/gün iş yapmıştır. Robotik süreç otomasyonu, hem işleri çalışanlara göre daha kısa yapmakta, hem de 7/24 çalışmaktadır. Bu nedenlerle, bankanın ticari kredi tahsis süreçlerinde robotik süreç otomasyonu kullanımının önemli üretkenlik kazanımlara sebep olduğu ortaya çıkmaktadır. Ticari kredi tahsis süreçlerinde robotik süreç otomasyonun kullanılmasının önemli etki yarattığı diğer iki alan istihdam ve işlerin niteliğidir. Bankanın ticari kredi tahsis süreçlerinde robotik süreç otomasyonu kullanması, istihdam kaybına neden olmamıştır. Dolayısıyla, üretkenlik etkisi, yer değiştirme etkisine üstün gelmiştir. Çalışanlar, tekrarlı, rutin ve manuel olan dosya oluşturma işi ile uğraşmayı bırakmışlar; değerlendirme ve karar verme gibi yüksek katma değerli ve nitelikli işleri yapmaya başlamışlardır. Böylece ticari kredi tahsis süreci daha etkin hale gelmiştir. Ticari kredi tahsis süreçlerinde dosya oluşturmak için robot süreç otomasyonu kullanmanın maliyeti de oldukça düşüktür. Ticari kredi tahsis süreçlerinde dosya oluşturmak için robot süreç otomasyonu geliştirilmesi, 45 adam/gün kadar maliyete neden olmaktadır. Bu maliyet ise, diğer bankacılık uygulamaların geliştirilmesi için ihtiyaç duyulan maliyet ile kıyaslandığında oldukça azdır. Bütün bu faydalarının işaret ettiği gibi, ticari kredi tahsis süreçlerinde robotik süreç otomasyonun kullanılması, bankacılık sektöründe önemli değişimlere neden olmaktadır. Çok düşük yatırım maliyeti ile çalışanlar, düşük nitelikli operasyonel işleri yapmayı bırakmakta,

katma değeri daha yüksek işlere daha fazla zaman ayırabilmektedirler. Bu durum, önemli verimlilik kazanımlarını beraberinde getirmektedir.

3.2. Uygulama 2: Nakit Yönetimi Pazarlama Müdürlüğü Tarafından Kullanılan Robotik Süreç Otomasyonu Uygulaması

Bu bölümde tartışılacak ikinci robotik süreç otomasyonu uygulaması, örnek bankanın fatura ödeme süreçlerinde nakit yönetimi pazarlama müdürlüğü tarafından kullanılmaktadır. Müşterilerin yaptığı fatura ödemelerinde belirli bir adet sınırı bulunmaktadır. Bu sınırın üzerinde fatura ödemesi yapmak isteyen müşteriler, müşteri memnuniyeti ve çözüm merkezi müdürlüğü aracılığıyla fatura ödeme limitlerini artırmak için talepte bulunmaktadırlar. Bu talepler, nakit yönetimi pazarlama müdürlüğü çalışanları tarafından, müşterinin türü, müşterinin son bir ayda ödediği fatura sayısı gibi kriterlere bakılarak değerlendirilmektedir. Talepler, değerlendirmenin sonucunda, onaylanmakta ya da ret edilmektedirler. Bu süreç, otomatik hale getirilerek; gelen talepler robotik süreç otomasyonu tarafından değerlendirilmeye başlanmıştır. Robotik süreç otomasyonu, daha önce belirlenen kriterlere göre, müşterilerden gelen talepleri ret etmekte veya onaylamaktadır. Robotik süreç otomasyonu, istisna olarak belirlenen durumlar için herhangi bir işlem yapmamakta; ilgili talebi, nakit yönetimi pazarlama müdürlüğü çalışanlarına yönlendirmektedir.

