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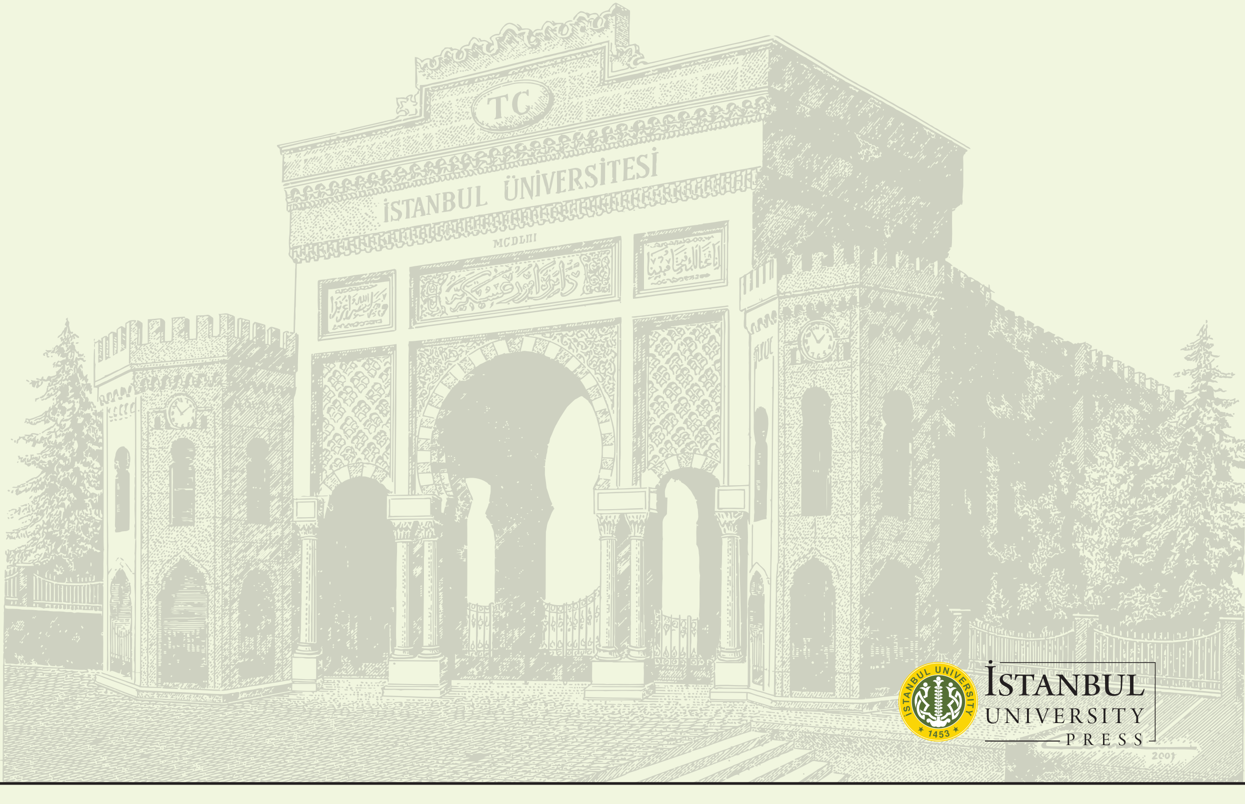

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RESEARCH ARTICLE

Decoding Inflation: Role of Institutional Quality in Türkiye Using Advanced Econometric Techniques

Yıldırım Beyazıt ÇİÇEN[1]

ABSTRACT
Persistent inflation remains a significant economic challenge in Türkiye. The causes of high inflation have been examined through various factors, including supply and demand, as well as monetary and fiscal policies. However, few studies have included institutional factors in their analyses. The objective of this study is to determine whether institutional quality affects inflation in Türkiye. A novel and robust econometric analysis method is employed in this study. Between 2005 and 2019, the inflation rate, the International Country Risk Guide's (ICRG) Political Risk Rating index, which measures the quality of institutional structure, and the changes in currency exchange rate basket variables in Türkiye were examined using the Fourier KPSS stationarity test and the Fourier Shin cointegration test. The results of the analysis indicate that inflation rate is co-integrated with institutional quality. The deterioration of institutional quality in Türkiye between 2005 and 2019 has been associated with an increase in inflation. While the implicit inflation targeting period in the inflation targeting regime implemented in Türkiye after 2002 was relatively successful, the explicit inflation targeting period failed to reduce inflation. The primary reason for the inability to achieve the specified inflation targets during these periods is the deterioration in the quality of institutions. It is also important to note that central bank independence is not immune to political influence and is one of the most important factors affecting inflation targeting.

Keywords: Institutional structure, Inflation, Inflation-targeting, Central bank, Fourier analysis
JEL Classification: D02, E31, E58

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1. Introduction

The structural and economic institutions of private property, the rule of law, political stability, and investment protection play a pivotal role in fostering economic growth and development (Acemoğlu, Johnson and Robinson, 2005). In countries with weak institutional structures, fluctuations in macroeconomic variables occur through both microeconomic and macroeconomic channels. An enhanced institutional structure exerts a robust positive influence on macroeconomic stability, including growth and low inflation (Acemoglu et al., 2003; Barro and Sala-i Martin, 2004).

Inflation gives rise to significant social and political complications within societies. For this reason, the determinants of inflation have constituted a central focus of extensive economic literature research, with the objective of providing policymakers with guidance in their decision-making processes. Nevertheless, a significant proportion of these studies tend to analyse monetary policies and indicators without incorporating the role of institutions. In the economic literature, macroeconomic instability has been attributed to purely economic arguments, and monetary and fiscal policies are considered the main tools to achieve macroeconomic stability and control inflation (Fenira, 2014; Minea, Tapsoba and Villieu, 2021, p. 2108). In essence, inflation has long been considered a predominantly monetary phenomenon in the long run (Friedman, 1963). However, recent contributions from post-Keynesian-structuralist economists underscore the significance of supply-side factors in triggering inflationary processes. These factors include exchange rate shocks, import and commodity price increases, and wage fluctuations in non-tradable sectors (Abeles and Panigo, 2015).

Conversely, recent studies have investigated the effects of institutional factors on inflation (Cukierman, 1992). The general conclusion of these studies, which take institutions into account in the literature, is that the emergence and rise of inflation is due to the lack of central bank (CB) independence, weak financial structure, and underdevelopment of democratic institutions. Furthermore, the pace and quality of economic growth are additional factors that influence inflation (Lim, 2021, p. 310; Khan and Hanif, 2020, pp. 628-629). Moreover, the institutional structure can affect inflation through various channels, including property rights, the rule of law, the enforceability of contracts, and political stability (Knack and Keefer, 1995).

CBs are crucial institutions within economic structures that are tasked with reducing and controlling inflation. The primary CB objective is to ensure price stability[1]. Clearly defining the role of the CB is essential for mitigating market failures. When CBs have the capacity to analyze comprehensive market information, they can make more effective decisions. The first notable example of this is New Zealand. The implementation of an inflation targeting regime in New Zealand resulted in a reduction in inflation, a precedent followed by other countries (Mishkin and Posen, 1998). For an inflation targeting regime to be effective, it is essential that the CB operates independently, free from political pressure, in selecting and implementing monetary policy tools. The credibility, transparency and autonomy of the CB are crucial prerequisites for achieving sustained inflation reduction (Aguir, 2018).

Furthermore, the quality of institutions plays a pivotal role in determining the autonomy of CBs and the efficacy of monetary policy. When institutional quality is deficient, there is an elevated risk of CBs being exploited by governments for monetization. This vulnerability is particularly evident during election cycles when expansive monetary and fiscal policies are often pursued to stimulate economic growth and reduce unemployment. The delayed effects of monetary policy on inflation, resulting from fiscal choices, become noticeable following elections (Leeper, 1991; Alesina, Cohen and Roubini, 1993). However, with CB independence, effective measures, such as interest rate adjustments, can be implemented to curb demand in an overheated economy without succumbing to political pressure. This makes it more feasible to achieve inflation targets.

[1] https://www.tcmb.gov.tr/wps/wcm/connect/TR/TCMB+TR/Main+Menu/Temel+Faaliyetler/Para+Politikasi/Fiyat+Istikrari+ve+Enflasyon/#:~:text=Fiyat%20istikrar%C4%B1%20ise%20para%20politikas%C4%B1n%C4%B1n,temel%20amac%C4%B1%2C%20fiyat%20istikrar%C4%B1n%C4%B1%20sa%C4%9Flamakt%C4%B1r. – Access date: 09.03.2023

Nevertheless, it is evident that policymakers often prioritize economic growth over inflation control. For example, the national electoral policies of Türkiye from 2004 to 2016 were based on promoting economic growth (Luca, 2022).

On the other hand, a lack of institutional quality erodes credibility, increases risk premiums, and causes inflation to rise through exchange rate depreciation, leading to deviations from the target and making it challenging for policymakers to manage inflation expectations (Samadi, Marzban and Owjimehr, 2017, p. 33). Acemoğlu et al. (2008) expanded upon this perspective, noting that in countries with weak institutional structures, politicians, if not constrained, CB independence alone is insufficient to reduce inflation. Consequently, the promotion of institutional reforms (such as the separation of powers, accountability, etc.) in developing countries becomes a pressing necessity with the objective of enhancing economic performance, which would result in more consistent monetary policy, a deeper financial sector, and reduced monetary shocks (Posen, 1995, p. 270). Furthermore, Acemoğlu et al. (2008) demonstrated that countries with strong institutional structures can regulate inflation even in the absence of robust CB independence through the implementation of appropriate policies, thereby underscoring the correlation between institutional quality and inflation levels. This mechanism is exemplified by the rapid decline in inflation in Türkiye following its institutional transformation after 2001 (Kara and Öğünç, 2008, pp. 60-62). However, the reduction in the tenure of the governors of the Central Bank of the Republic of Türkiye (CBRT) suggests a decline in the CBRT's independence[2] and a deviation from the inflation target. Moreover, controlling inflation has the additional benefit of increasing the efficiency of investment decisions and reducing the volatility of interest rates and risk premiums, which significantly improves economic performance beyond expectations (Gürkaynak et al., 2007). Therefore, a detailed study of this issue is crucial for both developed and developing countries to improve economic indicators such as economic growth, employment, foreign trade, and income distribution.

[2] Demiralp (2022, October) - https://istanpol.org/post-merkez-bankasi-bag-ms-zl-ve-turkiye-tecr-besi - Access date: 09.03.2023

Conversely, studies have indicated that institutional quality is not a significant factor in disinflation. For instance, Aisen and Veiga (2008a) argued that institutional quality does not play a pivotal role in explaining inflation performance, citing high levels of political instability as contributing to more volatile inflation rates. Lin and Ye (2009) further suggest that the success of inflation targeting in developing countries is influenced by a number of factors, including the government's fiscal condition, the CB's desire to limit exchange rate movements, the fulfilment of prerequisites for policy adoption, and the time elapsed since policy adoption. These studies highlight that the success of inflation targeting is contingent upon a range of country-specific factors that extend beyond the institutional quality of the economy.

These studies demonstrate that countries with comparable levels of institutional quality may experience varying inflation rates despite implementing similar inflation targeting strategies. This indicates that factors such as political stability and macroeconomic policies also significantly influence the effectiveness of inflation targeting. Consequently, the relationship between institutional quality and inflation reduction is intricate and contingent on numerous variables. In this context, Samarina and De Haan (2014) proposed that past macroeconomic performance, fiscal discipline, exchange rate arrangements, and the structure and development of the financial system are crucial in adopting an inflation targeting regime within a country. An examination of these findings in the context of Türkiye is crucial to understanding their applicability within the country's unique conditions and economic framework. This will aid in the devising of more effective strategies for designing and implementing inflation management policies.

This study empirically examines the relationship between institutional quality and inflation in Türkiye. This study addresses a gap in the existing literature on this topic in the Turkish context, where few studies have been conducted on the subject. The discussion expands to consider whether inflation is merely a monetary phenomenon by integrating a New Institutional Economics (NIE) perspective. NIE underscores the critical role that institutional structures play in facilitating the effective functioning of public services. It elucidates how inadequate legal frameworks can lead to incomplete contracts, engendering challenges in economic institutions that are influenced by both de facto and de jure political institutions. These challenges can give rise to market failures, which have a negative impact on economic indicators and can hinder macroeconomic stability (Çiçen, 2017). NIE underscores the significance of independent regulatory authorities in maintaining reliable commitments during policymaking (North, 1993). In light of these considerations, the quality of institutional structure and independence of CBs emerge as crucial factors. An understanding of these dynamics is essential for a thorough examination of the interaction between institutional factors and inflation rates, which contributes substantially to both academic discussion and policy recommendations in the context of the Turkish economy.

The second section examines the relationship between institutional structure and inflation, with a particular focus on inflation targeting and the distinctions between developed and developing countries. A subsection of this section presents a detailed analysis of the Turkish case. The third section offers an extensive review of the existing literature in this field. The fourth section presents the fundamental economic model that serves as the foundation for the study. Subsequently, Section 5 provides a detailed account of the econometric methodology employed, including Fourier stationary and cointegration tests. In the sixth and the final section, the data used and the resulting findings are presented, and the study's empirical contributions are encapsulated. The conclusion section then synthesizes these findings and offers pertinent policy recommendations.

2. Quality of Institutional Structure and Inflation

The marked differences in economic structure and institutional frameworks between developed and developing countries are an important factor in the formulation and implementation of economic policies. Advanced economies generally have strong legal infrastructures, efficient governance mechanisms, and deep financial structures. In contrast, emerging economies are often characterized by weaker institutional structures. These countries tend to be influenced by international financial markets when determining their economic policies and have more endogenous vulnerability. Furthermore, developing countries are more susceptible to external economic shocks and are less equipped than developed countries to respond to such shocks. These disparities should be taken into account in research on inflation and the quality of institutions, particularly in economic analysis of developing countries. Given that structural institutions in developing countries are not as strong as in developed countries, financial and economic institutions remain weak, making it challenging to implement inflation targeting policies effectively (Ibarra and Trupkin, 2016).

Since the 1990s, Türkiye and other developing countries have implemented inflation targeting regimes. However, despite institutional reforms, these targets have not been met in most periods. This is because the success of inflation targeting in developing countries requires the elimination of political uncertainties as well as a number of conditions, including fiscal dominance, high dollarization, trade imbalances, and the absence of volatility in financial markets. However, for instance, developing countries have limited control over exchange rates. In addition, developing countries often have fewer reserves to manage monetary policy, which makes it challenging for them to respond effectively to changes in economic conditions and to stabilize the exchange rate (Aizenman, 2019). Moreover, a high level of dollarization devalues the local currency and affects the monetary policy of the CB, making inflation targeting more difficult. In this context, the macroeconomic performance of emerging markets is also important. In the periods of high global liquidity, the weaknesses accumulated in emerging markets through capital inflows can suddenly turn into a crisis (Borio and Disyatat, 2015, pp. 25-26). In addition to high dollarization and depreciation of the local currency during a crisis, inflation can be adversely affected by a combination of factors, including fluctuations in financial markets, increases in import costs, credit expansion, and demand growth through capital flows (Obstfeld and Zhou, 2023). For example, Argentina, a Latin American country, has recently faced high levels of inflation due to fiscal and monetary policies. The inflation targeting regime, which commenced in September 2016, was only sustained for 25 months. This was due to two main factors. Firstly, in December 2017, a political dispute between the government and the Central Bank of Argentina (BCRA) led to a negative credibility shock, as the public perceived an intervention in the autonomy of the BCRA. Secondly, the currency crisis in April 2018 led to a significant devaluation of the Argentine peso, which in turn led to high inflation. Following these problems, the inflation targeting regime was terminated (Cachanosky and Mazza, 2021). In this context, it is insufficient to focus solely on economic measures for the success of the inflation targeting regime. In addition to economic measures, structural adjustments are also necessary. These include the creation of strong and accountable institutions, public administration reforms, and strengthening the legal framework. By combining all these elements, an integrated approach can provide a comprehensive solution.

2.1. Türkiye's Inflation Targeting Experience

In the 1990s, Türkiye experienced a prolonged period of inflationary pressures, which had a detrimental impact on the country's economic stability. The 1994 financial crisis resulted in a surge in the CPI, reaching 125.5%. As an external shock, the 1997 energy crisis contributed to an increase in inflation. The average CPI for the 1990s was 75.3%. Moreover, the 2000-2001 crisis led to a depreciation of the Turkish lira and a subsequent surge in inflation, which had declined to 39% in 2000 but rose rapidly to 68.5% in 2001. The primary drivers of elevated inflation in Türkiye during the 1990s were the time-inconsistent monetary policies implemented by coalitions, the high public debt and fiscal indiscipline, fluctuations in the exchange rate, and structural deficiencies (Özatay, 2015, p. 10).

In the aftermath of 2001 financial crisis in Türkiye, the coalition invited Kemal Derviş to visit the country to address the country's macroeconomic instability. As a result, the Strong Economy Transition Program (SET) was developed with the support of the International Monetary Fund (IMF), starting in April 2001. Following the early elections in November 2002, the program was continued by the Justice and Development Party (JDP) upon its coming to power. The program's primary objectives were to achieve sustainable growth and reduce inflation. To achieve these goals, the SET framework established independent regulatory bodies and granted the CBRT autonomy. Legislation specified that the CBRT's primary objective was to ensure price stability. Furthermore, the CBRT's practice of financing deficits for the Treasury and other public institutions was legally terminated. Among the independent regulatory bodies established was the Banking Regulation and Supervision Agency (BRSA). The BRSA was established following bank bankruptcies during the 2000-2001 crisis with the objective of stabilizing the financial sector. CBRT and BRSA, working in coordination after 2001, made significant contributions to macroeconomic stability[3]. The Banking Restructuring Program, implemented under the SET, facilitated the restructuring of the banking sector and resolved deteriorating balance sheets and capital structures after 2001. This ensured that banks resumed their core functions rather than lending to the Treasury, thereby deepening the financial sector (Öniş, 2009, pp. 421-422). This development was of critical importance in reducing inflation because financial instability can significantly disrupt the transmission mechanism, potentially reducing the effectiveness of standard interest rate policies (Svensson, 2010, p. 1283).

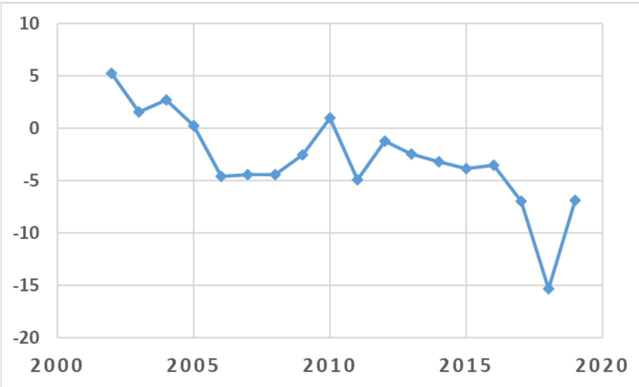
Following the attainment of autonomy, the CBRT initiated the implementation of inflation targeting regime in 2002. Between 2002 and 2005, an implicit inflation targeting was employed, followed by an explicit inflation targeting from 2006 to the present. The rationale behind the introduction of implicit inflation targeting was the necessity to reduce initially high inflation rates to a specific level (below 15%). In 2002, Türkiye's inflation rate was 29.7%, which decreased to 18.4% in 2003. After falling below 10% in 2005, Türkiye transitioned to an explicit inflation targeting regime. During the period of implicit inflation targeting, certain measures were implemented in preparation for the transition to the explicit inflation targeting regime. These included the establishment of the BRSA, the

[3] The 2003 Annual Report of the CBRT, which includes contributions from the CBRT, BRSA, Undersecretariat of Treasury, and SDIF, serves as an example of collaborative efforts within the framework of cooperation. https://www.tcmb.gov.tr/wps/wcm/connect/667c7904-1baa-4ca3-9c7d-eb0a23d28826/2003_Yillik_Rapor.pdf?MOD=AJPERES&CACHEID=ROOTWORKSPACE-667c7904-1baa-4ca3-9c7d-eb0a23d28826-mh5zofC - Access date: 14.01.2024

strengthening of the banking system, and the deepening of the financial sector (Bakir & Öniş, 2010, p. 84).

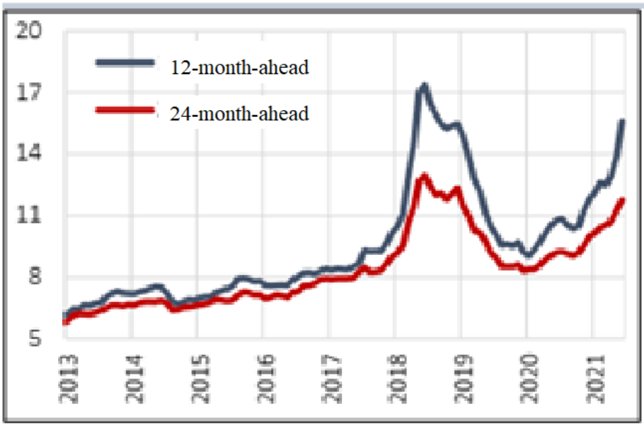
Figure 1 illustrates the discrepancies between targeted and actual inflation rates during the inflation targeting regime post-2002. An analysis of the deviation values reveals that the implicit inflation targeting period (2002-2005) achieved greater success than the explicit inflation targeting period (2006 onwards). Also, during the explicit inflation targeting period (2006 onwards), deviations consistently exceeded the two-percentage-point band, with the exception of 2010 and 2012. This indicates a failure of inflation targeting during this phase. Notably, in 2018, inflation deviated by 15.3 percentage points from the 5% target. Prior to the global financial crisis, the CBRT employed monetary policy instruments to maintain price stability within the inflation-targeting regime. This approach served to reinforce institutional confidence and to align the inflation expectations of economic entities with the set target. Nevertheless, following 2010, a growing divergence between targeted and actual outcomes undermined the CBRT's credibility. In addition to the rise in dollarization, the increase in the exchange rate pass-through coefficient has led to an increase in inflation expectations, as illustrated in Figure 2. Prior to 2017, the 12-month and 24-month inflation expectations were 7% and 6.4%, respectively. However, following 2018, there was a rapid increase, reaching 17.4% and 13% (Kara and Sarıkaya, 2021, p. 2). As a result, the rise in inflation expectations in Türkiye led to a notable increase in actual inflation. This can be attributed primarily to the CBRT's assertive policy measures aimed at curbing inflation and stabilizing currency depreciation expectations, which have yielded limited success (Gürkaynak et al., 2015, p. 34).

Figure 1. Deviations from the Inflation Target



Source: The graph was constructed by the author using data from the Turkish Statistical Institute database.

Figure 2. Inflation Expectations (%)



Source: Kara and Sarıkaya (2021)

In contrast to the prevailing view that fiscal dominance drives inflation, an analysis of the ratio of public net debt stock to GDP in Türkiye reveals a different trend. The ratio in question decreased significantly from 60.1% in 2002 to 32.3% in 2006, further dropping to 20.5% in 2011 and significantly declining to 8.6% by 2018[4]. Consequently, during the analysis period of 2005-2019, Türkiye did not experience inflationary pressures typically associated with expansive fiscal policies

[4] https://www.hmb.gov.tr/kamu-finansmani-istatistikleri - Access date: 20.12.2023

and public debt burdens seen in many other developing countries. Instead, fiscal discipline acted as a stabilizing force, reinforcing the effectiveness of inflation targeting (Ersel and Özatay, 2008, p. 32).

3. Literature

This section presents a summary of studies that examined the relationship between institutional quality and inflation, with a focus on differentiating between developed and developing countries. The literature generally analyzes developed and developing countries as a panel; thus, this summary begins with mixed-structured studies, followed by discussions on studies focused on developing countries and, finally, studies specific to Türkiye. In addition to studies with similar thematic coherence, emphasis was placed on chronological order and the analysis period. This approach was deemed appropriate given the prevalence of inflation targeting regimes after 1990.

In his 1995 study, Posen examined the period between 1960 and 1989 for 32 countries. These countries were characterized by low and medium incomes and included both developing and developed nations. CB independence was incorporated into the model through proxy variables. First, banks are assigned a value of 1 if they are permitted to operate in at least two of the following sectors: securities, insurance, and commercial lending. In the absence of this, a value of 0 is assigned. Second, banking supervision is assigned a value of 1 if it is not under the control of the CB, 0.5 if it is shared between the CB and another institution, and 0 if it is solely under the responsibility of the CB. Furthermore, another proxy variable is set to 1 for a federal political structure and 0 otherwise. In addition, the probability of two randomly selected legislators belonging to different parties is also considered. The four variables are used to construct an Effective Financial Opposition to Inflation (FOI) index. The findings indicate that CBs with legal independence provide significant different degrees of protection against inflation as political conditions change. Therefore, it is crucial that CBs be insulated from the deviations identified by the Barro-Gordon and Kydland-Prescott models and not be subjected to political pressure when controlling inflation (Cukierman and Gerlach, 2003, pp. 541-545).

In a separate study conducted between 1973 and 1994, a cross-sectional regression analysis was performed on 62 developed and developing countries. The findings of this study indicate that the effectiveness of CB independence may be less pronounced than previously claimed. This study revealed that inflation realizations and tax rates from previous periods play a significant role in determining inflation. Therefore, in addition to CB independence, other institutional reforms should be implemented. These include ensuring political stability and addressing time inconsistencies to reduce inflation. Furthermore, optimal tax policies and openness to international trade are other crucial factors. The study found that rapid adjustments aimed at increasing the tenure of the CB President do not make a significant difference unless fundamental conditions are met (Campillo and Miron, 1997, pp. 355-356). Furthermore, it was observed that in countries with high inflation rates, the banking system and financial firms adapt to the prevailing monetary environment, making it challenging to reduce inflation in such a setting (p. 338).

Aisen and Veiga (2008b) employed data on economic, political, and institutional variables for approximately 100 developed and developing economies between 1960 and 1999. The researchers employed the Generalized Method of Moments (GMM) estimator to conclude that political instability, in conjunction with low-quality democracy and institutional development, leads to volatility in inflation rates. Furthermore, the volatility of inflation is higher in developing economies where CB independence and economic freedom are at lower levels. This underscores the necessity to develop institutions that promote greater political stability as a means to reduce dependency on seigniorage financing of public deficits. Increased seigniorage leads to more political instability and inflationary outcomes, which highlights the importance of enhancing political stability through institutional development.

In a study conducted by Neyaptı (2012), 166 developed and developing countries were examined from 2000 to 2010. Regression analysis was performed, considering CB independence, inflation targeting, monetary boards, and other monetary unions. The findings revealed that countries that adopted inflation targeting and monetary boards in the 2000s had a lower average inflation rate over the past decade than other countries. In a subsequent study, Garriga (2016) examined the effects of CB independence over the period 1970-2012, using annual data from 182 countries. The index used to measure CB independence was constructed using two primary factors: the political nature of the CB (assignment, dismissal, and term of office) and the objectives and limits of lending to the public sector. The index ranges from 0 (lowest independence) to 1 (highest independence). The findings from the analysis indicate that countries where CB independence is ensured experience reduced inflation. Furthermore, all components related to independence contribute to inflation control.

Guisinger and Singer (2010) conducted a study focusing on exchange rates by examining 110 developed and developing countries from 1974 to 2004. The study found that in a floating exchange rate regime, governments aim to have greater discretion over monetary policy. Institutionalized mechanisms become crucial in combating inflation under such circumstances. Therefore, independent CBs can achieve lower inflation rates.

In their 2017 study, Gelos and Ustyugova examined the impact of international commodity price shocks on local inflation in 31 developed and 61 developing economies from 2001 to 2010. Employing panel estimations of Phillips curves, the researchers used commodity prices, such as oil and food, as proxy variables for inflation uncertainty. The study's findings indicate that countries with stronger governance and CB independence are more successful in stabilizing inflation expectations and controlling price shocks.

Fazio et al. (2018) examined the relationship between institutions, inflation targeting, and financial stability using data from 66 countries from 1998 to 2014. Panel regression analysis revealed a negative correlation between institutional quality and outcomes related to inflation targeting and financial stability, which was particularly pronounced in countries with lower institutional quality. This result is consistent with the findings of Campillo and Miron (1997). Another study by Law and Soon (2020) examined 65 developing and developed countries from

1987 to 2014. Using a two-stage Generalized Method of Moments (GMM) estimator, this study found that countries with higher institutional quality tend to experience a mitigated impact of inflation. Moreover, improving institutional quality contributes to reducing inflation-induced income inequality.

Lim (2021) conducted a study to analyze the impact of CB independence on inflation in 147 developed and developing countries from 1970 to 2012. The study found that CB independence has a positive impact on disinflation. This emphasizes the importance of not only de jure independence but also de facto independence of CBs for successful inflation control. The study also highlights the need to address opaque CB operating structures in low and middle-income countries.

A synthesis of studies from developed and developing countries reveals that the impact of political stability, CB independence, financial depth, and macroeconomic balance on inflation is a prominent area of analysis. CB independence, as an indicator of institutional structure, is generally identified as a significant factor in reducing inflation. Additionally, the quality levels of institutional structure and governance should not be overlooked, as they can influence the level of political stability, fiscal policy, financial structure depth, and external shock impact. Consequently, the trajectory of inflation may shift in either a positive or negative direction. Countries which have stronger institutional and economic structures are better positioned to regulate inflation.

This paper will now examine the existing literature on developing countries. The majority of studies on this subject examine the effects of CB independence. The initial study indicates that in economies that were formerly socialist, the independence of CBs contributes to disinflation only above a certain threshold of liberalization level. The analysis of the variables indicates that an increase in the quality of the institutions that regulate the banking system, as measured by the ratio of domestic credit to the private sector, has a significant and substantial impact on inflation. Consequently, the level of institutional development in the banking system is found to be a significant determinant of non-inflationary policies in developing countries. Consequently, transition economies can create favorable tools for controlling inflation over the long run by imposing constraints on policymakers and implementing banking system reforms to address macroeconomic instability (Cukierman, Miller and Neyapti, 2002). In a subsequent study, an inverse relationship between CB independence and inflation was observed in 22 countries where institutional structures underwent a transition following the collapse of socialism. The degree of correlation in question did not decline during periods of low inflation (Koziuk, 2019).

The findings of Huang and Wei (2006) indicate that the lack of credibility in monetary policy due to weak institutions leads to dollarization, even when the government is determined to maintain low inflation. The main reason is the absence of de jure and de facto CB independence. Additionally, factors such as the inability to ensure political and macroeconomic stability and weakness of the banking system lead to higher inflation rates than optimal in developing economies with low institutional quality.

In their 2020 study, Garriga and Rodriguez examined the correlation between CB independence and inflation in 118 developing countries over the 1980-2013 period. Their findings indicated that elevated CB independence is associated with reduced inflationary pressures. Notably, this influence on inflation is more pronounced in countries with greater democratic governance. In contrast, Çiçen (2023) examined the relationship between institutional quality and inflation, as well as the standard deviation of inflation and the sound money index, in 24 emerging economies over the period 2000-2019. The Fourier causality test was employed to investigate this relationship. The findings revealed a bidirectional causality relationship between institutional quality and inflation, as well as the standard deviation of inflation and the sound money index.

Studies conducted in developing economies typically examine the impact of CB independence and other factors on inflation in environments where institutional quality is often low, political instability is more pronounced, and financial markets are less developed. In these countries, strong CB independence not only contributes to reducing inflation but also enhances economic stability. However, establishing a robust institutional structure and ensuring political and economic stability are complex and challenging processes. Consequently, the independence of CBs in developing countries is constrained by political interventions and uncertainty.

In regard to the studies on Türkiye, Kibritçioğlu (2002) analyzed the inflation dynamics in Türkiye after 1980. The study found that the majority of the inflation literature in Türkiye has focused on supply and demand side determinants. However, the role of political institutions and processes should also be taken into account for more accurate modeling. In a subsequent study on Türkiye, Demiralp and Demiralp (2019) highlight the mounting pressure on the CBRT over the past decade, despite the CBRT Law that guarantees instrument independence. The study posits that this relationship between the government and the CBRT constrains the capacity for price stability and sustainable growth.

Türkiye's inflation course exhibits similarities to that of other developing countries, although it differs in certain respects. Unlike other countries, certain internal and external shocks and crises in Türkiye can affect the economy and inflation in a more pronounced manner. Periodic political instability, economic fluctuations, exchange rate volatility, political pressures on CB independence and weaknesses in institutional quality present challenges to effective inflation control[5].

4. Fundemantal Economic Model

A model was constructed based on the study by Acemoğlu et al. (2008) in the econometrics section of the research, with the objective of elucidating the efficacy of political reforms and the enhancement of institutional quality:

$$v(\pi, \lambda, t) = \lambda(\hat{\pi} - \pi_{-1}) + (1 + \lambda)\rho \tag{1}$$

[5] To illustrate this, the 2016 coup attempt, the 2018 Brunson diplomatic crisis, the unconventional monetary policy initiated in 2021 following the pandemic, the 2022 Russia-Ukraine war, and the 2023 Kahramanmaraş earthquakes have caused economic and structural disruptions in Türkiye.

In the equation, the function v represents the variables that comprise the model. The notation π represents measured inflation, $\hat{\pi}$ represents inflation expectations, and π_{-1} represents inflation in the previous period. ρ indicates the constraints faced by policymakers when implementing inflation targeting. As discussed in the introduction and literature review, populist policies implemented alongside monetary and fiscal expansion increase inflation expectations through ρ, thereby creating inflationary effects, particularly during election periods. The symbol λ in the equation represents the quality of institutional structure and varies within the range of $\lambda \sim [0,1]$. There is a close relationship between institutional quality and CB independence. When the value of λ is close to 0, CB independence is emphasized, public trust in CB policies increases, and inflation expectations over time are lower than the previous period's inflation. Consequently, policies designed to reduce inflation may be successful, resulting in lower inflation than the average inflation in previous periods $(\pi < \bar{\pi})$. However, as λ approaches 1, policymakers' behaviours become more dominant, and CB independence diminishes. In this instance, the discrepancy between the expected inflation rate and the actual inflation rate from the previous period widens. Consequently, the implementation of inconsistent policies will result in a failure to achieve the inflation target over time.

5. Econometric Methodology

The econometric analysis of this study is distinguished from existing literature by the incorporation of Fourier functions into the tests. In our analysis, we initially conducted a Fourier-stationarity test to ascertain the stationarity of the variables. This is of particular importance for cointegration analysis, as it is necessary for variables to be stationary at the same level. Subsequently, a Fourier cointegration test was conducted among the variables to determine whether there is a long-term relationship between them. The rationale behind conducting cointegration analysis is to observe the impact of institutional factors—the fundamental determinants of economic performance in the long term—on inflation rather than focusing on how short-term factors affect inflation. The superior aspects of the relevant Fourier methods are elucidated in the following subsections. The use of the Fourier function allows for a more accurate modeling of the variables' changes over time. The graphs of the inflation rate and degree of political risk in Figure 3 and Figure 4 demonstrate the effectiveness of this approach. Consequently, the findings obtained from the econometric model are more robust and contribute new insights to the existing literature.

5.1. Fourier Stationarity Test

In this study, the Fourier KPSS (FKPSS) test by Becker, Enders and Lee (2006) was employed for the stationarity test. The KPSS test is a significant unit root test that does not incorporate structural breaks, as first introduced to the literature by Kwiatkowski et al. (1992). Becker et al. (2006) enhanced the FKPSS stationarity test by incorporating a Fourier function. The FKPSS test is capable of detecting not only rapid structural breaks but also slow changes. Fourier functions are able to capture nonlinear changes by using sine and cosine terms.

One of the key advantages of this method is that it does not require determining the number of breaks before constructing the model. The frequency number (k) in the Fourier function corresponds to the number of peaks, which is the number of breaks. Furthermore, the number of breaks in the Fourier function does not reduce the degrees of freedom, thereby maintaining the test's power. Becker et al. (2006) employed the following data generation procedure:

$$y_t = X_t'\beta + Z_t'\gamma + r_t + \varepsilon_t \tag{2}$$

$$r_t = r_{t-1} + u_t \tag{3}$$

In Equation (2) and (3), ε_t represents the stationary error term, while denotes the independently and identically distributed error term with a variance of σ_u^2. The vector $Z_t = [\sin\left(\frac{2\pi kt}{T}\right), \cos\left(\frac{2\pi kt}{T}\right)]$ is employed to capture structural breaks or other nonlinear fluctuations. In this equation, t represents the trend term, T denotes the sample size, and k signifies the frequency.

In order to test the hypothesis of stationarity $(H_0: \sigma_u^2 = 0)$, one of the models with a constant or a trend is estimated. The residuals are computed as follows:

$$y_t = \alpha_0 + \gamma_1 \sin\left(\frac{2\pi kt}{T}\right) + \delta_2 \cos\left(\frac{2\pi kt}{T}\right) + e_t \tag{4a}$$

$$y_t = \alpha_0 + \beta t + \gamma_1 \sin\left(\frac{2\pi kt}{T}\right) + \delta_2 \cos\left(\frac{2\pi kt}{T}\right) + e_t \tag{4b}$$

Equation (4a) tests the stationarity hypothesis, while Equation (4b) tests the trend stationarity hypothesis. The test statistic is calculated as follows:

$$\tau_\mu(k) \text{ veya } \tau_t(k) = \frac{1}{T^2}\frac{\sum_{t=1}^{T} \tilde{S}_t(k)^2}{\tilde{\sigma}^2} \tag{5}$$

In Equation (5), $\tilde{S}_t(k)$ is defined as the sum of the residuals of the (4a) and (4b) models, represented by et al. Becker et al. (2006) estimate $\tilde{\sigma}^2$ as follows:

$$\tilde{\sigma}^2 = \tilde{\gamma}_0 + 2\sum w_j \tilde{\gamma}_j \tag{6}$$

In Equation (6), $\tilde{\gamma}_j$ represents the j-th sample autocovariance obtained from Equations (4a) and (4b). Additionally, $w_j, j = 1,2, \dots, l$ is the weight series and l is the lag parameter. k is the frequency value that minimizes the sum of squared residuals (SSR), also known as the residual sum of squares (RSS).

In the absence of a nonlinear trend in the data generation process, the standard KPSS test yields more robust results than the FKPSS test. Consequently, it is essential to identify the absence of a nonlinear trend $(H^0: \gamma_1 = \gamma_2 = 0)$. The F test statistic is constructed as follows:

$$F_i(k) = \frac{(SSR_0 - SSR_1(k))/2}{SSR_1(k)/(T-q)} \qquad i = \mu, \tau \tag{7}$$

In Equation (7), $SSR_1(k)$ represents the SSR calculated from Equations (4a) or (4b), while SSR_0 represents the SSR of the regression without trigonometric terms.

q is the number of independent variables. In the event that the null hypothesis is rejected based on the FKPSS test result for stationarity, the series has a unit root and the variable is nonstationary. Becker et al. (2006) posited that the F test should be employed when the stationarity hypothesis is not rejected in the FKPSS test, as the F test may exhibit excessive power when series are nonstationary in the FKPSS test (p. 391). Consequently, the findings from the F test will inform the decision regarding the use of the KPSS test without trigonometric terms in the subsequent analysis.

5.2. Fourier Cointegration Test

Tsong et al. (2016) introduced the Fourier Shin cointegration (FSHIN) test, which employs Fourier functions to contribute to the existing literature on cointegration testing. The FSHIN test was designed to test for the presence of cointegration in its fundamental hypothesis. In this context, the FSHIN cointegration test exhibits similarities to the FKPSS stationarity test. The test produces robust results that are independent of the form and number of structural changes.

The FSHIN test employs the following model:

$$y_t = d_t + x_t'\beta + \eta_t \,,\; \eta_t = \gamma_t + v_{1t} \,,\; \gamma_t = \gamma_{t-1} + u_t \,,\; x_t = x_{t-1} + v_{2t} \qquad (8)$$

In Equation (8), u_t represents an independent identically distributed error term, and γ_t indicates a zero-mean random walk process. y_t and x_t are first-difference stationary processes. The deterministic component d_t can be defined as in Equation (9):

$$d_t = \gamma_0 + \gamma_1 t + f_t \qquad (9)$$

It is possible to estimate Equation (9) without a trend. In this equation, f_t represents the Fourier function, which is defined as follows:

$$f_t = \alpha_k \sin\left(\frac{2\pi kt}{T}\right) + \beta_k \cos\left(\frac{2\pi kt}{T}\right) \tag{10}$$

In this function, the values of k, t and T are defined in accordance with the specifications of the FKPSS test. Equation (11) is employed to evaluate the fundamental hypothesis of cointegration $(\sigma_u^2 = 0)$ against the alternative hypothesis of no cointegration $(\sigma_u^2 > 0)$:

$$y_t = \delta_0 + \alpha_k \sin\left(\frac{2\pi kt}{T}\right) + \beta_k \cos\left(\frac{2\pi kt}{T}\right) + x_t'\beta + v_{1t} \tag{11}$$

The FSHIN cointegration test statistic is calculated as follows:

$$\mathrm{CI}_f^m = T^{-2}\hat{\omega}_1^{-2} \sum_{t=1}^{T} S_t^2 \tag{12}$$

In Equation (12), $\hat{\omega}_1^{-2}$ represents a consistent estimator of the long-run variance of v_{1t}. Additionally, S_t represents the partial sum of residuals in Equation (11).

6. Data and Findings

In this study, three variables were employed. Inflation rate, which we seek to elucidate, is the dependent variable. The independent variables are institutional quality and change in the exchange rate basket (CERB). The CERB variable was incorporated into the analysis as a control variable. This was done because the depreciation of the exchange rate, as discussed in the introduction, literature, and fundamental model, is a significant factor that increases inflation expectations and, consequently, inflation itself (McCarthy, 2007). Moreover, fluctuations in the exchange rate in developing countries can create vulnerability in foreign trade as an external factor. This is because the financial development levels of these countries are lower than those of developed countries, and these conjunctural fluctuations in the exchange rate can disrupt the optimal monetary policy that the CB is trying to implement. This situation may lead to the adoption of a monetary policy that takes into account the Taylor rule and considers growth changes alongside targeted inflation. Consequently, exchange rate fluctuations can influence future inflation. Nevertheless, the stability of the exchange rate alone may not be a reliable predictor of future inflation (Aizenman, Hutchison and Noy, 2011). In Türkiye, governments have occasionally devalue the exchange rate in order to balance foreign trade, increase exports, and accelerate growth. The expected and unexpected changes in the exchange rate affect inflation through exchange rate pass-through on consumption, capital, trade goods, and energy prices. It is also notable that inflation rates in Türkiye are highly sensitive to fluctuations in the exchange rate (Dinçer and Kandil, 2011; Akgül and Özdemir, 2018). Furthermore, since the stabilization of the exchange rate post-2000, inflation targeting regimes have consistently achieved their inflation targets (Demez and Ustaoğlu, 2012, p. 169).

The analysis employs data on Türkiye's quarterly inflation rates, institutional quality, and CERB data for the period 2005-2019. The post-pandemic period is excluded from the analysis. Inflation rate data was obtained from the Turkish Statistical Institute (TSI). TSI changed the base year after 2003. However, since consumer price index figures are available on the TSI data portal after 2005[6], the starting year for the analysis was set to 2005. The Political Risk Rating (PRR) index, obtained from the ICRG database, was used as an indicator of institutional quality, which is commonly used in the literature. The PRR variable is published quarterly after 2016, so quarterly data was used in our analysis. The CERB variable was obtained from the CBRT's Electronic Data Delivery System (EDDS). The CERB was created by taking the average of the dollar/TL and euro/TL exchange rates.

The PRS Group is headquartered in the United Kingdom and initiated its institutional quality measurement program in 1979. The PRS Group has been calculating statistics for Türkiye since 1984. As of 2022, the PRS Group monitors 141 countries worldwide for political, economic, and financial risks, and updates the ICRG database on a monthly basis. The PRR variable has been employed as an indicator of institutional quality in numerous studies, including those by Knack

[6] https://data.tuik.gov.tr/Bulten/DownloadIstatistikselTablo?p=KMExlm5AVU2ln21dc2evQ2SnPKPmGEBqV6H8CcJSjNNBzZZT2CJNzYtIqx1WGQK8 – Access date: 19.04.2024

and Keefer (1995), Hall and Jones (1999), Narayan, Narayan and Thuraisamy (2014), and hundreds of other studies. The selection of ICRG as the institutional proxy is due to its extensive time-series coverage of a large number of countries and its reflection of a broader range of relevant institutional indicators (Cubeddu et al., 2019, p. 14). Furthermore, when examining the correlations of the ICRG index with other databases measuring institutional quality, a high positive relationship is observed, ranging from 81% to 89%. This indicates that consistent results can be obtained in econometric analysis by using the PRR variable as a proxy variable (Aron, 2000, p. 116).

The PRR is comprised of 12 variables, including government stability, socioeconomic conditions, investment profile, internal and external conflict, corruption, military influence in politics, religious and ethnic tensions, law and order, democratic accountability, and quality of the bureaucracy. The risk score, which ranges from 0 to 100, is used to assess the level of political risk in a given country. A score below 50 is indicative of a high level of political risk, while a score above 50 is indicative of a low level of political risk. A risk score of 50-60 is indicative of a high risk, 60-70 of a moderate risk, 70-80 of a low risk, and 80-100 of a very low risk.