Üretkenlik artışı, fatura ödeme süreçlerinde limit artırım taleplerini değerlendirmek için robotik süreç otomasyonu kullanılmasının yarattığı en önemli kazanımdır. Örnek bankada fatura ödeme süreçlerinde limit artırım taleplerini değerlendirmek için robotik süreç otomasyonu kullanımı, 2023 yılının ekim ayında başlamıştır. Robotik süreç otomasyonu, kullanıldığı bir aylık süreçte, hem gelen 320 talebin 247'sini cevaplamış, hem de bu taleplerin çözüm süresini yarıya indirmiştir. Bu durumun sonucu olarak, fatura ödeme süreçlerinde robotik süreç otomasyonu kullanılması, önemli üretkenlik artışına neden olmuştur. Fatura ödeme süreçlerinde robotik süreç otomasyonundan yararlanılmasının önemli etki yarattığı diğer iki alan, istihdam ve işlerin niteliğidir. Fatura ödeme süreçlerinde robotik süreç otomasyonu kullanımı, istihdam kaybına neden olmamıştır. Bu nedenle, üretkenlik etkisi, yer değiştirme etkisine üstün gelmiştir. Nakit yönetimi pazarlama müdürlüğü çalışanları, robotik süreç otomasyonu sayesinde, operasyonel yükü fazla olan fatura limit artırım taleplerini değerlendirme işini yapmayı azaltmışlardır. Bu durum, nakit yönetimi pazarlama müdürlüğü çalışanlarının, AR-GE ve pazarlama gibi katma değeri fazla olan faaliyetlere daha çok zaman ayırmasına imkân sağlamıştır. Fatura ödeme süreçlerinde limit artırım taleplerini değerlendirmek için robotik süreç otomasyonu geliştirmenin maliyeti, 20 adam gündür. Bu yazılım geliştirme maliyeti, bankacılık sektöründe kullanılan diğer uygulamalar ile karşılaştırıldığında oldukça düşüktür. Dolayısıyla, düşük yatırım maliyeti ile geliştirilen robotik süreç otomasyonunun fatura ödeme süreçlerinde kullanılması, bankacılık sektörüne önemli katkı sağlamaktadır. Hem çalışanlar, operasyonel yükü fazla olan işleri yapmayı bırakıp, katma değeri daha fazla olan işlere daha fazla vakit ayırabilmekte; hem de bankanın üretkenliği artmaktadır.

3.3. Ticari Kredi Tahsis Birimleri ve Nakit Yönetimi Pazarlama Müdürlüğü Tarafından Kullanılan Robotik Süreç Otomasyonu Uygulamalarının Yarattığı Etkilerin Değerlendirilmesi

Ticari kredi tahsis ve fatura ödeme süreçlerinde robotik süreç otomasyonu kullanılmasının yarattığı etkiler, aşağıda bulunan Tablo 4'te özetlenmektedir. Hem fatura ödeme süreçlerinde limit arttırım taleplerini değerlendirmek için, hem de ticari kredi tahsis süreçlerinde dosya oluşturmak için robotik süreç otomasyonu kullanımı, örnek bankada üretkenlik artışına neden olmuştur. Bu durum, iki faktörden kaynaklanmaktadır. İlk olarak, her iki robotik süreç otomasyonu uygulaması da işlerin yapılış sürelerini çalışanların yaptığı duruma göre önemli ölçüde azaltmışlardır. İkinci olarak, her iki süreçte de robotik süreç otomasyonu kullanımı, çalışanların katma değeri daha yüksek olan faaliyetlere daha fazla zaman ayırabilmesine imkân sağlamıştır. Her iki robotik süreç otomasyonu uygulamasının iş süreçlerinde kullanımı, örnek bankada istihdam kaybına neden olmamıştır. Bu sebeple, üretkenlik etkisi, yer değiştirme etkisine üstün gelmiştir. Ticari kredi tahsis ve fatura ödeme süreçlerinde kullanılan robotik süreç otomasyonu uygulamalarını geliştirmenin maliyeti, diğer bankacılık uygulamalarına göre oldukça düşüktür. Bu nedenle, örnek banka, düşük yatırım maliyeti ile önemli kazanımlar elde etmektedir. Bu durum, robotik süreç otomasyonu kullanımının bankacılık sektöründe önemli değişim yarattığını ve gelecek dönemde de kullanımının daha çok artacağına işaret etmektedir.

Tablo 4. Ticari Kredi Tahsis ve Fatura Ödeme Süreçlerinde Robotik Süreç Otomasyonu Kullanmanın Yarattığı Etkilerin Sonuçları

Uygulama Alanı	Üretkenlik	İşlerin Niteliği	İstihdam	Yatırım	Hizmetler Sektörü Etkisi
Ticari Kredi Tahsis Süreçleri	Arttırıyor	Yüksek nitelikli işlerin yapılmasına neden olur.	İstihdam kaybına neden olmaz.	Düşük yatırım maliyeti ile gerçekleştirilebiliyor	Dönüşüm yaratıyor.
Fatura Ödeme Süreçleri	Arttırıyor	Yüksek nitelikli işlerin yapılmasına neden olur.	İstihdam kaybına neden olmaz.	Düşük yatırım maliyeti ile gerçekleştirilebiliyor	Dönüşüm yaratıyor.

Kaynak: Yazarlar tarafından hazırlanmıştır.

Ticari kredi tahsis ve fatura ödeme süreçlerinde robotik süreç otomasyonu kullanmanın örnek bankada ortaya çıkardığı kazanımları şu gibi özetleyebiliriz. Her iki uygulamanın kullanılması da örnek bankada istihdam kaybına neden olmamıştır. Bu durum, üretkenlik etkisinin yer değiştirme etkisinden fazla olmasından dolayı ortaya çıkmıştır. Hem ticari kredi tahsis süreçlerinde hem de fatura ödeme süreçlerinde kullanılan robotik süreç otomasyonu uygulamalarını geliştirmenin maliyeti, diğer bankacılık uygulamalarına göre oldukça düşüktür. Ticari kredi tahsis süreçlerinde kullanılan robotik süreç otomasyonunu geliştirmenin maliyeti 45 adam/gündür. Fatura ödeme süreçlerinde kullanılan robotik süreç otomasyonunu geliştirmenin maliyeti ise 20 adam/gündür. Robotik süreç otomasyonu, düşük maliyet ile büyük kazanımlara neden olmaktadır. Her iki uygulamanın da kullanılması, ilgili birimlerde yapılan işlerin niteliğinde önemli değişimlere neden olmuştur. Çalışanlar bankaya katma değeri daha fazla olan faaliyetlere daha fazla zaman ayırma imkanına kavuşmuşlardır. Hem ticari kredi tahsis süreçlerinde hem de fatura ödeme süreçlerinde robotik süreç otomasyonundan faydalanılmasını, örnek bankada önemli üretkenlik kazanımlarına neden olmuştur. Robotik süreç otomasyonu, 7/24 çalışmakta ve işleri çalışanlara göre daha kısa sürede bitirmektedir. Robotik süreç

otomasyonu, sahip olduğu özellikler sayesinde hizmetler sektöründe önemli dönüşümlere neden olmaktadır. Bu durum, örnek bankadaki robotik süreç otomasyonu uygulamaları için de geçerlidir. Robotik süreç otomasyonu, üretkenlik ve istihdam üzerinde değişimler yaratarak, iş süreçlerinin daha verimli hale gelmesine neden olmaktadır.

4. Sonuç

Teknolojik değişme, ekonomik büyüme sürecinin arkasındaki temel güçtür. Genel amaçlı teknolojiler, çok farklı alanlarda kullanılabilme, yeni ürün ve hizmetlerin ortaya çıkmasına neden olma ve zaman içinde geliştirilmeye açık olma gibi niteliklere sahiptirler. Genel amaçlı teknolojiler, sahip oldukları bu özellikler nedeniyle teknolojik değişim sürecinde önemli rol oynamaktadırlar. Genel amaçlı teknolojilerin niteliklerine sahip olan robotik süreç otomasyonu ve robotlar da daha önce ortaya çıkan buhar teknolojisi, elektrik enerjisi gibi toplumun her alanında önemli değişimler yaratacak potansiyele sahiptirler.