Table 1: Descriptive Statistics

	Inflation Rate	PRR	CERB
Average	9.461333	57.225	2.407332
Median	8.705	56.5	1.385016
Maximum	24.52	70	26.26003
Minimum	3.99	50	-7.598811
Standard Deviation	3.5111	5.238729	6.200851
Number of Observations	60	60	60

Table 1 presents the descriptive statistics of the variables. The average quarterly inflation rate for the period 2005-2019, which includes 60 observations, is 9.5%. During this period, inflation rate ranged as high as 24.5%, with a low of 4%. The mean PRR variable is 57, with a maximum of 70 and a minimum of 50. The standard deviation of the PRR variable is higher than that of inflation rate.

However, the CERB is the most volatile variable. Although the average of this variable is 2.4 points, there was a 7.6-point change in the exchange rate in the first quarter of 2005, indicating appreciation. In contrast, a significant depreciation of the currency basket was observed in the third quarter of 2018.

Figure 3 demonstrates that the inflation rate remained within the single-digit range of 10-11% until the first quarter of 2018. However, in the third quarter of 2018, there was a notable increase in inflation, reaching 24.5%. Figure 4 illustrates that the PRR index for Türkiye exhibited a gradual increase from low risk in 2005 to average risk in 2008, before reaching high risk levels after 2008. This elevated risk persisted until 2019. As is evident from Figure 5, there has been a pronounced degree of volatility in the shift in the exchange rate basket, as indicated by the considerable fluctuations evident in the data.

Figure 3. Inflation Rate and its Fourier Function

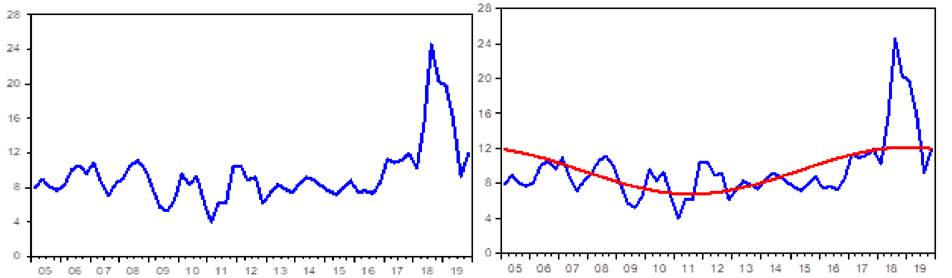


Figure 4. Political Risk Rating and its Fourier Function

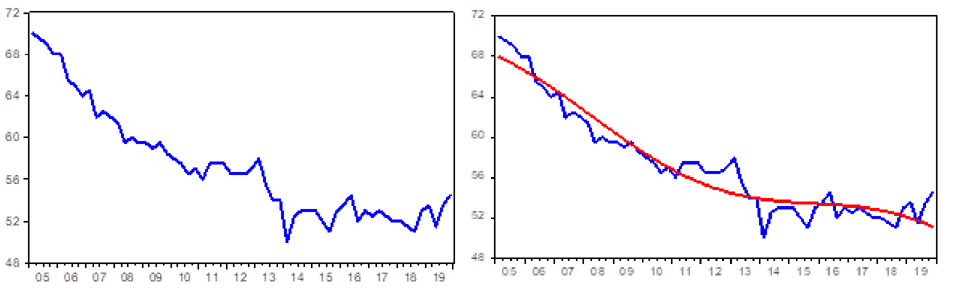
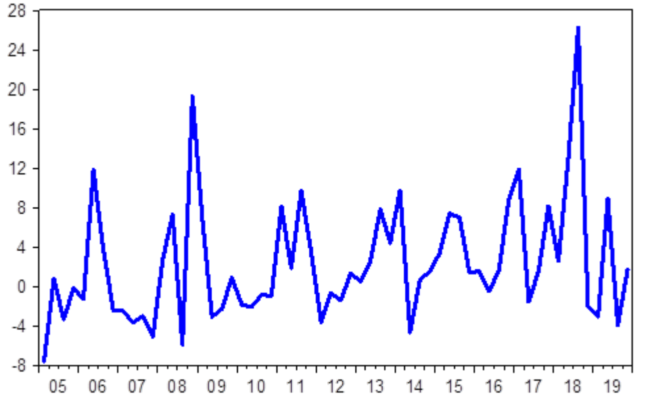


Figure 5. Change in Exchange Rate Basket



6.1. Stationarity Tests of Variables

Unit root tests were conducted at the 5% significance level.

6.1.1. Stationarity Test of Inflation Rate

The inflation rate variable did not demonstrate a discernible trend in the FKPSS test, as illustrated in Figure 3. Consequently, a model with a constant was employed. The findings are presented in Table 2.

Table 2: Stationarity Test Results of Inflation Rate

Frequency	1.000000
Min. SSR	516.3340
Fourier KPSS	0.256826
Bandwith	4.000000
F-test statistic	11.64695

Note: Critical values for FKPSS are 0.2699, 0.1720, and 0.1318 for 1%, 5%, and 10%.

As demonstrated in Table 2, the FKPSS test statistic is greater than the FKPSS critical value (0.257>0.172), indicating that the null hypothesis is rejected. Consequently, the inflation rate variable is stationary.

6.1.2. Stationarity Test of PRR

In light of the observed trend in the PRR variable, as illustrated in Figure 4, a model with a constant and trend was employed in the FKPSS test. The findings are presented in Table 3.

Table 3: Stationarity Test Results of PRR

Frequency	1.000000
Min. SSR	122.8441
Fourier KPSS	0.069707
Bandwith	5.000000
F-test statistic	37.22889

Note: Critical values for FKPSS are 0.0716, 0.0546, and 0.0471 for 1%, 5%, and 10%.

The calculated FKPSS test statistic is greater than the FKPSS critical value (0.0697>0.0546), indicating that the null hypothesis is rejected. Consequently, the PRR variable is also stationary.

6.1.3. Stationarity Test of the CERB

As illustrated in Figure 5, the CERB exhibited no discernible trend, necessitating the application of a model with a constant term. Upon comparing the FKPSS test statistic presented in Table 4 with the critical value (0.0101 < 0.0269), it becomes clear that the CERB variable is not stationary. In such instances, as elucidated in the methodology section, the F test is employed. The calculated F-test statistic is less than the critical value (1.53 < 4.93), indicating that the FKPSS test is not an appropriate statistical test for this variable. Therefore, the KPSS test was employed.

Table 4: Fourier-Test Results of CERB

Frequency	1.000000
Min. SSR	2152.539
Fourier KPSS	0.101348
Bandwith	0.000000
F-test statistic	1.532630

Note: Critical values for FKPSS are 0.2699, 0.1720, and 0.1318 for 1%, 5%, and 10%. The critical values for the F test are 6.730, 4.929, and 4.133 for the 1%, 5%, and 10% levels, respectively.

Table 5 presents the results of the KPSS test for the exchange rate variable. The KPSS test statistic is greater than the critical value of the LM statistic at the 5% significance level (0.475>0.463), indicating that the null hypothesis is rejected. The null hypothesis in the KPSS test states that the variable contains a unit root and is non-stationary. Therefore, the CERB is stationary.

Table 5: Stationarity Test Results of CERB

		LM statistic
KPSS test statistic		0.475
Asymptotic critical values	1%1 significance level	0.739
	5% significance level	0.463
	10% significance level	0.347

6.2. Cointegration Test

The FSHIN cointegration test, which is based on the FKPSS test, is employed as the cointegration test. Following the stationarity tests, which revealed that the inflation rate, PRR, and CERB variables were stationary, the FSHIN test was applied. In the test, the inflation rate variable is dependent, whereas the PRR and CERB variables are independent. The PRR variable indicates an appropriate institutional structure that encompasses several institutional factors, consistent with the index methodology. Moreover, the CERB is employed as a control variable in the cointegration analysis. This is because alterations in the exchange rate basket may influence inflation through disparate dynamics, both within Türkiye and in other countries (Kibritçioğlu, 2002; Dornbusch, 1991). Moreover, exchange rate fluctuations in an inflation-targeting regime exert a more pronounced influence on domestic prices than in other developing countries (Leigh and Rossi, 2002). Consequently, the long-run direct and indirect effects of institutional quality on inflation can be elucidated through this model. Table 6 presents the results of the FSHIN cointegration test, which was employed to examine the long-run relationship between Türkiye's inflation level, institutional quality, and CERB variables.

Table 6: Fourier-Shin Cointegration Test Results

Frequency	1.000000
Min. SSR	342.6916
Fourier cointegration test statistic	0.068399
Bandwidth for Fourier cointegration test	2.000000
Shin test statistic	0.226554
Bandwidth of the Shin test	5.000000
F-test statistic for Fourier cointegration test	20.63021

Note: Critical values for SHIN cointegration at 1%, 5%, and 10% levels (for p=1 and k=1) are 0.198, 0.124, and 0.095, respectively. The critical F test are 5.774, 4.066, and 3.352 at the 1%, 5%, and 10% levels.

A comparison of the FSHIN cointegration test statistic with the critical value at the 5% significance level (0.068 < 0.124) indicates that the null hypothesis cannot be rejected. This suggests the presence of cointegration between institutional quality and inflation rate in Türkiye.

The results indicate that alterations in Türkiye's institutional quality exert a significant influence on the country's inflation dynamics, particularly in the long term. These findings offer a crucial perspective for policymakers and decision makers in considering the potential benefits of institutional quality enhancements on inflation.

7. Conclusion

A review of countries experiencing high inflation, large budget deficits, and depreciated currency reveals a commonality in their weak institutional structures. In addition to political instability, property rights are not fully enforced, necessary constraints on politicians are lacking, and corruption is prevalent in these countries. Countries with such exclusionary institutions tend to experience serious economic crises and higher volatility in economic indicators.

This study examines the long-term relationship between institutional quality and inflation rate in Türkiye using quarterly data from 2005 to 2019. Initially, the stationarity of the series was examined by performing the FKPSS and KPSS tests. It was determined that inflation rate, institutional quality, and exchange rate changes were all stationary. Subsequently, the cointegration relationship between these variables was tested using the newly introduced FSHIN test in the literature. The results suggest the existence of a long-term relationship between institutional quality and inflation rate in Türkiye.

A review of the inflation targeting regime in Türkiye during the relevant period reveals that the implicit inflation targeting period (2002-2005) was more successful than the explicit inflation targeting period (after 2006), which saw deviations from the inflation targets. Although the CBRT became legally independent in 2001, particularly in the wake of the global financial crisis, the CBRT remained susceptible to political influence and was constrained in its ability to utilize its monetary policy instruments independently. This factor serves to impede the decline of inflation and, in fact, to exacerbate it. This is due to the fact that the prerequisites for the inflation targeting regime could not be met. Consequently, during the 2005-2019 period, when positive developments were observed in the PRR variable, single-digit inflation figures were recorded. However, due to a decline in institutional quality (increased political risks) over time, inflation has been on an upward trend since 2012. Subsequently, following 2017, inflation commenced to fluctuate in double digits. The decline in the CBRT's independence, the inflation target remaining unaltered despite deviations, reduced transparency and accountability, external shocks, loose monetary policy and undervalued exchange rate policy in Türkiye all contribute to the deterioration of institutional quality.

The Turkish example offers significant insights, particularly for developing countries with fragile economic and political systems. Consequently, further research on inflation's impact on Türkiye is warranted. In future studies, the relationships between the government, CBRT and voters can be examined more closely through the lens of principal-agent theory over an extended period. At this juncture, it is imperative to examine the reconstruction of the CBRT to enable it to implement monetary policy independently and to determine how the this institution will instill confidence in the markets. It is evident that CBRT must have an effective communication strategy to guide the markets. In establishing this strategy, it is crucial to clarify which new meso-institutions can be created. Additionally, the necessity for financial infrastructure should be discussed. Furthermore, the impact of the CBRT's interventions in the foreign exchange market on inflation can be examined through an analysis of gold, energy, and commodity prices, determining the currency pass-through arising from exchange rate volatility and analyzing the effects of output gaps within the framework of the Hybrid New Keynesian Phillips curve. In such research, the role of foreign capital inflows should also be considered for the CBRT to take appropriate measures. Moreover, the impact of economic policies implemented in conjunction with the government on income distribution and the welfare of different segments should be investigated. Additionally, with the global pandemic affecting the world and the subsequent formalization of inflation, a cross-sectional analysis can be conducted to examine how inflationary transmission mechanisms differ between developing countries like Türkiye and developed countries.

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RESEARCH ARTICLE

Analysis of Istanbul Stock Market Returns Volatility with ARCH and GARCH Models

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ABSTRACT

In today's world where globalization is intensely experienced, differences in risk perception, developments in capital markets, and the negativities faced in the markets due to uncertainty are very important when researching the structures of the stock markets, and therefore determining current volatilities. One of the biggest problems encountered is the inability to price stocks effectively. Therefore, estimating and modeling volatility becomes crucial. The diversity of the portfolio, created by international investors in the financial markets and the sustainability of their investment decisions, are closely related to the volatility variable. However, the fact that financial markets are more fragile in developing countries increases the importance of volatility. There are many different methods in the literature when estimating volatility. Due to the inadequacy of traditional time series models in estimating volatility, conditional heteroskedasticity models are used with ARCH and GARCH class models being frequently used. In this study, the series of daily opening values of the ISE100 Index covering from 02.01.2003 to 30.09.2022 was estimated using ARCH/GARCH models for volatility with the aim to determine which model has the higher explanatory power. According to the findings, the GARCH(1,1) model gave more meaningful results in explaining the ISE100 return volatility.

Keywords: Volatility, Conditional Heteroskedasticity Models, Istanbul Stock Market
JEL Classification: E00, C53, D53

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1. Introduction and Conceptual Framework

Volatility is a concept that appears in many areas of economic theory, especially in financial markets. In many models of financial markets, volatility is used as the main variable because volatility is of great importance to investors. In its most general form, volatility means that a variable takes very high or very low values compared to its average value and is considered an indicator of macroeconomic stability.

Volatility is accepted as a measure of price change in various markets for the period under consideration. That is, it can be defined as the standard deviation of the change in the logarithm of the price or price index within a certain period (Taylor, 2005, p.189). In the literature, the stock market is a concept that is often encountered in exchange rates, inflation, crypto money, and similar variables. Volatility is shaped by the concepts of volatility on the one hand and uncertainty on the other. While variability covers all movements, the concept of uncertainty refers to unknown movements (Çiçek, 2010, p. 2).

The importance of volatility can also be associated with its use as a risk measure. The main reason for this is based on the definition of the concept of risk together with volatility in line with the modern portfolio theory by Markowitz in the 1950s. Although volatility and risk are not synonymous terms, they express the same directional relationship with each other. It is known that risk perception is high in an economy with high volatility. The increase in volatility makes investments riskier. This brings great changes in stock prices.

Another feature of volatility is its permanence. The estimation of the volatility in the future depends on the information set obtained in the present. Volatility is considered to be permanent if the return in the current period can greatly affect the variance estimation in future periods (Engle and Patton, 2001, p. 239).

Volatility is associated with the speed of information flow. If information comes in clusters, asset returns or prices may fluctuate as the market adapts perfectly and instantly to the news. Studying the volatility spill can help decipher how information is communicated between assets and markets. Whether the volatility correlates between the markets is important when examining the speed at which the market adapts to new information. Additionally, it is assumed that changes in market volatility are related to the volatility of macroeconomic variables (Hong, 2001, p. 184).

Determining the reasons for volatility in the stock market has been investigated by policymakers and market actors. Policymakers focus on the factors that determine volatility and how these affect the real sector whereas market actors are concerned with how volatility determines pricing in the stock market and its effects on hedging.

While volatility refers to the variability in the returns of financial assets, it is also an important indicator for estimating the returns of these assets. Volatility in the capital markets is the price mobility of any stock or index during the period under consideration. Stock markets are greatly affected by economic, political, and unexpected disasters. For these reasons, investors need to determine stock price volatility and to predict price changes (Kanalıcı Akay and Nargeleçekenler, 2006, p. 6).

Volatility in financial markets is carefully observed by investors and policymakers. High volatility can be considered as high risk, and investment decisions can change. At this point, whether investors are risk-takers or risk-averse shapes their investment decisions. The situation differs for policymakers. According to them, the fluctuation that will occur in the stock markets may affect the real sector, which may affect macroeconomic variables such as inflation, investment expenditures, and growth. Thus, large volatility in financial markets can harm the economy.

Opinions differ on how fluctuations in stock markets affect consumption expenditures. According to one view, the decrease in stock prices increases future uncertainty and decreases consumption and investment expenditures. According to another view, consumption expenditures will not be affected as much as it is thought because the actors in the stock market are in the high-income group (Garner, 1988, p. 4).

In studies investigating the determinants of volatility changes in stock markets, five main factors stand out (Nelson, 1996, p. 3-4):

- Positive serial correlation occurring in volatility; major changes come after major changes. Similarly, minor changes are followed by minor changes. Major movements in the current period may shape volatility expectations in future periods.

- Days on which stock transactions can and cannot be made. Both trading and nontrading days are known to contribute to market volatility. Markets are expected to be more volatile on Mondays compared to the other days of the week.

- Leverage effect. A company with a decreasing stock price needs a higher leverage ratio and therefore increases the volatility in its earnings.

- Recession and financial crises. During economic and financial crises, volatility in stock markets is expected to increase.

- Nominal interest rates. With the rise in nominal interest rates, there is an expectation that market volatility will also increase.

In models used to determine volatility, the features of financial time series should also be included. Therefore, instead of using classical econometric methods that act on the assumption of constant variance in the measurement of volatility, models that allow time-varying variance should be used (Büberkökü and Kızıldere, 2017; Emeç and Özdemir, 2014). It is striking that there are different calculation methods of volatility. The first is the basic or dynamic standard deviation method. Another is the autoregressive conditional heteroskedasticity

(ARCH) method and its many versions. To be able to apply the ARCH method, the error terms must have the property of time-varying variance.

In this study, the daily opening values of the ISE100 Index, which is obtained by considering the days when the Istanbul Stock Market is open for trading, were used. The aim, while covering the period from 02.01.2003 to 30.09.2022, is to determine the best autoregressive conditional variable variance model that models the volatility of the ISE100 Index in Turkey using model selection criteria.

This study consists of four main parts. The first part includes the theoretical foundations of the concept of volatility. The second part examines the empirical studies on stock market volatility in the literature. The third section explains the ARCH/GARCH models used while the volatility of the Istanbul Stock Market series is tested. Finally, the fourth part brings the conclusions and suggestions.

2. Empirical Literature

When analyzed from a macroeconomic perspective, the volatility experienced in stock markets affects many economic areas. Therefore, a great deal of theoretical and empirical research has been done. The empirical estimation and measurement of this volatility are very important for both policymakers and investors. This section considers examples of literature on measuring volatility in stock markets.

Fabozzi, Tunaru, and Wu (2004) investigated volatility in China's Shenzhen and Shanghai stock markets. Using the daily data set between 1.11.1992 and 1.11.2001, it was determined that the explanatory power of the GARCH(1,1) model for the Shenzhen stock market and the TGARCH(1,1) model for the Shanghai stock market were higher.

Goudarzi and Ramanarayanan (2010) determined the volatility of the Indian stock market with ARCH-GARCH models. The BSE500 Index was investigated using the daily data set between 26.07.2000 and 20.01.2009. According to results, the GARCH(1,1) model was determined as the model that best explained the volatility of the stock index.

Uğurlu, Thalassinos, and Muratoğlu (2014) compared the stock market volatility of four European countries and Turkey in their study. Evaluating Bulgaria, Czech Republic, Poland, Hungary, and Turkey, daily data between 08.01.2001 and 20.07.2012 were used and it was determined that GARCH, GJR-GARCH, and EGARCH effects were present in all markets except Bulgaria. It was determined that old news affects volatility in these markets.

Al-Najjar (2016) modeled volatility for the Amman Stock Exchange and identified the impact of volatility on risk and portfolio management. For this purpose, the daily data set covering January 1, 2005 to December 31, 2014 was used. ARCH, GARCH, and EGARCH models were used and it was determined that the GARCH model was the most effective in explaining volatility.

Ali, Suri, Kaur, and Bisht (2022) analyzed volatility in the Indian stock market using a daily data set covering January 1, 2008, to December 2, 2021. GARCH(1,1) and FIGARCH methods were used and the presence of the GARCH effect was observed. It was determined that the effects of shocks on the economy continued for a long time. On the other hand, it was determined that the effect of bad news on stock volatility was greater than that of good news.

Kalaycı (2005) used a monthly data set covering 1990–2003. In this study, in which the sources of the ISE100 Index return volatility were investigated, it was concluded that inflation and money supply variables affected the ISE return volatility, together with the regression model created by estimating the volatility with the GARCH(1,1) method.

Kanalıcı Akay and Nargeleçeken (2006) investigated the volatility effects by considering the closing prices of the ISE National 100 Index covering October 23, 1987, to July 28, 2006. The most suitable model was determined by using ARCH/GARCH models where the GARCH(1,2) model was the most significant and most suitable model. According to the results, despite the increase in index volatility, which was noticeable during crisis periods, the volatility decreased after the uncertainty environment was eliminated.

In Özden's (2008) study, the logarithmic return series of the daily ISE100 Index covering the period between 04.01.2000 and 29.09.2008 was used. In the study, the return series determined to have ARCH effect were tested separately with conditional heteroskedasticity models and the study concluded that the most significant model was TGARCH(1,1).

Atakan (2009), using the daily closing data of ISE100 Index between 03.07.1987 and 18.07.2008, researched the most proper model for the determination of volatility in the Istanbul Stock Market. The results concluded that the volatility of the ISE100 Index had the effect of ARCH and the most appropriate model for estimating the volatility was the GARCH (1,1) model.

In Çabuk, Özmen, and Kökcen (2011), data on the ISE100 national index, Service index, and financial index between 2004–2009 were searched daily. This study aimed to determine the most appropriate model to define volatility and the EGARCH(1,1) model was determined as the model with the highest explanatory power in explaining volatility.

The daily return series of the ISE100 Index between 04.01.1995 and 18.06.2010 was used by Güriş and Saçaklı Saçıldı (2011). It determined the model in which volatility is best explained by using the classical and Bayesian GARCH models. According to the findings, it was concluded that the Bayesian GARCH model gave significant results in the period range that was the subject of the analysis in terms of determining the volatility.

Karabacak, Meçik, and Genç (2014) aimed to determine the most suitable conditional heteroskedasticity model to model volatility by using the closing prices of the daily ISE100 Index between January 3, 2003, and September 11, 2013. The most appropriate model in terms of ISE100 Index volatility was the

TARCH(1,1) model. In line with this model, it has been determined that there are asymmetrical effects on the ISE100 Index return.

In Kuzu (2018), the volatility of the closing values of the daily ISE100 Index was tested across 4.2011–4.2017. The model that best explained the existence of volatility was the TGARCH model, as it gave the most significant results in explaining the existence of volatility.

Taştan and Güngör (2019) used the daily closing data set of the ISE100 Index between January 1, 2001 and January 4, 2019. In the first stage of the study, the long-term component of volatility was estimated using the GARCH-MIDAS method, and in the second stage, macroeconomic indicators affecting the long-term volatility were analyzed. It was concluded that the exchange rate variable was the most important determinant in explaining the volatility of the ISE100 Index. Additionally, the inflation rate was not a significant variable affecting volatility. Finally, it was observed that the increase in the real sector confidence index decreased the index volatility.

In their study, Ay and Gün (2020) estimated volatility modeling using the daily closing data of the ISE Bank Index. In the analysis covering between January 4, 2010, and December 31, 2019, the model that gave the best results in estimating the volatility modeling of the ISE Bank series was TGARCH (0,1,1) when evaluated according to the information criteria. However, when compared according to forecasting performance, the EGARCH (1,1,1) model gave the best results.

Atıcı Ustalar and Şanlısoy (2021) analyzed the impact of the crisis created by the COVID-19 pandemic process on the volatility of the stock markets in Turkey and the G7 countries. The closing prices of the stock market indices of the countries in question were the subject of the research. The EGARCH(1,1) model was used, in which the daily data set was used between March 11, 2020, and January 15, 2021. According to the findings, the increase in the number of daily cases in Turkey, Canada, France, and Japan increased the volatility in the stock market indices.

Güzel and Acar (2021) investigated how stock markets were affected during epidemics. The study, based on the example of the Istanbul Stock Market, tried to determine the appropriate volatility model among ARCH, GARCH, T-GARCH, and EGARCH models by considering the date range 1/2/2009–8/11/2020. According to the results obtained, it was concluded that the EGARCH (1,1) model was more suitable for modeling the BIST100 Index volatility.

Öner and Öner (2023) aimed to determine the most explanatory model that could be used by both investors and researchers in estimating the BIST100 Index return. ARCH, GARCH, EGARCH, and TARCH models were used in which the date range of 04.01.2010 and 28.07.2020 was analyzed. It was determined that the model with the highest explanatory power among the models that revealed the ISE100 Index return volatility was the TARCH model.

This study aims to determine the model that gives the most meaningful results among the models that explain the return volatility of the ISE100 Index. The ISE100 Index shows the performance of the first 100 stocks traded in the Istanbul Stock Market in terms of market and trading volume and is a very important indicator for investors. The course of volatility in the Istanbul Stock Market has been investigated, especially during the period when the country was governed by the same political authority.

3. Econometric Method

3.1. Autoregressive Conditional Heteroskedasticity (ARCH) Model

The ARCH model was first introduced by Engle in 1982. Although the starting point is to try to explain the inflationary environment in England, it has become a method used for many different variables. With this study conducted in 1982, the error term variance changed over time. It was related to the past values, and there was autocorrelation between the error term variances in the UK inflation variable. In light of this information, the ARCH model was developed in line with the argument that the model should be constructed (Engle, 1982, p. 987).

According to traditional time series models, the variance of the error terms will take a constant value. When examined within the framework of these models, in the presence of the heteroskedasticity problem, the estimator of the least squares method continues to have unbiased and consistent features. However, it will result in statistically insignificant results in the estimation of the parameters. Therefore, it is necessary to eliminate the problem of heteroskedasticity or to construct models that allow this change in variance (Songül, 2010, p. 4).

With Engle's (1982) study, a relationship was established between the error term variance and the squares of the error terms belonging to the previous period. Essentially, the constant variance assumption has been abandoned. With the ARCH model, to model the volatility of the time series that is the subject of the evaluation, it is necessary to include an independent variable that can describe this volatility. Modeling volatility by adding an independent variable can be expressed with the following equation (Enders, 2004, p. 112-113):

$$y_{t+1} = \varepsilon_{t+1} x_t \tag{1}$$

While the variable ε_{t+1} in equation (1) represents an error term with σ^2 variance, x_t is an independent variable. If the independent variable is constant in the past periods, it will be determined that the y_t series is in a white noise process with a constant variance. However, if the independent variable takes variable values rather than constants, the variance of the y_{t+1} variable is shown with the following expression (Enders, 2004; Songül, 2010):

$$Var(y_{t+1}|x_t) = x_t^2 \sigma^2 \tag{2}$$

In equation (2), it is concluded that the actual value of the x_t independent variable and the conditional variance of the y_{t+1} variable are related to each other. Under these conditions, there will be a same-way relationship between the value of the variable and the conditional variance value of the y_{t+1} variable. Therefore, defining the x_t variable also allows the volatility of the y_t series to be determined (Enders, 2004, p. 113).

In case of moving away from the constant variance assumption, the conditional variance is defined as an AR(q) process.

$$\hat{\varepsilon}_t^2 = \alpha_0 + \alpha_1 \hat{\varepsilon}_{t-1}^2 + \alpha_2 \hat{\varepsilon}_{t-2}^2 + \cdots + \alpha_q \hat{\varepsilon}_{t-q}^2 + \nu_t \tag{3}$$

According to equation (3), α_1, α_2, …, α_n values being zero means that the variance value is equal to α_0 value. On the other hand, the conditional variance of y_t occurs in line with the autoregressive process discussed in equation (3). Equation (3) also stands out as a general form of the ARCH model (Enders, 2004; Gürsakal, 2009).

When the estimation process of equation (3) is evaluated as AR(q) model together with Lagrangian multipliers test, the existence of ARCH effect is investigated. The ARCH-LM test statistical value is calculated with the formula $LM = (T - q)R^2$ and includes a χ^2 distribution with q degrees of freedom. According to this;

$$\begin{gathered} H_0 = \alpha_1 = \alpha_2 = \cdots = \alpha_q = 0 \\ H_1 = \alpha_1 \neq \alpha_2 \neq \cdots \neq \alpha_q \neq 0 \end{gathered} \tag{4}$$

hypotheses are tested. According to the findings, $\text{if} LM_{ARCH} < \chi_q^2$ table, the H_0 hypothesis is rejected and the existence of ARCH effect is accepted in this way (Gürsakal, 2009; Özden, 2008).

Some features of the ARCH model stand out. These are (Nargeleçekenler, 2011; Songül, 2010):

- Conditional variance parameter must be positive
- $\alpha_{0,}$ α_1, α_2, …, α_n parameters must be positive
- It must be "$\alpha_i \geq 0$" with $\alpha_0 > 0$ and I = 1,2,...,p
- If α_1, α_2,…,α_n = 0 then variance = α_0
- Each or sum of α_n's must be less than 1. The stability of the ARCH process is provided by this constraint.

The ARCH model, developed by Engle in 1982, has been the subject of research in many different ways. The ARCH model, which was reconsidered with the studies of Bollerslev (1986), Engle, Lilien, and Robins (1987), Nelson (1991), and Baillie, Bollerslev, and Mikkelsen (1996), was generalized and developed. Among these different models, the GARCH model, which is the most frequently encountered in the literature, was used.

3.2. Generalized Autoregressive Conditional Heteroskedasticity (GARCH) Model

The ARCH model is a conditional heteroskedasticity model based on the assumption that error terms follow an AR process. With the GARCH model developed by Bollerslev in 1986, it is accepted that the error terms follow the ARMA process. With this assumption, the GARCH model was created.

Since ARCH model analyses allow the lag lengths to go back much further, the number of parameters to be estimated increases, and therefore it becomes difficult to fulfill the assumption that the equation parameters are not negative. To eliminate this problem, the GARCH model has been developed. According to the ARCH(q) process, the conditional variance is specified only as a linear function of past sample variances. In the GARCH(p,q) process, lagged conditional variances are also included. In this way, the GARCH model has been applied (Bollerslev, 1986; Songül, 2010).

The most general representation of the GARCH(p,q) model is as follows (Bollerslev, 1986, p. 308-309):

$$\varepsilon_t|\psi_{t-1} \sim N(0, h_t), \tag{5}$$

$$h_t = \alpha_0 + \sum_{i=1}^{q} \alpha_i\, \varepsilon_{t-i}^2 + \sum_{i=1}^{p} \beta_i h_{t-i} = \alpha_0 + A(L)\varepsilon_t^2 + B(L)h_t \tag{6}$$

In the GARCH model expressed by the equation above, some constraints need to be met. These constraints are $p{\geq}0, q{>}0; \alpha_0{>}0, \alpha_i{\geq}0, i{=}1,\ldots,q,; \beta_i{\geq}0, i{=}1,\ldots,p$. On the other hand, in the case of the GARCH(1,1) model, which is frequently encountered in the literature, it is observed that there is a condition of being $\alpha_1 + \beta_1 < 1$ (Bollerslev, 1986, p. 311).

ARCH and GARCH models are frequently used models in the literature for measuring conditional variance. The importance of these models in the calculation of financial volatility in the literature is discussed in Franses and McAleer (2002) studies. With the GARCH model, it is possible to construct models with fewer coefficients and it is easier to control the constraints specific to these coefficients.

3.3. Data Set and Analysis Results

The daily opening values of the ISE100 Index covering the period between 02.01.2003 and 30.09.2022 were analyzed, taking into account the days when the Istanbul Stock Market was open for trading. The volatility analysis of this series, accessed from the Istanbul Stock Market Data Platform, was carried out using the ARCH-GARCH method. The ISE100 Index variable, the subject of the research, was included in the analysis by taking its natural logarithm.

Stationarity is accepted as the first step of time series analysis. As such, the stationarity research of the series in question was carried out.

Table 1: Results of unit root tests

	ISE100 Index	
	Test Statistics	**5% Critical Value**
ADF unit root test	2.156699	−3.410712
Phillips Perron (PP) unit root test	2.729006	−3.410711

According to both ADF and Phillips Perron (PP) unit root test results, Table 1 shows that the ISE100 Index return series contains a unit root at the 5% significance level. The stationarity level is retested by taking the first difference of the series. It has been determined that the d(ISE100) series, whose first-order difference is taken, is stationary in the direction of ADF and PP tests.

Table 2: Results of the series with first-order difference of unit root tests

	d(ISE100 Index)	
	Test Statistics	**5% Critical Value**
ADF unit root test	–31.63209	–3.410712
PP unit root test	–76.28813	–3.410712

Table 2 shows the stationarity test results of the ISE100 return series with first-order difference. The ISE100 series, whose difference is taken, is stationary at the 5% significance level. It has been determined that the series, whose first difference is taken, becomes stationary.

To define the concept of volatility in the context of the variable we are considering, the ARCH-GARCH model is used and, in this direction, lagged conditional variances are added to the model. As the first step to creating this model, it is necessary to develop the mean equations from ARMA models in line with the structure of the variables that are the subject of the research. In this direction, the significance of the parameters of the ISE100 variable was investigated. Accordingly, ARMA(1,1) model was determined as the most suitable model.

Table 3: ARMA(1,1) Model Forecast Results for ISE100 Return Series

	Coefficients	**Standard Error**	**t Value**	**Probability Value**
Constant	0.000689	0.000259	2.666000	0.0077
AR(1)	–0.957716	0.014829	–64.58506	0.000
MA(1)	0.935821	0.017849	52.42944	0.000
AIC	–5.229536			
SC	–5.224282			
Log. L.	12960.17			

ARCH-LM test was performed to investigate the ARCH effect on the error terms of the ARMA(1,1) model estimated for the ISE100 series we discussed. Table 4 shows the results.

Table 4: ARCH-LM test results for the ARMA(1,1) model

F-statistic: 72.50479		Prob. F(5,4944) 0.0000		
Obs*R-squared: 338.1674		Prob. Chi-Square(5): 0.0000		
Variable	**Coefficient**	**Standard Error**	**t Value**	**Probability Value**
c	0.000179	1.42E–05	12.61495	0.000
RESID^2(-1)	0.155862	0.014171	10.99877	0.000
RESID^2(-2)	0.119801	0.014316	8.368347	0.000
RESID^2(-3)	0.032292	0.014407	2.241362	0.0250
RESID^2(-4)	0.033786	0.014313	2.360432	0.0183
RESID^2(-5)	0.084265	0.014145	5.957301	0.000

In Table 4, the existence of the ARCH effect is tested in line with the ARMA(1,1) model. Accordingly, the null hypothesis that symbolizes the absence of ARCH effect is not accepted. That is, the probability values of the ARCH-LM test results of the ISE100 series, which are the subject of the research, are less than 0.05, indicating that there are five ARCH effects of the series. Accordingly, the ARCH(5) model is established.

Table 5: Test results of ARCH(5) model

Variable	**Coefficient**	**Standard Error**	**z Value**	**Probability Value**
c	0.001230	0.000211	5.821153	0.000
AR(1)	–0.991661	0.004259	–232.8406	0.000
MA(1)	0.986478	0.005746	171.6703	0.000
VARIANCE EQUATION				
C	0.000132	4.57E–06	28.97897	0.000
RESID(-1)^2	0.136075	0.010401	13.08233	0.000
RESID(-2)^2	0.154938	0.015743	9.841503	0.000
RESID(-3)^2	0.110543	0.012796	8.638681	0.000
RESID(-4)^2	0.075162	0.012122	6.200568	0.000
RESID(-5)^2	0.126997	0.007746	16.39545	0.000

Accordingly, the system of equations for the ARCH(5) model is:

$$ISE100_t = 0.001230 - 0.991661 ISE100_{t-1} + 0.986478\varepsilon_{t-1} \qquad (7)$$

The variance equation is:

$$h_t = 0.000132 + 0.136075h_{t-1}^2 + 0.154938h_{t-2}^2 + 0.110543h_{t-3}^2 + 0.075162h_{t-4}^2 + 0.126997h_{t-5}^2 \qquad (8)$$

The equation of variance (8) where all coefficients take positive values. All coefficients in the equation are expected to take positive values and this condition is also satisfied. The sum of the coefficients in the equation (0.136075 + 0.154938 + 0.110543 + 0.075162 + 0.126997 = 0.603715) is less than 1. A value close to 1 in the sum of the coefficients is considered as high volatility. The value of this coefficient is considered as an average size. Therefore, it can be said that the volatility inertia is at a comparatively low level.

To check the presence of ARCH effect in ARCH(5) model ARCH-LM test is applied. The null hypothesis ignores the ARCH effect, and the alternative hypothesis tests whether there is an ARCH effect. In other words, not accepting the null hypothesis indicates the existence of the ARCH effect. Table 6 shows the 1, 4, 8, and 12 delayed ARCH-LM test results.

Table 6: ARCH–LM test results for the ARCH(5) model

F-statistic Obs*R-squared	1.464754 1.464912	Prob.-F-(1,4951) Prob. Chi-Square (1)	0.2262 0.2262
F-statistic Obs*R-squared	1.160276 4.641441	Prob.-F-(4,4945) Prob. Chi-Square (4)	0.3263 0.3261
F-statistic Obs*R-squared	0.849021 6.795202	Prob. F (8,4937) Prob. Chi-Square (8)	0.5593 0.5589
F-statistic Obs*R-squared	5.052463 60.05080	Prob. F (12,4929) Prob. Chi-Square (12)	0.0000 0.0000

According to the findings obtained from the ARCH-LM test, used to determine the volatility of the ISE100 series, volatility was not detected in the 1,4 and 8 lags, while the presence of volatility in the 12th lag stands out. Since all of the lags discussed do not give a common result that there is no ARCH effect, the GARCH model is used. In this way, it is aimed to determine a model without volatility.

The GARCH model is established to eliminate the ARCH effect and to determine which of the ARCH(5) or GARCH(1,1) models of the ISE100 variable is more appropriate.

Table 7: Test results for the GARCH(1,1) model

Variable	Coefficient	Standard Error	z Value	Probability Value
c	0.001183	0.000202	5.860189	0.0000
AR(1)	–0.991729	0.004464	–222.1645	0.0000
MA(1)	0.984987	0.006318	155.8972	0.0000
VARIANCE EQUATION				
C	1.38E–05	1.18E–06	11.73233	0.0000
RESID(-1)^2	0.121560	0.006650	18.27899	0.0000
GARCH(-1)	0.838315	0.007858	106.6868	0.0000

According to Table 7, the GARCH variable reflects significant results. At this point, the ARCH-LM test is applied to detect the presence of ARCH effect in the GARCH(1,1) model. These test results are listed in Table 8.

Table 8: ARCH–LM test results for the GARCH(1,1) model

F-statistic Obs*R-squared	1.066577 1.066779	Prob.-F-(1,4951) Prob. Chi-Square (1)	0.3018 0.3017
F-statistic Obs*R-squared	0.504787 2.020365	Prob.-F-(4,4945) Prob. Chi-Square (4)	0.7322 0.7320
F-statistic Obs*R-squared	0.831969 6.658904	Prob.-F-(8,4937) Prob. Chi-Square (8)	0.5742 0.5738
F-statistic Obs*R-squared	0.850099 10.20697	Prob.-F-(12,4929) Prob. Chi-Square (12)	0.5983 0.5978

Table 8 shows that there is no ARCH effect in the model. When the GARCH(1,1) model is used, it is concluded that the ARCH effect in the ISE100 variable is eliminated.

It is also possible to determine which of the ARCH(5) and GARCH(1,1) models is more suitable. In this direction, it is necessary to examine the model selection criteria of both models.

Table 9: Model Selection Criteria

MODEL SELECTION CRITERIA			
Criteria	**ARCH(5)**	**GARCH(1,1)**	**Best Choice**
Loglikelihood	13351.02	13403.93	GARCH(1,1)
Akaike	–5.386362	–5.408933	GARCH(1,1)
Schwarz	–5.374539	–5.401051	GARCH(1,1)
Hannan-Quinn	–5.382217	–5.406169	GARCH(1,1)

Table 9 shows the selection criteria for both models. Accordingly, it is observed that the GARCH(1,1) model is more suitable in terms of ISE100 variable. The model that is large when examining loglikelihood values, and models that are large in terms of absolute value are considered suitable when examining Akaike, Schwarz, and Hannan-Quinn values. In this direction, when the ISE100 return series, which is the subject of the study, is analyzed, it has been determined that the GARCH(1,1) model is the more appropriate model.

4. Conclusion and Recommendations

Volatility expresses the fluctuation around the equilibrium value of the variable that is the subject of the research. This concept, which has found many different variables in many different markets such as finance, foreign exchange, money, and crypto, has a rich research area. Volatility in the stock market, which is considered the research area of the study, gains importance due to the global integration of financial markets being affected by the decisions of political authorities and being shaped by the perception of risk and uncertainty. The volatility in the stock markets affects many macroeconomic variables, especially international trade, investment, capital movements, and portfolio diversification of investors. As such, estimation of volatility and analysis of how volatility processes work are extremely important for their widespread economic impact.

To estimate the volatility experienced in the stock markets in Turkey, the daily opening values of the ISE100 Index covering 2003–2022 were used. Regarding the series, to determine the model with the highest explanatory power, the stationarity condition of the series was provided and then the constancy of the variance of the error terms was determined by the ARCH-LM test. The partial and autocorrelation functions of the series, which are made stationary by taking the first difference, are examined and the most suitable ARMA model is determined. The ARCH effect is investigated and it is concluded that the series are volatile. This study tried to determine which ARCH or GARCH model was more suitable. Accordingly, as a result of the analysis made for modeling volatility, it is concluded that the most appropriate model is the GARCH(1,1) model. As a result of the ARCH-LM test applied again to investigate the reliability of the model, it is determined that there is no ARCH effect in the GARCH(1,1) model. It is concluded that the GARCH(1,1) model is a model that eliminates the effect of stock market volatility.

As in many countries in the globalizing world, stock markets and the volatility experienced have critical importance in the Turkish economy. Stock markets are extremely important, and directly affect foreign trade and capital movements and indirectly the foreign exchange markets. At this point, as in other variables, the stable structure of the stock markets contributes to the overall macroeconomic stability. The existence of a stable market gains importance in determining the short and long-term capital movements within the country and in creating a portfolio by determining the investment preferences of the investors. However, stock markets are markets where the reflections of the decisions taken by both political authorities and economic policymakers can be followed very closely.

There is a close relationship between volatility and risk perception. Confidence in economies with high volatility decreases and creates risks for investors. High fragility, especially in developing countries, reduces confidence in the economy, and also affects the risk perception of investors. The high volatility causes this cycle to deepen and therefore the fragility of the markets to increase. Volatility has an importance that affects the decision-making processes of investors. In economies with a fragile structure, such as Turkey, where stock markets are heavily affected by the decisions of political and economic authorities, it is necessary to develop policies that will reduce fluctuations in the markets, and implement these announced policies. Studies aimed at understanding the volatility in the stock markets are also important at this point and will be guiding. However, in line with the findings, the ISE100 Index is more affected by negative news rather than positive news. Koy and Ekim Dertli (2016) interpreted this situation as the presence of a leverage effect. Essentially, the volatility of the return of the ISE100 Index increases during periods of uncertainty or economic crisis. It is observed that volatility clusters are formed during these periods.

Ethics Committee Approval: The data set used in the study was obtained from the internet and since it is not of primary nature, an ethics report is not needed.
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RESEARCH ARTICLE

Empirical Analysis of Turkish Banking Sector Institutional and Macroeconomic Determinants of Risks*

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ABSTRACT

This research examines the macroeconomic and institutional sources of individual, systemic, and systematic risks in the Turkish banking sector. The period between 2008:Q3 and 2019:Q3 of the nine deposit banks selected for this purpose were estimated using panel data analysis estimators. The results indicate that selected macroeconomic and institutional variables affect banking risks. These findings are important for revealing the institutional and macroeconomic sources of risks in the Turkish banking sector. Therefore, the results contain significant propositions for researchers, market participants, and politicians. Market participants and researchers can anticipate defaults and financial instability using selected macroeconomic and institutional variables. The estimation results reveal Turkish banks' institutional soundness and financial performance strength. In addition, the extent to which banks are effective intermediaries in the sector was analysed. This research documented a strong link between global market indicators and banking risks.