Bu çalışmada, ilk olarak, robotların ve robotik süreç otomasyonun ekonomide yarattığı değişimler açıklanmaya çalışılmıştır. Bu çerçevede, robotların ve robotik süreç otomasyonun emek üretkenliği, istihdam, işlerin niteliği, yatırımlar, hizmetler sektörü gibi alanlarda yarattığı dönüşümler ve gelecek dönemde yaratabilecekleri etkiler incelenmiştir. Hem robotlar hem de robotik süreç otomasyonu, kullanıldıkları sektörlerde önemli üretkenlik artışına neden olmaktadırlar. Robotların ve robotik süreç otomasyonun iş süreçlerinde kullanılmasının istihdam üzerinde yarattığı değişim, üretkenlik etkisi ile yer değiştirme etkisinin sonucu olarak ortaya çıkmaktadır. Bu nedenle, robotlardan ve robotik süreç otomasyonundan iş süreçlerinde yararlanmanın istihdam üzerinde yarattığı etkiler, ülkeler arasında farklılık göstermektedir. Robotlardan ve robotik süreç otomasyonundan iş süreçlerinde faydalanılması, işlerin niteliği üzerinde de önemli değişimler yaratmaktadır. Hem robotlar hem de robotik süreç otomasyonu sayesinde, çalışanlar rutin, manuel ve tekrarlı işleri yapmayı bırakmakta; katma değeri daha fazla olan işlere daha fazla zaman ayırma imkânına kavuşmaktadırlar. Bu durum, özellikle firma düzeyinde önemli katma değer artışına neden olmaktadır. Robotlar esas olarak imalat sanayisinde kullanılmaktadırlar. Hasta bakımı gibi alanlarda kullanımları artmasına rağmen; hizmetler sektöründe kullanımları oldukça sınırlıdır. Robotik süreç otomasyonundan ise esas olarak hizmetler sektöründe faydalanılmaktadır. Robotik süreç otomasyonu, özellikle bankacılık sektöründe yaygın olarak kullanılmaktadır. Hem robot yatırımlarının hem de robotik süreç otomasyonları yatırımlarının toplam yatırımlar içindeki payı oldukça düşüktür. Bu eğilime rağmen hem robotik süreç otomasyonu hem de robot yatırımlarının ilerleyen dönemlerde artması beklenmektedir.

Çalışmada ikinci olarak, robotik süreç otomasyonun yarattığı etkiler, örnek bankanın ticari kredi tahsis ve fatura ödeme süreçleri üzerinden gösterilmiştir. Her iki süreçte de robotik süreç otomasyonun kullanılması, üretkenlik artışına neden olmuştur. Bu süreçlerde robotik süreç otomasyonundan faydalanılması, istihdam kaybına neden olmamıştır. Dolayısıyla, üretkenlik etkisi, yer değiştirme etkisine üstün gelmiştir. Ticari kredi tahsis ve fatura ödeme süreçlerinde robotik süreç otomasyonundan yararlanılması sonucunda çalışanlar, rutin manuel ve tekrarlı işleri yapmayı bırakmışlar, katma değeri daha yüksek olan faaliyetlere daha fazla zaman ayırma imkanına kavuşmuşlardır. Robotik süreç otomasyonu, bütün bu kazanımları diğer bankacılık uygulamaları ile karşılaştırıldığında oldukça düşük yatırım maliyeti ile

gerçekleştirmektedir. Yarattığı bütün bu etkiler sayesinde robotik süreç otomasyonu, örnek bankada önemli değişim yaratmıştır.

Devlete robotik süreç otomasyonun ve robotların yarattığı etkileri yönetme sürecinde önemli görevler düşmektedir. Robotik süreç otomasyonu ve robotlar, rutin, manuel ve tekrarlı işleri yapmaktadırlar. Bu sebeple, bu işleri yapan düşük nitelikli çalışanlar işlerini kaybetme riski ile karşı karşıya kalmaktadırlar. Dolayısıyla çalışanların yeniden eğitilmesi ve yeni yetenekler kazanması büyük önemdedir. Hükümetler, eğitim programlarını yeniden düzenlemeli ve çalışanların yeniden eğitimini teşvik etmelidirler. Robotları geliştirme sürecinde AR-GE ve imalat aşamaları gelişmiş ülkelerde yoğunlaşmaktadır. Benzer bir durum robotik süreç otomasyonu için de söz konusudur. Gelişmiş ülkelerde faaliyet gösteren firmalar, robotik süreç otomasyonu geliştirme sürecinin AR-GE ve yazılım aşamalarında ön plana çıkmaktadırlar. Robotların ve robotik süreç otomasyonun neden olduğu faydalar göz önüne alındığında, gelişmekte olan ülkelerin AR-GE ile geliştirme aşamalarına ağırlık vermesi büyük önemdedir. Gelişmekte olan ülkelerin gelişmiş ülkeleri AR-GE ve geliştirme alanlarında yakalayabilmesi için devletin aktif rol oynaması ve özel sektörün yetmediği yerde müdahil olması gerekmektedir.