Keywords: Individual risk, Systematic risk, Systemic risk, Macro-Finance
JEL Classification: E44, G20, G21

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1. Introduction

The Global Financial Crisis, which began with the collapse of the financial giant Lehman Brothers in 2008, spread from the United States to the entire world and affected the macroeconomic and financial systems of both developed and developing countries. The crisis has demonstrated how devastating systemic risks can be for the banking and financial sector. The complex nature of systemic risks makes it difficult to understand them in advance and develop effective policy instruments. Because of its strong organic link to the financial sector and macroeconomic structure, it can quickly spread to the entire sector and economy. Systemic risk-taking can lead to higher growth, but in the long run, it can exacerbate financial distortion and cause economic crisis (Ranciere and Tornell, 2004; Ranciere et al., 2010). However, increased banking performance and credit growth may lead to overheating of the economy and increased credit risk (Festic, Kavkler and Repina , 2011). Moreover, systemic risk may increase during periods of rising inflation (Stolbov, 2017). In addition to basic macroeconomic variables, institutional factors such as capital requirements, financial leverage, and bank size have a strong relationship with systemic risks (Pais and Stork, 2013; Anginer and Kunt, 2014; Bhagat, Bolton and Lu, 2015; Kuzubaş, Saltoğlu and Sever, 2016; Grill, Lang and Smith, 2016; Dreyer, Schmid and Zugrav, 2018). High leverage makes financial institutions more sensitive to systemic risks (Acharya and Thakor, 2016, p.5). However, larger banks may have more systemic risk (Pais and Stork, 2013). Therefore, academic interest in these risks increased after the 2008 crisis. (Anginer and Kunt, 2014; Laeven, Ratnovski and Tong, 2014; Smaga, 2014; Kuzubaş et al., 2016; Wibowo, 2017; Dreyer et al., 2018; Varotto and Zhao, 2018). There is no accepted definition of systemic risk (ECB, 2009, p.134, Smaga, 2014, p.2). One of the main reasons for this is that this phenomenon has a complex structure (Allen and Carlatti, 2013, p.29). Borri et al. (2014) defined systemic risks as risks typically triggered by the default of one or more interconnected financial institutions and that may lead to the collapse of the entire financial system. For this reason, the major source of these risks is the banks themselves, and emerging through various channels. The trigger for a systemic risk event may be an exogenous shock from outside the financial system, or the event may occur endogenously within the financial system or the economy (ECB, 2009, p.134). Systemic risks are therefore of critical importance to the banking sector. Another key risk factor in the banking sector is systematic risk. Systematic risks arise from economic and political factors and affect securities prices. Therefore, banks cannot overcome these risks through portfolio diversification. In this regard, systematic risks have the power to affect the entire financial system and the economy, similar to systemic risks. Moreover, these risks force banks to take various measures, undermining the efficiency of their intermediation activities. Because systematic risks are a risk that banks must bear, the length of market conditions, economic factors, and other factors that cause these risks to increase threaten financial stability by distorting banking ratios. The third critical risk indicator for the banking sector is individual risk. We can consider these risks under the headings of credit, operational, liquidity, etc. risks. However, there are also studies that use stock returns to assess individual risk levels among banking institutions (Laeven et al., 2014, 2016; Dreyer et al., 2018). Equity markets are central to financial markets. For example, rising stocks may demonstrate that banks' financial position is stable or is increasing in value. In contrast, stocks in a constant state of decline may reflect instability or depreciation. In this respect, stock returns allow financial performance, corporate structure, and the probability of default to be measured quickly, effectively, and simply. This research focuses on the sources of systemic, systematic, and individual risks in the banking sector in Turkey. In this study, we empirically examine the macroeconomic and institutional determinants of banking risk. In this context, we estimated regression using a large panel dataset. The objectives to be achieved within the research framework are as follows:

- By revealing the strength of the interaction between institutional and macroeconomic variables and risk indicators, this study aimed to determine the level of vulnerability of the Turkish banking sector through different risk indicators.
- This study attempts to show the effects of macro-prudential and monetary policies on banking risks.
- The extent of the effects of the variables on banking risks was analysed. Thus, institutional and macroeconomic sources of banking risks are comparatively examined.

- It attempts to demonstrate how sensitive Turkish banking risks are to global developments.

The research is divided into six sections. The first part is the introduction, and the second part is the conceptual framework. In the third section, some empirical studies are provided. In the fourth section, the dataset and econometric method used are explained. The fifth section provides estimation results. The sixth chapter includes a discussion and conclusion.

2. Conceptual Framework

Traditional financial theories, which have a major place in macrofinance, clearly reveal the limits of the relationship between financial risks and macroeconomic variables. *The Arbitrage Pricing* Hypothesis (APT) assumes that macroeconomic factors, such as interest rates, money supply, and economic growth, affect stock returns (Hussain and Shah, 2018, p.222). According to this hypothesis, new information about macroeconomic variables and expected or unexpected developments in policy decisions will further increase stock returns by changing stock prices, future cash flows, and changes in expected dividends (Fahmi, Geetha and Mohidin, 2017, p.62). Similarly, *The Efficient Markets* Hypothesis (EMH) argues that an economically efficient market helps to allocate economic resources, emphasising that asset price fluctuations and volatilities also reflect the underlying economic factors as well (Macau and Ambrose, 2018, p.1137). *The Capital Asset Pricing* (CAPM) Hypothesis suggests that risks to stock returns arise solely because of macroeconomic variables. According to CAPM, stock returns are a function of a firm's systematic risk, which determines the expected return that a potential investor demands from his/her investments in a firm's stock (Fahmi et al., 2017, p.62). This model also associates firms with two types of risk: systematic and non-systematic (Iqbal and Shah, 2012, p.48). By diversifying their portfolio against unsystematic risks, banks can eliminate them or reduce their negative impact. However, portfolio diversification is not sufficient to avoid systematic risks. Therefore, these risks, represented by market betas, are the risks that banks must bear. Market betas are higher under poor economic conditions and lower under good economic conditions (Drobetz, Menzel and Schröder, 2016, p.130). Therefore, a predictable economy with low inflation, stable exchange rates, and sustainable economic growth can lower market risk. However, studies on the effects of financial ratios on market risks date back to the 1960s. Hamada (1972) showed a positive correlation between financial leverage ratios and beta. Bowman (1980) concluded that financial leverage has a significant impact on equity risk. Mandelker and Rhee (1984) found that operational and financial leverage explain beta variations. The theoretical dimension of the relationship between capital requirements and systematic risks can be based on Modiglani and Miller (1958). Toader (2015) stated that this model is because higher amounts of loss-reducing capital increase bank stability and financial capacity, so investors expect lower returns on equity as the amount of risk will be lower, and the higher cost of the increased amount of equity will be offset by a decrease in the return on bank capital. Researchers have debated the relationship between size and systematic risks for decades (Sullivan, 1978; 1980; Banz, 1981; Lakonishok and Sahpiro, 1984; Daves et al., 2000; Stever, 2007; Dreyer et al., 2018). Sullivan (1978) demonstrated a negative correlation between beta and firm size and interpreted this result as evidence that market power decreases beta. Banz (1981) found that small firms have higher risk-adjusted returns than large firms. Stever (2007) found that the equity betas of large banks are two to five times greater than those of small banks. Profitability plays an important role in the financial conduct of company's activities (Sirivige, 2017, p.3). Besides profitability, another corporate factor associated with systematic risks is liquidity ratios. Logically, since there is an inverse relationship between a firm's liquidity level and risk, firms having a high liquidity level should show that they have a low risk (Puspitaningtyas, 2017, p.49). However, the empirical literature has yielded complex findings on the relationship between profitability, liquidity ratios, and market risks (Lee and Jang, 2007; Iqbal and Shah, 2012; Nimalathasan and Pratheepkanth, 2012; Karakuş, 2017; Puspitaningtyas, 2017).

Another important banking risk is systemic risk. There are many empirical studies in the literature that address the definition and various aspects of this concept, from the risk contributions of large and complex financial institutions to the effects of contagion and spillover between counterparties and market segments, and even macro-financial linkages (Kubinschi and Barnea, 2016, p.81). Systemic risks arise as declines in economic growth and prosperity disrupt the functions of the financial system after a certain point and become widespread (ECB, 2009, p.134). However, an above-average growth rate is also probably associated with systemic risk. According to Ranciere and Tornell (2004), average economic growth rates in countries that have experienced financial crises for decades have been recorded more rapidly than in countries with financial stability, and so systemic risk-taking triggers higher growth, although it produces financial vulnerabilities that lead to crises as a by-product. According to this theoretical mechanism, taking systemic risks reduces financial bottlenecks and increases growth in countries with weak financial institutions (Ranciere, Tornell and Westermann 2008, p.359). In another study, Ranciere et al. (2010) argued that money discord exposes economies to systemic risk and is a key driver of economic growth. Systemic risks may also spread to the entire economy through monetary transmission mechanisms. According to the ECB, the low-interest rate environment, which is appropriate for monetary policy objectives, can adversely affect financial stability by causing financial institutions to take risks in money and capital markets (Kabundi and De Simone, 2019, p.1). In periods when low interest rate policies are applied, banks' risk-taking behaviours may increase (Dell'ariccia, Laeven and Suarez, 2017; Abbate and Thaler, 2019). A low risk-free interest rate may encourage banks to substitute safer assets with riskier ones, increasing their portfolio risk (Colletaz, Levieuge and Popescu, 2018, p.167). In addition, expansionary monetary policies may contribute to systemic risk trends (Ha and Quyen, 2018). In addition, exchange rates constitute one of the main transmission mechanisms of monetary policies (Lopotenco, 2017, p.168). Exchange rate fluctuations affect firms' production costs (raw materials, energy and other inputs) and their ability to pay their foreign currency debts to banks. Rising exchange rates during periods of increased country credit risk or inflation may increase banks' borrowing costs or cause debt payment problems.

There is extensive literature on the relationship between systemic risk and financial ratios. Many researchers have argued that high financial leverage encourages banks to engage in illiquid, risky loans and securities activities that commonly result in the failure of these institutions (Acharya and Thakor, 2016, p.5). Grill et al. (2016) provided evidence that leverage requirements encourage banks to take risks. Increased leverage increases the systemic risk or collective vulnerability of financial institutions, such as banks (Acharya and Thakor, 2016, p.5). Financial leverage weakens measures to reduce systemic risk. Kuzubaş et al. (2016) showed that leverage differences sharply distort systemic risk measures. The Global Financial Crisis of 2007-2008 showed that regulatory capital obligations did not prevent a system-wide banking crisis (Anginer and Kunt, 2014, p.19). Some studies advocating a positive relationship between capital liabilities and banks' risk-taking behaviours have referred to *the regulatory hypothesis* by arguing that regulators and policy practitioners encourage banks to increase their capital in proportion to the amount of risk they take (Lee and Hsieh, 2013, p.252). One of the most important purposes of tight capital obligations is to prevent banks from incurring significant and unexpected losses in their assets while fulfilling deposit transactions and other obligations (Anginer and Kunt, 2014, p.3). Traditional bank regulation approaches have highlighted the positive effects of capital adequacy requirements (Bouheni, 2014, p.246, Bouheni and Rachdi., 2015, p.232). On the contrary, some argue that increases in capital requirements encourage banks to take risks and lead to the emergence of systemic risks. Some studies arguing for a negative relationship between capital requirements and risk-taking behaviour have referred to *the moral hazard hypothesis*, arguing that banks are encouraged to abuse existing deposit insurance schemes (Lee and Hsieh, 2013, p.252). Some studies show that the relationship between bank size and systemic risks existed during the pre-crisis period. Bhagat et al. (2015) showed that a positive relationship between bank size and risk was present in the pre-crisis period (2002-2006) and the crisis period (2007-2009), but it disappeared in the post-crisis period (2010-2012). Pais and Stork (2013) stated that one of the key components of systemic risks is the moral hazard posed by the idea of *too big to fail*. Varotto and Zhao (2018) find that there is a close relationship between size and systemic risks, which is a major concern for *too big to fail* institutions. Pais and Stork (2013), Leaeven et al. (2014), and Dreyer et al. (2018) showed that larger banks carry higher systemic risk.

3. Literature Review

Maysami, Howe and Hamzah (2004) documented that short- and long-term interest rates have a positive and negative relationship with stock returns, respectively. Adami et al. (2010) demonstrated a negative relationship between leverage ratios and stock returns. Boztosun (2010) documented a negative relationship between deposit interest rates, portfolio investments, and the banking index. In contrast, he documented a positive relationship between other explanatory variables and stock returns. Kasman, Vardar and Tunç (2011) showed that interest rates negatively affect contingent stock returns. Iqbal and Shah (2012) found that profitability and systematic risks are positively related. Pais and Stork (2013) showed that bank size has a limited effect on banks' univariate risk (VaR), whereas large banks have significantly higher systemic risk. Nimalathasan and Pratheepkanth (2012) showed that there is a positive relationship between profitability and systematic risks. Al-Qudah and Laham (2013) documented that leverage ratios and betas negatively affect stock returns. In his research examining 17 European countries, Yeşin (2013) concluded that systemic risks are significant outside the eurozone but relatively low in the Eurozone. Anginer and Kunt (2014) demonstrated that regulatory capital is effective in reducing systemic risk and that regulatory risk weights are associated with high future asset volatility; however, they observed that this relationship is weaker for larger banks. Bouheni (2014) showed that restrictions on bank operations, auditor power, and capital adequacy reduce risk-taking and increase bank stability through regulation and audits. Laeven et al. (2014) documented that large banks create more individual and systemic risk, especially when they are not capitalised and have unstable funds. Mazviona and Nyangara (2014) found that firm size has a positive but insignificant effect on stock returns. Narayan, Narayan and Singh (2014) revealed that interest rates negatively affect stock prices. Şentürk and Dücan (2014) found a negative relationship between interest rates and stock returns. Adhikari (2015) documented a positive relationship between profitability and systemic risks. Bhagat et al. (2015) showed that size and risk-taking behaviours are positively related. Öztürk and Yılmaz (2015) found that firms with lower leverage ratios outperform firms with higher leverage ratios. Amtiran et al. (2016) showed that exchange rates affect systematic risks. Grill et al.

(2016) showed that a leverage ratio requirement may encourage banks to increase risk-taking behaviour, even if the requirement is low. Kuzubaş et al. (2016) analysed 25 banks and documented that leverage differences disrupt systemic risk measures. Langfield and Pagano (2016) showed that increases in private bonds and yields in the banking sector in developed economies are associated with high systemic risk and low economic growth. This trend is most prevalent during housing market crises. Chung, Ariff and M. (2017) found that changes in money supply lead to positive liquidity. In addition, banking liquidity positively affects stock market prices. Dedunu (2017) documented a positive relationship between systematic risks and profitability and liquidity ratios. Rutkowska-Ziarko and Pyke (2017) have shown that there is a positive relationship between ROA and ROE and market beta. Akyol and Baltacı (2018) showed that CDS spreads negatively affect stock returns. Dreyer et al. (2018) showed that capital adequacy positively affects stock returns and bank size positively affects systemic risks. Ha and Quyen (2018) documented that lax monetary policies increase risk-taking behaviour. Xu, Hu and Udaibir (2019) found that profitability was negatively correlated with banks' contributions to systemic and idiosyncratic risk.

4. Data and Methods

This section introduces the data, methods, and models used in the predictions.

4.1. Data

This research addresses the institutional and macroeconomic drivers of financial risks for nine deposit banks operating in the Turkish banking sector. The research sample consisted of Akbank, Finansbank, Halkbank, Vakıfbank, Garanti Bank, Yapı Kredi, Şekerbank, İş Bank, and Denizbank. The selection of risk indicators for the banking sector is based on the studies of Laeven et al. (2014, 2016) and Dreyer et al. (2018). Four different proxy indicators representing banking risks were used in this study. There are several indicators of systemic risk. Huang et al. (2009) DIP, Adrian and Brunnermeier (2011) CoVaR[1], Acharya et al. (2010) SES, Brownlees and Engle (2012, 2017). The SRISK and MES indices are the most commonly used. In this study, the SRISK and LRMES index proposed by Brownlees and Engle (2017) were used to represent the systemic risks of nine deposit banks. SRISK is a firm's expected capital shortfall in the event of a crisis, with firms with a high rate of capital loss during a crisis not only the most damaged in the crisis but also the largest contributors to the crisis (NYU-Stern, 2020. Retrieved from https://vlab.stern.nyu.edu/docs/srisk/MES. In this respect, bankruptcies that occur in firms with high SRISK likely dominate the entire sector or the market. SRISK is calculated as follows (NYU-Stern, 2020. Retrieved from https://vlab.stern.nyu.edu/docs/srisk/MES):

$$SRISK=k.\ DEBT-(1-k).\ EQUITY.\ (1-LRMES) \tag{1}$$

where k is the capital requirement.

LRMES denotes the long-run marginal expected shortfall.
EQUITY is the current market capitalisation of this firm

DEBT is the book value of debt, calculated as the book value of assets divided by the book value of equity.

LRMES, which is one of the leading indicators of systemic risk, is an important financial risk indicator instrument because it is used to predict the expected equity losses of companies in the event of a crisis. LRMES is calculated as 1-exp (log (1-d) * beta); where "d" is the six-month crisis threshold for market index declines, and the default value is 40%. Beta is the beta coefficient of the firm. (Retrieved from https://vlab.stern.nyu.edu/docs/srisk/MES). In the predicted models, market betas are used to represent banks' systematic risks. According to the CAPM, the market beta is calculated as follows (Mehrara et al., 2014, p. 28-29):

$$Rj - Rf = \alpha j + \beta j\ (Rm - Rf) + \varepsilon j \tag{2}$$

[1] DIP (Distress Insurance Premium), CoVaR (Conditional Value at Risk), SES (Systemic Expected Shortfall), SRISK (Systemic Risk Index), MES (Marginal Expected Shortfall) and LRMES (Long-Run Marginal Expected Shortfall). VaR is the value at risk.

If time effects are included in the model;

$$Rit - Rft = \alpha + \beta j(Rmt\text{-}Rft) + \varepsilon it;\ t = 1,\dots T \tag{3}$$

If the assumption of the model is correct, αi does not differ significantly from zero;

$$H0{:}\ \alpha i = 0,\ i = 1, \dots, N \tag{4}$$

where N: is the number of securities.

$$Rit - Rft = \beta j\ (Rmt - Rft) + \varepsilon it\ ;\ t = 1, \dots , T \tag{5}$$

Rit = i expected return for the stock.
Rft = risk free interest rate.
βj = beta.
Rmt = market return.

When estimating regression models, we took quarterly average monthly data from the NYU Stern V-lab database. In this study, the stock returns of the banks were used to represent the individual risks of the banks[2]. In this study, stock returns were calculated using the following formula using the closing prices of the stocks of the banks obtained from the official website of Borsa Istanbul:

$$SR = (PD_t\text{-}PDt_{-1})\ /PD_{t-1} \tag{6}$$

SR is the return on stock.
PD_t, is the Bank's stock price in the current period.
PDt_{-1} is the previous-period stock price.

Table 2 provides information about macroeconomic variables that affect Turkish banking sector risks. Table 3 provides selected banks' institutional

[2] See Laeven et al. (2014, 2016) and Dreyer et al. (2018).

variables. While selecting institutional variables affecting banking risks, we examined previous empirical literature (Bowman, 1980; Mandelker and Rhee, 1984; Stever, 2007; Iqbal and Shah, 2012; Nimalathasan and Pratheepkanth, 2012; Lee and Hsieh, 2013; Pais and Stork, 2013; Anginer and Kunt, 2014; Bhagat et al., 2015; Bouheni and Rachdi., 2015; Acharya and Thakor, 2016; Grill et al., 2016; Kuzubaş et al., 2016; Puspitaningtyas, 2017; Dreyer et al., 2018). We obtained the financial ratios used in this study from the official website of the Banks Association of Turkey (TBB). When selecting ratios, we considered data limitations. Similarly, a larger empirical literature has been used to select macroeconomic drivers (Maysami et al., 2004; Ranciere and Tornell, 2004; Yeşin, 2013; Amtiran et al., 2016; Drobetz et al., 2016; Chung et al., 2017; Lopotenco, 2017; Akyol and Baltacı, 2018; Colletaz et al., 2018; Ha and Quyen, 2018; Hussain and Shah, 2018). Globalisation has strongly integrated the financial systems of countries into each other. For this reason, any uncertainty or pessimism in the world markets can adversely affect the financial sector of all countries. The VIX index was used to determine the effect of global uncertainties on banking sector risks (Bianconi et al, 2015; Kownatzki, 2016).

Table 1: Dependent Variables Used in Research (2008Q3-2019Q3)

Variable	Description	Type	Source
SR	This is the bank stock returns.	The quarterly average monthly stock returns were taken.	Denizbank data is taken from Investing.com, and other bank data were obtained from https://www.borsaistanbul.com/veriler/verileralt/gunluk-bulten.
BETA	The indicator of market risk (systematic risk).	The quarterly average of the monthly data was obtained.	https://vlab.stern.nyu.edu/
SRISK	The SRISK index was used as a systemic risk indicator (the US Dollar).	The quarterly average of the monthly data was obtained.	https://vlab.stern.nyu.edu/
LRMES	Long-Run Marginal Expected Shortfall	The quarterly average of the monthly data was obtained.	https://vlab.stern.nyu.edu/

Table 2: Macroeconomic Variables of the Research (2008Q3-2019Q3)

Variable	Description	Type	Source
GSYH	Gross Domestic Product Ratio	The annual percentage change rate was calculated.	TCMB
LN (CDS)	Turkey's 5-year CDS spreads	Quarterly averages were calculated by taking month-end data, and a natural logarithm was calculated.	Longstaff et al. (2007,2011) for the period 2007-2010, Mcgraw Hill Financial -S&P Capital IQ Reports for the period 2011-2014, and Paragaranti.com for the period 2015-2019.
LN (VIX)	VIX uncertainty index	The natural logarithm of is taken.	Yahoo Finance
M2	M2 money supply rate	The rate of annual percentage change is taken. The exchange rate effect has been adjusted.	CBRT
REFK	Real effective exchange rate	The CPI-based effective exchange rate is the annual percentage rate of change.	CBRT
TÜFE	Consumer price ındex	Annual percentage change rates are calculated.	CBRT
MFAIZ	Deposit Interest rates	The percentage change rate of deposit interest rates in TL was taken.	CBRT
LN (MSCI-E)	MCSI-Europe index	The natural logarithm of is taken.	https://www.msci.com/
CID	Current Balance	The ratio is taken to GDP.	CBRT

Table 3: Institutional Variables of Research (2008Q3-2019Q3)

Variable	Description	Type	Source
	Capital Adequacy Ratios		
SER1	Capital adequacy ratios	Equity/ (CRET+PRET+ORET) *100	TBB
SER2	Capital adequacy ratios	Equity/Total Assets	TBB
	Profitability Ratios		
ROA	Profitability	Net period Profit (Loss)/Total Assets	TBB
ROE	Profitability	Net period Profit (Loss)/ Equity	TBB
	Asset Ratios		
AKTIF2	Asset Quality	Total Loans/Total Assets	TBB
AKTIF4	Asset Quality	Fixed Assets/Total Assets	TBB
	Liquidity Ratios		
LIKIT1	Liquidity Ratio	Liquid Assets and Total Assets	TBB
LIKIT2	Liquidity Ratio	Liquid Assets/(Deposit + Non-Deposit Resources)	TBB

Table 3: Continued

	Income-Expense Ratios		
GGIDER1	Income-expenditure ratios	Interest Incomes/Interest Expenses	TBB
GGIDER2	Income-expenditure ratios	Other operating expenses/total assets	TBB
	Other Financial Ratios		
LN (BOYUT)	Bank Size	The natural logarithm of total assets is taken.	TBB
KAL	Financial Leverage	The quarterly average of monthly data was obtained.	https://vlab.stern.nyu.edu/

4.2. Methods and Models

In this study, the period from 2008Q3 to 2019Q3 was estimated using panel data analysis. Linear models showing the long-term relationship between banking risks and selected macroeconomic and institutional variables are given below:

$$Y_{it}=\beta_0 + \beta_1 KAL_{it} + \beta_2\, LN\,(BOYUT)_{it} + \beta_3\, LN\,(VIX)_{it} + \beta_4\, GSYH_{it} + \beta_5\, ROA_{it} + \beta_6\, AKTIF4_{it} + \beta_7\, GGIDER2_{it}\ \mu i_t \tag{7}$$

$$Y_{it}=\beta_0 + \beta_1 KAL_{it} + \beta_2\, GSYH_{it} + \beta_3\, LN\,(VIX)_{it} + \beta_4\, ROE_{it}+ \beta_5\, M2_{it} + \beta_6\, AKTIF4_{it} + \beta_7\, TUFE_{it} + \beta_8\, EFKUR_{it} +\mu i_t \tag{8}$$

$$Y_{it}=\beta_0 + \beta_1 SER2_{it} + \beta_2\, LIKIT1_{it} + \beta_3\, LN\,(VIX)_{it} + \beta_4\, MFAIZ_{it}+ \beta_5\, TUFE_{it} + \beta_6\, GGIDER1_{it} + \mu i_t \tag{9}$$

$$Y_{it}=\beta_0 + \beta_1 SER1_{it} + \beta_2 LN(CDS)_{it} + \beta_3\, LN\,(BOYUT)_{it} + \beta_4\, TUFE_{it}+ \beta_5\, LIKIT2_{it} + \beta_6\, LN\,(VIX)_{it} + \beta_7\, GGIDER2_{it}+ \beta_8\, MFAIZ_{it} + \beta_9\, AKTIF2_{it} +\mu i_t \tag{10}$$

The dependent variable here, "Y_{it}", represents the banks' individual, systemic, and systematic risks (SR, BETA, LRMES, and SRISK).

5. Empirical Analysis

5.1. First Generation Panel Unit Root Test

In this study, the stability of selected macroeconomic variables is examined using first-generation panel unit root tests. These tests were conducted by LLC, Hadri (2000), Breitung (2000), Im, Pesaran and Shin (2003), Maddala and Wu (1999), and Choi (2001). Table 4 shows that all series are stationary at level values.

Table 4: First Generation Panel Unit Root Test Results

Variables	LLC	Hadri (2000)	Breitung (2000)	IPS (2003)	Maddala- Wu (1999)	Choi (2001)
GSYH	-3.473***	13.593	-6.916***	-3.195***	36.343***	41.529***
GSYH	-19.823***	-2.331**	-8.281***	-19.000***	269.817***	271.457***
LN (CDS)	-7.364***	10.554	-5.556***	-6.698***	79.213***	32.344***
LN (CDS)	-9.684***	-1.298**	-4.343***	-14.195***	193.294***	193.294***
LN (VIX)	-6.196***	43.873	-4.309***	-4.151***	46.340***	46.340***
LN (VIX)	-14.468***	-2.644**	-5.570***	-19.111***	275.111***	399.979***
M2	-7.175***	24.678	-2.516***	-7.545***	90.770***	53.868***
M2	-5.382***	-0.289**	-4.466***	-6.933***	80.811***	79.389***
EFKUR	-3.343***	1.615	-6.647***	-4.247***	47.093***	63.579***
EFKUR	-9.530***	-0.930**	-3.598***	-11.866***	166.825***	165.786***
TUFE	-3.962***	32.535	-4.397***	-3.399***	38.916***	20.604***
TUFE	-9.056***	-0.903**	-10.451***	-14.363***	202.945***	101.636***
MFAIZ	-1.405*	23.946	-2.074***	-2.137***	8.984	15.076
MFAIZ	-9.983***	7.000	-10.269***	-11.462***	148.713***	154.527***
LN (MSCI-E)	-8.798***	37.876	-5.592***	-7.638***	30.555***	35.134***
LN (MSCI-E)	-15.339***	-1.966**	-1.583**	-20.551***	250.933***	280.6014***
CID	-0.982	8.130	-10.064***	-1.884**	96.248***	104.274***
CID	-36.980***	-2.656**	-16.152***	-34.548***	404.101***	404.013***

Note: ***, **, and * represent significance at p≤0.01, p≤0.05 and p≤0.10, respectively.

5.2 Cross-sectional Dependence Test

In this study,whether the institutional series contained cross-sectional problems was examined by using Breusch-Pagan LM, Baltaci , Feng and Kao (2012) Bias Corrected-Scaled LM and Pesaran (2015) CD tests. Table 5 presents the test results of the cross-sectional dependence on the institutional variables of the selected banks. According to the results of all three test statistics, all series include the cross-sectional-dependence problem.

Table 5: Cross-sectional Dependence Test Results

Variables	Breusch-Pagan LM		Bias-corrected-scaled LM:		Pesaran (2015), CD	
	Statistics	Prob.	Statistics	Prob.	Statistics	Prob.
SR	525.079	0.000	57.638	0.000	19.322	0.000
BETA	711.397	0.000	79.494	0.000	39.588	0.000
SRISK	868.311	0.000	97.986	0.000	19.921	0.000
LRMES	732.991	0.000	82.038	0.000	39.924	0.000
SER1	385.635	0.000	41.102	0.000	39.991	0.000
SER2	669.079	0.000	74.506	0.000	39.996	0.000
ROA	1194.143	0.000	136.386	0.000	38.016	0.000
ROE	1135.998	0.000	129.533	0.000	37.498	0.000
AKTIF2	849.705	0.000	95.793	0.000	40.161	0.000
AKTIF4	363.923	0.000	38.543	0.000	37.913	0.000
LIKIT1	1209.527	0.000	138.199	0.000	39.743	0.000
LIKIT2	1227.461	0.000	140.312	0.000	39.778	0.000
GGIDER1	834.879	0.000	94.046	0.000	40.049	0.000
GGIDER2	1523.511	0.000	175.202	0.000	39.962	0.000
LN (BOYUT)	1352.479	0.000	155.046	0.000	40.234	0.000
KAL	945.734	0.000	107.111	0.000	37.199	0.000

5.3. Second Generation Panel Unit Root Test

In the presence of cross-sectional dependence, first-generation panel unit root tests lose their reliability. In this respect, the stationary of institutional variables in the study was examined using Pesaran (2007) CADF, Taylor and Sarno (1998), MADF, Bai and Ng (2004, 2010), PANIC and Hadri (2000), Breitung (2000), and IPS (2003) panel unit root tests, which were updated to consider cross-sectional dependence. Bai and Ng (2004, 2010) reported the PANIC panel unit root test results in Table 7. The MQ_c and MQ_f tests show the stability of common factors, whereas the P_a, P_b, and PMSB tests test the stationary levels of residues. According to the test results, some of the series became stationary in common factors (MQ_c and MQ_f or at least one), some became stationary in residues, and some became stationary in both common factors and residues. According to all test results in Table 6, the LN (BOYUT) variable, which is stationary in the first differences, is stationary in common factors according to the PANIC panel unit root test results, whereas the residues contain unit roots. In this respect, when panel unit root tests were considered as a whole, the institutional series was found to be static according to at least one test result.

Table 6: Second Generation Panel Unit Root Test Results

Variables	Breitung (2000)		IPS (2003)		CADF		MADF	
	I [0]	I [1]	I [0]	I [1]	I [0]	I [1]	I [0]	I [1]
SR	-6.165***	-8.806***	-20.525***	-22.092***	-5.254***	-6.190***	562.851**	1372.287**
BETA	-3.497***	-10.052***	12.071***	-23.543***	-3.780***	-6.040***	270.384**	895.477**
SRISK	-2.585***	-9.056***	-2.691***	-15.550***	-1.606	-5.056***	38.410**	438.117**
LRMES	-3.623***	-10.710***	-11.019***	-23.490***	-3.880***	-5.954***	249.288**	927.908**
SER1	-3.520***	-6.833***	-5.615***	-19.743***	-2.339**	-5.513***	68.534**	660.765**
SER2	-1.072	-7.118***	0.140	-17.237***	-1.631	-4.657***	40.557**	447.242**
ROA	-5.232***	-13.843***	-6.263***	15.966***	-2.737***	-5.411***	119.664**	643.518**
ROE	-3.092***	-11.421***	-4.687***	-14.971***	-2.290**	-5.013***	114.504**	542.339**
AKTIF2	-1.861**	-11.195***	-1.989**	-20.335***	-2.581***	-5.222***	59.032**	586.931**
AKTIF4	-1.367*	-11.006***	-3.826***	-18.777***	-1.533	-4.850***	38.085**	558.730**
LIKIT1	0.284	-11.448***	-2.465***	-20.621***	-2.732***	-5.200***	45.887**	540.872**
LIKIT2	0.028	-11.223***	-1.955**	-19.408***	-2.631***	-5.127***	47.432**	559.396**
GGIDER1	-2.498***	-12.426***	-0.300	-15.637***	-1.556	-4.524***	31.625**	340.893**
GGIDER2	-6.332***	-10.439***	-17.535***	-21.744***	-3.369***	-6.022***	179.090**	797.319**
LN (BOYUT)	3.627	-12.097***	1.815	-16.432***	-1.520	-4.175***	18.390	463.846**
KAL	0.132	-5.868***	-0.129	-16.683***	-1.843	-4.466***	60.423**	500.386**

Note: ***, **, and * represent significance at $p \leq 0.01$, $p \leq 0.05$ and $p \leq 0.10$, respectively.

Table 7: PANIC Panel Unit Root Test

	k	MQ_c	H0 Reject	k	MQ_f	H0 Reject	P_a	P_b	PMSB
SR	2 1 0	-39.159 -39.815 0	1 1 0	2	-7.746	0	-9.123***	-2.846***	-1.452*
BETA	2 1 0	-42.261 -37.178 0	1 1 0	2	-8.248	0	-2.407***	-1.758**	-.993
SRISK	2	-7.453	0	2	-3.663	0	-3.122***	-1.753**	-1.518*
LRMES	2 1 0	-41.957 -36.663 0	1 1 0	2	-9.459	0	-3.212***	-2.105***	-1.193
SER1	2 1	-44.46 -8.647	1 0	2	-5.286	0	-3.963***	-2.438***	-1.398*
SER2	2	-9.848	0	2	-5.505	0	-.202	-.165	-.564
ROA	2 1	-42.223 -6.112	1 0	2	-13.508	0	-30.772***	-7.879***	-2.141***
ROE	2 1	-43.697 -3.133	1 0	2	-11.608	0	-14.104***	-5.043***	-1.954**
AKTIF2	2	-19.514	0	2	-4.093	0	.365	.445	1.268
AKTIF4	2 1	-24.029 1.66	1 0	2	-8.041	0	-1.149	-1.117	-.08
LIKIT1	2 1	-29.505 .138	1 0	2	-6.544	0	-.571	-.511	-.368
LIKIT2	2 1	-25.476 -.024	1 0	2	-4.224	0	-.991	-.816	-.62
GGIDER1	2	-14.242	0	2	-5.504	0	-2.271***	-1.596**	-1.142
GGIDER2	2 1	-35.235 -8.709	1 0	2	-6.143	0	-2.278***	-1.797**	-.824
LN (BOYUT)	2	-8.555	0	2	-4.309	0	1.784	2.409	1.905
KAL	2	-11.136	0	2	-3.534	0	-5.716***	-2.708***	-1.583**

Note:***, **, and * represent significance at p≤0.01, p≤0.05 and p≤0.10, respectively.

5.4. Determining Institutional and Macroeconomics Determinants of Risks in the Banking Sector

Table 8 shows the effect of selected institutional and macroeconomic variables on SRISK and the results of the regression estimation. The relationship between SRISK and explanatory variables was estimated using the Driscoll-Kraay (1998) standard error estimator. The estimation results indicate that the effects of the SER1 and SER variables on SRISK were negative for the third and fourth models. Similarly, the effects of ROA, AKTIF4, LIKIT1, and LIKIT2 on SRISK were negative in the first, third, and fourth models. The KAL, LN (BOYUT), and GGIDER2 variables were positively correlated with SRISK. The effects of AKTIF2, GGIDER1, and ROE on SRISK were insignificant. When the effect of macroeconomic variables on SRISK was examined, it was revealed that the effect of GSYH, EFKUR, TUFE, and LN (VIX) variables was negative, whereas the effect of MFAIZ and LN (CDS) is positive. However, the effect of the M2 broad money supply on SRISK is meaningless.

Table 9 provides estimation results for the regression relationship between LRMES, another systemic indicator used in this study, and the explanatory variables. The effects of KAL, ROE, GGIDER1, GGIDER2, and LIKIT1 variables on LRMES were positive. LN (BOYUT), AKTIF2, and AKTIF4 were found to have negative effects on LRMES. The effects of SER1, SER2, ROA, and LIKIT2 on the dependent variable are insignificant. It has been demonstrated that GSYH, LN (VIX), and EFKUR have a negative relationship with LRMES. The effects of MFAIZ, M2, and LN (CDS) on LRMES were positive. The effect of TUFE on LRMES was insignificant.

Table 10 provides robust estimation results for institutional and macroeconomic variables affecting BETA. The effect of LN (BOYUT) on BETA was negative in the first and fourth models. Similarly, the effect of AKTIF2 on BETA was negative. It has been shown that the effects of KAL, ROE, GGIDER1, GGIDER2, and LIKIT1 on BETA are positive. It was observed that the effects of SER1, SER2, ROA, AKTIF4, and LIKIT2 on the dependent variable were insignificant. When the effects of macroeconomic variables on BETA are examined in the table given, it is shown that the effects of TUFE, MFAIZ, M2, and LN (CDS) are positive, while the effects of LN (VIX), GSYH, and EFKUR are negative.

Table 11 presents the estimation results showing the regression relationship between SR and explanatory variables. The estimation results indicate that KAL and GGIDER2 variables have a negative relationship with SR. The effects of SER2, ROA, AKTIF2, AKTIF4, LIKIT1, and LIKIT2 on SR were positive. The effects of the LN (SIZE), ROE, and GGIDER1 variables on SR were meaningless. The estimation results demonstrate that selected macroeconomic variables exert a powerful effect on SR. It was found that GSYH, LN (VIX), and LN (CDS) had negative effects on the dependent variable, whereas MFAIZ and EFKUR had positive effects on SR. The effects of TUFE on SR were mixed. The effect of TUFE on SR was positive in the second model and negative in the fourth model.

Table 8: Estimation of Institutional and Macroeconomic Variables Affecting SRISK

	I	II	III	IV
	DK FE	DK FE	DK FE	DK FE
SER1				-234.811*** (68.117)
SER2			-486.068*** (116.277)	
KAL	124.611*** (13.026)	119.974*** (22.484)		
LN (BOYUT)	710.883*** (199.927)			-331.630 (303.611)
LN (VIX)	-596.454** (286.214)	-1501.662*** (376.687)	-1033.596* (483.950)	-2435.993*** (376.294)
TUFE		42.793 (47.955)	-179.202** (75.550)	-106.154** (48.285)
MFAIZ			229.049*** (72.509)	-3.378 (80.185)
GSYH	-50.737*** (13.448)	-74.016** (25.681)		
M2		-29.145 (36.859)		
EFKUR		-45.683*** (14.244)		
ROA	-84650.92*** (20980.56)			

Table 8: Continued

ROE		-1016.655 (2440.894)		
AKTIF2				-60.061 (44.158)
AKTIF4	-252.233** (116.296)	-242.273 (149.888)		
GGIDER1			9.521 (5.538)	
GGIDER2	443.436*** (127.807)			209.770 (116.476)
LIKIT1			-75.590*** (17.670)	
LIKIT2				-93.501** (33.428)
LN (CDS)				3568.452*** (444.912)
C	-7390.274*** (2833.359)	3651.74* (1676.776)	6831.722*** (2230.019)	2085.086 (7892.762)
Obs.	405	405	405	405
Bank	9	9	9	9
Wald (F-statistic)	30.99 (0.000) ***	10.45 (0.000) ***	13.66 (0.000) ***	34.95 (0.000) ***
R2	0.487	0.518	0.463	0.586
Diagnostic Tests				
F Test	9.633 (0.000)	13.20 (0.000)	14.57 (0.000)	20.84 (0.000)
VIF	1.85	1.51	3.55	3.85
Hausman Test	18.20 (0.002)	14.84 (0.000)	14.36 (0.002)	29.35 (0.000)
Wald Test	913.89 (0.000)	223.73 (0.000)	278.25 (0.000)	691.42 (0.000)
Baltagi-Wu (1999)	.540	.611	.637	.716
DW	.454	.532	.541	.600
LM	447.328 (0.000)	458.796 (0.000)	469.288 (0.000)	411.271 (0.000)
Pesaran (2004), CD	8.429 (0.000)	11.212 (0.000)	12.970 (0.000)	11.780 (0.000)
Friedman (1937)	110.418 (0.000)	146.448 (0.000)	151.348 (0.000)	131.923 (0.000)
Frees (1995, 2004)	1.952 (0.000)	2.268 (0.000)	2.271 (0.000)	1.716 (0.000)

Note***, **, and * represent significance at $p \leq 0.01$, $p \leq 0.05$ and $p \leq 0.10$, respectively.

Table 9: Estimation of Institutional and Macroeconomic Variables Affecting LRMES

	I	II	III	IV
	DK FE	AFR RE	DK FE	DK FE
SER1				-.149 (.206)
SER2			-.637 (.695)	
KAL	.208** (.083)	-.013 (.047)		
LN (BOYUT)	-5.392*** (.794)			-7.307*** (1.283)
LN (VIX)	-12.303*** (2.654)	-10.583*** (1.169)	-8.962*** (1.939)	-19.394*** (2.793)
TUFE		.146 (.121)	-.177 (.285)	.130 (.241)
MFAIZ			.668** (.300)	
GSYH	-.031 (.106)	-.265*** (.053)		
M2		.455*** (.080)		
EFKUR		-.159*** (.026)		
ROA	182.285 (115.672)			
ROE		19.307*** (3.378)		
AKTIF2				-.514** (.202)
AKTIF4	.468 (.564)	.537* (.323)		
GGIDER1			.092*** (.025)	
GGIDER2	-.351 (.636)			.988** (.419)
LIKIT1			.209*** (.062)	
LIKIT2				-.171 (.107)
LN (CDS)				10.266** (3.814)
C	139.523*** (15.277)	69.095*** (4.956)	47.849*** (5.944)	170.949*** (18.506)
Obs.	405	405	405	405
Banka	9	9	9	9
Wald (F-statistic)	9.31	10315.13 (0.000) ***	4.97 (0.020) **	10.98 (0.003) ***

Table 9: Continued

R^2	0.233	0.234	0.189	0.348
	Diagnostic Tests			
F Test	51.47 (0.000)	55.19 (0.000)	49.40 (0.000)	60.10 (0.000)
VIF	1.85	1.51	3.55	3.85
Hausman Test	37.48 (0.000)	55.19 (0.000)	26.88 (0.000)	42.43 (0.000)
Wald Test	10.19 (0.3352)	4.48 (0.214)	13.95 (0.124)	11.45 (0.246)
LBI	1.555	1.619	1.595	1.553
DW Test	1.509	1.573	1.541	1.506
LM	553.561 (0.000)		539.982 (0.000)	498.714 (0.000)
Pesaran (2004), CD	21.217 (0.000)		20.641 (0.000)	19.761 (0.000)
Friedman (1937)	220.218 (0.000)		209.440 (0.000)	214.242 (0.000)
Frees (1995, 2004)	2.535 (0.000)		2.355 (0.000)	2.507 (0.000)
LBS Prob.		W0:0.598 W50:0.734 W10:0.615		

Note: ***, **, and * represent significance at p≤0.01, p≤0.05 and p≤0.10, respectively.

Table 10: Estimation of Institutional and Macroeconomic Variables Affecting BETA

	I	**II**	**III**	**IV**
	DK FE	**ARF RE**	**DK FE**	**DK FE**
SER1				-.006 (.008)
SER2			-.029 (.028)	
KAL	.008* (.004)	-.0007 (.002)		
LN (BOYUT)	-.201*** (.036)			-.289*** (.052)
LN (VIX)	-.451*** (.104)	-.400*** (.053)	-.324*** (.076)	-.756*** (.119)
TUFE		.008* (.004)	-.002 (.012)	.009 (.010)
MFAIZ			.023* (.012)	-.017 (.020)
GSYH		-.009*** (.001)		
M2		.017*** (.003)		
EFKUR		-.007*** (.001)		

Table 10: Continued

ROA	8.695 (5.443)			
ROE		.786*** (.154)		
AKTIF2				-.022** (.008)
AKTIF4	.016 (.022)	.016 (.012)		
GGIDER1			.003*** (.001)	
GGIDER2	-.024 (.028)			.038* (.017)
LIKIT1			.007*** (.002)	
LIKIT2				-.008 (.005)
LN (CDS)				.450** (.164)
C	4.691*** (.619)	2.077*** (.194)	1.271*** (.224)	6.126*** (.848)
Gözlem	405	405	405	405
Banka	9	9	9	9
Wald (F-İstatistik)	7.55 (0.005) ***	21129.12 (0.000) ***	3.72 (0.045) **	8.74 (0.002) ***
R2	0.201	0.227	0.172	0.338
		Diagnostic Tests		
F Testi	36.82 (0.000)	41.14 (0.000)	37.30 (0.000)	47.29 (0.000)
VIF	1.85	1.51	3.55	3.85
Hausman Testi	33.57 (0.000)	4.34 (0.226)	26.02 (0.000)	40.38 (0.000)
Wald Testi	59.07 (0.000)		57.92 (0.000)	35.14 (0.000)
Baltagi-Wu (1999)	1.615	1.686	1.673	1.651
DW Testi	1.563	1.636	1.616	1.592
LM	536.039 (0.000)		532.924 (0.000)	482.045 (0.000)
Pesaran (2004), CD	20.592 (0.000)		20. 305 (0.000)	19.124 (0.000)
Friedman (1937)	212.794 (0.000)		203.976 (0.000)	212.072 (0.000)
Frees (1995, 2004)	2.370 (0.000)		2.234 (0.000)	2.503 (0.000)
LBS Prob Değeri		W0:0.975 W50:0.968 W10:0.968		

Note:***, **, and * represent significance at p≤0.01, p≤0.05 and p≤0.10, respectively.

Table 11: Estimation of Institutional and Macroeconomic Variables Affecting SR

	I	II	III	IV
	DK FE	**POLS**	**DK FE**	**POLS**
SER1				.003 (.002)
SER2			.0194*** (.004)	
KAL	-.002*** (.000)	-.002*** (.000)		
LN (BOYUT)	.021 (.020)			-.004 (.005)
LN (VIX)	-.019 (.032)	-.027** (.014)	-.062*** (.021)	-.011 (.019)
TUFE		.005*** (.001)	-.004 (.003)	-.004* (.002)
MFAIZ			.011*** (.003)	.014*** (.002)
GSYH	-.004*** (.001)	-.004*** (.000)		
M2		-.0004 (.001)		
EFKUR		.0008** (.0004)		
ROA	3.093* (1.588)			
ROE		.036 (.078)		
AKTIF2				.003*** (.001)
AKTIF4	.013** (.004)	-.0009 (.003)		
GGIDER1			-.00006 (.000)	
GGIDER2	-.017* (.008)			-.006 (.004)
LIKIT1			.002** (.000)	
LIKIT2				.003*** (.000)
LN (CDS)				-.078*** (.021)
C	-.130 (.309)	.134*** (.046)	-.141 (.079)	.021 (.188)
Gözlem	405	405	405	405
Banka	9	9	9	9
Wald (F-İstatistik)	6.46 (0.008) ***	7.41 (0.000) ***	7.41 (0.006) ***	4.75 (0.000) ***
R^2	0.113	0.130	0.111	0.077

Table 11: Continued

	Diagnostic Tests			
F Testi	2.59 (0.009)	1.38 (0.202)	3.89 (0.000)	1.42 (0.187)
LR Testi		0.05 (0.409)		0.02 (0.444)
VIF	1.85	1.51	3.55	3.85
Hausman Testi	17.42 (0.003)		27.21 (0.000)	
Green (2000). Wald Testi	228.22 (0.000)		190.64 (0.000)	
Baltagi-Wu (1999)	2.397		2.313	
DW Testi	2.195		2.159	
Breusch-Pagan LM	384.266 (0.000)		354.722 (0.000)	
Pesaran (2004), CD	15.535 (0.000)		14.085 (0.000)	
Friedman (1937)	177.393 (0.000)		157.554 (0.000)	
Frees (1995, 2004)	1.952 (0.000)		1.715 (0.000)	
White (1980)		101.084 (2.2e)		139.657 (1.6e)
Wooldridge (2002)		0.022 (0.885)		0.156 (0.703)

Note:***, **, and * represent significance at $p \leq 0.01$, $p \leq 0.05$ and $p \leq 0.10$, respectively.

6. Discussion

In Table 12, the findings obtained from analyses made to estimate the relationship between the risks in the Turkish banking sector and selected institutional variables are given. Applied analyses have shown that capital adequacy ratios positively affect banks' individual risks. These findings are contrary to Modigliani and Miller (1958) irrelevance proposition that corporate finance decisions will not affect firm value under certain circumstances. Empirically, the Dreyer (2018) study was supported. Although the effects of capital adequacy ratios on market betas and LRMES are meaningless, their impact on SRISK is negative. These findings confirm traditional hypotheses that capital adequacy ratios act as buffers against capital losses and failure, limiting banks' tendency to engage in high-risk activities. Empirically supported by Anginer and Kunt (2014), Bouheni (2014), and Rahman et al. (2018). In this study, we demonstrated that profitability rates positively affect stock returns and market betas. It has been shown that there is a positive relationship between profitability rates and bank betas. Theoretically, the relationship between profit rates and systematic risks is negative. On the contrary, when empirical studies are examined, increased profitability rates are often accompanied by high betas[3]. The findings support the studies of Iqbal and Shah (2012), Nimalathasan and Pratheepkanth (2012), Dedunu (2017), and Rutkowska-Ziarko and Pyke (2017). The impact of profitability rates on SRISK is negative, while the impact on LRMES is positive. Given the relationship between profitability ratios and stock returns and systematic risks, increasing profitability is expected to reduce systemic risk trends. In addition, increased profit rates can encourage banks to make riskier investments. These findings support the studies of Xu et al. (2019) and Adhikari (2015). Asset ratios have been shown to positively affect stock returns and negatively affect systemic and systematic risks. The results show that liquidity ratios have a positive effect on stock returns and systematic risks. These results support the work of Borde (1998), Chung et al. (2017), Dedunu (2017), and Marozva (2019). In this study, it was determined that an inverse relationship between liquidity ratios with SRISK and an upward relationship with LRMES. It has been shown that income-expense ratios affect stock returns negatively and systemic and systematic risks affect them positively. The results of the research showed that the relationship between bank size and stock returns is meaningless. These findings support the work of Mazviona and Nyangara (2014). Bank size has been shown to negatively affect systematic risks. Empirically, Dreyer et al. (2018) supported these studies. Although the effect of bank size on SRISK is positive, its relationship with LRMES is inverse. These findings support the work of Pais and Stork (2013), Leaeven et al. (2014), Bhagat et al. (2015), and Dreyer et al. (2018). The research showed that leverage ratios reduce stock returns and increase systemic and systematic risks. The Modigliani and Miller (1958) model argued that an increase in financial leverage would directly increase cash flow risk to shareholders (Giacomini, Ling and Naranjo, 2015, p.126). However, Mirza, Rahat and Reddy (2016) stated that the main purpose of a firm's use of financial leverage is to generate more income and fulfil its obligations compared to debt financing. If the firm cannot meet its obligations, its receivables may force the firm to enter bankruptcy. In such cases, financial leverage may become a major source of credit risk for the firm. Therefore, an increase in financial leverage ratios can adversely affect stock returns. The

[3] See Kim (2007) and Rowe and Kim (2010).

results of this research support the studies of Muradoglu and Sivaprasad (2008), Adami et al. (2010), Al-Qudah and Laham (2013), Öztürk and Yılmaz (2015). Theoretically, there is a positive relationship between leverage ratios and systematic risks. According to Hamada (1969,1972) and Rubinstein (1973), when a firm issues debt, its beta should increase because it assumes financial and commercial risks (Aharon and Yagil, 2019, p.3). The research results support the work of Hamada (1969,1972) and Rubinstein (1973). Empirically, Alaghi (2011) and Rahim et al. (2016) were supported. According to many researchers, high financial leverage encourages banks to engage in illiquid, risky loans and securities activities that result in the failure of these institutions (Acharya and Thakor, 2016, p.5). These findings support the work of Grill et al. (2016) and Kuzubaş et al. (2016).

Table 12: Institutional Determinants of Risk in Turkish Banking Sector

	SR		BETA		SRISK		LRMES	
	Expected	Result	Expected	Result	Expected	Result	Expected	Result
SER1	(+)	meaningless	(-)	meaningless	(-)	(-)	(-)	meaningless
SER2	(+)	(+)	(-)	meaningless	(-)	(-)	(-)	meaningless
ROA	(+)	(+)	(-)	meaningless	(-)	(-)	(-)	meaningless
ROE	(+)	meaningless	(-)	(+)	(-)	meaningless	(-)	(+)
AKTIF2	(+)	(+)	(-)	(-)	(-)	meaningless	(-)	(-)
AKTIF4	(+)	(+)	(-)	meaningless	(-)	(-)	(-)	(+)
LIKIT1	(+)	(+)	(+)	(+)	(-)	(-)	(-)	(+)
LIKIT2	(+)	(+)	(+)	meaningless	(-)	(-)	(-)	meaningless
GGIDER1	(-)	meaningless	(+)	(+)	(+)	meaningless	(+)	(+)
GGIDER2	(-)	(-)	(+)	(+)	(+)	(+)	(+)	(+)
LN (BOYUT)	(-)	meaningless	(-)	(-)	(+)	(+)	(+)	(-)
KAL	(+)	(-)	(+)	(+)	(+)	(+)	(+)	(+)

Table 13 presents the expected direction of the relationship between banking risks and macroeconomic variables and the results obtained. According to Patrick (1966), there must be a positive relationship between two variables. Levine (1997) emphasised the functions of the financial system, such as facilitating commercial life, allocating resources, and mobilising savings, implying a positive relationship between equity markets and economic growth. The findings show that by contrast, there is an inverse relationship between the two variables. According to Drobetz et al. (2016), market betas are higher under poor but lower under good economic conditions. The research findings supported the study of Karakuş (2017). As emphasised by the European Central Bank (2009), significant economic growth and prosperity disrupt the functions of the financial system after a certain point, causing systemic risks to increase. Steady growth plays a significant role in reducing the current risks to the banking sector. The findings support Langfield and Pagano (2016). CDS spreads have been shown to negatively affect stock returns and positively affect systemic and systematic risks. The results show an inverse relationship between CDS spreads and stock returns. The findings theoretically support the Merton (1973) model. Empirically, Akyol and Baltacı's (2018) study is supported. Kim (2019) showed that the likelihood of market default on average significantly affects credit risk premiums. In this regard, increased CDS premiums may also indicate increased systemic and systematic risks. According to this research, the VIX index negatively impacts banking risksA change in the VIX index, which is an indicator of increasing uncertainty and pessimism in the global investment environment, inevitably affects the returns of the Turkish banking sector. These findings support the work of Fu, Sandri and Shackleton (2016) and Sarwar and Khan (2017). Bianconi, Hua and Tan (2015) showed that VIX is a major determinant of systemic risk and can dominate consumer pessimism. These findings support the findings of Bianconi et al. (2015). According to research, money supply does not affect stock returns but positively affects systemic and systematic risks. These results support the work of Lee (1997) and Alper and Kara (2017) in that they show that there is no relationship between stock returns and money supply. Ha and Quyen (2018) provided evidence of a positive relationship between money supply and systemic risks. The results of this research reveal that there is a positive relationship between real effective exchange rates and stock returns and an inverse relationship between systemic and systematic risks. The finding that there is a positive relationship between stock returns and effective exchange rates demonstrates that the stock market-oriented model hypothesis is valid for the banking sector. The findings support Berke (2012), Belen and Karamelikli (2015), and Daelemans, Daniels and Nourzad

(2018). Exchange rate increases may lead to serious systemic and systematic risk problems for the Turkish banking sector. The results support Yeşin's studies (2013), Amtiran et al. (2016), and Andrieş and Nistor (2018). In this research, it was shown that there is a positive relationship between interest rates and banking sector returns. The findings support the studies of Maysami et al. (2004), Ahmad, Ur Rehman and Raoof (2010), Boztosun (2010), Kasman et al. (2011), Narayan et al. (2014), Şentürk and Dücan (2014), Akyol and Baltacı (2018). Interest rate risk is a significant component of systematic risk. There is a direct relationship between interest rates and systematic risks, according to the study. In this context, Booth, Officer and Henderson (1985), McCurdy and Morgan (1991), and Hussain and Shah (2018) were supported. According to traditional portfolio allocation models, a negative relationship between real interest rates and banks' risk-taking (Colletaz et al., 2018, p.167). An increase in interest rates increased systemic risks, according to the study. It has been shown that inflation raises systematic risks and reduces systemic risks. Regarding the effect of inflation rates on stock returns, complex findings were reached.

Table 13: Macroeconomic Determinants of Risks in Turkish Banking Sector

	SR		BETA		SRISK		LRMES	
	Expected	Result	Expected	Result	Expected	Result	Expected	Result
GSYH	(+)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
LN (CDS)	(-)	(-)	(+)	(+)	(+)	(+)	(+)	(+)
LN (VIX)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
M2	(+)	meaningless	(+)	(+)	(+)	meaningless	(+)	(+)
REFK	(+)	(+)	(-)	(-)	(-)	(-)	(-)	(-)
TÜFE	(+)	(-)/(+)	(+)	(+)	(+)	(-)	(+)	meaningless
MFAIZ	(-)	(+)	(+)	(+)	(-)	(+)	(-)	(+)

7. Conclusion and Recommendations

Lehman Brothers' bankruptcy demonstrated that any banking sector instability could threaten the global economy. Therefore, monitoring banking risks is imperative. This research analyzes the institutional and macroeconomic variables affecting the individual, systemic, and systematic risks of nine deposit banks operating in the Turkish banking sector. Within the framework of this study, we first examined the stationaries of the series using panel-unit root analysis. For this purpose, we analysed macroeconomic variables using a first-generation conventional analysis and institutional series with cross-sectional dependency problems using a second-generation panel unit root analysis. We estimated the econometric relationships between the variables using panel regression analyses to find all series stationary at the level. Because of the analysis, comprehensive findings were revealed. Thus, institutional and macroeconomic sources of risks in banking are revealed. We demonstrate that capital adequacy ratios can play a critical role in mitigating systemic risks. Increasing banks' capital adequacy can secure them against financial instabilities and risks of default. The results of the analysis reveal that improvements in profitability, asset quality, and liquidity ratios reduce SRISK. On the other hand, we documented that profitability and liquidity ratios have a positive relationship with LRMES. We found that bank size positively correlated with SRISK but a negative correlation with LRMES. However, the estimation results showed that leverage ratios increase banks' instability and financial risks for both SRISK and LRMES. We reached very strong conclusions about the effects of macroeconomic variables on systemic risks. Economic growth and improvements in real effective exchange rates have a positive impact on banks' systemic risk. These findings demonstrate that the stability of the banking sector will increase in an economic system in which exchange rates are stable and sustainable economic growth is achieved. The results of the analysis reveal that banks are more cautious despite increasing risks and uncertainties both in the United States and abroad. There is an inverse relationship between inflation and increases in the VIX index and systemic risks. On the other hand, it has been determined that expansionary monetary policies, deposit interest rates, and sovereign credit risk are significant sources of instability in the banking sector. Second, we analyse the effects of selected institutional and macroeconomic variables on market risks. Although capital adequacy did not have any significant effect on BETA, it was determined that bank profitability, leverage ratios, income-expense ratios, and liquidity ratios increased market risks. In contrast, positive developments in bank size and asset ratio have an inverse relationship with banking sector market risks. When we analysed the effects of macroeconomic drivers on market risks, we observed positive changes in economic growth and exchange rates that reduced market risks. Similarly, the effects of global market uncertainties on Turkish banks' market risks are negative. The results show that expansionary monetary policies, inflation, deposit rates, and CDS spreads contributed to increased market risk. Third, we estimate the econometric relationship between bank returns and explanatory variables. The findings indicate that capital adequacy, profitability, asset quality, and liquidity ratios contribute to an increase in equity returns and thus individual risk. However, leverage and income-expense ratios have reduced banking returns. The effects of the VIX index, GDP, and CDS spreads on banking returns are negative, whereas the effects of deposit interest and real effective exchange rate on the dependent variable are positive. The effects of inflation on stock returns are mixed.

The results contain helpful recommendations for researchers, market participants, and politicians. These findings can help policymakers shape macroprudential and monetary policies and make fine-grained adjustments. Policymakers can evaluate the effects of their policies on banking sector risks. It can also help bank managers adjust to macroeconomic changes that affect their institutions' risks. Bank managers who evaluate results can reduce risks and increase investor interest in stocks by adjusting financial ratios. Conversely, they can avoid regulations that increase the likelihood of default. Agents who invest in bank assets can adjust their portfolios by observing the effects of macroeconomic and financial ratios on stock returns. Market participants and researchers can anticipate defaults and financial instability using selected macroeconomic and institutional variables. These results are important to demonstrate institutional soundness, financial performance strength, and the extent to which Turkish banks are effective in performing their financial intermediary roles. The findings demonstrate that the SRISK index is more effective than LRMES in representing systemic risks. These results show that sustainable economic growth and stable foreign exchange markets play critical roles in the banking sector and financial stability. Moreover, it has been revealed that increasing uncertainties in global markets encourage Turkish banks to not engage in risky behaviour.

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RESEARCH ARTICLE

Panel Data Analysis of Export Structure and Growth: Case of BRICS-T Countries*

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ABSTRACT

Realisation of specialisation in areas dominated by technological production structure and the technological level of exported goods are essential determinants of macroeconomic performance. Therefore, the export structure and technological level of exported goods are highly significant. In this study, the relationship between real GDP and exports of goods produced in BRICS-T countries with low, medium, and high levels of skill and technology is investigated. In the panel data analysis using data for the period 1995–2020, the cointegration relationship between the variables was examined, and it was concluded that there is no long-run relationship between real GDP and goods produced in labour-resource intensive, low, medium, and high skill and technology levels of countries. In addition, a causality test using Dumitrescu and Hurlin's (2012) linear heterogeneous model was carried out. The test results showed a unidirectional causality relationship between real GDP and goods with low and high skill and technology but a bidirectional causality relationship between real GDP and labour-resource-intensive goods.

Keywords: Export structure, Exports, Real GDP, Technological level, BRICS-T

JEL Classification: E60, F10, O50

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1. Introduction

Exports have an influence on macroeconomic performance as a part of economic growth and are typically linked to a number of ideas, including access to international markets, processing of goods to satisfy international consumers' tastes, and development of new networks (Hu and Tan, 2015). Export growth raises national income by enabling the repayment of foreign debt and more effective use of resources. Moreover, exports support imports, which boost the national economy. Developing or developing countries can obtain the latest technologies or ideas through exports that they cannot obtain through their own means (Gylfason, 1997). Moreover, higher export revenue raises imports of intermediate goods, which in turn raises production levels (Awokuse, 2007).

The export structure includes the distribution of goods by commodity groups, including consumption, intermediate goods/raw materials, and investment, as well as changes in market shares by nation, country group, or region. It also considers the distribution of factor use intensity, including labour-intensive, low, medium, or high-technology. On the other hand, it also includes the distribution of goods by industry sectors, including mining, agriculture, food, fuel, and manufacturing. As a result, the export structure can be considered a crucial element in determining the macroeconomic success of a nation.

Thanks to their geographic location and population potential, the BRICS countries are setting the standard for emerging economies internationally and regionally. BRICS has increased its total trade volume and begun to influence global commerce, particularly since the 2000s. BRICS exports, which were over 330 trillion dollars in 1995, rose to 3,494 trillion dollars in 2020, while its imports, which were above 315 trillion dollars, amounted to roughly 2,929 trillion dollars in that year, according to the United Nations UNCTAD data. Furthermore, BRICS exports, which comprised 6.5% of global exports in 1995, increased to approximately 19.8% in 2020. The BRICS countries' share of global imports climbed from 6% to 16.3% within the same period. This shift in foreign trade statistics is a crucial sign of the BRICS' growing influence. Turkey's efficacy in international trade began to shift in the 1980s by adopting the export-oriented industrialisation model. As a result, Turkey's share of global exports climbed from 0.4% in 1995 to 1% in 2020. Correspondingly, its share of global imports has grown from 0.68% in 1995 to 1.2% in 2020. This paper includes panel data analysis to investigate the link between real GDP (LGDP) and exports of labour-resource intensive, low, medium, and high skill and technology goods (Labour/Low/Medium/High) in the foreign trade of BRICS-T countries from 1995 to 2020.

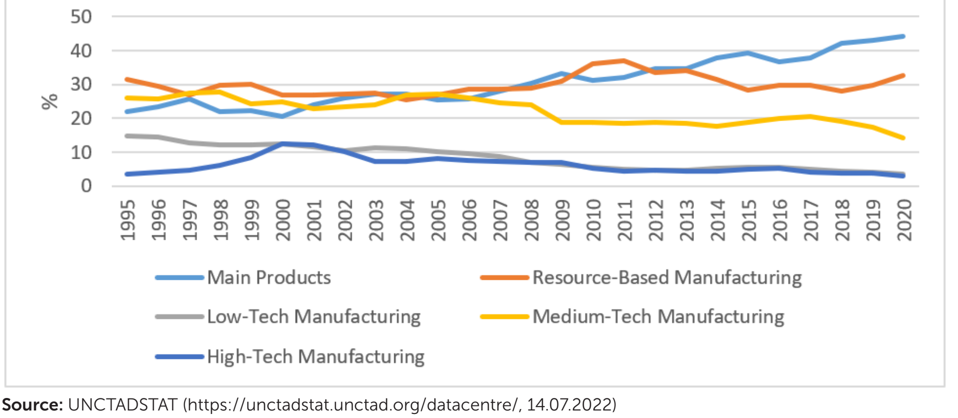
2. Export Structure in the BRICS-T Countries

Investors have greater investment potential in developing nations than in developed nations. In this regard, developing nations are undergoing rapid economic expansion. Similarly, the term BRICS is made up of the initials of several nations that are rapidly developing, including Brazil, Russia, India, China, and South Africa. Jim O'Neill, the head economist at Goldman Sachs, first mentioned BRIC in 2001, referring to Brazil, Russia, India, and China (O'Neill, 2001). Features like rapid population growth and high growth rates unite BRIC nations. In 2010, South Africa, a distinct and emerging market, joined the BRICS, making it the BRICS (Khan, Barua & Bhuiya, 2015). Each BRICS nation has a crucial industry-leading or dominating world market. The BRICS countries are characterised by Brazil's dominant position in agricultural production, Russia's richness in mining or subsurface resources, India's low-cost intellectual capital, China's low-cost labour resources, and South Africa's abundant natural resources. South Africa, Brazil, and Russia are raw material suppliers because of their great potential, whereas India and China are suppliers of labour-intensive commodities, manufactured goods, and consumer goods (Chychkalo-Kondratska, Bezrukova & Svichkar, 2017).

Macroeconomic performance during the phase of economic growth is determined mainly by the realisation of specialisation in fields dominated by technological production structures and the technological level of exported products. Specific categories are used to classify the level of technology of exported goods while examining the relevant literature. Lall (2000) was the first to identify the technological level of exported commodities as primary-finished items made up of raw materials like meat, fresh fruit, cocoa, rice, tea, coffee, coal, timber, and crude oil. These goods are divided into resource-based, low, medium, and high-technology categories.

This study examines the export structures of the BRICS-T nations in terms of the technology of the exported items. As noted in Figure 1, a significant portion of Brazil's exports are commodities with primary and resource-based technology levels. When the relevant years are considered, the proportion of primary items climbed from roughly 21% of exports in 1995 to 45% in 2020. Nevertheless, exports of goods manufactured with low technology fell from 14% to 3%, and those manufactured with medium technology fell from 26% to 14%. In addition, the number of products manufactured using high technology has decreased, notably since 2000.

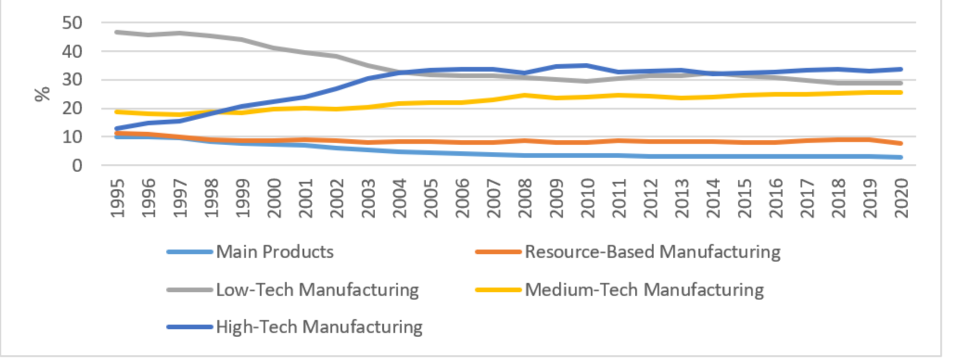
Figure 1: Technological Structure of Exports in Brazil



Source: UNCTADSTAT (https://unctadstat.unctad.org/datacentre/, 14.07.2022)

Particularly after the 2000s, the importance of high-tech products stands out in China's export structure. Approximately 13% of exports were high-tech products in 1995; by 2020, that percentage was expected to rise to 34%. The weight of resource-based, primary, and low-tech commodities in exports has consistently declined over the years under study. On the other hand, although after the 2000s, exports of medium-tech goods did not grow significantly in proportion, there is still an upward trend.

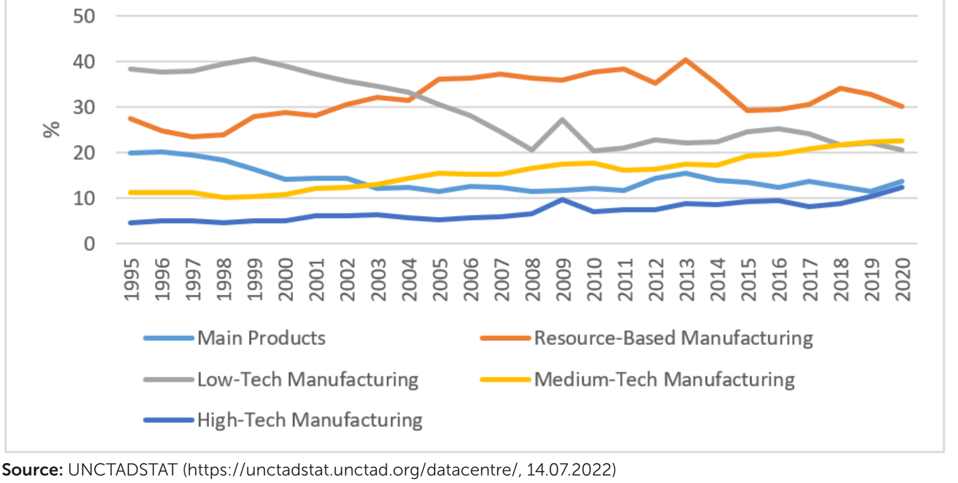
Figure 2: Technological Structure of Exports in China



Source: UNCTADSTAT (https://unctadstat.unctad.org/datacentre/, 14.07.2022)

Since the mid-2000s, goods based on natural resources have dominated the technological structure of India's exports. Although the share of low-tech exports has decreased over time, they still constitute more than 20% of all exports. Conversely, exports of goods with medium technology sophistication have increased over time and now constitute more than 20% of total exports. On the other hand, despite a tendency to expand over time, high-tech goods still make up a minor portion of overall exports.

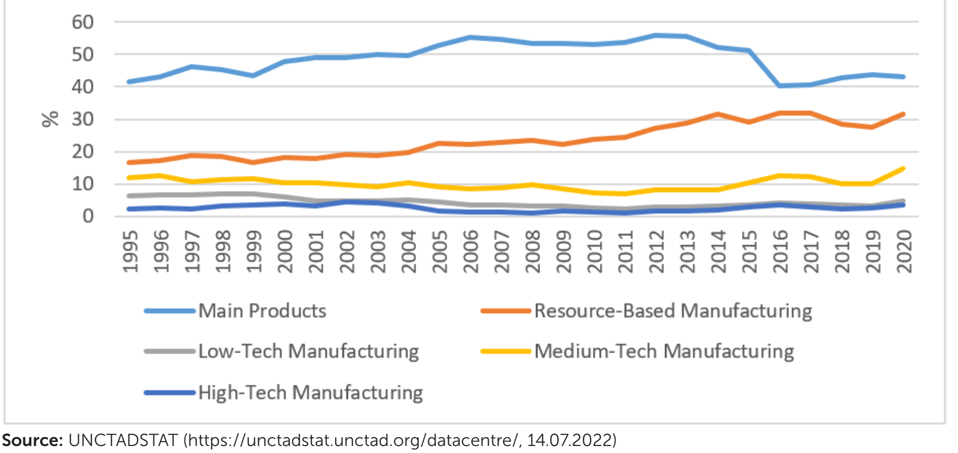
Figure 3: Technological Structure of Exports in India



Source: UNCTADSTAT (https://unctadstat.unctad.org/datacentre/, 14.07.2022)

Primary and resource-based products dominate the technological structure of Russian exports. Nevertheless, the weight of low-, medium-, and high-tech goods also tends to increase over the years. However, these commodities constitute a smaller percentage of exports.

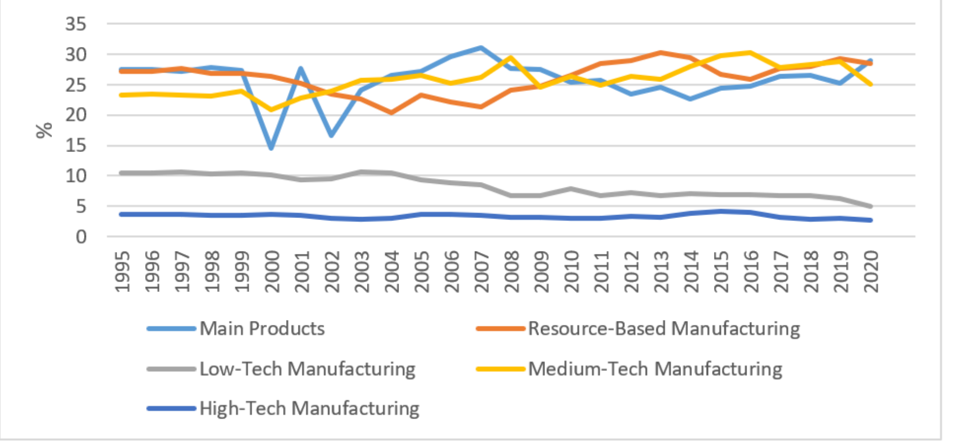
Figure 4: Technological Structure of Russian Exports



Source: UNCTADSTAT (https://unctadstat.unctad.org/datacentre/, 14.07.2022)

Notably, the percentage of low- and high-tech products in South Africa's exports has declined and remained deficient. However, the share of primary goods based on export resources has usually increased in recent years. On the other hand, since the 2000s, the percentage of medium-tech goods in exports has expanded, accounting for approximately 30% of exports in 2015. However, it has decreased to approximately 25% in recent years.

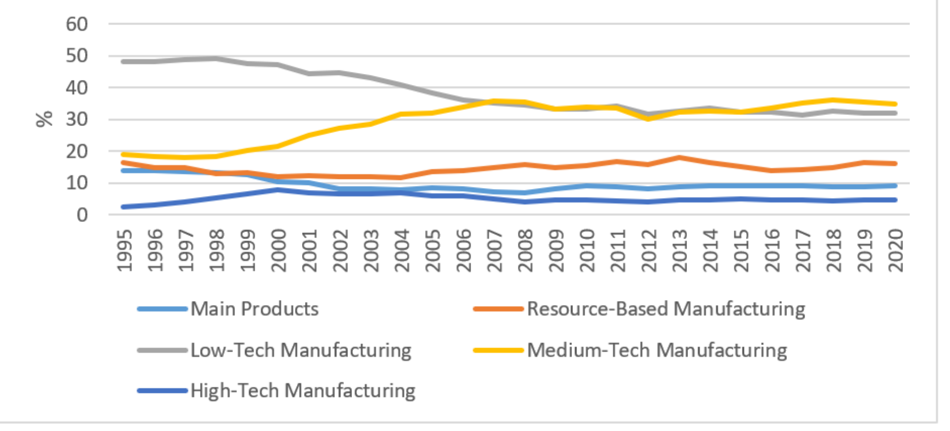
Figure 5: Technological Structure of Exports in South Africa



Source: UNCTADSTAT (https://unctadstat.unctad.org/datacentre/, 14.07.2022)

During the study period, Turkey's technological composition of exports showed a notable tendency for a decline in the percentage of low-tech goods exports. In contrast, the percentage of goods produced using medium technology is rising. As a result, the percentage of low-tech goods, which comprised approximately 48% of exports in 1995, fell to approximately 35% in 2020. The percentage of primary and resource-based products has risen since the mid-2000s. Moreover, exports of high-tech goods rose significantly relative to total exports near 2000, reaching 7.8%. It was, however, realised at a deficient level and began to decrease in the following years.

Figure 6: Technological Structure of Exports in Turkey



Source: UNCTADSTAT (https://unctadstat.unctad.org/datacentre/, 14.07.2022)

3. Literature Review

Empirical literature on economic growth and export structure mainly examines the relationship between export diversification, product concentration in exports, product sophistication, or technological structure of exports and growth.

Using data from 1960–1980 and the augmented production function, Fosu (1990) investigated the link between primary and manufactured export goods and growth in less developed countries. The study concluded that primary export goods have little effect on GDP growth, but the manufacturing sector positively affects growth.

Based on data from 1989 to 1991, Mayer and Wood (2001) compared and assessed the export structures of 111 nations from various continents, including South Africa. The study indicates that nations with higher skill levels per worker are more likely to export a larger proportion of their primary goods. Whereas East Asia prioritizes skill-intensive production, South Asia focuses on labor-intensive production.

Using data from 1993 to 2000, Funke and Ruhwedel (2003) investigated the link between export diversification and GDP per capita in 14 Eastern European transition economies. This study finds that high export diversification explains GDP per capita.

Gertler (2006) examined the link between export structure and growth in 22 European Union member countries for 1995-2004 within the framework of the Heckscher-Ohlin model and found a high correlation between the two variables. Guerson, Parks, and Torrado (2007) divided Argentina's exporting nations into two groups and used data for the 1994–2004 and 1960–2004 periods to examine the link between export structure and GDP per capita. According to the study, export structure significantly affects growth.

Hesse (2008) investigated the link between export diversification and growth in GDP per capita for 99 countries using data from 1961 to 2000 using the panel data method. According to the findings, export diversification is crucial for these countries' economic progress and increases GDP per capita.

Sun and Heshmati (2010) used the panel data approach to evaluate the link between trade structure and growth for 31 Chinese provinces from 2002 to 2007. This study confirms that China's trade volume and high-tech trade structure favourably affect its regional productivity.

Basu and Das (2011) used data from 1995–2007 and a nonparametric technique to evaluate the relationship between export structure and growth in 88 developing nations. According to the study, there is a strong link between growth and the export of goods with advanced technology and skill levels.

Lee (2011) performed a cross-country regression analysis for 1970–2004 to quantify the link between export specialisation and growth for 71 countries. According to the study, countries specialising more in exporting high-technology commodities than traditional or low-technology goods typically experience faster economic growth.

Jarreau and Poncet (2012) examined the link between economic performance and export sophistication in Chinese provinces using data from 1997 to 2009 using the panel regression method. According to the study, areas that focus on more complex products experience faster growth.

Aditya and Acharyya (2013) conducted a cross-country analysis of 65 countries using data from 1965 to 2005. Using the dynamic panel approach, this study examines the link between export specialisation and diversity in terms of growth. These results indicate that export specialisation and diversity boost growth.

Kadochnikov and Fedyunina (2013) used data from 2000 to 2008 to apply a simple linear cross-section model to examine the link between export structure and growth in Russia. The findings of this study indicate that diversifying exports is good for economic growth.

Using data from 1995–2010, Altunç and Aydın (2015) used a nonparametric method to investigate the link between export structure and growth for 11 G-20 countries. According to the study, exports of goods with high skill and technology levels are strongly correlated with growth.

Gözgör and Can (2017) examined the link between export product diversification, economic globalisation, and economic growth for 139 countries using data from 1970 to 2010. Cross-country panel data research reveals a link between growth and the diversity of export products. Moreover, it has been found through several robustness tests that export diversification is only positively related to growth in upper-middle economies.

Demir (2018) analysed the relationship between the sectoral structure of exports, technology diversification, and the technological structure of exports with growth in 34 upper-middle-income countries from 1995 to 2015 using the dynamic panel data method. According to the findings, high-tech goods have a major impact on growth, medium-tech goods have limited effects, and low-tech goods have a negative long-term impact.

Erdil Sahin (2019) analysed the link between high-tech exports and Turkey's growth for 1989-2017 by applying VAR analysis and the Granger causality test. According to the study, there is a significant causal link between the export of high-tech goods and growth.

Lazarov (2019) used the Granger causality test and VAR analysis to assess the link between export sophistication and growth in Macedonia from 1995 to 2017. This study finds a strong and statistically significant causal link between export sophistication and growth.

Belkania (2020) analysed the effect of export commodity structure on growth in 11 transition economies from 1997 to 2017 using the panel data method. These findings indicate a significant relationship between the commodity composition of exports and growth.

Dündar (2020) used a nonparametric approach to investigate the link between macroeconomic performance and export structure for the BRICS-T countries from 1995 to 2017. This research highlights a significant relationship between export technology level and macroeconomic performance. In addition, for most countries subject to the analysis, exporting medium-tech goods had a more significant positive impact on GDP per capita.

Akbulut Yıldız and Adıyaman (2021) applied panel data analysis to investigate the relationship between growth and high-tech exports for upper-middle-income nations from 1996 to 2017. The research finds that high-tech goods significantly and positively affect growth in the countries considered.

Considering the related literature, there is a high correlation between export diversity, product sophistication, export structure, and macroeconomic performance. In addition, the technological level of exported items as an export structure generally has a favourable impact on both export level and macroeconomic performance. Unlike previous research, this study uses panel data analysis to assess the link between export structure and growth for BRICS-T countries, focussing on labour-intensive, low-, medium-, and high-tech goods exports.

4. Data and Model Used in the Study

This study uses the panel data approach to investigate the link between the gross domestic product (GDP) of BRICS-T countries and labour-resource intensive, low-, medium-, and high-tech export goods. In this study, the annual series of gross domestic product (GDP) and total exports consisting of labour-resource intensive export goods (Labour), low, medium, and high-skill and technology-intensive export goods (Low/Medium/High) obtained from the World Bank and United Nations UNCTAD database for 1995–2020 were used. Table 1 lists all the series used in the model. Due to the limited data for all variables for the BRICS-T countries before 1995, the analysis began in 1995. On the other hand, the fact that the BRICS countries, which comprise approximately 20% of the world GDP, have a high global economic weight and are located in different continents of the world together with Turkey in the context of global representation has been influential in the selection of this sample group.

The analysis uses the GDP logarithm. The Labour/Low/Medium/High variables used to represent the export structure are included as independent factors in the model, whereas the LGDP variable reflecting growth is the dependent variable. The study's developed model is presented below.

$$LGDP_{it} = B_{0it} + B_{1it}Labor_{it} + B_{2it}Low_{it} + B_{3it}Medium_{it} + B_{4it}High_{it} + \varepsilon_{it} \quad (1)$$

Table 1: Abbreviation, Variable and Data Sources

Abbreviation	**Variable**	**Data Source**
LGDP	GDP (Constant $ Prices)	World Bank Indicators
Labour	Percentage of Labour and Resource-Intensive Export Goods in Exports	UNCTADSTAT
Low	Percentage of Low-Skill and Technology-Intensive Export Goods	UNCTADSTAT
Medium	Percentage of Medium Skill and Technology Intensive Export Goods	UNCTADSTAT
High	Percentage of High-Skill and Technology-Intensive Export Goods	UNCTADSTAT

Note: *Stata 15 and Eviews package programmes were used in this study.

5. Methodology

Panel data consists of several cross-sectional units (individuals, households, firms, states, and countries) observed over time (Carter Hill, Griffiths & Lim, 2011). Panel data analysis allows for modelling differences between units, revealing dynamic relationships, and using both time and cross-sectional observations. Moreover, panel data enable the generation of more observations, a greater degree of freedom, and a weakening of the linear relationship between explanatory factors, all of which improve the accuracy of econometric estimations (Taş, 2012). These factors influenced how the panel data approach was applied in the study on the link between the gross domestic product and export structure of the BRICS-T countries for 1995-2020. Several presumptions must be verified before conducting panel data analysis. First, unit root tests for each series should be run. When choosing the unit root test to be applied to the series whose stationary value will be determined, cross-section dependence is crucial. If the time dimension of the dataset is larger than the cross-sectional dimension (T>N), the Lagrange Multiplier (LM) test developed by Breusch and Pagan (1980) can be used to analyse the cross-sectional dependency between variables. Breusch and Pagan (1980) employed the Lagrange Multiplier (LM) test statistic to determine whether cross-sectional dependence exists.

$$\mathrm{LM} = \mathrm{T} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \acute{\rho}^2 ij \tag{2}$$

The symbol $\acute{\rho}^2 ij$ in Equation 2 represents the sample estimate of the pairwise correlation of the residuals.
The following hypotheses are evaluated to determine if there is a dependency between the cross-sections:

H_0: The panel shows no cross − section dependency.

H_1: The panel shows cross − section dependency.

The Swamy S test assesses whether the slope coefficients are homogenous, and the results are used to determine the causality tests. (Tatoğlu, 2020). The parameters are homogeneous according to the test hypothesis H0=β1=β. Equation 3 shows the Swamy S test.

$$\hat{S} = X_{k(N-1)^2} = \sum_{i=1}^{N}(\widehat{\beta\tau} - \overline{\beta})' \,\hat{V}i^{-1}\, (\widehat{\beta\tau} - \overline{\beta} \tag{3}$$

Pesaran and Yamagata (2008) extended Swamy's test as the delta (Δ) test. These tests' hypotheses are as follows:

H_0: $\beta i = \beta$ Homogeneity exists in the slope coefficients.

H_1: $\beta \neq \beta j$ Homogeneity does not exist in the slope coefficients.

Pesaran and Yamagata (2008) established the delta and adjusted delta test statistics for equations (4) and (5) to verify the hypotheses mentioned above (Pesaran and Yamagata, 2008).

$$\hat{\Delta} = \sqrt{N}\left(\frac{N^{-1}\hat{S} - k}{\sqrt{2k}}\right) \tag{4}$$

$$\hat{\Delta}_{adj} = \sqrt{N}\left(\frac{N^{-1}\hat{S} - E(\hat{Z}_{it})}{\sqrt{Var(\hat{Z}_{it})}}\right) \tag{5}$$

Pesaran (2007) provides a simple way to eliminate inter-unit correlation. He conducted a Cross-Sectionally Augmented Dickey-Fuller (CADF) unit root test by combining the Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) regression with the cross-sectional averages of the lagged levels and initial differences of individual series. The Im, Pesaran and Shin (IPS) (2003) test's extended cross-section variant, known as the CIPS statistic, is the average of the CADF statistic in equations 6 or 7 (Tatoğlu, 2020).

$$CIPS\ (N,T) = t - bar = \frac{1}{N}\sum_{i=1}^{N} t_i\ (N,T) \tag{6}$$

$$CIPS\ (N,T) = N^{-1}\sum_{i=1}^{N} CADF_i \tag{7}$$

Panel co-integration tests in panel data analysis can be used to determine whether two nonstationary variables have a long-term relationship. Moreover, second-generation unit root tests are used in cases with an inter-unit correlation, whereas first-generation unit root tests are used in cases without. Gengenbach, Urbain, and Westerlund (2016) developed a panel cointegration test based on error correction using a standard factor structure considering cross-unit correlation, unbalanced panels, and various lag times between units. The error correction model in equation 8 is the basis for this series' second-generation panel co-integration test (Tatoğlu, 2020):

$$\Delta_{yi} = d\delta_{y.xi} + \alpha_{yi}y_{i,-1} + \omega_{i,-1}\gamma_i + \vartheta_i\pi_i + \varepsilon_{y.xi} = \alpha_{yi}y_{i,-1} + g_i^{d}\lambda_i + \varepsilon_{y.xi} \tag{8}$$

Hypotheses of the test:

H_0: No cointegration relationship exists

H_1: Cointegration relationship exists

Dumitrescu-Hurlin (2012) tests Granger causality against two opposing hypotheses.

H_0 = No Granger causality exists between Y and X

H_1 = Granger causality from Y to X exists

Dumitrescu-Hurlin (2012) developed the panel $Wald\ (W_{N,T}^{Hnc})$ statistic to test these hypotheses.

$$\text{Wald}\ (W_{N,T}^{Hnc}) = \frac{1}{N}\sum_{i=1}^{N} W_{i,T} \tag{9}$$

If the cross-sectional dimension is smaller than the time dimension (N<T), Dumitrescu-Hurlin (2012) found Znhc $(Z_{N,T}^{Hnc})$ statistics with an asymptotic distribution, and Ztild (Z_{N}^{Hnc}) statistics with a semi-asymptotic distribution when the time dimension is smaller than cross-sectional dimension (N>T). The following equations provide the statistical calculations for these tests.

$$(Z_{N,T}^{Hnc}) = \sqrt{\frac{N}{2K}\left(W_{N,T}^{Hnc} - K\right)} \tag{10}$$

$$(Z_{N}^{Hnc}) = \frac{\sqrt{N}\,\left[W_{N,T}^{Hnc} - N^{-1}\sum_{i=1}^{N} E(W_{i,T})\right]}{\sqrt{N^{-1}\sum_{i=1}^{N} Var(W_{i,T})}} \xrightarrow[N,T\to\infty]{d} N(0,1) \tag{11}$$

6. Findings

Obviously, the dataset used in this research has a time dimension (T=26) that is larger than a cross-sectional dimension (N=6). According to Table 2, when the Breusch-Pagan LM (1980) test results for the established model are assessed, the probability value is less than 5%. Therefore, the panel does not support the H_0 hypothesis, which states no cross-sectional dependency.

Table 2: Testing the Model's Cross-Section Dependence

Test	Statistic
LM	32.37 *

Note: * indicates significance at the 1% level

Second-generation tests were used for unit root tests because the probability value was less than 5% when the test results for the variables were examined separately.

Table 3: Testing for Cross-Sectional Dependence on Variables

Test	Statistic
LGDP	368.7579*
Labour	286.7993*
Low	72.13110*
Medium	143.6862*
High	63.24524*

Note: * indicates significance at the 1% level

The next step tests parameter homogeneity using the Delta and Delta Adj. tests of Pesaran and Yamagata (2008). Because the parameters are heterogeneous, the null hypothesis H_0, which claims that the model is homogeneous, is rejected.

Table 4: Homogeneity Test

Test	Statistic
Delta	11.272 *
Delta adj.	12.852 *

Note: * indicates significance at the 1% level

Verifying the series' stationarity before conducting panel data analysis is essential. If it is determined that the variables are not stationary, their differences should be used to make them stationary. To establish the stationarity of the series in this direction, the Im, Pesaran, and Shin (CIPS) Panel Unit Root Test, a second-generation first-group panel unit root test, was applied. The findings of the unit root tests conducted on the constant and constant trend models in the Im, Pesaran, and Shin (CIPS) panel are presented in Table 5.