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.

Kaynakça

Acemoglu, D., Koster, H.R. and Ozgen, C. (2023). *Robots and workers: Evidence from the Netherlands* (NBER Working Paper No. 31009). Retrieved from http://www.nber.org/papers/w31009

Acemoglu, D., Lelarge, C. and Restrepo, P. (2020). Competing with robots: Firm-level evidence from France. *AEA Papers and Proceedings,* 128(6), 2188-2244. https://doi.org/10.1086/705716

Acemoglu, D. and Restrepo, P. (2020). Robots and jobs: Evidence from US labor markets. *Journal of Political Economy*, 128(6), 383–388. https://doi.org/10.1257/pandp.20201003

Aguirre, S. and Rodriguez, A. (2017). Automation of a business process using robotic process automation (RPA): A case study. In Figueroa-García, J., López-Santana, E., Villa-Ramírez, J., Ferro-Escobar, R. (Eds), *Applied computer sciences in engineering. 4th workshop on engineering applications proceedings* (pp.65-71). Cham: Springer.

Anagnoste, S. (2017). Robotic automation process-the next major revolution in terms of back office operations improvement. *Proceedings of the International Conference on Business Excellence* 11(1), 676-686. https://doi.org/10.1515/picbe-2017-0072

Allen, A. (2022). *Küresel ekonomi tarihi kısa bir giriş* (Çev. Hande Koçak Cimitoğlu). İstanbul: Türkiye İş Bankası Kültür Yayınları.

Atkinson, R.D. (2018). *Which nations really lead in industrial robot adoption?* (Information Technology & Innovation Foundation November 2018). Retrieved from https://www2.itif.org/2018-industrial-robot-adoption.pdf

Baldwin, R. and Forslid, R. (2020). *Globotics and development: When manufacturing is jobless and services are tradable* (NBER Working Paper No. 26731). Retrieved from http://www.nber.org/papers/w26731

Bartodziej, C.J. (2017). *The concept industry 4.0*. Wiesbaden: Springer Gabler

Benmelech, E. and Zator, M. (2022). *Robots and firm investment* (NBER Working Paper No. 29676). Retrieved from http://www.nber.org/papers/w29676

Bill, M., Müller, C., Kraus, W. and Bieller, S. (2022). *World robotics 2022* (IFR World Robotics 2022). Retrieved from https://ifr.org/downloads/press2018/2022_WR_extended_version.pdf

Börü, F. ve Tahsin, E. (2023). Türkiye'nin endüstri 4.0'a geçiş sürecinin teknoloji kapasitesi yaklaşımları temelli analizi. *Abant Sosyal Bilimler Dergisi*, 23(3), 1293-1314 https://doi.org/10.11616/asbi.1265937

Bresnahan, T.F. and Trajtenberg, M. (1995). General purpose technologies 'Engines of growth'? *Journal of Econometrics*, 65(1), 83-108. https://doi.org/10.1016/0304-4076(94)01598-T

Cette, G., Devillard, A. and Spiezia, V. (2021). The contribution of robots to productivity growth in 30 OECD countries over 1975–2019. *Economics Letters*, 200, 109762. https://doi.org/10.1016/j.econlet.2021.109762

Cheng, H., Jia, R., Li, D. and Li, H. (2019). The rise of robots in China. *Journal of Economic Perspectives*, 33(2), 71-88. doi:10.1257/jep.33.2.71

Crafts, N. (2004). Steam as a general purpose technology: A growth accounting perspective. *The Economic Journal*, 114(495), 338-351. https://doi.org/10.1111/j.1468-0297.2003.00200.x

Cséfalvay, Z. (2019). Robotization in Central and Eastern Europe: Catching up or dependence? *European Planning Studies,* 28(8), 1534-1553. https://doi.org/10.1080/09654313.2019.1694647

Cséfalvay, Z. (2023). As "robots are moving out of the cages"–toward a geography of robotization. *Eurasian Geography and Economics*, 64(1), 89-119. https://doi.org/10.1080/15387216.2021.1972022

Cséfalvay, Z. and Gkotsis, P. (2022). Robotisation race in Europe: The robotisation chain approach. *Economics of Innovation and New Technology*, 31(8), 693-710. https://doi.org/10.1080/10438599.2020.1849968