Table 5: Im, Pesaran and Shin (CIPS) Panel Unit Root Test

	Constant	Constant+Trend
LGDP	-1.698	-1.417
Labour	-1.597	-2.170
Low	-1.502	-2.286
Medium	-1.648	-2.087
High	-1.998	-2.708
ΔLGDP	-2.767*	-2.910**
ΔLabor	-4.420*	-4.579*
ΔLow	-4.800*	-5.093*
ΔMedium	-4.375*	-4.467*
ΔHigh	-4.071*	-4.214*

Note: * and ** indicate significance at the 1% and 5% levels respectively.

When the stationarity of the series is tested for the level values of the LGDP, Labour, Low, Medium, and High variables, it can be said that the CIPS test statistics are non-stationary because they are smaller in absolute value than the critical values specified at 90% , 95%, and 99% confidence levels in the constant and constant + trend models. When the differences are considered, it becomes clear that the CIPS test statistic is stationary because its absolute value is more extensive than all the critical values in both models.

Table 6: Gengenbach, Urbain, and Westerlund Panel Co-integration Test

	d.y	Coef	T-bar	P-value*
Labour	y(t-1)	-0.308	-2.211	>0.1
Low	y(t-1)	-0.229	-1.425	>0.1
Medium	y(t-1)	-0.246	-1.626	>0.1
High	y(t-1)	-0.209	-1.756	>0.1

Given the panel cointegration test's significance of y(t-1) and the p-value of more than 0.1, the null hypothesis H0-that there is no long-run link between the LGDP and the labour, low, medium, and high variables cannot be rejected. The homogeneity test result reveals that the panel is heterogeneous. Hence, a heterogeneous panel causality analysis needs to be performed. Dumitrescu and Hurlin (2012) conducted a causality test in this situation using the linear heterogeneous model. This study uses the Z-bar test statistic based on the asymptotic distribution results because the time dimension is larger than the unit dimension. As the probability value is less than 5%, the test results in Table 7 show a bidirectional causal relationship between the BRICS-T countries' exports of labour-intensive goods and the LGDP variable. Additionally, a unidirectional causality relationship is found between the LGDP variable and the Low and High variables, which reflect export goods with low and high technology.

Table 7: Dumitrescu-Hurlin (2012) Causality Test

	Z-bar	Z-bar Tilde
LGDP ⇏ Labour	5.7911*	4.2998*
Labour ⇏ LGDP	3.8195*	1.3621
LGDP ⇏ Low	7.6655*	1.6530***
Low ⇏ LGDP	1.3991	1.0150
LGDP ⇏ Medium	-0.7154	-0.7488
Medium ⇏ LGDP	-0.4837	-0.5555
LGDP ⇏ High	7.8542*	1.7092***
High ⇏ LGDP	0.5974	0.3463

Note: * and *** indicate significance at the 1% and 10% levels respectively.

7. Conclusions and Recommendations

Various advantages exist for developing countries, including abundant natural resources, rapid population growth, cheaper labour, and great potential for profit for investors. Using these advantages, developing countries close the gap with advanced economies by increasing their exports. The technological structure of exports, which refers to the distribution of exported goods based on the intensity of factor use, such as labour-resource intensive, low, medium, or high technology, comes to the fore at this point because it is significant to the level of macroeconomic performance. As of 2020, the BRICS nations, which comprise more than 40% of the global population and represent over 19.8% of global exports and 16% of global imports, as well as Turkey, were included in the analysis because of their common characteristics. In this study, panel data analysis is used to examine the relationship between real GDP (LGDP) and exports of goods that are labour-resource intensive, low, medium, and high skill and technology goods (Labour/Low/Medium/High) subject to the foreign trade of BRICS-T countries using data for 1995–2020. The study results show that the labour and LGDP variables have a bidirectional causal link. Moreover, it is observed that there is a unidirectional causal link between the LGDP variable and the Low and High variables, which represent export goods with low and high technology.

By considering the results of the panel analysis as a whole, the following conclusions may be drawn: i) The level of national GDP and the technological capabilities of export goods are strongly correlated. ii) An increase or decrease in the economic growth of BRICS-T countries will change the share of labour-resource-intensive export goods. iii) An increase or decrease in the labour-resource-intensive export goods of BRICS-T countries will have a similar effect on the growth of these countries. iv) Changes in the level of national income may affect total exports and accordingly determine the share of labour-resource intensive, low, and high-technology export goods.

The study's findings are consistent with studies by Kunst and Marin (1989), Henriques and Sadorsky (1996), where the export-led export approach is valid, and Awokuse (2003) and Kwan and Kwok (1995), where the growth-led export strategy is correct. Therefore, implementing policies towards high growth targets in BRICS-T countries will increase their export levels. Accordingly, implementing measures that would boost BRICS-T countries' export levels will enhance their growth performance.

The technological structure of exports from all countries, except China, is similar when the BRICS-T countries are examined. These countries' production structures are likely to be dominated by primary, resource-based, and low-tech goods, and their infrastructure is insufficient to manufacture high-tech goods. To demonstrate stronger growth performances at this point, the BRICS-T countries must try to increase their export structure in terms of technology, sector, product, or market. In this context, they should change their production structure to a high tone with more value added. In addition to the variables included in the analysis within the scope of this study, it is worthwhile to examine the variables that affect the structure of exports by commodity or sector groups. These factors include unit labour costs and product diversity in exports, which include exporting firms or sectors and are primarily based on micro Fundamentals. Similar analyses can also be conducted for other developing countries or country groups.

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RESEARCH ARTICLE

Contribution of Finance and Transport Indicators on Carbon Emissions: Evidence from Eurasian Countries

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ABSTRACT

Carbon emission is one of the most significant causes of environmental degradation, global warming, and extraordinary meteorological events. It has reached a level that threatens the future of countries and human beings. To combat carbon emission, it is necessary to know the causes for developing policies. Environmental quality is a fundamental aspect of sustainable development in economies worldwide. In this context, Eurasian geography has always been an important region in the history of the world with its location, underground, and surface resources. Today, the region makes its strategic importance even more evident. The communist USSR ruled Eurasian countries, which served as a buffer between the Western world and China for many years. These countries, which gained their independence in the 1990s, have not yet fully captured the values of the modern world, such as democracy and a free market economy. This study focuses on Eurasian countries. This study aimed to determine the factors affecting carbon emissions. Foreign direct investment and transportation contribute significantly to carbon emission, which reduces environmental quality. Therefore, in this study, we investigated whether rail and road passenger transport and foreign direct investment affect carbon emission in Eurasian countries. The concurrent panel quantile regression method was used to estimate this relationship between 1992 and 2020. The results revealed that rail and road passenger transport and foreign direct investment increase emissions. Additionally, no clear result could be obtained regarding the effect of the GDP per capita variable. To support these findings, analyses were performed using the robust quantile regression method, and strong empirical evidence was obtained, particularly for the impacts of foreign direct investment and rail passenger transport on emissions.

Keywords: Environmental quality, Transportation, Foreign direct investment, Quantile regression

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1. Introduction

The intensive use of fossil resources has brought about significant problems for human beings, the environment, and the world since the Industrial Revolution. Greenhouse gas (GHG) emissions from carbon are the main cause of climate change and many other meteorological events. As Leal and Marques (2022) emphasise, climate change is largely influenced by anthropogenic behaviours, such as the manufacturing of goods and services, energy consumption (ENCO), transportation, and agricultural activities. Extreme environmental and meteorological events caused by climate change have reached dimensions that threaten the future of humanity and our planet. According to the Global Risks Report 2022 by the World Economic Forum (2022), three potentially most serious global risks relate to environmental factors for the next decade: extreme weather, climate action failure, and loss of biodiversity.

This study provides empirical evidence of the effect of foreign direct investment (FDI) inflows and rail (RAILpt) and road (ROADpt) passenger transport on carbon emission (COEm) in Eurasia. The results are anticipated to have considerable policy implications for decision makers in the struggle against climate change. In this sense, the link between FDIs and the environment was examined within the structure of two reverse hypotheses. The initial hypothesis is the Pollution Haven Hypothesis (PHav), which posits that multinational companies in industrial economies tend to relocate heavy pollution industries in their economies to emerging economies. Environmental rules and regulations are less feasible to comply with in these developed economies because of carbon taxes and higher operational costs. Owing to growing economic activity, FDIs boost economic activity and ENCO. Therefore, pollution-intensive industries utilising outdated and unfriendly technologies that have been relocated through FDIs significantly boost GHG emissions and, thus, environmental destruction in these economies (Cil, 2022; Wang and Luo, 2022; Musah et al, 2022; Apergis, Pinar and Unlu, 2022; Chaudhry et al, 2022; Bashir, 2022; Akram et al, 2022a; Firoj et al, 2023; Bulut et al, 2022). However, in addition to poor environmental protections in developing countries, an abundance of natural resources, inexpensive labour, and low tax rates (Handoyo et al., 2022; Pavel, Tepperova and Arltova, 2021) are also attractive factors for FDI. The other hypothesis is the Pollution Halo Hypothesis (PHal), which argues that foreign companies, particularly those from industrialised economies, bring advanced, cleaner technologies and new management techniques that can improve the environmental quality of the host country (Liu et al., 2022; Gao et al., 2022; Caetano et al., 2022; Polloni-Silva et al., 2021; Xu et al., 2021a; Duan and Jiang, 2021; Bandyopadhyay and Rej, 2021). Therefore, FDIs also reduce environmental pollution and improve environmental quality in host countries. Tayyar (2022) draw attention to the fact that the management expertise, efficiency of energy, and environmental practices of organizations established in the host economy by FDIs can be followed as examples and implemented by domestic corporations. Practices arising from such foreign capital inflows may thus have spillover effects and improve environmental quality.

Since the Industrial Revolution and with globalization, transportation has played an increasingly prominent social and economic role by connecting people to each other and to goods and services. Global transport services have seen significant increases in both passenger and freight transport, particularly given overall economic growth and increased international trade (Godil et al., 2020). Various activities that impact the economy, such as large-scale improvements in transport infrastructure, heavy vehicular traffic, population increases, and economic development, have boosted the demand for means of transport, posing a serious threat to the long-term environmental outlook. For example, the construction of highways, railways, airports, and ports requires vast resources, such as land, energy, and technology, also involving industrialization, urbanization, and economic externalities that directly or indirectly decrease green spaces and increase GHG emissions. Eventually, the quality of the environment deteriorates over time (Khan et al. 2021b). The transportation industry is a significant source of COEm, accounting for approximately 25% of the total emissions (IPPC, 2018; Eurostat, 2020; Seum, Ehrenberger and Pregger, 2020; Sohail et al., 2021; Churchill et al., 2021). According to 2018 data, global COEm from transportation ran up to 8 billion tonnes, corresponding to approximately 24% of total energy-related emissions (IEA, 2019a). Due to the lack of effective reduction strategies, COEm from the global transportation industry is projected to increase by 60% by 2050 (ITF, 2019). An analysis of energy usage revealed that highway and rail transportation emit a significant amount of COEm (Heinold, 2020), and transportation-related COEm are projected to continue rising owing to ENCO. Passenger and freight transport, as its two subsectors, have many similarities and important differences. Both passenger and freight turnover and COEm tend to follow economic growth patterns (Hussain, Khan and Xia, 2022). In addition, road transport-related ENCO introduces high-density emissions and exceeds rail and water transport-related emissions (Lin, Luo and Yang, 2019). Likewise, consumption demands related to private automobile use also increase with road infrastructure development and rising income levels. Rising numbers of vehicles increase ENCO and create traffic problems in cities. Traffic problems and exhaust emissions are interrelated, as heavy traffic increases ENCO by increasing travel times (Shi et al., 2018; Lu et al., 2021). Meanwhile, rail transport is the principal means of conveyance between places such as cities, provinces, and countries. It has the distinction of larger freight capacity, lower ENCO, and greater safety and comfort, making it more efficient and inexpensive than long-haul road transport. In recent years, high-speed rail systems have developed rapidly. Aside from lower ENCO and operating costs, it offers incomparable advantages in terms of transport efficiency, safety, timeliness, and convenience, drastically changing the travel landscape while also replacing road traffic to a certain extent (Li and Luo, 2020). Rail transport has significantly streamlined economic activities and social interactions while adding timeliness and reliability to transport systems (Rodrigue, Comtois and Slack, 2020).

In line with the theoretical background, this study empirically scrutinises the impacts of FDI inflows and rail and road passenger transport on COEm through a sample of eight Eurasian countries. It was designed within the framework of the following research questions:

Research Question 1: Do FDIs affect COEm?

Research Question 2: Does rail passenger transport affect COEm?

Research Question 3: Does road passenger transport impact COEm?

Research Question 4: Does GDP per capita impact COEm?

This study is important in the context of Eurasian countries for several reasons. First, Eurasian geography has occupied a strategic position throughout history, as it is at the intersection of Eastern and Western civilisations and religions. The region's strategic and geo-political importance is expressed in Mackinder's Heartland Theory (1904), which argued that whoever controlled Eastern Europe—the "Heartland"—controlled the world, as well as in Brzezinski's (1998) work describing Eurasia as the centre of world power. Second, the region attracts the attention of countries and businesses in terms of investment and cooperation opportunities because of its underground and surface treasures. For instance, the World Bank (2014) data states that Eurasia is home to the greatest fossil energy and mineral ore reserves. Third, as stated by Chen et al. (2019), the region's ecosystem is susceptible to risks related to global climate change and anthropogenic activities. In addition, Xenarios, Gafurov and Schmidt-Vogt (2019) identified Kyrgyzstan and Tajikistan as the most climate-sensitive countries in the former Soviet Union. Batmunkh et al. (2022) drew attention to the recent increase in temperature and humidity in Central Asia. Poberezhskaya and Bychkova (2022) emphasized that climate change adversely affects Kazakhstan's already vulnerable water security. In short, climate change, which is largely caused by COEm, carries significant environmental, economic, and sociological risks. In this direction, All Eurasian countries have become members of the Paris Climate Agreement, which was signed in 2015 and came into force in 2016, aiming to combat climate change and global warming at the global level and imposing certain obligations on the party countries. Kyrgyzstan became the last country in the region to ratify this agreement in 2020. Countries have some tasks to achieve the main goals of a green economy and a sustainable life. One is carbon neutrality. Many countries have initiated a green transformation in their economies to achieve the goal of zero carbon emissions by 2050, and this transition process continues despite significant challenges. Among the Eurasian countries, Russia and Kazakhstan have targeted 2060 for carbon neutrality. To understand and manage these risks, their exact causes must be determined. Therefore, the abovementioned reasons constitute the main motivation for our study to focus on Eurasia.

Developments in Eurasian countries regarding the variables are summarised in the following paragraph. In this context, Figure A1 presented in the Appendix section shows the proportional distribution of energy production in Eurasian countries according to their sources in the period 1992-2020. Energy production from fossil sources is dominant in this group of countries. While the share of fossil resources in energy production was 72% in 1992, this rate decreased to 60% in 2020. On the other hand, the share of nuclear energy in energy production has gradually increased, reaching 18.44% in 2020, which was 12% in 1992. While the share of energy obtained from renewable energy sources (including hydroelectricity) was 15.72% in 1992, this rate will reach around 20.65% in 2020. Although the dominant source of energy production in the Eurasian region is fossil resources (oil, natural gas, coal), the decline seen here has been met by energy production from nuclear and renewable sources.

One of the important issues is capital insufficiency, especially for underdeveloped or developing countries. Owing to a lack of capital, these countries have not been able to complete their economic improvement and development. FDI is seen as an important source of external finance for these countries and is the subject of numerous scientific studies because of its positive/negative contributions to the country's economies. The positive effects of FDI on country economies can emerge through the following channels (Bergougui and Murshed 2023; Serfraz, Qamruzzaman and Karim, 2023; Polloni-Silva et al, 2022; Joo, Shawl and Makine, 2022; Rezk et al., 2022; Vujanović et al., 2022; Dinh et al., 2019). Economic and financial contributions: It can be listed as reducing the volatility in the exchange rate due to the inflow of foreign currency into the country, reducing the balance of payments deficits, increasing employment, increasing exports, reducing imports, increasing tax revenues, increasing productivity, increasing national and international competition, breaking into new markets, and allowing international economic and financial integration. Technological contributions: Enabling technology transfer can be expressed as R&D investments. Managerial and human resource contributions: These include introducing new and updated management processes, providing qualified senior managers, and developing human capital. In this context, the development of FDI inflows is shown in Figure A2 for the period 1992-2021 in Eurasian countries, consisting of underdeveloped and developing countries. As these countries achieved their independence, FDI inflows increased and reached their peak in 2007-2008 ($77 Billion and $100 Billion, respectively). After the 2008 global economic crisis, there was a decrease in FDI inflows, and the average FDI inflows were approximately $51 Billion in the 2009-2021 period. In addition, the first three countries in the total FDI inflows (as a period average) were Russia with 59.76%, Kazakhstan with 20.86%, and Azerbaijan with 8.71%, respectively among the countries of the region.

This study offers various contributions to the literature. First, it addresses a serious gap by shedding light on the Eurasian COEm issue from different disciplines such as economy, finance, and transportation. Second, the simultaneous panel provides non-parametric evidence for the decisive factors of COEm along the conditional distribution using methods such as quantile regression (QR) and robust quantile regression (Robust-QR).

This study examines the subject in the context of the theoretical discussions in the introduction. The second section provides a brief review of the related literature. The third section describes the model and data used in the empirical analysis. Finally, the results and policy implications are discussed.

2. Literature

There is a large body of literature on the decisive factors of COEm analysing individual economies, countries, or country groups. For example, we can cite studies on China (Shahbaz et al., 2022; Zhao et al., 2022; Pan et al., 2022; Fang et al., 2022; Akram et al., 2022a; Ma, Murshed and Khan, 2021; Xu et al., 2021b; Yu and Zhang, 2021; Wu et al., 2021); on the USA (Yang, Shahzadi and Hussain, 2021b; Xiangyu, Jammazi and Aloui, 2021; Sun et al., 2021; Yamaka, Phadkantha and Rakpho, 2021; Dedeoğlu, Koçak and Uucak, 2021); on Turkey (Raihan and Tuspekova, 2022; Yıldırım and Yıldırım, 2021; Akkaya and Hepsag, 2021); on Pakistan (Huang et al., 2022a; Qudrat-Ullah, 2022; Yousaf, Amin and Baloch, 2021); on India (Akadiri and Adebayo, 2022; Dwivedi and Soni, 2022; Kirikkaleli and Adebayo, 2021); on MINT countries (Adebayo et al., 2022; Du et al., 2022;

Akram et al., 2022b; Joof and Isiksal, 2021); on OECD countries (Albulescu, Boatca-Barabas and Diaconescu, 2022; Cao, Khan and Rehman, 2022; Yang et al., 2021a; Cheng et al., 2021; Zaidi, Hussain and Zaman, 2021); on developing countries (Wang et al., 2022; Çakar et al., 2021); on developed countries (Dong et al., 2022; Tufail, Song and Adebayo, 2021; Ponce and Khan, 2021; Doğan et al., 2020); on G20 countries (Huang, Kuldasheva and Bobojanov, 2022b; D'Orazio and Dirks, 2022; Ajide and Ibrahim, 2021; Habiba, Xinbang and Ahmad, 2021); and on the European Union (EU) (Dechezlepretre, Nachtigall and Venmans, 2023; Bekun et al., 2021; Adedoyin, Alola and Bekun, Alola and Gyamfi, 2021; Radmehr, Henneberry and Shayanmehr, 2021). This study contributes to the empirical literature from the Eurasian perspective.

2.1. Link between COEm and FDIs

FDIs are an important source of external financing, especially in emerging economies. There is extensive literature on them, such as their contributions to economic growth (Djellouli et al., 2022; Iqbal, Tang and Rasool, 2022; Hussain, Bashir and Shahzad, 2021), increasing export performance (Aghasafari et al., 2021; Do et al., 2022; Ajija, Zakia and Purwono, 2021), and reducing unemployment (Mkombe et al., 2021; Ni et al., 2021; Mukit, Abdel-Razzaq and Islam, 2020). However, the association between the environment and FDIs is unclear and is addressed by two antagonistic hypotheses: the PHav hypothesis, which posits that FDIs may have adverse environmental impacts, and the PHal hypothesis, which posits that they have positive impacts (Song, Mao and Han, 2021; Nasir, Huynh and Tram, 2019). In this context, the following studies provide empirical evidence that FDIs increase COEm, and therefore the PHav hypothesis is valid: Abdul-Mumuni, Amoh and Mensah (2023) through the panel NARDL in sub-Saharan Africa for the 1996–2018 period; Balsalobre-Lorente et al. (2022) through the DOLS method in PIIGS countries for 1990–2019; Gyamfi et al. (2022) through OLS and QR methods in E7 countries for 1990–2016; Jijian et al. (2021) through CCEMG and AMG estimation techniques in one generation and one road countries for 1993–2018; Wu, and Zhang (2021) through the spatial Durbin model (SDM) in China for 2003–2017; and finally, Salahodjaev, and Isaeva (2022) through the panel FMOLS and

DOLS methods in post-social states for 1995–2017. However, the following studies provide empirical evidence that FDIs reduce COEm, validating the PHal hypothesis: Abbass et al. (2022) through the ARDL method for the 2000–2020 period in South Asian countries; Abid, Mehmood, and Tariq (2022) using the FMOLS and DOLS methods in G8 countries for 1990–2019; Polloni-Silva et al. (2021) using the LIML technique in Brazil for 2010–2016; Neves, Marques and Patrico (2020) for 1995–2017 in the EU; and Nguyen, Huynh and Nasir (2021) in G6 countries for 1978–2014. FDI-related effects on the environment may vary according to the degree of economic development (Benli and Acar, 2022; Habiba et al., 2021; Kisswani and Zaitouni, 2023; Nguyen, 2021; Benzerrouk, Abid and Sekrafi, 2021; Arif, Arif and Khan, 2022; Shahbaz et al., 2015a) and have been empirically shown to increase emissions in developing economies and decrease emissions in developed economies.

We developed the following hypothesis from the literature summary above, with the countries comprising the study sample considered underdeveloped or developing:

H_1: FDIs have positive and meaningful effects on COEm.

2.2. Link Between COEm and ROADpt

Since the Industrial Revolution, rapid socioeconomic growth, financial development, and improved living standards have increased demands on the transportation industry (Khan, Ponce and Yu, 2021a; Hussain et al., 2022; Wang et al., 2018). Transport-related ENCO accounted for 22% and 16%, respectively, of carbon and GHG emissions worldwide in 2019, ranking second after electricity and heating (Ritchie, Roser and Rosado, 2020). Therefore, the transportation sector has been the subject of considerable scientific research because of its impact on climate change. The literature on land transport is summarised as follows. The study by Zhang, Huang and Wu (2022) for BRICS countries covers 1990–2018. Results showed that freight and passenger transport significantly contribute to higher PM 2.5 concentrations, with the effect of freight transport being approximately twice that of passengers. Hussain et al. (2022) investigated the effect of economic improvement, environmental expenditures, transportation-related COEm, and income inequality on transportation-related COEm for the OECD using panel data for 2000–2020. Results showed that transportation increased transportation-related COEm levels by 46.45%, and the combined impact of economic improvement and environmental taxes reduced transportation-related COEm by 14.70%. Raza, Shah and Sharif (2019) examined the link between transportation-related ENCO and environmental degradation in the United States using the Wavelet method for monthly data between January 1973 and July 2015. Results showed that ENCO increased COEm in the short, medium, and long term. Moreover, the causality test showed unidirectional causality from ENCO to COEm. In a similar study, Andres and Padilla (2018) investigated the effect of the transport industry of several EU-28 countries on GHG emissions using panel data econometric models and the STIRPAT method for 1980–2014. Findings deduced that transport energy density and transport volume are significantly and positively correlated with GHG emissions. There is concurrence in the literature that the transportation sector increases COEm. The findings of studies conducted by Wang et al. (2018) in China, Mustapa and Bekhet (2015) in Malaysia, and Shahbaz, Khraief and Jemaa (2015b) in Tunisia support this consensus.

As the world moves towards lower-carbon sources of electricity, the rise of electric vehicles offers a viable option for reducing emissions from passenger vehicles. In this context, Zhu, Jianguo and Ali (2023) evaluated the transition to sustainable resources and the promotion of green initiatives such as green logistics, green investments, and environmental policies (such as environmental technology and environmental tax) as potential ways to overcome this challenge. They also stated that environmental technology, environmental taxes, and renewable energy will help reduce transportation emissions. In contrast, Li, Sohail and Majeed (2021) revealed that green logistics performance increases economic growth in the One Belt and Road Initiative (OBRI), Europe, and the Middle East and North Africa (MENA) economies. It has also been emphasised that while green logistics performance increases environmental pollution in OBRI, Central Asia, and MENA economies, it significantly increases environmental quality in Europe and East and Southeast Asia.

We developed the following hypothesis in keeping with the theoretical expectations outlined in the literature summary:

H_2: ROADpt has a positive and meaningful effect on COEm.

2.3. Link Between COEm and RAILpt

Railways are the most energy-efficient and lowest-emission mode of transport. Despite the freight and passenger traffic it carries, rail accounts for only 2% of the total transport-related energy demand (IEA, 2019b). Studies have shown that RAILpt affects COEm in different ways. For example, Dzator, Acheampong and Dzator (2021) revealed that rail transport infrastructure directly contributed to higher emissions in emerging countries from 1990 to 2018. On the other hand, Abul and Satrovic (2022) underscored the importance of using clean energy in terms of energy efficiency in the transportation sector, while showing that railway transportation increases COEm in Turkey and Croatia, which are among the South-East Europe (SEE) countries. A study by Mu et al. (2022) revealed that the logistics sector in Pakistan caused environmental degradation from 1990 to 2019, when rail transport increased COEm in the short and long term. They mention that the country's rail system is ageing, and railway engines are inefficient in terms of fuel consumption and maintenance needs, which may account for this scenario. In another study specific to Pakistan, Sohail et al. (2021) concluded that positive shocks in RAILpt increased long-term COEm from 1991 to 2019. On the other hand, studies have shown that rail transport reduces COEm, the argument being that demand for road and air transportation decreases with the introduction of high-speed trains because they are faster, safer, and cheaper. Zhou, Xu and Tao (2022), Sun and Li (2021), Strauss, Li and Cui (2021), Tang, Mei and Zou (2021), Lin, Qin and Wu (2021), and Jia, Shao and Yang (2021) provide empirical evidence supporting this result.

We developed the following hypothesis in keeping with the theoretical expectations outlined in the literature summary:

H_3: RAILpt has a meaningful effect on COEm.

2.4. Link between COEm and GDP

Although economic expansion greatly increases public welfare, this growth seriously affects environmental quality (Djellouli et al., 2022). Increasing greenhouse gas emissions (GHGs) primarily caused environmental degradation. Energy consumption caused these emissions, too through the fossil fuels used in various economic activities (Beton Kalmaz and Awosusi 2022). This part of the study includes studies on the effects of economic growth (GDP) on COEm. Kirikkaleli, Awosusi and Adebayo (2023) examined the effect of COEm intensity on GDP, energy consumption, renewable energy, and economic growth on CO2 emissions in Portugal. The nonlinear autoregressive distributed lag (NARDL) method was used in the analysis of data for the period 1990-2019. According to the results, a positive change in energy consumption positively affects COEm, whereas a negative shock in energy consumption has a neutral effect on COEm. Additionally, it is revealed that positive/negative shocks of economic growth and COEm intensity of GDP increase/decrease environmental degradation by increasing/decreasing COEm. Abbasi, Kirikkaleli and Altuntaş (2022) investigated the effect of COEm intensity of GDP on COEm in Turkiye. The NARDL method was used in the analysis of data for the years 1990-2018. According to the results, they found that both economic development (GDP) and the increase in carbon intensity increased COEm. Chen et al. (2022) examined the interaction between GDP and COEm in China. They used the QARDL method in analysing data for the period 1990-2020. According to their results, GDP positively affects COEm in China. Similarly, Adebayo (2023) and Xie et al. (2022) in China, Qayyum et al. (2022) in India, Adeshola et al. (2022) in Portugal, Ahmed et al. (2021) in G7 countries, Sikder et al. (2022) in developing economies, and Yu et al. (2022) in 25 developing economies reveal that there is a positive and significant connexion between GDP and COEm. In contrast, Acheampong, Dzator and Amponsah (2022) analysed data for Australia for the period 1970-2018 using the NARDL approach, and according to the results, they found that increases and decreases in GDP had an insignificant effect on COEm. In this regard, we developed the following hypothesis in keeping with the theoretical expectations outlined in the literature summary above:

H_4: GDP per capita has a meaningful effect on COEm.

3. Methodology

3.1. Data

The sample of the study consists of eight Eurasian countries (Russia, Kazakhstan, Uzbekistan, Turkmenistan, Azerbaijan, Georgia, Kyrgyzstan, and Tajikistan)[1] using data from 1992 to 2020. Because these countries achieved their independence after the collapse of the USSR in December 1991, pre-1992 data were not available. The data series with their nominal values were included in the analysis. For some years, the dataset exhibited an unbalanced panel data structure because the number of observations was missing. The data are presented in Table 1.

Table 1: Description of variables

Variable	Definition	Source
COEm	It covers carbon dioxide emissions from coal, oil, gas use (combustion and industrial processes), and gas combustion and cement manufacture. Expressed in metric tonnes ($MtCO_2$).	www.globalcarbonatlas.org
FDI	Foreign Direct Investment, net inflows (US$)	www.worldbank.org
RAILpt	Number of passengers transported by rail per km (Millions)	www.oecd.org
ROADpt	Number of passengers transported by road per km (Millions)	www.oecd.org
PGDP	GDP per capita (US$)	www.worldbank.org

3.2. Method

The QR method, a non-parametric technique, was preferred in this study because the data did not show a normal distribution. Additional reasons to use this method are as follows: QR allows the model to consider outliers and search for determinants of the response variable throughout the conditional distribution compared with the OLS method, which is more precise to outliers. Regression

[1] There is no consensus in international organisations regarding which countries are Eurasian countries. For example, the United Nations considers 14 countries, the OECD considers 13 countries, and the International Energy Agency (IEA) considers 9 countries as Eurasian countries. In this study, the classification made by the IEA was considered.

coefficients obtained using the OLS method were calculated using the mean function. However, the different coefficients calculated for each quantile level in QR reflect the dissimilar effects of the conditional distribution of the response variable. In other words, the QR model is appropriate when the factors involved have dissimilar impacts at several points in the conditional distribution of the response factor (Belaid, Elsayed and Omri, 2021; Alvarado et al., 2021). In addition, the residuals of the QR model do not need to meet the classical assumptions of OLS (Opoku and Aluko, 2021). Therefore, the QR method provides more powerful and effective econometric consequences by estimating the heterogeneous impacts of the explanatory variables on the response variable (Bilgili et al., 2022).

The QR model can be mathematically represented as follows (Maji and Saha, 2021):

$$y_i = x_i^{'}\beta_\tau + \varepsilon_i^\tau \ldots$$
$$Q_\tau(y_i \mid x_i) = x_i^\tau \beta_\tau \ldots \tag{1}$$

Here, β_τ ; τ'th estimated coefficient for QR ((0<τ<1) and ε_i^τ ; $Q_\tau(\varepsilon_i^\tau \mid x_i)$ represents the error term that satisfies the condition. For the panel data, the model can be mathematically represented as follows:

$$Y_{i,t} = \alpha_i + \beta_{\tau,1}X_{i,t}^1 + \beta_{\tau,2}X_{i,t}^2 + \ldots + \beta_{\tau,m}X_{i,t}^m + \varepsilon_{i,t}^\tau \tag{2}$$

where i is the unit of country (i=1, 2, …, N) and t represents year (t=1, 2, …, T). The model simultaneously calculates the coefficient estimates at different quantile levels using the following minimisation approach:

$$\min_{(\alpha,\beta)} \sum_{k=1}^{q}\sum_{t=1}^{T}\sum_{i=1}^{n} w_k \rho_{\tau_k}(y_{it} - \alpha_i - x_{it}^{'}\beta_{\tau_k})\ldots \tag{3}$$

This study used a simultaneous QR estimation model to test whether the coefficients were similar at the conditional quantile levels. Simultaneous QR is a powerful econometric technique that explains the non-normal distribution of error terms and varying variances. The standard errors of the coefficients are estimated using the bootstrap method in the simultaneous QR model, and the inter-quantile variance-covariance matrix is obtained (Ercan, 2021; Delisi et al., 2011). On the basis of the above notation, we can express the simultaneous QR model with fixed effects for panel data as follows:

$$Q_\tau(COEm_{i,t} \mid FDI_{i,t}, RAILpt_{i,t}, ROADpt_{i,t}, PGDP_{i,t}) = \alpha_i + \beta_{\tau,1}FDI_{i,t} + \beta_{\tau,2}RAILpt_{i,t} + \beta_{\tau,3}ROADpt_{i,t} + \beta_{\tau,4}PGDP_{i,t}\varepsilon^{\tau}_{i,t} \tag{4}$$

The Hausman test was performed to determine the most suitable econometric feature, and the fixed-effects model was preferred for the Chi-Square statistic (110.83) considering a p value=0.000.

4. Analysis Results and Findings

4.1. Basic Statistical Tests and Correlation Analysis

Basic statistical tests and their results are shown in Panel A of Table 2. These were performed to explain and define the basic/key features of the series. The results of the correlation analysis were carried out to understand the direction and size of the connexions between the variables. They are shown in Panel B of Table 2.

Table 2: Basic statistical tests and correlation analysis

	COEm	**FDI**	**RAILpt**	**ROADpt**	**PGDP**
Mean	255.574	4.20E+09	38541.60	70775.10	3013.181
Median	37.022	6.91E+08	2100.000	24657.50	1308.140
Maximum	1957.886	7.48E+10	272167.0	260581.0	15974.64
Minimum	1.877	-4.02E+08	172.000	954.000	60.458
Std. Dev.	517.852	1.07E+10	68126.57	73896.69	3508.127
Skewness	2.210	4.267	1.605	0.788	1.627
Kurtosis	6.089	22.609	4.187	2.294	4.959
Jarque-Bera	281.168	4345.380	63.452	16.155	138.870
Probability	0.000	0.000	0.000	0.000	0.000
Panel B: Correlation Analysis					
COEm	1				
FDI	0.604	1			
RAILpt	0.968	0.521	1		
ROADpt	0.675	0.381	0.669	1	
PGDP	0.451	0.695	0.338	0.535	1

According to the JB test statistic results in Table 2, none of the variables showed a normal distribution. The dataset has an unbalanced panel feature because of the difference in the number of observations. The correlation coefficients showed a positive correlation between the response and exposure variables. These findings shed light on method selection, analysis results, and hypothesis development.

4.2. Stationarity Analysis

Before checking the stationary characteristics of the variables for carbon emissions, rail passenger transport, road passenger transport, and FDIs, each panel series had to be investigated for cross-sectional dependence (CSD). Because this study was based on panel data, there was a high possibility of cross-sectional dependence. This may occur because of spatial or diffuse effects or unobserved co-factors. Ignoring the existence of CSD may affect the objectivity and consistency of classic panel estimators (Usman et al., 2022; Rahman, Nepal and Alam, 2021; Cheng and Yao, 2021; Zafar et al., 2021).

Table 3: CSD test results

	Breusch-Pagan LM test	**Pesaran CD test**
Variables	Test statistic	Test statistic
COEm	307.285 (0.000) ***	11.632 (0.000) ***
FDI	254.502 (0.000) ***	15.182 (0.000) ***
RAILpt	81.728 (0.000) ***	7.498 (0.000) ***
ROADpt	170.781 (0.000) ***	3.033 (0.002) ***
PGDP	715.377 (0.000)***	26.724 (0.000)***

Note: Significance level; *** %1

According to the CSD test results in Table 3, CSD was found for all variables, indicating that second-generation unit root tests are mandatory to check the stationarity of the series. For this purpose, the PANIC test suggested by Bai and Ng (2004), which allows the analysis of both observed variables and common factors, was used (Esen, Yıldırım and Yıldırım, 2021; Çakar et al., 2021; Tayebi, Önel and Moss, 2021). Another feature is that the tests for factors and specific errors do not depend on whether the error term is I(0) or I(1) (Barbieri, 2009). This test also offers strong statistical results in the case of cross-correlations (Yang, Ali and Hashmi, 2022; Erdogan, 2021). In other words, the space occupied by unobserved joint elements and idiosyncratic disorders allows consistent prediction without knowing whether they are static or integrated into the PANIC approach (Gengenbach, Palm and Urbain, 2009). Additionally, these test statistics are suitable for balanced and unbalanced data and can handle missing values (Yang et al., 2022; Milanez, 2020). The PANIC test results are shown in Table 4.

Table 4: Bai and Ng-PANIC test results

	Level	
Variables	test statistics	p-value
COEm	3.759	(0.000)***
FDI	6.434	(0.000)***
RAILpt	1.863	(0.068)*
ROADpt	-2.209	(0.027)**
PGDP	-1.890	(0.058)*

Note: Significance Level; ***%1, **%5, *%10

Results show that all series were stationary in the model with constant level values. Therefore, these variables can be used in regression analyses according to their level values.

4.3. Results of the Simultaneous PQR Analysis

The results of the simultaneous PQR analysis performed to estimate the effects of different levels of FDI, RAILpt, ROADpt, and PGDP on COEm in Eurasian countries are shown in Table 5. The impact of explanatory variables on COEm was estimated for nine quantile levels (10, 20, 30,…,90).

Table 5: Results of the Simultaneous PQR Analysis

	Quantile Levels								
	10	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**
FDI	0.000 (0.005) ***	0.000 (0.013) **	0.000 (0.083) *	0.000 (0.027) **	0.000 (0.007) ***	0.000 (0.025) **	0.000 (0.056) *	0.000 (0.811)	0.000 (0.880)
RAILpt	0.006 (0.000) ***	0.007 (0.000) ***	0.007 (0.000) ***	0.008 (0.000) ***	0.008 (0.000) ***	0.008 (0.000) ***	0.008 (0.000) ***	0.010 (0.000) ***	0.011 (0.000) ***
ROADpt	0.000 (0.003) ***	0.000 (0.000) ***	0.000 (0.001) ***	0.000 (0.000) ***	0.000 (0.000) ***	0.000 (0.000) ***	0.000 (0.032) **	-0.000 (0.709)	-0.000 (0.308)
PGDP	-0.001 (0.544)	-0.001 (0.245)	-0.002 (0.263)	-0.002 (0.212)	-0.004 (0.034)**	-0.004 (0.121)	-0.005 (0.520)	0.009 (0.424)	0.013 (0.469)
C	-1.000 (0.698)	0.871 (0.844)	5.187 (0.443)	7.068 (0.389)	16.362 (0.026)**	21.637 (0.011) **	33.772 (0.020) **	75.039 (0.000) ***	101.656 (0.000) ***
Pseudo R^2	0.736	0.759	0.782	0.805	0.823	0.841	0.861	0.865	0.839

Note: Significance level: ***1%, ** 5%, *10%

The results show that FDI inflows have a positive and significant impact on COEm in Eurasian countries, and this effect is particularly significant at all quintile levels except quintiles 8 and 9. Therefore, although FDIs are an important source of external financing, they cause environmental pollution in Eurasian countries. According to the theoretical background, PHav is said to be valid for the period examined in this example. A reason for this situation is that the region is rich in fossil resources, which attracts the attention of foreign investors. The impact of GDP per capita on COEm is heterogeneous and significant only at the 5th quartile. Therefore, a clear picture of the effect of this variable on the dependent variable could not be obtained. Additionally, transportation infrastructure had a positive and significant impact on COEm in this sample group. RAILpt had a positive impact on COEm at all quantile levels, and this impact trended upward. ROADpt also had a significant impact on COEm; this was especially true for low and medium quantile levels. Note that the sample countries belong to the former USSR, and the main means of transport for both freight and passengers is rail; however, the fact that the trains are outdated and run on old technology explains why railway is the highest contributor to COEm. It is also worth noting that the effect of the independent variables on the dependent variable is close to zero and therefore quite limited.

Table 6: Testing for slope heterogeneity

	Pesaran, Yamagata (2008) Testi	Blomquist, Westerlund (2013) Testi
Δ	3.898***	10.815***
$\Delta_{adj.}$	4.465***	12.390***

Note: Significance level, ***%1

The test statistics were significant at the 1% significance level (Table 6). Therefore, the H_0 hypothesis, which states that the slope is homogeneous across quantities, is rejected. This result provides evidence that the connexion between endogenous and exogenous variables varies across several quantities.

4.4. Robustness Check

At this stage, the validity of the findings obtained from the simultaneous PQR analysis was tested using the Robust QR model to capture the unobserved distributional heterogeneity among economies within a panel. This technique can produce robust and reliable estimates even in the presence of outliers (John, 2015; John and Enduka, 2009). These results are presented in Table 7.

The results of the Robust-QR method applied to support the results of simultaneous PQR analysis, which is the basic method, are given in Table 7. In particular, the results obtained for FDI, RAILpt, and ROADpt largely overlap with the findings of the basic analysis method. Therefore, we have obtained solid empirical evidence to identify issues affecting COEm in Eurasian countries.

5. Conclusions and Recommendations

A better understanding of the key factors affecting environmental quality is essential for the implementation of policies that successfully reduce emissions. This study conducted analyses within the framework of QR methods to examine the heterogeneous effects of FDIs and road and rail passenger transport COEm in

Table 7: Results of robust QR (ROBREG)

Variable	Quantile Levels								
	10	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**
FDI	0.000 (0.013)**	0.000 (0.052)*	0.000 (0.199)	0.000 (0.257)	0.000 (0.002)**	0.000 (0.003)***	0.000 (0.000)***	0.000 (0.774)	-0.000 (0.882)
RAILpt	0.006 (0.000)000	0.007 (0.000)***	0.007 (0.000)***	0.008 (0.000)***	0.008 (0.000)***	0.008 (0.000)***	0.008 (0.000)***	0.010 (0.000)***	0.011 (0.000)***
ROADpt	0.000 (0.010)***	0.000 (0.000)***	0.000 (0.001)***	0.000 (0.000)***	0.000 (0.001)***	0.000 (0.000)***	0.000 (0.000)***	-0.000 (0.609)	-0.000 (0.069)*
PGDP	-0.001 (0.658)	-0.001 (0.547)	-0.002 (0.600)	-0.002 (0.563)	-0.004 (0.336)	-0.004 (0.318)	-0.005 (0.224)	0.009 (0.347)	0.013 (0.121)
C	-1.000 (0.926)	0.871 (0.941)	5.187 (0.661)	7.068 (0.558)	16.362 (0.188)	21.637 (0.049)**	33.772 (0.002)***	75.039 (0.000)***	101.656 (0.000)***
Pseudo R^2	0.736	0.759	0.782	0.805	0.823	0.841	0.861	0.865	0.839

Note: Significance level: ***1%, ** 5%, *10%

a sample of eight Eurasian countries between 1992 and 2020. Transport-based indicators and financial variables such as FDI, which are frequently used in the empirical literature, were chosen to more comprehensively consider factors affecting COEm. Therefore, the inclusion of relevant indicators adds a unique dimension to this study focussing on Eurasia. After the preliminary tests, the simultaneous PQR method was used as the main analysis method. To test the robustness of the findings, analyses were carried out within the framework of the Robust-QR method. Three important results were obtained: 1) The impact of FDIs on COEm at low and medium quantile levels is statistically significant and positive. Therefore, FDIs in Eurasian countries increase COEm, making the PHav hypothesis valid for Eurasian economies. 2) The effect of RAILpt on COEm is statistically significant and positive at all quantile levels, and it tends to increase. Therefore, the impact of rail transport on COEm is heterogeneous. The main reason for this is the widespread use of diesel locomotives with old technology. In addition, it is seen that the railways cannot be used effectively and the capacity utilisation rate decreases due to the decrease in the number of passengers carried over the years. This indicates that passengers do not prefer railways.

3) The effect of ROADpt on COEm is significant and positive at low and medium quantile levels; The main reason for this is the extensive and intensive exploitation of fossil resources in Eurasian countries. 4) No clear result could be obtained regarding the role of PGDP on the dependent variable. This result shows that, on average, per capita income is quite low in the countries of the region; therefore, consumption preferences are not sufficient to increase/decrease carbon emissions.

These results offer important implications for investors and political decision makers. These countries offer valuable opportunities to investors, especially in terms of renewable energy investments, which can be facilitated by legislation that encourages foreign capital inflow. Steps should be taken towards financial liberalisation and their implementation should be encouraged. In terms of public services, old railway transportation technologies need to be replaced with environmentally friendly systems. Rail transport can only reduce emissions when the fuel source is electricity and its use is more widespread; This can be achieved by increasing population awareness and effective tariffs. I In this context, every aspect of the travel experience needs to be improved, from the time cargo leaves warehouses and passengers leave their homes to their safe arrival at their destination, through policies yet to be established. To achieve this, the entire end-to-end journey must be examined. Rehabilitating the transportation infrastructure, especially in a way that protects the environment, will make travel more comfortable for both freight and passengers and will contribute to the creation of economies of scale, which is one of the main purposes of transportation systems. Thus, creating economic, social, and environmental benefits can achieve sustainability.

The most important limitation of this research is that the data regarding railway and road transportation are not regular. If these data are more organised, the findings and results of the research may be more meaningful.

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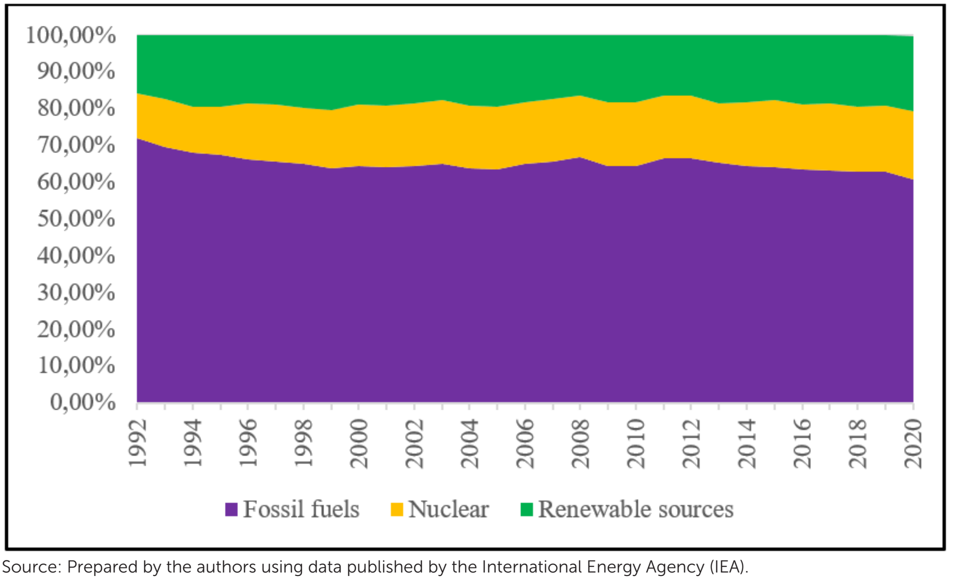
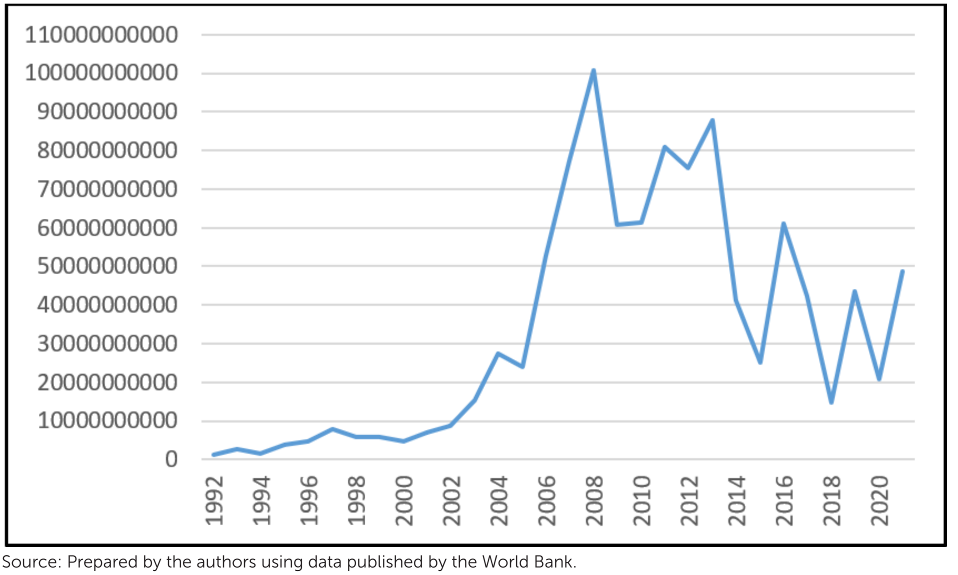
APPENDIX

Figure A1. Energy Production by Source in Eurasian Region



Source: Prepared by the authors using data published by the International Energy Agency (IEA).

Figure A2. FDI inflow ($) in Eurasia Region



Source: Prepared by the authors using data published by the World Bank.

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RESEARCH ARTICLE

Panel Causality Analysis of the Relationship among the Rule of Law, Technological Advances, Competitiveness, and Value-Added*

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ABSTRACT

The status of countries within the global value chain varies depending on the importance of national production capabilities in the global economy. From this perspective, there is a need for a value-added production approach that focuses on innovation and competitiveness. Technological advances and institutions are considered to play a significant role in transforming the economy towards an innovation-driven one to meet these needs. The aim of this paper is to investigate the relationship among technological advances, the rule of law as a proxy for institutions, value-added production, and competitiveness in a way that reflects cross-country divergence. Through an analysis employed independently of countries' existing levels of development, it will be possible to evaluate whether the factors associated with institutions and innovation can produce similar results in all circumstances and for each country. In this context, a panel causality analysis that considers cross-sectional heterogeneity is employed. The analysis shows bidirectional causality between the variables, except for value-added to the rule of law. However, the results also support the existence of cross-country divergence. These findings suggest that future policy plans should be designed to consider the multidimensional nature of country-specific factors, alongside technological advances and the rule of law, and to ensure the integration of both national and international economic objectives.

Keywords: Technological advance, The rule of law, Competitiveness, Value-Added production
JEL Classification: F10, P48, O32, O47

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1. Introduction

As a natural consequence of globalisation and internationalisation trends in supply processes, concepts such as production diversification, economic complexity, and competitiveness are frequently referenced. In a world where international competition is intense, developments in production processes have become crucial for enhancing and maintaining economic performance. As a reflection of this fact, it is noteworthy that the multidimensional relationship among these factors is considered in the policy texts and objectives of national and supranational organisations (e.g. European Commission, 2021; T.C. Strateji ve Bütçe Başkanlığı, 2019).

Several factors stand out in the development of the manufacturing industry and its sub-sectors, which are fundamental drivers of economic output. These factors are considered as inputs used in production, and among these inputs, technology deserves special mention, as it directly shapes product sophistication in a way that other inputs may not be able to achieve sufficiently. Technological advances enable a nation to transition from a cost- and factor-driven economy to an innovation-driven one. The phenomenon of technology, which can be formulated within the framework of economic growth and international trade theories (Grossman ve Helpman, 1991; Aghion ve Howitt, 1992; Posner, 1961), ensures economic performance and comparative advantage of a nation in a dynamic structure.

Technological advances that pave the way for innovation are crucial for countries seeking to gain a place in the global economy through foreign trade. Indeed, reports demonstrating a significant relationship between technological innovations and the competitiveness of countries support this statement (Schwab, 2010; IMD, 2022). Accordingly, it is possible to interpret these sectors that utilise technology intensively can produce more competitive and value-added products. On the other hand, it can be argued that technological inadequacies may hinder the competitiveness of countries by restricting production based on factor endowment and cost.

However, it would be incomplete to evaluate competitiveness and value-added production on the basis of technological advances alone. Therefore, considering country-specific factors would be the right approach (Dosi, Pavitt, and Soete, 1990). Institutions are a factor considered in this framework (Amendola, Dosi, and Papagni, 1993; Rodrik, 2009). Institutions determine the set of incentives and constraints for social actors by establishing the rules of the game and the governance structure (North, 1991; Williamson, 1998) and have various dimensions that shape entrepreneurs' decisions, productivity and specialisation, including the way in which technology evolves (Acemoğlu and Robinson, 2000; Baumol, 1996). The impact pathways of institutions include activities such as influencing transaction costs, re-allocating resources and human capital, increasing predictability, and addressing asymmetric information issues (Lin and Nugent, 1995; Tebaldi and Elmslie, 2008). In this framework, institutions are assumed to influence cross-country divergence in productivity and competitiveness and technological advances.

There are several reasons for using the rule of law as a proxy for institutions. First, a well-designed legal framework is one of the most effective ways to understand the institutional structure that reduces economic and social uncertainty (D'Ingiullo et al., 2023). Second, the rule of law is a broad phenomenon that includes the legal framework, contract enforcement, and property rights (Kaufmann, Kraay, and Mastruzzi, 2011). It also interacts with institutional factors such as regulatory quality and corruption (Haggard, MacIntyre, and Tiede, 2008), which affect transaction costs, ease of doing business, and trust.

It is believed that the evaluation of the potential effects of technological advances and the rule of law on value-added and competitiveness and the design of effective policies based on the findings at the cross-country level are important. This paper investigates the response of competitiveness, which refers to the comparative advantage of nations, and value-added production with respect to developments in technological capacity and the rule of law, particularly with country-specific dimensions. The analysis focuses on 29 countries for which data are available in the European Innovation Scoreboard (EIS). The EIS is a valuable index as it provides an evaluation of European Union innovation, industry, and competition policies and the outputs achieved (European Commission, 2022).

This paper is expected to contribute to the literature in two ways. First, in the existing literature, the effect of technology and technological advances on value-added and competitiveness is discussed separately. This study analyzes the relationship between these factors from a holistic perspective, considering the rule of law, and provides multidimensional explanations among the factors. Second, we employed a panel causality analysis to consider possible cross-country divergence. By doing so, we can evaluate both the results for the panel and those at the cross-country level and see the possible effect of the rule of law in explaining country patterns. In this context, the Dumitrescu and Hurlin (2012) panel causality method, which considers heterogeneity and allows for both panel and cross-sectional causality analysis, is employed. The findings are expected to provide useful outputs in terms of the integration and objectives of national and international economic policies.

The rest of the paper is structured as follows: Section 2 provides an explanation of the concepts of technological advances, the rule of law, value-added, and competitiveness, including their relationships. In Section 3, previous studies from the literature are included. Sections 4 and 5 present the data and the econometric model employed in the analysis and the findings, respectively. The final section includes concluding remarks.

2. Conceptual Framework

2.1. Technological advances and value-added

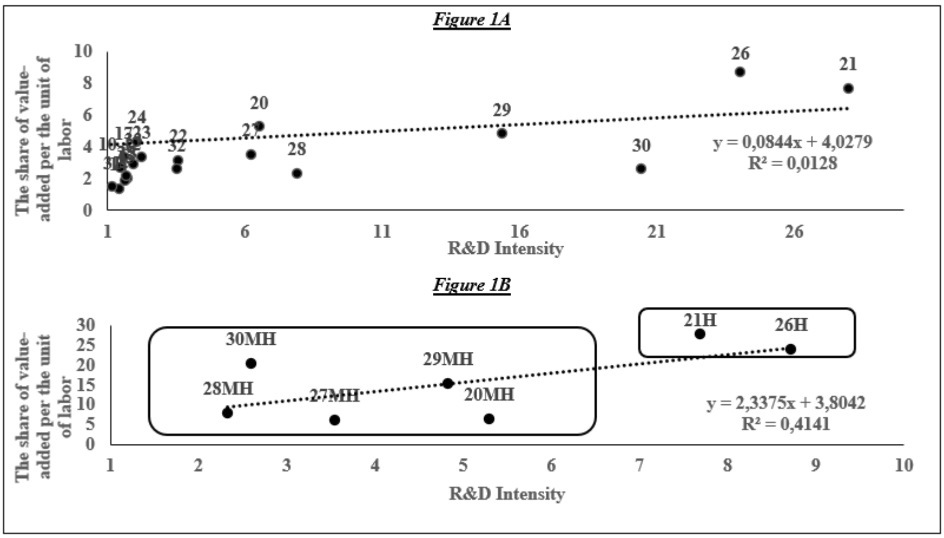
According to Lundvall (2010:28), technology is defined as the technical knowledge utilised in production processes. In addition, increases in existing knowledge that contribute to the economy are referred to as innovation. From this perspective, the commercialisation of technical knowledge emerges as innovation. From the Schumpeterian perspective, technological advances in terms of increases in the stock of technical knowledge enable the unveiling of innovation by transforming it into new products and processes (Mokyr, 1992: 6; Dosi and Nelson, 2010: 91).

Technological advances and innovation are widely recognised as the fundamental drivers of long-term economic performance. Within the process of creative destruction, technological advances that emerge as a conscious effort driven by competitive pressure and profit-seeking will ensure economic transition and sustain economic growth (Aghion and Howitt, 1992: 323-324). Explaining this fact, it has been revealed that there is a strong relationship between industrial transformation triggered by technological changes and economic development cycles in the historical process (Ayres, 1990: 3). Industries based on new technologies emerge as the engine of growth in every new cycle. Two concepts arise with respect to the effects of technological advances that can be observed on a national and international scale: *value-added production* and *competitiveness.*

Gross value added, which is equal to the difference between output and intermediate consumption, is a concept that emphasises the surplus value created in the production process (United Nations, 2009: 34). The change in value-added can occur in two ways. Value-added increases by producing more output with the same input compared with the previous period or by diversifying the product range. Technological advances play a crucial role in both cases. Technological advances shaped by R&D activities enable more efficient and high-quality intermediate goods to be used in the production process. Thus, increases in cost and innovation-based productivity and value-added per unit of labour are achieved (Lentz and Mortensen, 2008: 1318-1321). For instance, technological innovation may enable efficiency and value-added increases in the long term by allowing more effective use of energy (Zheng et al., 2022: 11). Similarly, long-term productivity gains can be achieved through the widespread adoption of automation processes in production (Camiňa, Diaz-Chao, and Torrent-Sellens, 2020: 2). Simultaneously, the sustainability of productivity is a function of the persistence of R&D. This is because the productivity-enhancing effect of R&D tends to diminish over time (Kafouros, 2005: 482). In other words, having invested in R&D in the past does not guarantee future productivity. Therefore, firms must continue investing in R&D uninterruptedly to maintain productivity and profitability (Baumann and Kritikos, 2016: 1264).

To observe the innovation-driven positive effects of technological advances on value-added at the sectoral level, it would be appropriate to understand the link between the two factors. This link is illustrated in Figure 1, which was compiled using data on sectoral value-added and R&D intensity for the manufacturing industry. Figure 1 consists of 1A, which includes all manufacturing industry sectors, and 1B, which is derived from section 1A and includes only sectors with high R&D intensity.

Figure 1. LightGBM SHAP summary plot.



Source: Galindo-Rueda ve Verger, (2016); UNIDO (2023).
Note: Sectoral classification is based on ISIC Rev. 4. R&D intensity data belongs to 2011 and value-added per unit of labour data belongs to 2019. MH: Medium-High Sector and H:High Sector

Figure 1A indicates that most of the manufacturing industry are characterised by low R&D and value-added levels. Furthermore, the effect of R&D activities on value-added in these sectors is relatively small. Considering the R^2 value (0.0128), the explanatory power is quite low. However, it is observed that some sectors lead in value-added production in parallel with the increase in R&D activities. The status of these sectors can be seen more clearly in Figure 1B. Among these sectors, chemicals and chemical products (20), electrical equipment (27), machinery and equipment, nec (28), motor vehicles and trailers (29), and other transportation vehicles (30) are medium-high technology sectors, whereas pharmaceuticals (21), computer, electronic, and optical products (26) are high technology sectors. The figure shows that the link between R&D intensity and value-added intensifies depending on the sectoral technological classification. R^2 value (0.4141) also supports this. While the effect of R&D is limited in sectors where technology use is relatively low, technological advances play a major role, especially in innovative sectors, depending on the sectoral technological intensity. This significant interaction affects national production and the country's export potential. The composition of production would directly affect export sophistication and intensity.

2.2. Technological advances and competitiveness

For a country to be competitive in global trade, it is important that it first understands the dynamics of global competition and adopts industrial policies in this direction. Otherwise, policies may have a temporary effect on the country's economy in the short term. Competitiveness can be defined differently depending on the level of competition. These definitions include the concept of competitiveness at the micro-scale, such as firm and/or national competitiveness (Chikán, 2008: 24), and at an intermediate scale, such as regional competitiveness (Filo, 2007: 324). Within the macro perspective, competitiveness is defined as "the set of institutions, policies, and factors that determine the level of productivity of a country" (Schwab, 2010: 4).[1] As the definition suggests, a competitive country has a multidimensional structure. Optimal alignment of these factors is essential for comprehensive competitiveness.

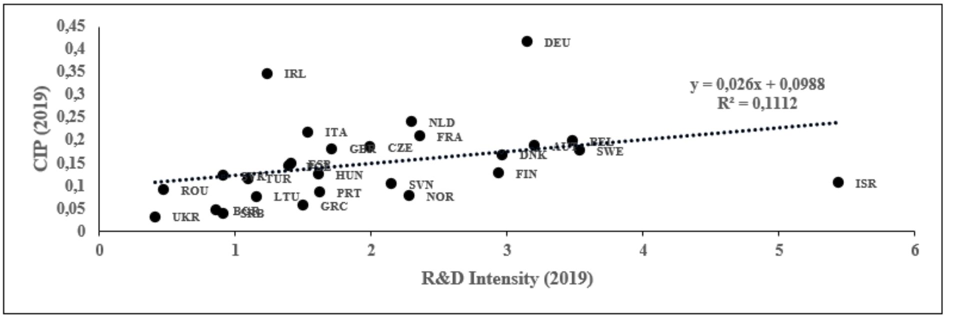
[1] This paper, on the other hand, considers macro-scale, innovation-oriented, and broadly defined competitiveness. In this context, competitiveness, as defined by UNIDO (2020), is largely determined by technological advances and knowledge required to produce new products. However, it is recognised that institutions may play a role in cross-country divergence.

The fact that technological innovation is a key factor of long-term economic performance due to its direct impact on production and triggering economic transition (Ayres, 1990) suggests that it is also a key determinant of competitiveness (Fagerberg, 1996: 49). Thus, technological advances play a key role in accelerating the creation of value-added and competitiveness by reshaping production processes. The use of new technologies in production will lead to cost-reducing and/or product diversification-enhancing developments. However, in the dynamic structure of the global economy, the sustainability of competitiveness depends on innovation-driven product competition rather than price competition (Aiginger, 1998: 160). In such an economic order, what countries produce becomes as important as how much they produce. This is consistent with the fact that a sophisticated and highly innovative production approach provides better export performance (Hausmann, Hwang, and Rodrik, 2007: 23-24).

Competitiveness can also influence technological advances. Increased competition may disadvantage domestic firms as more efficient multinational corporations enter established markets (Gandolfo and Trionfetti 2014: 145). Therefore, domestic firms will either invest in R&D to gain competitiveness or exit the market. Moreover, in the context of Schumpeterian competition, monopoly profits from innovation are elevated during periods of limited market competition. However, these profits decline with the introduction of new entries, subsequently hindering innovation and diminishing productivity. This dynamic posits an inverted U-shaped relationship between market competition and innovation activity (Aghion et al., 2005: 720-721).

Figure 2 demonstrates the link between R&D intensity and Competitive Industrial Performance (CIP) values when considering the countries analysed in this paper. Figure 2 shows a direct link between R&D intensity and CIP. Moreover, countries such as Germany, Austria, Belgium, Sweden, and Belgium have more competitive economies in return for their high R&D expenditures. On the other hand, Israel has a relatively low level of competitiveness despite its high R&D intensity, whereas Ireland has achieved a high level of competitiveness despite its relatively low R&D activities. In these cases, as discussed earlier, several factors, along with technological advances, may be considered important in these countries.

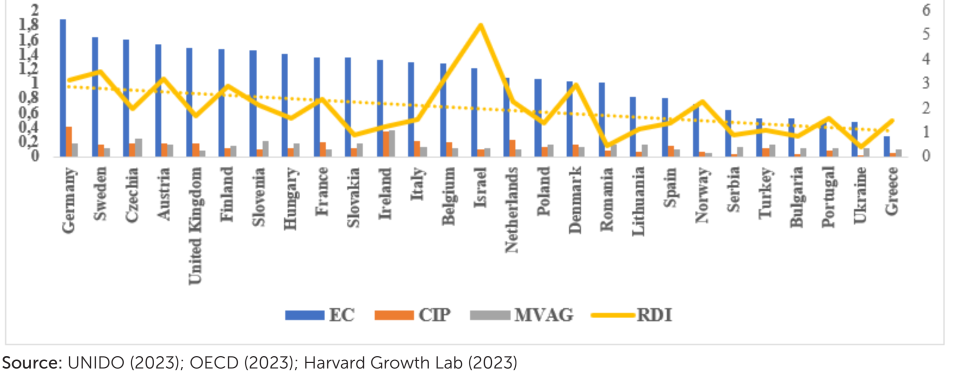
Figure 2. R&D intensity and competitiveness by country



Source: UNIDO (2023); OECD (2023)

The level of economic complexity of a country provides a better understanding of the relationship between technology, value-added and competitiveness. Economic complexity is a concept that emphasises the ability of an economy to obtain productive output from the available stock of knowledge (Hausmann et al., 2014: 18). Depending on sectoral technological intensity, sectoral complexity also increases and countries that export-related products are more competitive (Erkan and Yildirimci, 2015: 524). Figure 3 illustrates this multidimensional relationship.

Figure 3. Economic complexity, R&D intensity, value-Added, and competitiveness outlook



Source: UNIDO (2023); OECD (2023); Harvard Growth Lab (2023)
Note: EC: Economic Complexity, MVAG: The Share of Manufacturing Value-Added in GDP, RDI: R&D Intensity.

According to Figure 3, countries' levels of economic complexity increase in line with trends in R&D intensity. Similar to Figure 2, countries such as Germany, Austria, and Sweden stand out in terms of ranking economic complexity and competitiveness. At the bottom of the ranking, countries such as Greece, Ukraine, and Bulgaria have low levels of competitiveness and value-added production in parallel with low R&D intensity and lag behind in terms of economic complexity. Increases in value-added arising from cost-effective production and new products enable countries to gain advantages in terms of both price and product competition in world trade. For the sustainability of competition, a technology-intensive product composition characterised by a complex production structure must be adopted.

2.3. Institutional effects

Under today's complex production and trade structure, it is important to assess many other factors together to build a competitive economy. Although technological advances have a positive effect on productivity and competitiveness, this effect is subject to the influence of the education system and the quality of institutions in the country. As innovation and technological change are social processes, they are characterised by cumulative learning, knowledge diffusion, etc. (Lall, 2000: 345). This underscores the symbiotic relationship between technological advances and skills. More technology-intensive production is possible with more skilled labour. Reciprocally, technological innovation restructures the production process, foregrounding the necessity of an adaptable, proficient workforce (Goldin and Katz, 1998: 696-697). Institutions come into the equation by direct productivity and human capital allocation (Tebaldi and Elmslie, 2008: 5). Institutions establish the social infrastructure that can ensure the accumulation of skills and provide an environment in which firms can transform their capital accumulation into production (Hall and Jones, 1999: 84). In doing so, it can directly and indirectly influence how the firm performs. This reflects the productivity and competitiveness of the firm.

Institutions are a set of incentives and constraints that regulate political, economic, and social interactions and are created by human beings to maintain order and reduce uncertainty (North, 1991: 97). The significance of institutions lies in their ability to restructure the rule of games, thereby incentivizing entrepreneurs to augment productive capacity (Rodrik, 2009: 189). Institutional structure is particularly important in countries that mostly export complex products (Demir and Hu, 2022: 1215-1216). This shows that as the economic structure and production processes become more complex, the importance of institutional arrangement increases (Lin and Nugent, 1995: 2313). An effective institutional structure will pave the way for technological advances and encourage the use of new technologies in the production process (Tebaldi and Elmslie, 2008: 49-50). Weak institutional frameworks elevate the costs associated with the launch of novel products and render the returns on innovation uncertain, thereby diminishing the appeal of high-risk investments (Silve and Plekhanov, 2018: 340). In other words, the direction of technological advances can be shaped on the basis of the incentive and constraint structure of institutions. Countries with strong economic institutions are expected to specialise in sectors with high levels of innovation.

However, as innovation emerges in a society, the institutional structure may be forced to change accordingly. For instance, as the economic and social benefits of technological advancements in the 19th century became clear, patenting institutions gained importance (Khan and Sokoloff, 2004: 2-3). This situation is also related to why institutions promote technological advances. The potential economic and social returns of technological innovations make them important to countries (Lundvall, 2010: 6). However, the importance of the expected outcome force institutions to change. Increases in welfare driven by advancements in productivity and competitiveness also lead to increased societal demands for institutional features such as equal opportunity and sustainable democracy (Friedman, 2008: 131-132).

The rule of law is a concept characterised by its ability to reduce risk, uncertainty, and transaction costs. It provides an effective legal framework that encompasses contract enforcement and the protection of property rights (Kaufmann et al., 2011: 233). It promotes the competitiveness of firms by encouraging the entrepreneurial class in society to channel capital into productive investment (D'Ingiullo et al., 2023: 548). The rule of law mitigate conflict and encourages cooperation between social actors by providing both deterrence and reassurance (Rodrik, 2009: 165-166). This is achieved through the establishment of a framework of incentives and constraints that ensure that all actors act within a delineated legal space.

A well-defined and effective legal framework and property rights help prevent rent seeking and corruption while also hindering expropriation (Chaudhry and Garner, 2007: 36). These factors are important for entrepreneurial capacity and investment. High-risk, large-scale investments seek an environment of trust and avoid uncertainty. This in turn affects productivity, technological advances, and competitiveness. Contract enforcement and the quality of the legal system are particularly prominent for complex products that are quality-based (Nunn, 2007: 570). Potential reasons for this include reducing uncertainty regarding investments and resolving disputes between conflicting actors (Levchenko, 2007: 791-795). The rule of law can play a role in the divergence of value-added production and the competitive advantage between countries.

3. Literature Review

3.1. Technological advances and value-added

Griliches (1986), the first comprehensive empirical study on this relationship, focuses on the link between R&D expenditures and value-added as a proxy for productivity in the US manufacturing industry. The analysis states that R&D expenditures provide high returns, which are relatively higher with basic research and private R&D expenditures. Hall and Mairesse (1995) employed a similar analysis to Griliches (1986) for the French manufacturing industry data. The findings show that while R&D has a positive impact on value-added per employee, this effect may also vary with firm-specific/sector-specific factors.

Tsang, Yip, and Toh (2008) investigated the link between R&D expenditures and value-added in Singapore. It is observed that the R&D effect yields better results in foreign firms than in domestic ones. Moreover, this effect plays a dominant role in technology-intensive sectors. Roper and Arvanitis (2012) established a relationship between product and process innovations and value-added per unit of labour, which is taken as a proxy for productivity. Employing analysis on data from Ireland and Switzerland, it is found that cost-based process innovations in Ireland and product innovations in Switzerland are important for productivity.

Türker and İnel (2013) comparatively analysed the relationship between innovation-driven activities and value-added levels in Turkey and 23 European countries. Descriptive and correlation analysis were employed using 2011 data. The study emphasises that in Turkey, where product innovation is particularly prominent, low R&D expenditures and a lack of skilled employment are behind low value-added production. Similarly, Chandran, KKV, and Devadason (2017) emphasise the effect of R&D and human capital on value-added and argue that the R&D effect varies depending on the type of R&D activities. Arjun et al. (2020) also draw attention to technology transfer.

Padula, Novelli, and Conti (2015) analysed the profitability and invention performance of 550 firms in nine countries. The study finds that firms' invention performance increases due to technological specialisation. However, due to market structure and commercialisation issues, the study finds that firm profitability remains relatively low. Related to this study, Woo, Jang, and Kim (2015) showed that R&D activities strengthened by intellectual property rights have a direct effect on value-added creation.

Soltmann, Stucki, and Woerter (2015) analysed the relationship between green inventions and innovation and industrial value-added for 12 countries. The analysis revealed a U-shaped relationship, indicating that sectors with a high stock of invention and innovation may benefit from the positive effects of green innovation.

Overall, the positive effect of R&D expenditures and activities on value-added seems cleared. However, the magnitude of this effect varies depending on several

R&D-related factors. In addition to property rights and a knowledge-oriented employment structure, knowledge property and technology transfer stand out as the factors driving the gains from R&D investments. Nonetheless, the firm production approach and sector-specific technology utilisation shape the expected returns on R&D expenditures.

3.2. Technological advances and competitiveness

The first comprehensive study that can be considered as a pioneering work in the literature is Fagerberg (1988). This paper differs from other studies of the era with its criticism of cost-oriented competitiveness and empirical analysis that provides evidence for technology-oriented competitiveness. Fifteen OECD countries were included in the analysis. This study shows that technology and productive capacity shaped by R&D and patent activities are the key determinants of competitiveness in the medium and long term. It is stated that the impact of unit labour cost is limited. Amendola et al. (1993) criticise the cost-oriented view of competition and consider Fagerberg's (1988) static analysis inadequate by emphasising the dynamic nature of competitiveness. Within the framework of the evolutionary approach, it is concluded that the "technological gap" directly affects foreign trade performance. The study covers 16 OECD countries. Besides the "technological gap" approach, Milberg and Houston (2005) highlight the concept of "social gap" and conclude that competitiveness based solely on technology would be insufficient.

Narula and Wakelin (1998) focus on technology in shaping competitiveness. Because of the analysis, technology-related factors were found to be effective in explaining both export performance and FDI flows. It is emphasised that this effect is more significant, especially for developing countries.

Gustavvson, Hansson, and Lundberg (1999) investigated the relationship between technology and competitiveness in OECD countries. The study finds that R&D activities, factor endowment, and prices affect competitiveness. This effect becomes stronger depending on sectoral technology utilisation. In contrast to this study, Dosi, Grazzi, and Moschella (2015) showed that product and process innovation, rather than cost-driven factors characterised by resource allocation and low-cost labour, have a significant effect on competitiveness. Consistent with these findings, Ollo-López and Aramendía-Muneta (2012) emphasise that ICTs that enhance the emergence of product and process innovation promote firm competitiveness.

Barge-Gil and Modrego (2011) employed a field study and regression analysis on Spanish firms. It is concluded that a research- and technology-oriented institutional structure increases firm competitiveness through factors such as learning, skill development, and knowledge sharing. Similarly, Ivanova et al. (2017) discussed the multidimensional relationship between economic complexity, which represents a global market trend, patent diversification, knowledge, and wealth creation. The study emphasises that the relationship is reflected in the national innovation system. Petrakis, Kostis, and Valsamis (2015) evaluated innovation with cultural structure and concluded that having a culture that promotes innovation positively affects economic performance and competitiveness.

Costantini and Mazzanti (2012) investigated the effect of environmental regulation and innovation on the competitiveness of EU15 countries. Green innovation policies and activities can result in a competitive advantage. Fankhauser et al. (2013) focussed on the sustainability of competitiveness through green transition. This study shows that countries may lose their existing market shares under conditions where innovative transitions towards the green economy do not occur. Fernando et al. (2021) analysed such a relationship in terms of circular economy and ecological innovations. A positive relationship was found between the market-oriented performance of recycled products and competitiveness.

Hchaichi and Ghodbane (2014) highlight that R&D expenditures and innovation through human capital are at the core of competitiveness. Similarly, Popkova, Gornostaeva, and Tregulova (2018) stated that innovative activities are the background of the competitive advantage in Russia, Belgium, and the Czech Republic. The analysis indicates that demand-driven radical innovations positively affect competitiveness. Supporting these results, Androniceanu et al. (2020)

found that more innovation-oriented investments lead to higher competitiveness and welfare levels. Dobrzański et al. (2021) investigated a similar relationship in African countries. It is emphasised that incremental increases in R&D expenditures are required for innovation-driven growth and competitiveness.

When the literature is considered as a whole, we come across a set of major findings. The first notable point is that studies on technology-oriented competitiveness accelerated in the 1990s and declined in the early 2000s. On the other hand, it is observed that the scale at which competition is considered may affect the results of the relationship between technological advances and competitiveness. As we move from national competitiveness to firm competitiveness, the impact of technology and non-technology factors varies. The findings indicate that, just as in value-added, social and institutional factors, policies and regulations should be considered as a whole in addition to technology in competitiveness. However, because of the dynamic nature of competition, innovative activities characterised by product and process innovations remain at the centre of competitiveness.

3.3. Selected literature on institutional effects

Within the broader framework of institutional literature, several key sub-components hold particular significance: the rule of law, control of corruption, regulatory quality, government effectiveness, and accountability. The rule of law is the most emphasised factor among these subcomponents. These factors have both constraining and stimulating roles and are heterogeneous. The relationship between institutions and technological advances/innovation is evident. Institutions affects transaction costs, cooperation, reallocation of resources, and reduction of uncertainty. Institutions both promote and drive innovation and play a dominant role in innovation/technology-intensive sectors. Technological transformation is also associated with institutional transformation. However, this relationship varies across countries, regions, and even sectors. It is influenced by the socioeconomic conditions of the country or region. Finally, for the incentive role of institutions to be prominent, they must be flexible. The following studies are summarised, with a focus on their major findings.

Nunn (2007) found that contract enforcement and the quality of the legal system are significantly related to relationship-specific investments. There is also evidence of specialisation in relation to these investments. Relationship-specific investments refer to investments in which an input is customised to the needs of the producer of the final good. Moreover, the results show that specialisation in certain industries fosters certain types of institutional structures. Focussing on institutional similarities, Demir and Hu (2022) make a similar finding. Countries that export complex products are highly sensitive to contract enforcement. A better contract structure leads to increased trade in these products with countries with similar institutions.

Ranjan and Lee (2007) concluded that contract enforcement and property rights are particularly crucial for quality-oriented sophisticated products (heterogeneous goods). This depends on the transaction costs and the sensitivity of the contract. Lin et al. (2021) also found that institutional factors play a role in exporting complex products although their effects vary.

Khandelwal, Schott, and Wei (2013) showed that there are significant productivity gains when the allocation of quotas enforced by inefficient institutions is reallocated (from a political to an auction-based allocation). The findings highlight the importance of institutions in reallocating resources. Sharma, Sousa, and Woodward (2022) stated that strict patent practises can have a negative impact on patenting activities in countries with low technological capabilities. However, they also note that strong institutions, such as intellectual property rights, are not sufficient to promote innovation in countries with weak innovative capacity. Krammer (2015) posits that institutional quality affects productivity through two channels: foreign direct investment and trade flows. The heterogeneous impact of institutions is emphasised.

Tebaldi and Elmslie (2013) investigated the relationship between institutions and innovation. The impact mechanism occurs through different channels such as knowledge diffusion, property rights, and uncertainty, all of which strengthen R&D activities. In the long run, the allocation of human capital emerges as a key element shaping institutions. Boudreaux (2017) argues that institutions promote innovation through two primary channels: creativity and knowledge. Enhancing the quality of the legal system fosters an environment that encourages creativity within the institutional framework. Conversely, promoting free trade stimulates knowledge creation.

Silve and Plekhunov (2018) claim that specialisation in innovation-intensive industries is common in countries with strong economic institutions. Specialisation in these industries has a positive impact on productivity. Levchenko (2007) argues that institutional dependence, particularly contracts and property rights, is a technological input to the production process in several industries. The quality of institutions determines the extent of the barriers to transactions that arise from production relations. Barbero et al. (2021) found that institutional quality has heterogeneous sectoral impacts, with institutional effectiveness particularly intensive in information and communication technologies (ICT) and financial and professional services.

Hu, Sun, and Dai (2021) found that environmental regulations can hinder technological advances and competition because of several factors, including uncertain functions and powers of authorities and regulatory rigidity. This highlights the importance of flexible and well-defined institutions. Yasmeen et al. (2023) emphasise the significance of environmental taxation and green technology for energy efficiency, highlighting the rule of law as a determinant in the implementation of green technology and tax reform.

D'Ingiullo et al. (2023) studied the relationship between domestic institutions and export performance in Italian regions. The rule of law was found to be effective only in the northern regions. This result implies that the socioeconomic and institutional characteristics of the regions as a whole tend to influence export performance. Agostino et al. (2020) investigated the role of institutions in business creation in Italian regions. Their findings demonstrate that the effectiveness of different institutions, such as the rule of law and regulatory quality, varies across regions. The study also concludes that the impact of institutions is reduced during crisis periods, when innovation, human capital, and infrastructure become more relevant.

4. Data and Methodology

In this paper, the relationship among the rule of law, technological advances, competitiveness, and value-added is tested through panel causality analysis. In this context, 29 countries that are indexed in the European Innovation Scoreboard (European Commission, 2022) and for which data access is available have been included in the analysis. These countries are listed in Appendix 1. The longest possible time interval has been selected to reflect both past and current country experiences, and the annual data from 1996 to 2020 has been selected for analysis. Within the framework of the analysis investigating bidirectional causality between variables, the following 10 models have been established and estimated:

Model 1: $CIP_{i,t} = \alpha_{0i} + \beta_{1i} RDI_{i,t} + \varepsilon_{i,t}$ i: 1,…..,N and t:1,…,T *(Eq.1)*
Model 2: $RDI_{i,t} = \alpha_{0i} + \beta_{1i} CIP_{i,t} + \varepsilon_{i,t}$ i: 1,…..,N and t:1,…,T *(Eq.2)*
Model 3: $MVA_{i,t} = \alpha_{0i} + \beta_{1i} RDI_{i,t} + \varepsilon_{i,t}$ i: 1,…..,N and t:1,…,T *(Eq.3)*
Model 4: $RDI_{i,t} = \alpha_{0i} + \beta_{1i} MVA_{i,t} + \varepsilon_{i,t}$ i: 1,…..,N and t:1,…,T *(Eq.4)*
Model 5: $CIP_{i,t} = \alpha_{0i} + \beta_{1i} ROL_{i,t} + \varepsilon_{i,t}$ i: 1,…..,N and t:1,…,T *(Eq.5)*
Model 6: $ROL_{i,t} = \alpha_{0i} + \beta_{1i} CIP_{i,t} + \varepsilon_{i,t}$ i: 1,…..,N and t:1,…,T *(Eq.6)*
Model 7: $MVA_{i,t} = \alpha_{0i} + \beta_{1i} ROL_{i,t} + \varepsilon_{i,t}$ i: 1,…..,N and t:1,…,T *(Eq.7)*
Model 8: $ROL_{i,t} = \alpha_{0i} + \beta_{1i} MVA_{i,t} + \varepsilon_{i,t}$ i: 1,…..,N and t:1,…,T *(Eq.8)*
Model 9: $RDI_{i,t} = \alpha_{0i} + \beta_{1i} ROL_{i,t} + \varepsilon_{i,t}$ i: 1,…..,N and t:1,…,T *(Eq.9)*
Model 10: $ROL_{i,t} = \alpha_{0i} + \beta_{1i} RDI_{i,t} + \varepsilon_{i,t}$ i: 1,…..,N and t:1,…,T *(Eq.10)*

In the models, $MVA_{i,t}$, $CIP_{i,t}$, $RDI_{i,t}$, and $ROL_{i,t}$ indicate manufacturing value-added production per capita of country *i* in year *t*, competitiveness score of country *i* in year *t*, R&D intensity of country *i* in year *t*, and the rule of law score of country *i* in year *t*, respectively. The share of research and development expenditures in gross domestic product, also known as R&D intensity, is employed to measure technological advances. On the other hand, manufacturing value-added production per capita is taken as a proxy for value-added, while the Competitive Industrial Performance (CIP) Index, developed by the United Nations Industrial Development Organisation (UNIDO), is taken as a proxy for competitiveness. The variable "the rule of law" is taken from the World

Governance Indicators. The rule of law score ranges from -2.5 to 2.5. A high score indicates a strong legal system, secure property rights, and effective contract enforcement. Table 1 provides the definitions and sources of these variables.

Table 1: Definition of variables

Variable	Definition	Source
MVA	Manufacturing value-added per capita (2015-$)	UNIDO
CIP	Competitive industrial performance score	UNIDO
RDI	R&D Intensity	OECD
ROL	The Rule of Law	World Bank

The models established within the framework of panel causality analysis are employed using the Dumitrescu and Hurlin (2012) causality test. Granger causality analysis evaluates the panel as a whole and ignores the potential causality relationship between cross-section units. Heterogeneity assumption emphasises that the causality that is valid for the panel may not be valid for all units (Dumitrescu and Hurlin, 2012: 1451). Therefore, employing panel causality analysis that considers heterogeneity enables more reliable and comprehensive results. In this context, Dumitrescu and Hurlin (2012) developed the Granger causality test for heterogeneous panels.

Within the framework of the test, the model based on two stationary variables is as follows:

$$y_{i,t} = \alpha_i + \sum_{k=1}^{K} \gamma_i^{(k)} y_{i,t-k} + \sum_{k=1}^{K} \beta_i^{(k)} x_{i,t-k} + \varepsilon_{i,t} \qquad i: 1,....N \text{ and. } t: 1,...,T \qquad (Eq.11)$$

In Equation 11, y_{it} is the dependent variable and $x_{i,t-k}$ is the explanatory variable. $\gamma_i^{(k)}$ and $\beta_i^{(k)}$ denote autoregressive and slope parameters of the model, respectively, and these parameters differ across groups. Additionally, α_i, $\varepsilon_{i,t}$, and k denote the time-invariant constant of the model, error term, and lag order, respectively. Within the model, the null hypothesis states that there is no homogeneous causality between the variables, whereas the alternative hypothesis states that there may be heterogeneous causality for some of the cross-section units. The hypotheses are described as follows:

H_0: $\beta_i = 0 \quad i=1,\ldots\ldots,N$
H_1: $\beta_i = 0 \quad i=1,\ldots\ldots,N_1$
$\beta_i \neq 0 \quad i=N_1+1, N_1+2,\ldots\ldots\ldots,N$

Under the null and alternative hypotheses, it is assumed that there is no causality for $N_1<N$. Although N_1 is unknown, the condition $0 \leq N_1/N<1$ is satisfied. In case $N_1>0$, there is a heterogeneous causality. In testing the null hypothesis, the average of Wald statistics calculated for the individuals is considered and the following two test statistics are computed.

$$Z_{N,T}^{HNC} = \sqrt{\frac{N}{2K}}\left(W_{N,T}^{HNC} - K\right) \overrightarrow{T, N \rightarrow \infty} N(0,1) \qquad (Eq.12)$$

$$\tilde{Z}_{N}^{HNC} = \frac{\sqrt{N}\left[W_{N,T}^{HNC} - N^{-1}\sum_{i=1}^{N} E\left(W_{i,T}\right)\right]}{\sqrt{N^{-1}\sum_{i=1}^{N} Var\left(W_{i,T}\right)}} \overrightarrow{N \rightarrow \infty} N(0,1) \qquad (Eq.13)$$

$Z_{N,T}^{HNC}$ gives strong results when N<T, but is likely to reject the null hypothesis as N tends to infinity. In the case of N>T, $\tilde{Z}_{N}^{HNC}$ is effective even in small samples. Because N (29) and T (25) are close to each other in the sample, both test results are reported.

5. Estimation Results

Before proceeding to panel causality analysis, it is important to perform selected diagnostic tests to verify the robustness of the estimates. CD, CD_{LM}, LM, and LM_{adj} tests were used to determine cross-sectional dependence. Among the two tests developed by Pesaran (2004), CD_{LM} test gives strong results in the case of N>T, while CD test is efficient when N and T tend to infinity. While Breusch and Pagan (1980) LM test is valid for N<T, Pesaran, Ullah, and Yamagata (2008) LM_{adj} test is robust when N and T tend to infinity. Although the sample size in the paper is N<T, with N (29) and T (25) being quite close to each other, it is considered appropriate to report the results of all tests. Table 2 shows the results of the cross-sectional dependence test. According to these results, the null hypothesis is rejected for all models, and it is concluded that there is cross-sectional dependence.

Table 2: Cross-sectional dependence test results

Test	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10
LM	3666***	4190***	2278***	2233***	2063***	1999***	2625***	2452***	2610***	2269***
LM_{adj}	116***	136***	66***	65***	59***	57***	79***	72***	78***	66***
CD	181***	209***	75***	73***	50***	46***	180***	166***	121***	102***
CD_{LM}	114***	132***	65***	64***	58***	55***	77***	71***	77***	65***

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

Due to the presence of cross-sectional dependence, the stationarity of the variables is analysed with the Pesaran (2007) CADF test, which takes into account the cross-sectional dependence issue and is among the second generation panel unit root tests. Table 3 shows the results of the CADF unit root test. According to the test results, all variables are stationary in the first difference. In this context, the variables are included in the analysis considering their stationarity levels.

Table 3: CADF unit root test results

Değişken	Düzey	Fark
MVA	-1.480	-3.021***
CIP	-0.951	-3.135***
RDI	-1.827	-2.660***
ROL	-1.851	-3.553***

Note: ***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively. According to the significance levels, the critical values are 2.300, 2.150, and 2.070. The values in the level and difference columns indicate t-bar test statistics.

Identifying the homogeneity of the model coefficients is important for the choice of methodology. Pesaran and Yamagata (2008) developed a test to analyse whether the slope coefficients differ across units. The null hypothesis of the test is that the slope coefficients are homogeneous. Table 4 shows the homogeneity test results. According to the results, the null hypothesis is rejected for both models, and the slope coefficients are heterogeneous.

Table 4: Homogeneity test results

Test	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10
Δ	35***	35***	32***	27***	19***	26***	15***	20***		20***
$\tilde{\Delta}_{adj}$	37***	38***	34***	29***	20***	28***	16***	22***	22***	22***

Note: ***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively. Decimals are excluded to save space.

Considering the results of the diagnostic tests employed before panel causality analysis, it is feasible to employ Dumitrescu and Hurlin (2012) panel causality test. Table 5 shows both panel and cross-sectional results for all models.