Dauth, W., Findeisen, S., Suedekum, J. and Woessner, N. (2021). The adjustment of labor markets to robots. *Journal of the European Economic Association*, 19(6), 3104-3153. https://doi.org/10.1093/jeea/jvab012

De Vries, G.J., Gentile, E., Miroudot, S. and Wacker, K.M. (2020). The rise of robots and the fall of routine jobs. *Labour Economics*, 66, 101885. https://doi.org/10.1016/j.labeco.2020.101885

Doguc, O. (2022). Robot process automation (RPA) and its future. In U. Hacıoglu (Ed.), *Handbook of research on strategic fit and design in business ecosystems* (pp. 469-492). USA: IGI Global.

Eggleston, K., Lee, Y.S. and Iizuka, T. (2021). *Robots and labor in the service sector: Evidence from nursing homes* (NBER Working Paper No. 28322). Retrieved from http://www.nber.org/papers/w28322

Estolatan, E., Geuna, A., Guerzoni, M. and Nuccio, M. (2018). *Mapping the evolution of the robotics industry: A cross country comparison.* (Università di Torino Working Paper Series No. 12). Retrieved from https://iris.unive.it/retrieve/e4239ddd-cd40-7180-e053-3705fe0a3322/wp_12_2018.pdf

Fan, H., Hu, Y. and Tang, L. (2021). Labor costs and the adoption of robots in China. *Journal of Economic Behavior & Organization*, 186, 608-631. https://doi.org/10.1016/j.jebo.2020.11.024

Fernandez-Macias, E., Klenert, D. and Anton, J.I. (2021). Not so disruptive yet? Characteristics, distribution and determinants of robots in Europe. *Structural Change and Economic Dynamics*, 58, 76-89. https://doi.org/10.1016/j.strueco.2021.03.010

Fırat, S.Ü.O. (2023). Endüstri 4.0'dan endüstri 6.0'a yolculuk. Erişim adresi: https://www.sanayicidergisi.com.tr/endustri-40dan-endustri-60a-yolculuk-makale,857.html

Fırat, O.Z. ve Fırat, S.Ü. (2017). Endüstri 4.0 yolculuğunda trendler ve robotlar. *İstanbul Üniversitesi İşletme Fakültesi,* 46(2), 211-223. doi:10.5152/iujsb.2017.005

Fu, T. and Cheng, Y. (2022). Regionalisation or domesticalisation? Configurations of China's emerging domestic market-driven industrial robot production networks. *Cambridge Journal of Regions, Economy and Society*, 15(2), 343-365. https://doi.org/10.1093/cjres/rsac013

Ghiasi, G. and Larivière, V. (2015). Sectoral systems of innovation: The case of robotics research activities. *Scientometrics*, 104, 407-424. https://doi.org/10.1007/s11192-015-1611-9

Graetz, G. and Michaels, G. (2018). Robots at work. *Review of Economics and Statistics*, 100(5), 753-768. https://doi.org/10.1162/rest_a_00754

Grand View Research. (2023). Robotic process automation (RPA) market analysis, 2018-2030 opportunities beyond COVID-19 crisis. Retrieved from https://www.grandviewresearch.com/industry-analysis/robotic-process-automation-rpa-market#

Hofmann, P., Samp, C. and Urbach, N. (2020). Robotic process automation. *Electronic Markets*, 30(1), 99-106. https://doi.org/10.1007/s12525-019-00365-8

Jovanovic, B. and Rousseau, P. (2005). *General purpose technologies* (NBER Working Paper No. 11093). Retrieved from http://www.nber.org/papers/w11093

Jovanović, S.Z., Đurić, J.S. and Šibalija, T.V. (2018). Robotic process automation: Overview and opportunities. *International Journal Advanced Quality*, 46(3-4), 34-39. Retrieved from https://jusk.rs/

Jungmittag, A. (2021). Robotisation of the manufacturing industries in the EU: Convergence or divergence? *The Journal of Technology Transfer*, 46(5), 1269-1290. https://doi.org/10.1007/s10961-020-09819-0

Jungmittag, A. and Pesole, A. (2019). *The impact of robots on labour productivity: A panel data approach covering 9 industries and 12 countries* (JRC Working Papers Series on Labour,

Education and Technology No. 2019/08). Retrieved from https://www.econstor.eu/handle/10419/231332