When panel causality results are considered, it is found that there is bidirectional Granger causality between variables for panel except from value-added to rule of law. Both technological advances and the rule of law are Granger causes of competitiveness and value-added. In addition, there is a bidirectional causality relationship between the rule of law and technological advances. The results show a multidirectional relationship between the variables.

When examining cross-sectional findings, it becomes clear that the effects of technological advances and the rule of law vary among countries. On the other hand, the effect of technological advances and the rule of law on value-added and competitiveness emerges independently of the countries' level of development. This finding is consistent with studies that indicate technological advances and the rule of law on countries' production and foreign trade performance exhibiting a heterogeneous structure in terms of development (see Amendola et al., 1993; Dosi et al., 2015; Demir and Hu, 2022).

To take it separately, the effect of technological advances on competitiveness and value-added production differs across countries. Cyprus, France, Israel, Lithuania, Poland, and Romania have strong links between technological advances and value added/competitiveness. On the other hand, the relationship between the rule of law and value-added/competitiveness is strong in Czechia, Ireland, Romania, and Turkiye. Considering the rule of law and technological advances together, they jointly affect competitiveness in five countries and value added in six. The common effect is achieved through both competitiveness and value-added in Czechia, Lithuania, Romania, and Turkiye. Among these countries, the causality relationship between the rule of law to technological advances is found to be significant only for Czechia, Lithuania, and Turkiye. For these countries, the relationship between the rule of law, technological development, competitiveness, and value-added is evident. For other countries, the findings vary in terms of

Table 5: Dumitrescu-Hurlin Panel Causality Test Results

	rdi→cip		cip→rdi		rdi→mva		mva→rdi		rol→cip		cip→rol		rol→mva		mva→rol		rol→rdi		rdi→rol	
CS	**Wald**	**Caus.**	**Wald**	**Caus.**	**Wald**	**Caus.**	**Wald**	**Caus.**	**Wald**	**Caus.**	**Wald**	**Caus.**	**Wald**	**Caus.**	**Wald**	**Caus.**	**Wald**	**Caus.**	**Wald**	**Caus.**
AUT	2.93	→	5.59	→*	2.40	→	18.55	→***	1.72	→	1.48	→	0.00	→	3.70	→*	2.27	→	1.15	→
BEL	0.00	→	1.52	→	0.10	→	0.33	→	0.03	→	1.25	→	0.22	→	0.49	→	0.04	→	2.92	→*
BGR	4.24	→**	0.77	→	2.25	→	0.04	→	0.08	→	1.43	→	0.26	→	0.19	→	0.12	→	0.14	→
CYP	6.87	→***	0.00	→	9.63	→***	13.90	→***	0.20	→	0.69	→	1.65	→	9.02	→***	3.34	→*	5.70	→**
CZE	3.54	→*	2.11	→	3.93	→**	0.25	→	83.34	→***	2.23	→	6.76	→***	0.05	→	4.04	→**	0.65	→
DNK	0.16	→	8.22	→***	0.54	→	0.33	→	0.48	→	0.97	→	0.67	→	1.92	→	0.06	→	3.85	→**
FIN	24.70	→***	7.27	→***	5.64	→*	0.04	→	8.33	→***	0.56	→	0.20	→	0.16	→	11.16	→***	17.42	→***
FRA	8.18	→***	0.04	→	5.45	→**	0.00	→	0.59	→	0.58	→	0.03	→	0.28	→	0.88	→	0.24	→
DEU	1.77	→	4.44	→**	7.76	→***	3.20	→*	4.97	→**	0.54	→	0.34	→	0.00	→	0.95	→*	0.17	→
GRC	3.44	→*	0.71	→	5.47	→*	0.28	→	2.00	→	4.07	→**	7.16	→**	6.94	→**	0.13	→	0.61	→
HUN	0.12	→	5.61	→**	1.35	→	2.20	→	0.07	→	6.39	→**	0.25	→	1.82	→	5.58	→**	0.06	→
IRL	1.22	→	8.08	→***	0.10	→	1.0	→	20.25	→***	5.98	→**	30.67	→***	0.49	→	21.40	→***	3.75	→
ISR	19.49	→***	0.75	→	19.88	→***	6.52	→*	0.17	→	0.21	→	1.62	→	2.63	→	0.03	→	1.07	→
ITA	0.85	→	8.42	→***	2.72	→*	5.97	→**	1.62	→	0.01	→	0.01	→	2.43	→	1.84	→	0.17	→
LVA	11.05	→***	2.78	→	3.57	→*	0.98	→	1.82	→	0.26	→	5.36	→**	0.11	→	1.30	→	7.69	→***
LTU	6.85	→***	0.04	→	8.03	→***	0.07	→	9.55	→***	1.00	→	3.20	→*	0.00	→	12.43	→***	0.28	→
NLD	0.17	→	11.86	→***	0.98	→	3.49	→*	5.15	→**	4.05	→**	0.39	→	0.93	→	20.37	→***	0.82	→
NOR	2.19	→	8.69	→***	6.44	→**	4.37	→**	1.06	→	0.01	→	0.05	→	0.75	→	0.16	→	4.99	→**
POL	7.61	→***	11.12	→***	8.50	→***	11.66	→***	0.28	→	0.32	→	0.34	→	0.37	→	0.06	→	1.47	→
PRT	5.96	→*	1.39	→	5.21	→**	0.36	→	0.07	→	0.07	→	0.84	→	0.50	→	0.06	→	5.28	→**
ROU	5.22	→**	1.00	→	4.39	→**	3.42	→*	5.28	→**	3.89	→**	6.19	→**	0.04	→	0.00	→	2.18	→
SRB	4.47	→**	0.52	→	0.91	→	0.00	→	0.35	→	5.60	→**	4.50	→**	3.21	→*	0.68	→	2.59	→
SVK	2.56	→	1.97	→	2.21	→	0.03	→	4.93	→**	1.97	→	3.22	→*	1.12	→	0.00	→	2.19	→
SVN	8.64	→***	2.89	→*	1.85	→*	0.00	→	1.85	→	14.27	→***	0.98	→	1.29	→	6.05	→	3.30	→
ESP	0.17	→	3.27	→*	11.51	→***	20.24	→***	3.68	→*	0.16	→	0.73	→	2.49	→	0.77	→	0.28	→
SWE	0.05	→	1.03	→	0.05	→	0.04	→	3.69	→*	0.44	→	1.81	→	0.02	→	0.92	→	6.21	→**
TUR	3.76	→*	1.26	→	12.18	→***	6.69	→*	4.73	→**	1.99	→	9.39	→***	2.02	→	4.70	→**	0.00	→
UKR	1.05	→	2.48	→	0.55	→	1.47	→	0.03	→	2.42	→	1.80	→	2.23	→	4.25	→	9.03	→**
GBR	3.73	→*	3.54	→*	1.70	→	1.44	→	1.18	→	1.50	→	1.11	→	0.12	→	2.92	→*	0.44	→
$Z_{N,T}^{HNC}$	13.30	→***	9.16	→***	11.44	→***	8.14	→***	16.37	→***	3.88	→***	7.23	→***	1.68	→	8.09	→***	5.55	→***
$\tilde{Z}_{N}^{HNC}$	10.47	→***	7.10	→***	8.75	→***	6.11	→***	12.97	→***	2.79	→***	5.60	→***	1.02	→	6.07	→***	4.04	→***

Note: The test statistics denote $W_{i,T}$ for cross-sections and and for the panel. The maximum lag order is three, and the Schwarz information criteria are considered. ***, **, * indicate significance 1%, 5%, and 10% levels, respectively. *CS: Cross Section. Caus.: Causality. Lag lengths are not included to save place.*

technological development and the rule of law. The causal relationship between competitiveness/value-added and technological advance and rule of law shows a similar divergence, except for the relationship between value added and rule of law.

A number of factors affecting cross-country divergence have been considered in the literature review. These include market structure (Padula et al., 2015), social and institutional factors (Demir and Hu, 2022; Milberg and Houston, 2005), the nature of R&D activities (Chandran et al., 2017), changes in their cyclical effects (Soltmann et al., 2015), and innovation culture (Petrakis et al., 2015), and sector-specific factors (Hall and Mairesse, 1995). As an essential proxy for institutions, this study considers the rule of law as a possible factor of cross-country divergence. The findings showed that the analysis revealed significant results for several countries.

Institutions and technological innovation are the drivers of long-term economic performance (Fagerberg, 1988; Rodrik, 2009). However, a number of factors influence the channels of interaction for both technological advances and institutions. First, both the lagged effects of R&D activities (van Elk et al., 2019) and the changing nature of institutions over a long period of time (Williamson, 1998) may require a longer time-dimensional analysis of economic performance. Second, it is difficult to directly observe the effects of R&D activities and institutions. Institutions are often perceptive (Rodrik, 2009), and R&D is mostly embodied in product and process innovation. Third, the impact of institutions may also vary across regions and sectors (D'Ingiullo et al., 20-23; Levchenko, 2007). Therefore, further regional or sectoral analysis would be valuable in better understanding the interaction between variables in question.

6. Conclusions

The production and competitive landscape characterised by economic complexity drives nations to endlessly search for new opportunities. Technological advances and innovations are at the core of economic transition and performance. However, country-specific factors are at least as important as technological advances in terms of determining the direction and intensity of technology. Institutions are important both in their ability to direct technological advances and in affecting productivity. In this context, this study aims to analyse the relationship between technological development, value added and competitiveness across countries, considering institutions. The findings show that both technological advances and the rule of law are Granger causes of value added and competitiveness. However, this causality relationship diverges irrespective of a country's economic outlook. These results support the existence of cross-country divergence. In some countries, it appears that institutions and technological advances are related. On the other hand, the results also show that, in addition to institutions, other country-specific factors must be considered. In this context, technology-centred economic policy, considering these other factors in policy design processes, is crucial for unlocking and sustaining economic performance and gains from foreign trade.

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Appendix-1: Countries in the analysis

Austria (AUT)	*Belgium (BEL)*	*Bulgaria (BGR)*	*Cyprus (CYP)*	*Czechia (CZE)*	*Denmark (DNK)*	*Finland (FIN)*	*France (FRA)*
Germany (DEU)	*Greece (GRC)*	*Hungary (HUN)*	*Ireland (IRL)*	*Israel (ISR)*	*Italy (ITA)*	*Latvia (LVA)*	*Lithuania (LTU)*
Netherlands (NLD)	*Norway (NOR)*	*Poland (POL)*	*Portugal (PRT)*	*Romania (ROU)*	*Serbia (SRB)*	*Slovakia (SVK)*	*Slovenia (SVN)*
Spain (ESP)	*Sweden (SWE)*	*Turkiye (TUR)*	*Ukraine (UKR)*	*United Kingdom (GBR)*			

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RESEARCH ARTICLE

Public Policies on the Socioeconomic Effects of Migration*

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ABSTRACT

To develop a public policy, it is important to understand the experiences of forced migrants. This study reveals the effects of forced migration on public finances in countries hosting displaced people. In this context, public policy support for access to basic humanitarian needs such as education and health, which are semi-public goods, will be evaluated through a quantitative analysis. Interviews with refugees within the scope of this research draw a picture of the current situation. Thus, evaluating the effectiveness and shortcomings of existing policies and determining the policy support needed are among the unique values of this research. Since migration is a dynamic process, it is also aimed to provide a basis for future studies in this field and to reveal the current situation.

Keywords: Health policy, Education policy, Concept of migration, Theories of migration, Socioeconomic effects of migration
JEL Classification: H3, I18, I28, O15

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1. Introduction

Migration is a human story that is both an outcome and a beginning. The reasons that push people to decide to migrate may stem from the characteristics of the place where they currently live, as well as the attractive features of the countries they plan to migrate. The movement in question can be voluntary and based on an individual decision, or it can be based on a state of necessity such as a climate crisis or war. Due to its dynamics, migration has inevitable economic, social, and cultural impacts. Factors such as how the decision to migrate is taken, whether it is an individual or collective movement, social and economic differences between the country of origin and the country of destination, and whether people are skilled or not affect the form and magnitude of the social and economic effects of this movement on the destination country.

The migration process is not a one-way relationship. This process affects not only the immigrants but also the destinations and society living in these places economically, socially, and culturally. Refugees, especially those who came to their destination country within the scope of forced migration, need basic needs such as shelter, health, and education. Public policies to be implemented for these needs are an important part of the integration process. If policies for this process are not developed, a series of economic and social problems will arise at both personal and social levels. The dynamic nature of the integration process necessitates monitoring of the process at intervals, and the necessary policy support for integration can only be achieved by gaining awareness of the problems experienced.

This study provides information about the effects experienced by countries hosting forced migration in the field of public finance. In this context, public support for the access of displaced people to basic humanitarian needs such as education and health, which are quasi-public goods, will be evaluated through a quantitative analysis.

2. Concept and Classification of Migration

Various disciplines and focal points differ in the conceptual explanation of migration. According to the International Organisation of Migration, migration is defined as the movement of people from their usual place of residence, either domestically or internationally (International Organisation of Migration, 2020). Jessica Hagen-Zanker defines migration as the temporary or permanent movement of individuals or groups of people from one geographical location to another for various reasons, ranging from better employment opportunities to persecution (Hagen-Zanker, 2008, p. 4). According to Lee, migration is a permanent or semi-permanent change of residence (Lee, 1966, p. 49). In this very broad definition, there is no restriction on distinction points such as distance, necessity, and internationalisation of migration.

According to the Directorate General of Migration Management of Türkiye, migration is defined as follows (Directorate General of Migration Management, 2017, p. 20): "Regular migration, which refers to the entry of foreigners into, stay in, and exit from Türkiye through legal means; irregular migration, which refers to the entry of foreigners into, stay in, and exit from Türkiye through illegal means and unauthorised work in Türkiye; and international protection."

It is seen that migration movement has many aspects in terms of both theoretical and actual reasons why it occurs. The history of migration is related to economic history and cultural history because of the contact of cultures (Yavan, 2022, p. 514). This complex structure of migration makes it difficult to create a single theory of migration accepted by all fields and to classify a single type of migration. The common point of migration definitions is that migration movement has two basic starting points: space and time. These points are also the basic classification categories used to subdivide migration. However, the classification of migration does not consist only of time and space constraints. Apart from these, migration has several dimensions such as voluntary or involuntary migration, legality, continuity, geographical conditions, politics, and economy. In this study, the multidimensionality of migration types is analysed under four categories: distance, duration, reason for occurrence, and legality.

We divide the classification of migration in terms of distance into two categories: internal and external migration. Internal migration refers to movement from one city to another or from one region to another within the borders of a country (Bartram, Poros, and Monforte, 2019, p. 191). The fact that the population in all countries is on the move for social, economic, and educational purposes makes this type of migration quite common. Since internal migration occurs within the borders of the country, there is no change in the total population of the country, whereas changes are observed in the population density of cities or regions. Because this type of migration is generally from rural to urban areas, it causes local governments to increase their expenditures (Şahin, 2020, p. 359). The development and implementation of public policies for cohesion within the scope of internal migration is relatively easier than external migration because it takes place within the same country and migrants and hosts are from similar cultures (Güreşçi, 2016, p. 1062).

External migration is a type of flow that occurs across national borders. Internal migration generally stems from inequalities in income and living conditions, especially between developed and developing countries, domestic political unrest and development, employment opportunities, escape from domestic political unrest and development, employment opportunities. Labour migration with the desire to be employed (Bartram et al, 2019, p. 191) or brain drain, which is defined as the migration of highly qualified individuals, especially in underdeveloped countries, is an example of external migration.

When thinking about migration, the main distinction is made in terms of duration. The time criterion was first mentioned at the Geneva Congress in 1932. According to this criterion, migration movements lasting 1 year or more are categorised as "permanent migration", while migration movements lasting less than 1 year are classified as "temporary migration" (Özdal and Vardar Tutan, 2018, p. 35).

Another distinction, which is also used as legal and illegal migration, is more commonly referred to as regular and irregular migration. The concept of irregular migration includes migrants who enter a country without documents or with false documents and those who enter legally but continue to stay after their visas or work permits expire (Koser, 2007, p. 17). Mass migration, which is the large-scale relocation of a population within a country or from one country to another for economic, political, natural, etc. reasons, is an example of irregular migration (Smith, 2007, p. 622). Regular migration, on the other hand, is migration from one country to another by completing the necessary official documents and permits for purposes such as employment and education (İçduygu and Aksel, 2012, p. 20).

Another criterion in migration classification is the reason for movement. While migration is sometimes performed as voluntary action, it may become compulsory according to the situations and actions experienced. Voluntary migration occurs when individuals decide to migrate not because of external pressure but because they want to do so. The main incentive here is the individual desire to achieve better living standards in another region or country (Yılmaz, 2014, p. 1687). Forced migration, on the other hand, is a type of migration caused by various reasons such as war, economic difficulties, natural disasters, or as a result of the open/closed coercion of policymakers, the difficulty of individuals to maintain their lives in their places, or the pressure on their happiness (Özdal and Vardar Tutan, 2018, p. 35; Bartram et al, 2019, p. 151). The classification of forced and voluntary migration creates differences in the legal characterisation of the people who constitute this mobility. People who migrate for a compulsory reason are referred to as political refugees, exiles, asylum seekers; while people who migrate voluntarily are usually referred to as economic migrants (Sert, 2018, p. 30).

Forced migration has a quite different structure from economic migration. Although most migration decisions are ultimately based on choice, forced displacement is based on less choice and less voluntariness than economic migration. This is because forced displacement is a decision taken quickly after a sudden shock, unlike economic migration, which is a carefully planned movement. As a result, while forced migrants carry some small savings with them, economic migrants have the opportunity to carry all their savings and assets or to transfer these assets before departure. Economic migrants tend to rely on extensive networks in their countries of origin and destination and plan their movements accordingly. Forced migrants, on the other hand, move to destinations based on proximity and security criteria, although social networks sometimes play a role in their decisions. Moreover, while economic migration is a regular and individual element with increasing and decreasing trends, forced migration occurs in masse in the form of sudden and unexpected population explosions (Verme, 2017; Ceriani and Verme, 2018). As a result, forced displacement requires a separate assessment because it is a phenomenon different from economic migration.

3. Public Nature of Forced Migration

It is important to understand the responsibilities of countries in the aftermath of large-scale refugee movements, such as those that emerged from the Syrian conflict. Because of international migration flows, countries' policies to protect refugees produce benefits that cannot be excluded and divided at the local, regional, and global levels. Therefore, refugee policies are public.

Suhrke (1998), the first to study the relationship between refugee protection and the public good, argues that the reception of displaced persons is an international public good from which all states benefit. This is explained by the fact that the outcomes of refugee protection are characterised by externalities (Jayarama and Kanbur, 1999, p. 419). One of these outcomes is security. When states allow forced migrants to enter and stay in their territory through refugee protection, they lay the groundwork for future stability and security. The protection offered to forced migrants in their country of destination reduces their incentives for a second migration, thus preventing the instability that new movements may bring. Conversely, a state's refusal to protect refugees or its efforts to divert refugee flows to other countries can be expected to lead to border tensions, irregular migration, and thus increased instability and insecurity. What makes refugee protection a public good is, therefore, the fact that the enhanced stability and security provided by a country's refugee protection efforts will not only accrue to the country providing the protection, but the resulting benefits will spread to all countries in the region, whether they bear the financial cost of the protection effort. The stability and security benefits generated by refugee protection efforts are therefore indivisible and non-excludable (Thielemann, 2020, p. 170-171).

An increase in the number of refugees can create negative externalities such as traffic congestion in urban areas, an increase in informal settlements, and a decrease in the perception of security (Zetter, 2012, p. 52). On the other hand, the fact that the motivation of people arriving in destination countries to return to their country of origin is generally low (Fakhoury and Özkul, 2019, p. 28; Erdoğan, 2020, p. 14; Ghabash et al., 2020, p. 5) requires that the long-term effects of public services provided to these people should not be ignored. In this context, education and health services provided to people arriving through forced migration will not only provide individual benefits to these individuals but also create social benefits for the destination country.

Health and education, which are also the subjects of this study, constitute both fundamental rights and are considered to be among the main elements of human capital. It is a generally accepted view that individuals should benefit from health and education services, which are defined as semi-public goods, regardless of their innate differences in language, religion, race, gender, or acquired income, wealth, prestige, and status (Bulutoğlu, 2004, p. 252-263).

An important element in terms of social benefit is the provision of education services. For refugees, learning the local language and having knowledge about the history of the country of origin is one of the main factors of adaptation to the country of destination, but it is also an investment in society in terms of contribution to human capital. Education can prevent child labour, child marriage, exploitative and dangerous work, and crime. The fact that education is a human capital investment in the future will contribute positively to both integration (Erdoğdu and Akar 2018, p. 34) and society (See Table 1).

Table 1: Education Externalities at the Individual and Societal Levels

	Economics	**NON-ECONOMIC**
INDIVIDUAL	High Employment High Income Less Unemployment Higher Economic Mobility	High Level of Consumer Awareness Better Personal and Family Health Child Health Recovery and Talent Development
SOCIETY	High Tax Revenue Low Public Monetary Assistance	Decrease in the Crime Rate Reduced Level of Spread of Epidemic Diseases Better Social Cohesion Higher Level of Voting Participation

Source: Uzun, F. (2022). Eğitimin dışsallıkları ve toplumsal sistemlere etkisi. *Electronic Turkish Studies, 17*(6).

Education is one of the most important factors affecting the economic, social, and political development of countries. An increase in the level of education throughout the country means an increase in the qualified labour force, and acceleration of scientific and technological development and thus affects the level of national income. As the number of educated individuals in society increases, development and growth in the country accelerates (Öztürk, 2016, p. 15). Education can affect growth in three ways. The first of these, as briefly mentioned above, is that education positively affects labour productivity, i.e., it contributes to human capital, which leads to a higher level of production and an increase in growth. Second, education can stimulate growth by enabling the development of new technologies. Finally, education facilitates the transfer of knowledge among individuals necessary for new technologies that promote economic growth (Hanushek and Wößmann, 2010, p. 245; Mankiw, Romer and Weil, 1992; Lucas, 1988; Romer, 1990; Nelson and Phelps, 1966).

One of the external benefits of education is the increase in political participation and effective democratic functioning in societies consisting of informed individuals. In addition, as the level of education in a society increases, crime rates decrease, decreasing expenditures on both security and justice services. On the other hand, life expectancy increases, public health improves as individuals become more conscious about their health, and public health expenditures decrease. Moreover, as the level of education of individuals increases, their incomes also increase, thereby reducing transfer expenditures on low-income groups and increasing their capacity to pay taxes (McMahon, 1987, p. 134; Öztürk, 2005, p. 35; Lochner, 2011, p. 66).

The second element of social benefit is health services. Providing effective and accessible health services prevents inequality and protects public health while contributing to the integration process of refugees. Therefore, access to health services is as important as housing and education (Al-Fahoum et al., 2015, p. 2). If refugees are in poor health, it may negatively affect their ability to find a job, learn a language, interact with public institutions, and succeed in school, which in turn affects their integration processes in their countries of destination (Crawford, 2016; İçduygu & Şimşek, 2016, p. 65-66). This negative situation is not only limited to the individual level but also affects society in general. This is because health is a semi-public good with externalities like education. By providing preventive and curative health services to those who cannot purchase these services from the market, the state creates equality of opportunity and protects the public interest due to external benefits. In addition to personal health, the treatment methods offered and the R&D research conducted are also aimed at improving public health, such as in the case of epidemics. Thus, social and economic problems can be prevented. At the same time, since it is an investment in human capital, it ensures the continuity of individuals' contributions to employment and the national economy. As a result, it is an important tool both in the development of the country and in the fight against poverty (Yılmaz and Yaraşır, 2011, p. 10; Sağbaş, Saruç and Yorulmaz, 2017, p. 230; Altay, 2007, p. 36). Therefore, while access to health services is a personal need, it creates benefits that spread throughout society.

Especially when migration is mass and forced, the steps taken by the state for basic needs such as education and health, which are difficult to meet through social relations, become even more important. Forced migration increases the demand for public services for basic human needs such as security, education, health, and shelter in the destination country. Because the provision of these public services is planned according to the population, the increasing number of refugees may create qualitative and quantitative problems in access to public services. However, the long-term outputs of these services are not only basic human rights but also create social benefits as they affect the economic development, growth, income distribution, and public health of the destination country. When the motivation of arrivals to return is generally low, it is in the interest of not only refugees but also the society that these people benefit from these services effectively. In this context, the following section of the study presents research on the access of Syrian refugees living in Türkiye to selected public services.

4. Refugees' Access to Education and Health Services in the Country of Destination and Public Policies: Field Research on Syrian Refugees Living in Türkiye

Regardless of the cause, migration impacts the public finances of the destination country. As mentioned in the previous section, this impact can be positive or negative depending on the assumptions used. While the fiscal impact in the destination country provides a fiscal framework for the public policy to be implemented in the relevant area, revealing the experiences of the arrivals with public services is crucial for the content of the public policies to be determined. The reason behind this is both the personal vitality of basic humanitarian services received by migrants and the positive externalities they can create, regardless of the size of the impact created in the country of origin. In this section of the study, the access of internationally displaced people to education and health services will be evaluated through a quantitative analysis.

4.1. The Subject and Problematics of Research: Purpose and Importance

This study investigates the adaptation process by examining the relationship between public policies implemented for education and health services and the adaptation processes of refugees. In this direction, it is aimed to develop suggestions for planning forced migration management.

When the purpose of the research is considered, the difficulty of creating a universal reality independent of individuals emerges because of the human, time, and cultural relations that migration has. The aim of the proposed study is not to generalise by creating a situation with universal validity, but to have in-depth insight into a situation that is being experienced and to develop suggestions by putting forward interpretations.

The study is important in terms of national literature as it plans to approach studies on migration management from the perspective of refugees and in terms of international literature as it plans to reveal the current situation in Türkiye in the causal relationship between the adaptation processes of refugees and public policies towards health and education services. In addition to revealing the current situation since migration is a dynamic process, this study aims to create a basis for future studies in this field.

While the dynamic nature of the integration process makes it necessary to follow the process at intervals, the policy support necessary to ensure integration can only be possible with the awareness of the problems being experienced. The interviews to be conducted with refugees within the scope of the research will provide a picture of the current situation and provide an opportunity to compare with previous studies. Thus, evaluating the effectiveness and shortcomings of existing policies and determining the policy support needed are among the unique values of this research.

The research questions determined for this study are as follows:

- *Research Question 1: What public policies for education and health services should be implemented within the scope of the adaptation processes of refugees in a country receiving forced migration?*
- *Research Question 2: How are the current public policies on education and health services reflected in refugees undergoing forced migration?*
- *Research Question 3: Is there a relationship between the level of satisfaction with education services and the future intention of refugees arriving with forced migration to stay in Türkiye?*

- *Research Question 4: If refugees coming with forced migration receive aid, what is the relationship between the aid they receive and their satisfaction with education services?*
- *Research Question 5: What is the relationship between the preferred health institution and satisfaction with health services?*
- *Research Question 6: Is there a relationship between the degree of satisfaction with the health services received in Türkiye and the decision to stay in Türkiye?*
- *Research Question 7: Is there a relationship between the Turkish language skills of refugees who came with forced migration and their satisfaction with the health services they received in Türkiye?*

As in any study, there were some limitations in this study. One of these limitations is language. While interviewing Syrians, who are the main subjects of the study, Syrians who speak Turkish were preferred because it was not desired to lose information during the translation phase. This situation made it difficult to represent women and older people especially, because of their poor knowledge of Turkish. Another limitation of the study is its geographical scope. Considering the limited financial means, the study was conducted only in Istanbul, Türkiye. Therefore, the study can only reflect the opportunities in the big city; local policies in small cities are not included.

4.2. Methodology and Data Analysis

Within the scope of the study, the questionnaire method, a quantitative research method, was used. The scopes of the survey questions were created by making use of the domains and indicators (See Table 2) prepared by Ager and Strang to be used in the analysis of integration processes (Ager & Strang, 2004). This is because Ager and Strang's domains and indicators have become a common focal point for research, policy, and practise on migrant integration. In the scope of this study, it was deemed appropriate to narrow down these areas and indicators to education and health services, which are structural areas of integration.

Table 2: Adaptation Fields and Indicators

Adaptation Fields	**Adaptation Indicators**
Structural Alignment (Markers and Tools)	Employment, housing, education, and health
Interaction-based Adaptation (Social Connexions)	Social bridges, social ties, and social connexions
Cultural Adaptation (Facilitators)	Language and cultural knowledge, trust, and stability
Identity-Based Alignment (Basic)	Rights and citizenship

Resource: Ager, A., & Strang, A. (2004). Indicators of integration: Final, London: Home Office. *Home Office Development and Practise Report 28*.; Topçu, E., & Büyükbeşe, T., (2020). Göç bağlamında toplumsal uyum göstergeleri. *Aksaray Üniversitesi İktisadi ve İdari Bilimler Dergisi, 12*(1), 23-34.

While determining the questions for the survey method used in the study, both domestic and foreign literature were reviewed in the relevant field. Because of the literature review, closed-ended questions with both single and multiple options and open-ended questions were determined to reveal the special situations of the interviewees. These questions were divided into two main groups as personal and household questions: to gather information about the unique experiences of the interviewees in both individual and household situations. Each of these main groups consisted of questions on demographic characteristics, education, and health services. In addition, in the personal questions group, future-oriented questions were asked to predict the interviewees' long-term plans. Before starting the interviews within the scope of the study, the ethics committee approval certificate was obtained by submitting it to the Ethics Committee of Istanbul University Social Sciences and Humanities Research.

4.2.1. Main Population and Sample Selection

The main focus of this study is Istanbul, which hosts the largest number of people under temporary protection in Türkiye. To determine the size of the population, the statistics on the website of the Republic of Türkiye Ministry of Interior Directorate of Migration Management were analysed and the data under the Temporary Protection heading was used. According to the figures for February 2022, the number of Syrians under temporary protection living in Türkiye is 3,739,859. Of these, 531,816 live in Istanbul. Therefore, the number of people constituting the main mass of the research is 531,816.

The sample size of the study consisted of Turkish-speaking Syrians over the age of 18 who were selected from the main mass by purposive sampling. The sample size was calculated as approximately 384 individuals with a margin of error of ± 5% at a 95% confidence interval. Although this value is the smallest sample size required for the study, 510 people were interviewed within the scope of the study. Interviews with these 510 people cover 24 districts of Istanbul[1].

Because the study targets people who speak Turkish and are over the age of 18, convenience sampling was applied in these regions based on purposive sampling and selected for the study. Thus, demographic characteristics such as age, education, and socioeconomic status are thought to reflect the targeted population.

4.2.2. Data Collection

Within the scope of the study, a survey was applied as a measurement method to determine the current situation, access to public services, wishes, and needs of Turkish-speaking Syrians aged 18 and over living in Istanbul. Face-to-face interviews of approximately 20 minutes were conducted with 510 people in districts where Syrians live in Istanbul.

A pilot test was conducted in February 2022 to test the comprehensibility of the questions in the questionnaire and to make the necessary corrections. The questions were reviewed and revised in line with the inferences made from the pilot test. Following the necessary revisions, fieldwork was conducted in March-April 2022.

Microsoft Excel programme was used for coding and organising the data obtained from the questionnaires filled out as a result of the research; the IBM SPSS V28 package programme was used for making comparisons and cross-tabular analyses by taking frequencies and measuring their statistical significance.

[1] These districts are Arnavutköy, Avcılar, Bağcılar, Bahçelievler, Başakşehir, Bayrampaşa, Eyüpsultan, Esenler, Esenyurt, Fatih, Gaziosmanpaşa, Güngören, Kağıthane, Küçükçekmece, Sultangazi, Zeytinburnu, Ataşehir, Çekmeköy, Kartal, Pendik, Sancaktepe, Sultanbeyli, Tuzla, and Ümraniye.

4.2.3. Findings

At this stage of the study, descriptive statistics and cross-tabulations are presented.

4.2.3.1. Descriptive Statistics for the Demographic Characteristics

In this section, the frequency distribution was analysed over the data obtained in the survey. The frequency distribution shows the data obtained to see the distribution characteristics of the values or scores of one or more variables as numbers and percentages (Büyüköztürk, 2014, p. 21). Table 3 shows the frequency distributions of the participants' gender, age, education level, and duration of living in Türkiye. As shown in the table, 63.1% of the participants were male and 36.9% were female. In terms of age distribution, the 25-34 age group was the most common age group with 42.4%, followed by the 18-24 age group with 30.8%. The representation rate decreases as the age group increases. The number of Turkish-speaking Syrian refugees decreases at older ages because the study consists of Turkish-speaking Syrian refugees. When we look at the education level of the interviewees, the first three are high school graduates, middle school graduates, and primary school graduates.

Table 3: Information on Descriptive Statistics

		Number	Percentage (%)
Gender	Female	188	36.9
	Male	322	63.1
Age	18-24	157	30.8
	25-34	216	42.4
	35-44	97	19
	45-54	28	5.5
	55-65	11	2.2
	65 and over	1	0.2
Education Status	I never went to school	14	2.7
	Primary school dropout rate	25	4.9
	Primary School	89	17.5
	Secondary school dropout rate	42	8.2
	Secondary School	91	17.8
	High school dropout rate	36	7.1
	High School	111	21.8
	University dropout	17	3.3
	University	80	15.7
	Graduate dropout	-	-
	Postgraduate	5	1.0

Table 3: Continued

Life expectancy in Türkiye	Less than 1 year	3	0.6
	1-5 years	104	20.4
	5-10 years	374	73.3
	More than 10 years	29	5.7
Thoughts on Living in Türkiye in the Future	I am thinking of living in Türkiye.	373	73.1
	I am thinking of living in a third country.	52	10.2
	I want to return to my country.	84	16.5
	Undecided	1	0.2

When asked how long they have been living in Türkiye, 73.3% of the respondents stated that they have been living in Türkiye between 5 and 10 years, while 20.4% stated that they have been living between 1 and 5 years. Those who came from Syria through forced migration were also asked about their thoughts on living in Türkiye in the future. As seen in Table 3, it is concluded that a significant portion of the respondents, approximately 73%, intend to stay in Türkiye in the future. The rate of those who want to return to Syria is 16.5% and that of those who want to live in a third country is 10%. Those who have not decided where they will live in the future constitute a very small portion of the sample (0.2%).

4.2.3.2. Descriptive Statistics on Education Services

This section of the study focuses on the data obtained from the participants in terms of health services.

Table 4: The type of Institution where the Child Living in the Household and Attending School Receives Education

	Frequency	Percentage
Public School	381	95%
Private School	17	4.2%
Unofficial Religious Institutions	3	0.7%
Total	401	100 %

In the interviews related to the general household, participants who stated that there were children going to school in the household were asked which type of school these children attended. Accordingly, 95% of the total 401 children attending school in the household go to public school (See Table 4).

Table 5: Problems Experienced by Children in School

		Responses	
		N	Percentage
Problems children experience at school	Inability to understand lessons due to language difficulties	56	16.0%
	Facing discrimination	64	18.3%
	Experiencing problems due to cultural differences	57	16.3%
	Difficulty making friends	55	15.7%
	The education system in Türkiye is different from that in your country of origin	37	10.6%
	No problem	81	23.1%
Total		350	100.0%

Individuals with school-going children in the household were asked about the problems their children face at school. Accordingly, while 23.1% of the respondents stated that their children did not have any problems, it is noticeable that the most common problem is discrimination. After discrimination, cultural differences, and not being able to understand the lessons due to insufficient comprehension of the Turkish language (See Table 5).

Table 6: Reasons for Not Attending School

		Responses	
		N	Percentage
Reasons for not attending school	Must work	12	4.5%
	Wants to work	11	4.1%
	Couldn't enrol in school	11	4.1%
	Insufficient information about educational opportunities	4	1.5%
	Here temporarily	2	0.7%
	Could not afford the school fees.	6	2.2%
	Have difficulty with the lessons given at school	4	1.5%
	Due to transportation difficulties	4	1.5%
	Not of school age	196	72.9%
	No ID	13	4.8%
	Due to health problems	2	0.7%
	Due to residence address	1	0.4%
	Other	3	1.1%
Total		269	100.0%

Table 6 shows the reasons for children not attending school. Accordingly, approximately 73% of the respondents stated that their children did not attend school because they were not of school age. It is seen that the two most important reasons for the remaining participants are the lack of identity cards for their children and the need for children living in the household to work (See Table 6).

Table 7: Level of Satisfaction with Education Received in Türkiye

		Frequency	Percentage	Valid percentage
Valid	I am very satisfied.	28	5.5	44.4
	I am satisfied	29	5.7	46.0
	Neither satisfied nor dissatisfied	5	1.0	7.9
	Not satisfied	1	0.2	1.6
	Total	63	12.4	100.0
Missing	System	447	87.6	
Total		510	100.0	

In Türkiye, 63 respondents who directly benefited from education services were asked whether they were satisfied with the services they received. Of these 63 respondents, 46% were satisfied and 44.4% were very satisfied. Those who were not satisfied with the education service they received in Türkiye constituted 1.6% of the 63 respondents (See Table 7).

Table 8: Educational Support in Türkiye

		Responses	
		N	Percentage
Has your education been supported in Türkiye?	I do not/have not received support	43	68.3%
	Public/government scholarship	11	17.5%
	International institution scholarship	1	1.6%
	University scholarship	1	1.6%
	NGO support	4	6.3%
	Private institution	3	4.8%
Total		63	100.0%

In Türkiye, 63 school-going individuals were asked whether they received any educational support, and 68.3% stated that they did not. Among those who stated that they received support, 17.5% received support from public institutions (See Table 8).

Table 9: Problems Experienced Personally in Education

		Responses	
		N	Percentage
Problems encountered in education received in Türkiye	Inability to understand lessons due to language difficulties	18	23.1%
	Facing discrimination	11	14.1%
	Experiencing problems due to cultural differences	4	5.1%
	Difficulty making friends	10	12.8%
	The education system in Türkiye is different from the country we come from.	11	14.1%
	Having to work	1	1.3%
	I had no problems	22	28.2%
	All of them	1	1.3%
Total		78	100.0%

Considering the problems experienced by people in their education processes in Türkiye during their education process, they mostly stated that they could not understand the lessons due to insufficient knowledge of the language. Other problems other than Turkish language skills were discrimination and a different education system compared to their home country (See Table 9).

4.2.3.3. Descriptive Statistics on Health Services

This section of the study focuses on the data obtained from the participants in terms of health services.

Table 10: Frequency of Use of Health Institutions

		Frequency	Percentage	Valid percentage
Valid	1-3 months apart	166	32.5	32.5
	Every 6 months	143	28.0	28.0
	Once a year	138	27.1	27.1
	Never	63	12.4	12.4
	Total	510	100.0	100.0

Table 10 provides information on how often the respondents utilised health services in Türkiye. As can be seen from the table, 12.4% of the respondents have never visited a health institution in Türkiye, while among those who have, no specific time interval stands out according to the responses.

Table 11: Access to Health Services in Cases of Need

		Frequency	Percentage	Valid percentage
Valid	Yes	414	81.2	81.2
	No.	37	7.3	7.3
	I didn't need it	59	11.6	11.6
	Total	510	100.0	100.0

Participants were also asked whether they had access to health services when they needed them. Accordingly, approximately 81% of the participants stated that they could access health services in case of need (See Table 11). This rate indicates that a significant portion of people who came to Türkiye through forced migration can access health services in case of an emergency.

Table 12: Individually Most Frequently Consulted Health Institution

		Frequency	Percentage	Valid percentage
Valid	Health centre/Family doctor	71	13.9	13.9
	State hospital	338	66.3	66.3
	Private polyclinic	6	1.2	1.2
	Private hospital	32	6.3	6.3
	Private doctor	4	0.8	0.8
	Migrant health centre	5	1.0	1.0
	Syrian private doctor	3	0.6	0.6
	I've never been—none of them	51	10.0	10.0
	Total	510	100.0	100.0

When we look at which health institutions Syrians who came with forced migration prefer the most, it is seen that public hospitals come first with 66.3%. Public hospitals are followed by health centres (13.9%) and private hospitals (6.3%). Although the rate is very low, it is seen that Syrian private doctors are also preferred (See Table 12). Considering that this study was conducted with Turkish-speaking Syrians, people whose Turkish language skills are not sufficient may be more likely to prefer Syrian doctors to whom they can explain their problems.

Table 13: Level of Satisfaction with Individually Preferred Health Institutions

		Frequency	Percentage	Valid percentage
Valid	I am very satisfied.	155	30.4	30.4
	I am satisfied	256	50.2	50.2
	Neither satisfied nor dissatisfied	30	5.9	5.9
	Not satisfied	16	3.1	3.1
	I am very dissatisfied	5	1.0	1.0
	I didn't go—I don't know	48	9.4	9.4
	Total	510	100.0	100.0

The respondents were also asked about their level of satisfaction with their preferred health institution. Accordingly, 50% were satisfied with their preferred health institution, 30% were very satisfied, and 1% were not satisfied at all (See Table 13).

Table 14: Coverage of Health Services by Health Insurance

		Frequency	Percentage	Valid percentage
Valid	Yes, I receive support from the state institutions	163	32.0	32.0
	Yes, I receive support from private institutions	13	2.5	2.5
	No, I do not have health insurance	311	61.0	61.0
	I didn't go—I don't know	23	4.5	4.5
	Total	510	100.0	100.0

Participants were also asked whether they had any health insurance and, if so, where they obtained their health insurance. According to the data obtained, 61% of the participants did not have any health insurance. A significant proportion of those with health insurance stated that they were covered by general health insurance (See Table 14).

Table 15: Problems Experienced in Health Services

		Responses	
		N	Percentage
Problems Experienced in Health Services	I do not have easy access to health services	11	1.5%
	I do not know how to use health services	52	7.1%
	Health care institutions are crowded, and the queues are long.	151	20.7%
	Because I was not taken care of in the health institutions, I applied to	43	5.9%
	I cannot easily explain my illness/ complaints because of language difficulties	150	20.6%
	I cannot pay my share of expenses (co-payment) for medicines and treatment	45	6.2%
	I have problems accessing health services because I do not have an identity card or a foreign ID number	39	5.3%
	Discrimination	3	0.4%
	I had no problems	181	24.8%
	I did not use health services	54	7.4%
Total		729	100.0%

Table 15 shows whether the participants had any problems in terms of health services and, if so, what these problems were. According to the information obtained, approximately 25% of the participants stated that they had no problems. For those who responded positively, the most prominent problems were crowded health institutions, waiting in long queues, and not being able to convey complaints to the desired extent due to insufficient knowledge of Turkish (See Table 15). Considering that overcrowding in health institutions is not a problem specific to those who came to Türkiye through forced migration, insufficient language skills are the most prominent problem.

4.2.4. Cross Table Analyses

In this part of the study, the data obtained during the survey process were analysed using cross-tabulation and chi-square analyses. The crosstabulation table shows the frequency and percentage distributions of the participants in the survey according to two or more variables. Chi-square analysis examines the significance of the difference between the observed and expected values for each category of variables. In the analysis, it is expected that the number of categories with an expected value less than five should not exceed 20% of the total number of categories and that this value should be greater than one in all categories. Otherwise, if appropriate, categories can be combined (Büyüköztürk, 2014, p. 27; 155). Thus, we aimed to reveal whether the different responses provided by the participants have a relationship among themselves. Because it did not meet the normal distribution conditions according to the independent variables, the chi-square test, a nonparametric test, was used, and if the p-value was less than 0.05, the difference was considered to be statistically significant. In the process of cross-tabulation analysis in the SPSS programme, the relevant field for chi-square analysis was selected, and then the Pearson chi-square value was obtained with the cross-tabulation results given by the programme. If this value is less than 0.05 ($p<0.05$), it is interpreted that there is a significant relationship between the variables; otherwise, there is no significant difference between the two variables.

4.2.4.1. Cross Table Analyses of Education Services

In this section, a comparison is made between the relevant data obtained from the participants and their statements about educational services.

Table 16: Comparison of Level of Satisfaction with Education Services Received in Türkiye and Future Intention to Stay in Türkiye

	I am very satisfied.	I am satisfied	Neither satisfied nor dissatisfied	Not satisfied
I am thinking of living in Türkiye.	85.7%	75.9%	80.0%	0.0%
I am thinking of living in a third country.	7.1%	10.3%	20.0%	100.0%
I want to return to my country.	7.1%	10.3%	0.0%	0.0%
Total	100.0%	100.0%	100.0%	100.0%

In Table 16, the relationship between the satisfaction levels of the participants who benefited from educational services and their decision to stay in Türkiye in the future is analysed. In the cross-tabular analysis, $p > 0.05$, and therefore, no significant difference was found between satisfaction with the educational services received in Türkiye and the decision to live in Türkiye in the future. On the other hand, when we look at the distributions, 85.7% of those who stated that they were very satisfied with the services they received in Türkiye also stated that they would like to stay in Türkiye in the future. All the respondents who stated that they were not satisfied with the education services in Türkiye expressed that they would like to live in a third country.

4.2.4.2. Cross Table Analyses of Health Services

In this part of the study, comparisons were made based on the data obtained from the participants regarding health services.