Koch, M., Manuylov, I. and Smolka, M. (2021). Robots and firms. *The Economic Journal*, 131(638), 2553-2584. https://doi.org/10.1093/ej/ueab009

Kromann, L., Malchow-Møller, N., Skaksen, J.R. and Sørensen, A. (2020). Automation and productivity—a cross-country, cross-industry comparison. *Industrial and Corporate Change*, 29(2), 265-287. https://doi.org/10.1093/icc/dtz039

Lacity, M.C. and Willcocks, L.P. (2016). A new approach to automating services. *MIT Sloan Management Review*, 58(1), 41-49. Retrieved from https://sloanreview.mit.edu/

Lacity, M., Willcocks, L.P. and Craig, A. (2015) *Robotic process automation at Telefónica O2* (The Outsourcing Unit Working Research Paper Series No. 15/02). Retrieved from http://eprints.lse.ac.uk/64516/1/OUWRPS_15_02_published.pdf

Landes, D. (2017). *Milletlerin zenginliği ve yoksulluğu* (Çev. A.S. Doğru). İstanbul: Feylesof Kitap.

Leigh, N.G. and Kraft, B.R. (2018). Emerging robotic regions in the United States: Insights for regional economic evolution. *Regional Studies*, 52(6), 804-815. https://doi.org/10.1080/00343404.2016.1269158

Macrorie, R., Marvin, S. and While, A. (2021). Robotics and automation in the city: A research agenda. *Urban Geography*, 42(2), 197-217. https://doi.org/10.1080/02723638.2019.1698868

Madakam, S., Holmukhe, R.M. and Jaiswal, D.K. (2019). The future digital work force: Robotic process automation (RPA). *JISTEM-Journal of Information Systems and Technology Management*, 16, e201916001. doi 10.4301/s1807-1775201916001

Moser, P. and Nicholas, T. (2004). Was electricity a general purpose technology? Evidence from historical patent citations. *American Economic Review*, 94(2), 388-394. doi:10.1257/0002828041301407

Özdem, H. ve Bora, M.P. (2021). Türkiye'de robotik süreç otomasyonu. *Bilgisayar Bilimleri ve Teknolojileri Dergisi*, 3(1), 1-9. https://doi.org/10.54047/bibted.1008340

Pratt, G.A. (2015). Is a Cambrian explosion coming for robotics? *Journal of Economic Perspectives*, 29(3), 51-60. doi:10.1257/jep.29.3.51

Ribeiro, J., Lima, R., Eckhardt, T. and Paiva, S. (2021). Robotic process automation and artificial intelligence in industry 4.0–a literature review. *Procedia Computer Science*, 181, 51-58. https://doi.org/10.1016/j.procs.2021.01.104

Santos, F., Pereira, R. and Vasconcelos, J.B. (2020). Toward robotic process automation implementation: An end-to-end perspective. *Business Process Management Journal*, 26(2), 405-420. https://doi.org/10.1108/BPMJ-12-2018-0380

Seçkiner, S., Metehan, A. ve Eroğlu, Y. (2021). Robotik süreç otomasyonlarının havacılık sektörü uygulamaları ve geleceği. *Journal of Aviation*, 5(2), 290-297. https://doi.org/10.30518/jav.947025

Siderska, J. (2020). Robotic process automation – A driver of digital transformation? *Engineering Management in Production and Services*, 12(2), 21-31. https://doi.org/10.2478/emj-2020-0009

Sliż, P. (2019). Robotization of business processes and the future of the labor market in Poland – Preliminary research. *Organizacja i Kierowanie*, 185(2), 67-79. Retrieved from https://www.ceeol.com/

Suri, V.K., Elia, M. and Van Hillegersberg, J. (2017). Software bots - the next frontier for shared services and functional excellence. In Oshri, I., Kotlarsky, J. and Willcocks, L. (Eds.), *Global sourcing of digital services: Micro and macro perspectives. Lecture Notes in Business Information Processing* (pp. 81-94). Cham: Springer.

Syed, R., Suriadi, S., Adams, M., Bandara, W., Leemans, S.J., Ouyang, … Reijers, H.A. (2020). Robotic process automation: Contemporary themes and challenges. *Computers in Industry*, 115, 103162. https://doi.org/10.1016/j.compind.2019.103162

Tang, C., Huang, K. and Liu, Q. (2021). Robots and skill-biased development in employment structure: Evidence from China. *Economics Letters,* 205, 109960. https://doi.org/10.1016/j.econlet.2021.109960

Taulli, T. (2020). *The robotic process automation handbook: A guide to implementing RPA systems*. Berkeley: Apress.

Yetiz, F., Turan, Y. ve Canpolat, İ. (2021). Bankacılık süreç otomasyonu ve verimlilik ilişkisi: Bir banka örneği. *Verimlilik Dergisi,* 2(2), 65-80. https://doi.org/10.51551/verimlilik.765336

Zamalloa, I., Kojcev, R., Hernández, A., Muguruza, I., Usategui, L., Bilbao, A. and Mayoral, V. (2017). *Dissecting robotics-historical overview and future perspectives*. *Acutronic Robotics*, April 2017, 1-9. https://doi.org/10.48550/arXiv.1704.08617

ECONOMIC IMPACTS OF ROBOTS AND ROBOTIC PROCESS AUTOMATION IN THE AGE OF DIGITALIZATION

EXTENDED SUMMARY

The Purpose of the Study

The aim of this study is to explain the changes created by robots and robotic process automation in the economy and discuss the potential they will have in the future. The study differs from other studies by showing the effects of robotic process automation through the applications of the sample bank and trying to explain in detail the changes created by robots and robotic process automation in the economy.

Methodology

In this study, first of all, the changes which are brought about by robots and robotic process automation in the economy have been tried to explain. For this purpose, extensive literature on the subject was examined, and the results were summarized. Secondly, the impacts of robotic process automation are shown through the commercial loan allocation and bill payment processes of the sample bank. For this purpose, data regarding the application results of these two processes from the sample bank were used.

Discussions and Conclusion

In this study, firstly, the changes that are created by robots and robotic process automation in the economy have been tried to be explained. In this context, the transformations that are created by robots and robotic process automation in areas such as labor productivity, employment, quality of jobs, investments, and services sector, as well as the effects they may have in the future, have been examined. Both robots and robotic process automation cause significant productivity increases in the sectors where they are used. The changes that are created by the use of robots and robotic process automation in business processes on employment occur as a result of the productivity effect and the displacement effect. Therefore, the effects of using both robots and robotic process automation in business processes on employment vary between countries. The use of robots and robotic process automation in business processes also creates significant changes in the quality of work. Thanks to both robots and robotic process automation, employees stop doing routine, manual, and repetitive tasks as well as they have the opportunity to spend more time on jobs with more added value. Robots are mainly used in the manufacturing industry. Robot use in the services sector is quite limited. Robotic process automation is mainly used in the services sector. Robotic process automation is especially widely used in the banking industry. The share of both robot investments and robotic process automation investments in total investments is quite low. Despite this trend, both robotic process automation and robot investments are expected to increase in the future.

Secondly, the effects of robotic process automation are demonstrated through the commercial loan allocation and bill payment processes of the sample bank. The utilization of

robotic process automation in both processes has resulted in a productivity increase. Using robotic process automation in these processes did not cause employment loss. Therefore, the productivity effect is bigger than the displacement effect. As a result of utilizing robotic process automation in commercial loan allocation and bill payment processes, employees stopped doing routine, manual, and repetitive tasks. They had the opportunity to spend more time on activities with higher added value. Robotic process automation achieves all these gains with a very low investment cost compared to other banking applications. Thanks to all these effects, robotic process automation has created a significant change in the sample bank.

The state has important duties in managing the effects of robotic process automation and robots. Robotic process automation and robots perform routine, manual, and repetitive tasks. For this reason, low-qualified employees who perform these tasks face the risk of losing their jobs. Therefore, it is of great importance to retrain employees and acquire new skills. Governments should reform training programs and encourage employee retraining. In the robot development process, the R&D and manufacturing stages are concentrated in developed countries. A similar situation applies to robotic process automation. Companies that have operated in developed countries have come to the fore in the R&D and software stages of the robotic automation development process. Considering the benefits caused by robots and robotic process automation, it is of great importance for developing countries to focus on R&D and development stages. In order for developing countries to catch up with developed countries in R&D and development fields, the state must play an active role and intervene where the private sector is not sufficient.