Table 17: Comparison of the Preferred Health Institution and Level of Satisfaction with the Service Received

	I am very satisfied.	I am satisfied	Neither satisfied nor dissatisfied	Not satisfied	I am very dissatisfied	I haven't been—I don't known	Total
Health centre/Family doctor	46.5%	49.3%	2.8%	1.4%	0.0%	0.0%	100.0%
State hospital	31.4%	57.1%	6.2%	4.1%	1.2%	0.0%	100.0%
Private polyclinic	50.0%	33.3%	0.0%	0.0%	16.7%	0.0%	100.0%
Private hospital	31.3%	56.3%	12.5%	0.0%	0.0%	0.0%	100.0%
Private doctor	50.0%	50.0%	0.0%	0.0%	0.0%	0.0%	100.0%
Migrant Health Centre	0.0%	80.0%	0.0%	20.0%	0.0%	0.0%	100.0%
Syrian private doctor	0.0%	33.3%	66.7%	0.0%	0.0%	0.0%	100.0%
I've never been—none of them	2.0%	2.0%	2.0%	0.0%	0.0%	94.1%	100.0%

Health institutions preferred by the participants and their satisfaction with the services they received from these institutions were compared. Because of the chi-square analysis, p<.05, and significance was found between the variables. Refugees who mostly prefer public hospitals and health centres when they need health services have high levels of satisfaction with these institutions (See Table 17).

Table 18: Comparison of Satisfaction with Health Services and Intention to Stay in Türkiye in the Future

	I am very satisfied.	I am satisfied	Neither satisfied nor dissatisfied	Not satisfied	I am very dissatisfied	I haven't been—I don't known
I am thinking of living in Türkiye.	82.6%	71.5%	66.7%	68.8%	20.0%	62.5%
I am thinking of living in a third country.	5.8%	9.0%	13.3%	31.3%	60.0%	16.7%
I want to return to my country.	11.6%	19.1%	20.0%	0.0%	20.0%	20.8%
Undecided	0.0%	0.4%	0.0%	0.0%	0.0%	0.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Another comparison made in terms of health services is the degree of satisfaction with the services and the intention to stay in Türkiye in the future. In this comparison, $p<.05$, and a significant difference was found. Accordingly, while the rate of those who would like to stay in Türkiye is high among those who are satisfied with health services, the rate of those who would like to live in a third country is high among those who are not satisfied with health services at all (See Table 18).

5. Conclusion and Assessment

Migration, which is a state of mobility in terms of space and time, can occur for a wide variety of reasons. One of these reasons is whether migration is voluntary or not. Individuals may migrate voluntarily for economic reasons. On the other hand, environmental, political, etc. reasons may result in migration becoming a necessity when it becomes impossible for people to sustain their lives in the countries where they live.

While host countries can select individual migrants on the basis of their age, education, skills, etc., this is not the case for those who migrate because of a compulsory situation. Considering that forced migration is a mass displacement movement compared with voluntary migration, it is necessary to meet the basic humanitarian needs of the arrivals. Because of international migration movements, countries' policies to protect refugees produce benefits that cannot be excluded and divided at the local, regional, and global levels. Considering that people who migrate as refugees generally want to stay in the host country, meeting their basic humanitarian needs also creates long-term social benefits for destination countries, so basic humanitarian services to be provided are public. At this point, state intervention is required for needs that cannot be met by market conditions.

Two of these basic human rights, which are also the subject of this study, are education and health services. It is a basic human right for all individuals to benefit from these two services regardless of their personal, cultural, or economic status. On the other hand, these services benefit society as a whole because of the positive externalities they entail. Especially because of forced and mass migration, problems may arise in terms of both the quantity and quality of access to education and health services. Considering the low likelihood of return for a significant portion of people arriving through forced migration and the long-term social benefits of these services in terms of economic development, growth, income distribution, security, and public health, the effectiveness of public policies to be implemented in these areas will benefit all segments of society.

In this context, this study examines the access of Syrian refugees living in Türkiye to education and health services. It is seen that a significant portion of the participants interviewed within the scope of the study have been living in Türkiye for more than 5 years, and more than 70% of them want to live in Türkiye in the future. The results regarding low willingness to return support the literature. When considered in this context, the importance of policy-making that considers the long-term impact of education and health services offered to refugees becomes more evident.

In terms of both education and health services, the participants received a significant level of services from public institutions. The high number of people benefiting from public services indicates that these services may be negatively affected in terms of both quantity and quality. For example, although a significant portion of the beneficiaries of both services stated that they were satisfied with the services they received when asked about the problems they experienced while benefiting from health services, they stated that they had to wait in long queues due to the crowding in these institutions. This overcrowding is a common problem for both refugees and citizens of the country and shows the necessity of human and capital investments by revealing the lack of personnel and physical elements.

One of the common problems regarding the two services addressed in the study is the lack of Turkish language skills. Considering that a significant number of the participants have been living in Türkiye for a long time, the fact that they did not even have enough knowledge of Turkish to effectively utilise their fundamental rights until the time of the study shows that the policies implemented for language learning are not sufficient. In this context, it is recommended that the effectiveness and inclusiveness of the courses for teaching language knowledge should be monitored, and resources should be allocated to this field. Another reason why the participants were predominantly men was the language barrier. The women refugees who were asked to be interviewed could not participate in the research because they did not know the Turkish language or could communicate at a very basic level. Therefore, considering the role of women in the education and health of future generations, it is essential to develop public policies for women in this field.

This study has two important limitations. One of them is the language problem mentioned above. The second constraint stems from geographical scope. The study was conducted only in Istanbul, Türkiye within the framework of financial means. In future studies, investigating the access of refugees to education and health services across the country will provide much more inclusive results. Another suggestion for future studies is to examine the resources allocated from the budget for these two semi-public goods. In this way, both the inclusiveness of resource allocation can be seen, and comments can be developed on whether equal opportunities are provided for disadvantaged groups.

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RESEARCH ARTICLE

A Better Proxy for Technology Determinant of Economic Growth: The International Digital Economy and Society Index

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ABSTRACT

The importance of information communication technology in fueling economic growth is widely acknowledged. In the current digital era, the International Digital Economy and Society Index (I-DESI) offers a more precise depiction alternative to the ICT indicators by serving as a better proxy for changes in the factors of production. It monitors the advancement of ICT in the EU27 and 14 non-EU nations, highlighting their strides towards a technology-driven economy. The objective of the study was to evaluate the influence of the I-DESI on economic growth through the utilization of the panel data method. Hence, gross domestic product (GDP) measured at constant prices was utilized as the dependent variable in the analysis, while the Index of Digital Economy and Society Integration (I-DESI), calculated by the European Commission, served as the independent variable. However, it's important to note that the described index is current and limited at present. In line with this constraint, only four years of data, spanning from 2015 to 2018, were available. To ensure the accuracy of the model, diagnostic tests were conducted, and the Driscoll-Kraay standard error model was employed to assess the outcomes. Two models were constructed to achieve this goal, with the initial one revealing the relationship between the I-DESI and economic growth. The second model aimed to pinpoint the dimensions of the I-DESI that had the greatest impact on growth. According to findings obtained from the analysis, I-DESI and certain subdimensions which are digital skills, use of internet, integration of digital technology, and digital public services affect economic growth positively and significantly. A one percent increase in I-DESI results in a one percent increase in GDP. Similarly, each subdimension mentioned, where meaningful relationships have been identified, possesses explanatory power for GDP. Furthermore, evaluating the coefficient of these independent variables, changing the weight of dimensions can be considered.

Keywords: Digital economy, Economic growth, Technology, International digital economy and society index, Driscoll-Kraay model

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1. Introduction

For sustainable economic growth, it is essential to increase the quality, not just the quantity, of labor and capital. On the other hand, other inputs, especially technology penetration, play a substantial role in the production process (Kuznets, 1966).

There has been a continuing evolution in information and communication technology (ICT) since the early 1900s (Imran et al., 2022:1). The ICT is widely regarded as a crucial indicator of both economic growth and development (Mgadmi et al., 2021; Vishnevsky et al., 2021). These postulates provide a base for an alternative perspective to the exogenous growth model. Romer (1986) and Lucas (1988) conducted principal studies supporting these assumptions, and this alternative view is called the endogenous growth model. The growth rate can indeed increase over time, in contrast to diminishing returns. In addition to physical capital, human capital is also considered. Therefore, with an increase in physical capital, human capital also increases, and the law of diminishing returns does not apply. Romer's (1986) endogenous growth model is founded on the integration of three main assumptions. Firstly, the model proposed in Romer's (1986) paper posits that knowledge, as an input, exhibits increasing marginal productivity. Furthermore, knowledge possesses a natural externality, indicating that the new knowledge discovered by a firm can be utilized by other firms for their benefit. The primary reason for this externality lies in the non-exhaustive patenting of knowledge. Secondly, knowledge can expand limitlessly, resulting in increasing returns in the production of consumption goods. Finally, to prevent an excessively rapid increase in consumption and utility, there must be a diminishing return on new knowledge production. Additionally, the model represents a competitive equilibrium with endogenous technological change.

ICT has a catalytic effect on the country's economy. These effects are not only on the micro-scale but also on the macro-scale. Through progress in ICT, knowledge can be shared quickly, as never before. Despite an emerging awareness of the importance of protecting intellectual property rights, there are few obstacles to the diffusion of knowledge. As knowledge expands among households, firms, and countries, it can foster human capital through labor skills. It also enables individuals to make consumption or investment decisions efficiently. Similarly, firms can benefit from the ICT revolution to reduce costs and improve productivity in their production processes through R&D activities (Vu, 2011).

Moreover, developments and changes in ICT can serve as a valuable measure for assessing a country's degree of digitalization. Various techniques are employed to measure ICT and digitalization, such as the Digital Economy and Society Index (DESI), which provides a comprehensive evaluation of a country's digital progress across various dimensions. The index may be referred to as a comprehensive measurement tool that evaluates a country's digital performance. It is composed of five main dimensions, which are all equally important in determining a country's digitalization process, both economically and socially. Each one of the dimensions is equally weighted: human capital, connectivity, use of internet, integration of digital technology, and digital public services. Each of these dimensions has its own set of sub-dimensions that are evaluated to provide a more in-depth analysis of a country's digital structure (European Commission, 2022a).

The purpose of this paper is to investigate the impact of digitalization on economic growth by examining the sub-dimensions of the I-DESI. Unlike prior research, this study examines the impact of each dimension on economic growth independently to enhance comprehension of this connection. To accomplish this, a ratio is computed by dividing the value of each component by the total score of the I-DESI. This ratio reveals the proportionate contribution of each dimension to the overall performance of the I-DESI. Therefore, the main significance of the current paper is based on the variables and model employed.

This study comprises of four main sections in addition to the introduction. Section II explains the DESI and the I-DESI concepts, their sub-dimensions, and sub-indicators. In Section III, the current literature is given, and previous studies and their conclusions are briefly discussed. Section IV presents the methodology, explaining the data set, model estimation, and other diagnostic analyses. Finally, Section V is the conclusion.

2. The DESI and I-DESI: Emerging Proxies for Evaluating The ICT Advancements

The DESI and I-DESI, these two indices are used to follow countries' digitalization paths by the scale of some specific field. The DESI and I-DESI calculated by the European Commission are paving the way for tracking digital progress in EU countries (European Commission, 2021). In contrast to the DESI, non-European countries are also included in the I-DESI. The I-DESI is a more comprehensive index for the study's goals, as it includes not only the EU27 countries, but also 18 non-European Union countries. While the I-DESI is a broader version of the DESI, both indices can be used interchangeably. An applied correlation analysis shows a strong positive correlation of 0.89 between them and country rankings (European Commission, 2020; Kovács et al., 2022). It is important to point out that the DESI or I-DESI is dynamic. Their dimensions, sub-dimensions, and individual indicators can change over time.

The DESI was composed of five main dimensions until 2021. The previous version of the DESI consisted of human capital, connectivity, use of internet, integration of digital technology, and digital public services. All individual indicators were combined under the four main dimensions in the new version, as shown in Table 1. Since it is dynamic, seminal improvements and methodological changes have been made throughout the years (European Commission, 2022a). While every component is weighted equally in the modified DESI, they were weighted 0.25, 0.25, 0.15, 0.20, and 0.15 respectively in the previous version. In the DESI, human capital measures individuals' basic and advanced internet-using skills, while connectivity determines broadband features and power. In this component, fixed broadband take-up, fixed broadband coverage, mobile broadband, and broadband prices are calculated by considering their weight. The integration of digital technology represents business digitalization and e-commerce activity. Finally, digital public services inform about government services given to citizens electronically (European Commission, 2022b).

Sub-dimensions and individual indicators are collected in various units. Therefore, their values are normalized using the min-max method, assigning each indicator a value between 0 and 1. The minimum value in the series is equal to 0, while the maximum value in the series is equal to 1. The remaining values fall between 0 and 1.

The formulation of a country's DESI score, based on indicators' notation in the table, is:

$$DESI_{it} = 0{,}25HC_{it} + 0{,}25\ C_{it} + 0{,}25IDT_{it} + 0{,}25DPS_{it} \qquad \text{(I)}$$

In this notation, while *i* represents the country, *t* shows the date. *HC* and *C* denote human capital and connectivity dimensions, as *IDT* and *DPS* display integration of digital technology and digital public services, respectively. This formula can calculate a country's DESI score on a given date. The notation below can be followed if warranted, to examine digital progress in detail through sub-dimensions. In this version of the formula, sub-dimensions contribute to the score with their weight.

$$DESI_{it} = 0{,}25[0{,}5(1a)_{it} + 0{,}5(1b)_{it}] + 0{,}25[0{,}25(2a)_{it} + 0{,}25(2b)_{it} + 0{,}4(2c)_{it} + 0{,}1(2d)_{it}]$$
$$+ 0{,}25[0{,}15(3a)_{it} + 0{,}7(3b)_{it} + 0{,}15(3c)_{it}] + 0{,}25[(4a)_{it}] \qquad \text{(II)}$$

Table 1: Sub-dimensions and individual indicators of DESI

Dimensions of DESI, 2021	sub-dimensions		individual indicators
1. Human Capital 25%	1a. Internet user skills	**50%**	1a1, 1a2, 1a3
	1b. Advanced skills and development	**50%**	1b1, 1b2, 1b3, 1b4
2. Connectivity 25%	2a. Fixed broadband take-up	**25%**	2a1, 2a2, 2a3
	2b. Fixed broadband coverage	**25%**	2b1, 2b2, 2b3
	2c. Mobile broadband	**40%**	2c1, 2c2, 2c3
	2d. Broadband prices	**10%**	2d1
3. Integration of Digital Technology 25%	3a. Digital intensity	**15%**	3a1
	3b. Digital technologies for businesses	**70%**	3b4 3b5, 3b6, 3b7
	3c. e-Commerce	**15%**	3c1, 3c2, 3c3
4. Digital Public Services 25%	4a. e-Government	**100%**	4a1, 4a2, 4a3, 4a4, 4a5

Source: European Commission, Digital Economy and Society Index (2022)

Although the I-DESI is based on the components of the DESI, it only combines 24 individual indicators, while the DESI has 33 individual indicators. These indicators and sub-dimensions are listed in Table 1 and Table 2. Additionally, these tables show that individual indicators contribute to the total score based on their assigned weight.

$$I - DESI_{it} = 0{,}25C_{it} + 0{,}25\ DS_{it} + 0{,}15UI_{it} + 0{,}20IDT_{it} + 0{,}15DPS_{it} \qquad \text{(III)}$$

The differences between equation I and equation III are DS and UI, i.e., the "digital skills" and "use of internet" dimensions added in the last equation instead of , and the weight of sub-dimensions.

$$I - DESI_{it} = 0{,}25\left[\frac{1}{3}(1a)_{it} + \frac{2}{9}(1b)_{it} + \frac{1}{3}(1c)_{it} + \frac{1}{9}(1d)_{it}\right] + 0{,}25\left[\frac{1}{2}(2a)_{it} + \frac{1}{2}(2b)_{it}\right] + 0{,}15\ \left[\frac{1}{3}(3a)_{it} + \frac{1}{6}(3b)_{it} + \frac{1}{3}(3c)_{it} + \frac{1}{6}(3d)_{it}\right] + \ 0{,}20\left[\frac{3}{5}(4a)_{it} + \frac{2}{5}(4b)_{it}\right] + 0{,}15(5a)_{it} \qquad \text{(IV)}$$

Equation IV can be used to calculate every sub-dimension in the I-DESI and their weighted contribution to the score. The I-DESI score can also be derived from individual indicators. From $1a$ to $5a$, using variables are denoted in the table below.

Table 2: Sub-dimensions and individual indicators of I-DESI

Dimensions of I-DESI, 2020	sub-dimensions		individual indicators
1. Connectivity **25%**	1a. Fixed broadband	**33%**	1a1, 1a2
	1b. Mobile broadband	**22%**	1b1, 1b2
	1c. Speed	**33%**	1c1
	1d. affodabilitiy	**11%**	1d1
2. Human Capital **25%**	2a. Internet users skills	**50%**	2a1, 2a2, 2a3
	2b. Advanced skills and development	**50%**	2b1, 2b2
3. Use of Internet **15%**	3a. Content	**33%**	3a1
	3b. Communications	**16,5%**	3b
	3c.Transactions	**33%**	3c1, 3c2
	3d.Ubiquitous use	**16,5%**	3d1
4. Inetgration of Digital Technology **20%**	4a. Bussiness digitalisation	**60%**	4a1,4a2
	4b.e-Commerce	**40%**	4b1,4b2
5. Digital Public Services **15%**	5a. e-Government development index	**100%**	5a1, 5a2, 5a3

Source: European Commission, International Digital Economy and Society Index 2018, Smart 2017/0052, Final Report, 2020.

While the DESI is more comprehensive than the I-DESI, regarding individual indicators, the I-DESI provides a broader cross-national analysis. Therefore, I-DESI is preferred in this paper since it can include non-members of the EU in the analysis. However, it should be mentioned that since the I-DESI has been calculated recently, only four years of data are available so far.

3. Literature Review

In the literature, there are numerous studies claiming a positive relationship between ICT and economic growth. This claim is based on the ability of ICT to increase productivity (Pohjola, 2000; Vu, 2011; Olczyk & Kuc-Czarnecka, 2022; Imran et al., 2022). Nevertheless, a comprehensive appraisal of these investigations reveals divergent findings. Furthermore, it should be noted that there is currently no consensus on the impact of ICT on economic growth, with some research indicating a positive effect, while others suggest a negative effect or find no significant relationship between the two. In this context, Fernández-Portillo, Almodóvar-González, and Hernández-Mogollón (2020:2-4) thoroughly summarize the literature and findings by dividing the studies according to their exogenous and endogenous growth theory.

Previous studies have utilized different variables to represent the features of ICT in countries. For instance, Nasab and Aghaei (2009) investigated the relationship between ICT and economic growth using the Generalized Method of Moments (GMM). The study focused on the OPEC countries and utilized data spanning the period from 1990 to 2007. In their model, Nasab and Aghaei (2009) used ICT input, physical capital, human capital, and the labor force as independent variables. The ICT data encompassed computer hardware, software, computer services, and communication services, including wire and wireless communication equipment. According to the results of the dynamic panel model, investments in ICT were found to positively impact economic growth within the context of OPEC member countries' data. Similarly, Vu (2011) evaluated three different issues. In the first part, he aimed to determine whether there was a structural change in the 1996-2005 interval compared to the previous two decades. He used the Chow test to analyze data from 102 countries, which revealed a significant difference between the two periods. In line with this suggestion, improving ICT can contribute to economic growth. The main objective of the study was to determine if there was a causal relationship between ICT penetration and economic growth. Personal computers, mobile phones, and internet users were used as proxies for ICT. The GMM estimator demonstrated that each of the three variables positively affected economic growth.

As distinct from preceding studies, Ishida (2015) conducted autoregressive distributed lag (ARDL) tests, revealing that, whether in the long or short run, there is no statistically significant impact of ICT investment on real GDP. Ishida (2015) employed a model for a specific sample in his analysis, focusing on Japan, one of the most important partners in ICT development, during the period 1980-2004. The model specification in this study is grounded in the production function. Consequently, the dependent variable is real GDP, while independent variables include capital stock, labor hours, energy consumption, and ICT investment. The data for these variables were sourced from reputable institutions, specifically the Cabinet Office (for the first two variables), the Ministry of Internal Affairs and Communications, the Ministry of Health, Labor and Welfare, the Agency for Natural Resources and Energy, and the Ministry of Internal Affairs and Communications. Jin and Cho (2015) conducted a study using data from Korea, another leader in ICT. They noted some essential and supportive results to confirm the presence of the effect of ICT on economic growth. They incorporated both supply and demand proxies for ICT in their analysis. Determinants on the supply side included fixed-line internet network, PC penetration rate, mobile phone subscription rate, and imports of telecommunication equipment. On the demand side, variables encompassed internet use rate, total population of ICT workers, and annual earnings in telecom service. Additionally, related ICT policies are listed under the title "policy dimension" as an independent variable. Exports of telecommunications equipment were used as a proxy for policy. They also included moderating variables in the model, namely population, inflation, corruption perception index (CPI), and education capacity. Based on the results of the fixed effect with autocorrelation panel data analysis, they found a statistically significant impact of the mobile network adoption rate on economic growth but not for others in the supply dimension variables. Variables in the ICT demand dimension, namely internet use rate and telecom profit, had a statistically significant effect on economic growth. Moreover, the ICT policy dimension was found to be a rather impactful variable for economic growth.

Another substantial study belongs to Stanley, Doucouliagos, and Steel (2018). In their study, they focused on determining whether the effect of information and communication technology (ICT) growth is a genuine phenomenon or merely a result of publication bias. To address this question, they conducted a comprehensive analysis, employing meta-regression analysis encompassing 466 estimates from 59 different empirical analyses based on the Solow or Productivity Paradox. To compile relevant data, they used keywords related to ICT and economic growth, conducting their research through Google Scholar, Proquest, and SSRN. Following filtration, the dataset was narrowed down to 59 studies specifically examining the ICT growth effect. The analysis comprised of three main steps. Initially, they conducted a meta-analysis, followed by an investigation into the presence of publication bias. Finally, they examined potential variations in results between developed and developing countries, as well as variations based on different types of ICT. The meta-regression analysis estimation suggested a small effect of ICT on economic growth. Furthermore, the study employed Cochrane's Q test to assess the heterogeneity of the reported conclusions in the studies included. According to Cochrane's test results, the effect of ICT on economic growth could be influenced by other moderating factors. Interestingly, the study revealed differing results for developed and developing countries. Additionally, the impact of ICT was found to vary depending on its type. For example, the growth effect of cell technologies was almost twice as strong as landlines. Separately, computing has the most significant impact on growth in developed countries, with cells and landlines following. However, for developing countries, cell phones have the most significant effect, followed by landlines.

There are several other studies in the literature that examine the impact of ICT on economic growth using different proxies. While the results of empirical analyses reveal various relationships, it can be stated that studies advocating and supporting the positive effects of ICT are predominant (Saidi, Hassen, & Hammami, 2015; Shodiev, Turayey, & Shodiyev, 2021; Usman, et al., 2021). On the other hand, there are limited studies on DESI or I-DESI, which are widely accepted as the main content of the current study. The main reason for choosing I-DESI as the independent variable is precisely this. Examining how technological progress in the digital world, with a new and comprehensive proxy, will affect economic growth is crucial in drawing attention to the literature on this matter.

According to the literature review, the first study to examine the relationship between ICT and economic growth using DESI as a proxy was conducted by Fernández-Portillo, Almodóvar-González, and Hernández-Mogollón (2020). They used this proxy and applied Partial Least Squares (PLS) to analyze the effects of the DESI on economic growth. They obtained data from the OECD. Firstly, they generated a global conceptual map. This map shows the variables and indicators in the DESI and the three different representatives of GDP, namely GDP per capita

USD constant 2010 Purchasing Power Parity (PPP)", "GDP per person employed USD current PPP" and "GDP per person employed USD constant 2010 PPP". Therefore, twenty-five indicators into sub-dimensions in the DESI were used as a proxy of the ICT, and three particular GDP measures were used as dependent variables. In addition to this, the conclusions of the PLS suggest that fixed broadband connectivity and the use of internet variables influence GDP positively.

On the other hand, Gherghina, Paşa, and Onofrei (2021) used descriptive statistics to investigate where there is a correlation between the constituents of the DESI and real GDP rate and real GDP per capita. The Pearson product-moment correlation analysis proved a significant positive relationship between the DESI and real GDP per capita, but there was no such relationship between the DESI and real GDP rate.

Another current study belongs to Tokmergenova, Bánhidi, and Dobos (2021). They researched the I-DESI and its essential five dimensions using data from the EU28 countries and the Russian Federation. They investigated the development of Russia by comparing it with other countries. For this reason, they used a multivariate statistical analysis known as Principal Component Analysis (PCA). They examined the relationship between these principal dimensions using partial correlation coefficients. According to the results of their analysis, two dimensions can be explained by using the other three dimensions. They then used this conclusion to compose a group of the countries involved in the research. Thus, Russia is found obviously in the developing countries group that is related to the I-DESI score.

Similarly, Olczyk and Kuc-Czarnecka (2022) examined the relationship between DESI and economic growth. Firstly, they investigated whether the defined weights of indicators in the DESI are at the optimal level or not. After that, they analyzed the effect of the DESI on economic growth using a panel data model. In this analysis, GDP per capita was utilized as the dependent variable, while DESI served as the independent variable. Besides, they employed other control variables such as total factor productivity, government consumption, ICT capital compensation, gross fixed capital formation, financial direct investment (FDI), population size and growth, life expectancy, openness, and real effective exchange. The findings from the panel data model indicate a positive impact of DESI on GDP per capita.

Ghazy, Ghoneim, and Lang (2022) elaborated on the interconnections between the two assumptions. They examined their first hypothesis, that entrepreneurship positively impacts productivity, and the second hypothesis, that digitalism can foster entrepreneurship. Based on this postulate, digitalism was assumed to affect productivity. A two-stage GLS regression model (G2SLS) was used, with the DESI and its subdimensions as determinants, to examine the mentioned relationship. Additionally, both fixed-effects and random effects Generalized Least Squares (GLS) models were employed. Their analysis shows that four dimensions have a positive and significant relationship with entrepreneurship, except for human capital.

Comprehensive studies on the I-DESI in the literature should be done to attract attention, as it is a current proxy of ICT. Only research considering this index is given in this part of the study. There is a need for more analysis to support the I-DESI explanatory force and significance.

4. Methodology

In the section below, analysis results and interpretations are provided for estimating the static panel data model, aiming to examine the relationship between GDP and I-DESI, along with its subdimensions. After the application of diagnostic statistics, the Driscoll-Kraay Standard Errors Model was employed as the appropriate estimator for standard errors. At this juncture, the time constraint of the I-DESI dataset (4 years) necessitated the preference for static panel data models over dynamic panel data models (Fernández-Portillo, Almodóvar-González, and Hernández-Mogollón, 2020).

4.1. Dataset and model

To conduct our empirical analysis, we utilized a random effects model. Before implementation, we thoroughly assessed the model's assumptions and subsequently applied the Driscoll Kraay model to evaluate the connection between economic growth (dependent variable) and the subdimensions of I-DESI (independent variables). These data were obtained for the EU27 member countries and 18 non-member states for 2015-2018. Hence, the balanced panel data is employed, and the total number of observations is 180. The I-DESI dataset was obtained from EUROSTAT, and as a proxy of economic growth GDP at constant prices (the base year 2015), was attained from OECD. Stat. Equations given below demonstrate the models examined in this paper:

$$lnG_{it} = \beta_0 + \beta_1 \ln(I - DESI_{1it}) + \beta_2 D + \mu_i + u_{it} \tag{V}$$

where G_{it} represents country i's economic growth at t time, while lnG_{it} is logged G_{it}. $\ln(I - DESI_{it})$ is the explanatory variable and indicates the I-DESI score of country i's at t time. D is the dummy variable generated based on whether countries are members of the EU in the model. Beside μ_i and u_{it} demonstrate individual effects and the error term, respectively.

$$lnG_{it} = \beta_0 + \beta_1 \ln(RC_{1it}) + \beta_2 \ln(RDS_{2it}) + \beta_3 \ln(RUI_{3it}) + \beta_4 \ln(RIDT_{4it}) + \beta_5 \ln(RDPS_{5it}) + \beta_6 D + \mu_i + u_{it} \tag{VI}$$

where, at t time, , $\ln(RC_{it})$ represents country 's ratio of the contribution of connectivity to I-DESI, as $\ln(RDS_{it})$, $\ln(RUI_{it})$, $\ln(RIDT_{it})$, $\ln(RDPS_{it})$ demonstrate country i's ratios of the contribution of digital skills, use of internet, integration of digital technology and digital public services to I-DESI, respectively. Henceforward, equation V is expressed as Model I, and equation VI is expressed as Model II.

It should be specifically emphasized here that in internal economic growth models, human capital and physical capital are used as the main determinants. As a dimension, under the "connectivity" heading, physical capital that contributes to digitization is detailed, and under the "human capital" heading, the acquisitions and skills of individuals in the path of digitization are displayed. Since the probability of creating autocorrelation is high and could compromise the reliability of the results, the use of another dataset for these variables has been avoided. Additionally, sections showing the purposes of internet usage and integration of the private sector to digital technology, and public policy are included in the model as independent variables under the headings "use of internet", "integration of digital technology," and "digital public services," respectively. Finally, whether countries are members of the European Union is included in both models as a dummy and control variable. Testing alternative hypotheses in these models is given in Table 3.

Table 3: Alternative hypothesis

	H_A
Model I	$H_1$1: I-DESI contributes to economic growth
Model II	$H_1$2: Contribution of each components of I-DESI affects economic growth
	$H_1$2a: The RC affects economic growth
	$H_1$2b: The RDS affects economic growth
	$H_1$2c: The RUI affects economic growth
	$H_1$2d: The RIDT affects economic growth
	$H_1$2e: The RDPS affects economic growth

Note: The null hypothesis, i.e., H0 for each alternative, postulates that explanatory variables do not affect economic growth.

4.2. Model specification and the other diagnostic tests

To achieve optimal parameter estimation in panel data analysis, a meticulous evaluation of individual and time effects within the model is necessary. If the model incorporates either or both of these effects, it is categorized as non-classical. The F test, Likelihood Ratio (LR) test, Breusch and Pagan (1980) Lagrange multiplier (LM) test, adjusted LM (ALM) test, and Score test are used for testing the validity of the classical model.

As presented in Table 4, the results demonstrate the rejection of the null hypothesis that assumes the absence of individual effects, while the null hypothesis that assumes the absence of time effects cannot be rejected. Also, GLS is used to estimate the random and fixed effects models after determining the one-way individual effects model. The F-test and Wald Chi-Square test results show that the null hypothesis assuming no individual and time effects in all models was rejected either for Model I or Model II. The Hausman test was conducted to determine which estimator is most efficient. This test examines whether individual effects are correlated with the independent variables. The null hypothesis of the Hausman test is predicated upon this assumption, i.e., . If the null hypothesis is rejected, it is more appropriate to use the fixed-effects model estimator instead of the random-effects model, as the fixed-effect estimator is not impacted by violating the null hypothesis. It is expected that the difference between the fixed-effects and random-effects estimators is close to zero for using random effects estimator (Hausman, 1978:1263). Hence, the random-effects estimator, consistent under the null hypothesis, was deemed appropriate.

Table 4: Individual and time effects test results

	individual effects test			time effects test		
	H_0	Model I	Model II	H_0	Model I	Model II
F test	$H_0: \mu_i = 0$	269.2**	239.13**	$H_0: \lambda_t = 0$	0.00	0.00
LR test	$H_0: \sigma_\mu = 0$	570.34**	794.65**	$H_0: \sigma_\lambda = 0$	0.00	0.00
LM test	$H_0: \sigma_\mu^2 = 0$	16.41**	15.49**	$H_0: \sigma_\lambda^2 = 0$	-1.37	-1.25
ALM test	$H_0: \sigma_\mu^2 = 0$	7.68**	7.19**	$H_0: \sigma_\lambda^2 = 0$	-1.65	-1.43
Score test	$H_0: \sigma_\mu = 0$	570.84**	1.0e+10**	$H_0: \sigma_\lambda = 0$	0.00	0.00
Hausman-Test chi2 [prob > chi2]- FE vs RE	$H_0: E(\mu_i \mid X_{it}) = 0$	0.24 [0.623]	7.64 [0.177]			
rhausman Test chi2 [prob > chi2]- FE vs RE	$H_0: E(\mu_i \mid X_{it}) = 0$	0.26 [0.610]	2.14 [0.829]			

Note: In the table, values in the brackets denote p-values. The levels of significance of 1%, 5%, and 10% are indicated by symbols *, **, and ***, respectively.

While panel analysis has heteroscedasticity, autocorrelation, cross-sectional dependence, multicollinearity, or non-normal distributions, it is commonly assumed that the classical model cannot be estimated approximately. If even one of these assumptions is not provided, robust estimators are needed to estimate the model efficiently (Elamir, 2022). Table 5 displays the results of model specification tests and several tests used to examine deviations from the assumptions.

Diagnostic tests ensure the adequacy of model specifications and estimations. One of the most popular tests of the specification is Ramsey's (1969) regression specification error test (RESET). However, DeBenedictis and Giles (1989) claimed that the Ramsey RESET test could not have high power to examine whether the model specification is appropriate. So, they described this test as biased. Hence, they developed the RESET test, and because it was based on Fourier approximation, they named it FRESET. The modified RESET test is based on linear and sinusoidal transformations. As can be seen in Table 5, linear and sinusoidal transformations are represented by RESETL and RESETS, respectively. The test results denote that the null hypothesis that supposes no model specification error was not rejected.

Afterward performing the specification test in the presented paper, another diagnostic test was conducted to determine the violation of essential assumptions. As it is known commonly, the classical F-test examining homoscedasticity is appropriate for the assumption of normal distribution. Subsequently, several alternative methods have been developed over the years. Levene's (1960) test is one of the most famous. In this analysis, homoscedasticity, i.e., equal variances, was examined by the Levene and Brown-Forsythe (1974) test, which was a robust test of Levene (Shoemaker, 2003). According to the test results, the test statistics shown by W0, W50, and W10 are greater than the critical value of the Snedecor F table with (44, 135) degrees of freedom[1]. The null hypothesis that postulates equal variances was rejected for each of the three statistics. So, the first assumption was invalid for Model I and Model II. Both models contained heteroscedasticity.

When testing the model, autocorrelation is examined as another basic assumption. To examine whether errors form random walk, Durbin-Watson, modified by Bhargava, Franzini, and Narendranathan (1982), and Baltagi-Wu (1999) locally best invariant (LBI) tests are used. The null hypothesis of these tests assumes that the errors are serially independent, i.e., there is no autocorrelation in

[1] Only W50 statistics were demonstrated in Table 5. The other statistics are for Model I, W0=3.065, W10=3.065, and for Model II, W0=3.448, W10=3.448.

the residuals $(H_0: \rho = 0)$. The alternative hypothesis tested against the null hypothesis suggests the presence of either a positive $(H_0: \rho > 0)$ or negative correlation $(H_0: \rho < 0)$ in residuals. Test results are given in Table 5. Both tests rejected the null hypothesis, which assumes no autocorrelation since the test statistics were less than 2 (Tatoğlu, 2021:267). For Model I, the Bahargava test statistic is 0.956, and it is 0.814 for Model II. Besides, Baltagi-Wu test statistics 1.744 and 1.596 for Model I and Model II, respectively. Likewise, LM and ALM tests were also performed to detect serial correlation. Baltagi and Li (1991) modified Breush-Pagan (1980) LM test. This extended version of the LM test assumes a joint hypothesis that provides both the presence of random individual effects and serial correlation. Therefore, the null hypothesis was rejected according to LM, ALM, and the joint test results.

Pesaran (2004) conducted a test that can be convenient for determining cross-section dependence in stationary and unit root heterogeneous dynamic panel data The Pesaran test is applicable for utilization, also in conditions that used panel data consisting of short T and large N. The null hypothesis of the Pesaran test is based on the assumption of no cross-section dependence in the panel data. Other common tests for determining the presence of heterogeneity in panel data belong to Friedman (1937) and Frees (1995). While Friedman's (1937) test proposes the non-parametric test using Spearman's rank correlation coefficient, Frees's (1995) test statistic is related to the sum of the squared rank correlation coefficients. Table 5 represents the conclusion of these tests. The results demonstrate that the alternative hypothesis, which suggests the presence of cross-section dependency, was not rejected (De Hoyos & Sarafidis, 2006).

Another test used to determine a violation of assumptions is related to multicollinearity. The VIF (Variance Inflation Factor) criterion measures the presence of multicollinearity between the independent variables and the remaining variables using the rule of thumb. The VIF criterion is denoted as $VIF_{(\hat{\beta}_J)} = \frac{1}{1-R_2}$, where $\hat{\beta}_J$ represents the auxiliary regression and equals the count of independent variables, and R_2 is the proportion of variance in this regression model which is estimated for the explanatory variable. If the VIF criterion is less than 5, it is interpreted that there is no collinearity between the variables and the remaining variables. On the contrary, if this criterion is higher than 10, this finding is evaluated as an indicator of multicollinearity (O'Brien, 2007; Tatoğlu, 2021:274-275). In Table 5, the mean VIF value was given in both Model I and Model II, and the results supported that there was no collinearity for any independent variable[2].

As the final assumption, the normality of the error terms was investigated by conducting the D'Agostino-Belanger-D'Agostino test (1990). This test examines both the presence of skewness and kurtosis individually and their simultaneous existence. The null hypothesis, which tests simultaneous existence, is defined on the assumption that skewness and kurtosis are zero $(H_0{:}\, S = 0)$ and three $(H_0{:}\, K = 3)$, respectively. The results of the null hypothesis testing are provided jointly in Table 5. The joint normality test for "e" shows the normal distribution of errors, while the test for "u" indicates the normal distribution of unit effects. D'Agostino-Pearson K^2 statistic is used to test the distribution (D'Agostino, Belanger, & D'Agostino, 1990).

[2] For MODEL I, VIF criterion of ln*(I-DESI)* and *D* is 1.02. In Model II, criterions are ln*(RC)*, ln*(RDS)*, ln*(RUI)*, ln*(RIDT)*, ln*(RPDS)* and *D* are 4.83, 4.41, 1.87, 1.72, 1.59, 1.21, respectively.

Table 5: Results of diagnostic tests

		H_0	Model I	Model II
Model spesification test				
DeBenedictis-Giles	ResetL test	$H_0: \in \sim N(0, \sigma_2 \mathrm{I})$	0.146 [0.964]	0.389 [0.816]
Specification test	ResetS test		1.860 [0.119]	0.343 [0.848]
Heteroscedasticity test		$H_0: \sigma 1^2 = \sigma 2^2 = \cdots = \sigma k^2$		
Levene, Brown and Forsythe test			2.167**	2.790**
Autocorrelation test				
Durbin-Watson test for autocorrelation		$H_0: \rho = 0$	0.956	0.814
Baltagi-Wu LBI test for autocorrelation			1.744	1.596
LM test for serial correlation			237.17**	209.53**
ALM test for serial correlation		$H_0: \rho = 0$	30.83**	25.07**
Joint LM test		$H_0: \sigma_\mu^2 = 0, \rho = 0$	300.04**	264.20**
Cross sectional dependence test				
Pesaran test		$H_0: \rho_{ij} = \rho_{ji} = cor(u_{it}, u_{jt}) = 0$	29.576**	35.021**
Frees test			5.229** (0.8391)	15.571** (0.8391)
Friedman test			64.493**	76.760**
Multicollinearity test				
VIF test		$H_0: \hat{\beta}_1 = \hat{\beta}_2 = \hat{\beta}_3 = 0$	1.02	2.61
Normality test				
D'Agostino, Belanger and D'Agostino	joint nomality test on e	$H_0: S = 0, K = 3$	0.01	1.98
	joint nomality test on u		0.69	0.16

Note: In the table, values in the parentheses represent standard errors, and values in the brackets denote p-values. The levels of significance of 1%, 5%, and 10% are indicated by symbols *, **, and ***, respectively.

4.3. Estimation of robust model and results

Since Table 5 contains relevant information about deviation from substantial assumptions, it is necessary to use robust estimators to estimate the model. Driscoll and Kraay (1998) introduced a non-parametric covariance matrix that offers robust estimation against heteroscedasticity, autocorrelation, also cross-sectional dependence.

The analysis results of the Driscoll-Kraay standard error model demonstrated in Table 6 show that the estimation of both Model I and Model II is significant by Wald Chi-Square statistics at the five percent significance level. On the other hand, the values of the overall R square are significant, even though the main determinants for growth models are excluded from the analysis. Furthermore, the results from the estimate using the Driscoll-Kraay standard error model reveal that the I-DESI has a statistically significant positive effect on GDP at a confidence level of 5%. This result is partially the same line as Gherghina, Paşa, and Onofrei (2021). They defined that DESI positively impacts real GDP per capita but does not on real GDP. Nonetheless, as it is interpreted via test statistics in the present analysis, a positive relationship exists between I-DESI and GDP at constant prices.

In addition to these findings, it is essential to determine which component of the I-DESI contributes much more than others. The answer to this question can lead to countries' policy decisions about technology investment. Therefore, model II was estimated to respond to this substantial question. As mentioned above, this study emphasizes which part of the I-DESI is more explanatory for GDP. With this purpose, variables are generated as rates to measure the contribution.

Table 6: The results of Driscoll-Kraay standard error model estimation

	Model I	Model II
lnG as a dependent variable		
$ln(I-DESI)$	0.327**	
	(0.065)	-
$ln\ (RC)$		0.118
	-	(0.100)
$ln\ (RDS)$		0.109**
	-	(0.028)
$ln\ (RUI)$		0.200**
	-	(0.052)
$ln\ (RIDT)$		0.086**
	-	(0.021)
$ln\ (RDPS)$		0.068**
	-	(0.021)
D	-2.335**	-2.324**
	(0.653)	(0.463)
$constant$	13.489*	15.285*
	(0.606)	(0.763)
Wald Chi2 (prob > Chi2)	22.68 [0.000]	58.85[0.000]
Overall R-squard	0.388	0.388
rho	0.999	0.999
Number of obs	180	180
Number of groups	45	45

Note: In the table, values in the parentheses represent standard errors, and values in the brackets denote p-values. The levels of significance of 1%, 5%, and 10% are indicated by symbols *, **, and ***, respectively.

Drawing from the Driscoll-Kraay standard error model estimation, it can be inferred that, except for the rate of connectivity contribution to the I-DESI, each explanatory variable holds a statistically significant influence on GDP. Represented results in Table 6 corroborate digital skills, use of internet, integration of digital technology, and digital public services have an explanatory effect on GDP. Contrary to Fernández-Portillo, Almodóvar-González and Hernández-Mogollón (2020), there is no relationship between connectivity and GDP. Nevertheless, the results which are related to the use of internet are in the same line with their findings.

Besides, the most powerful explanatory variables are the use of internet and digital skills. Also, if digital skills are evaluated as factors for human capital, results support the theory that an increase in human capital impacts economic growth positively. Although Ghazy, Ghoneim, and Lang (2022) used dimension values without changing and different proxies for dependent variables in their analysis, this paper's findings partially support what they found. By corresponding with Vu's (2011) research on the impacts of the internet variable, this analysis confirms positive and significant impacts.

Moreover, this presented study shows that the ratio of the integration of digital technology and the ratio of digital public services can induce economic growth. These sub-dimensions and their indicators can accelerate production progress from the beginning of entrepreneurship to the last step for preparing for consumption because integrating technology brings many advantages, such as easily achieving a feasible project or target groups. This assumption can be predicated on Kuznet's (1966:286) suggestion: "*no matter where these innovations emerge… the economic growth of any given nation depends upon their adoption*". Another impressive conclusion benefit from the analysis is that, considering the coefficient of independent variables, the weight of dimensions can be reconsidered to compute the I-DESI score based on the postulation that digital technology stimulates GDP.

5. Conclusion

In the digital era, technology has been evaluated as an effective driver of economic growth. Concordantly, ICT is one of the outstanding determinants from the perspective of endogenous growth models. A huge number of analyses have enforced this assumption. Likewise, various explanatory variables have been used in the literature as a proxy for ICT. One of the most current proxies is I-DESI. Hence, to contribute to the literature, I-DESI was chosen as the main independent determinant. Also, sub-dimensions of the I-DESI and their contributions to the I-DESI were calculated as ratios and included in the second model.

As determined in the analysis results mentioned, the I-DESI can stimulate economic growth significantly. Therefore, all components and sub-indicators of the index may be evaluated as indicators of the technological gains of individuals, entrepreneurs, and governments. Especially in detail, the use of internet and digital skills variables may denote how individuals or households benefit from the technological revolution and its increasing time-saving and productivity effects. According to the results of the current empirical study, if the enhancement of individuals' human capital in alignment with the digital age is provided, positive outcomes for economic growth may be realized. Despite the absence of a statistically significant result concerning the connectivity variable, it nonetheless facilitates the potential contribution of human capital to economic output. In this context, investments in the requisite infrastructure services to effectively integrate individuals into the process of digitalization should be prioritized.

Furthermore, another variable demonstrating noteworthy and positive effects is digital integration. The digitization of e-commerce and business operations may ensure yield, economic and environmental cost reductions, facilitate the more effective functioning of the supply chain, and provide opportunities for swifter market penetration on both a national and international scale. Similarly, the migration of public services to the electronic environment in tandem with digitization may allow citizens to access public services instantly. Moreover, the transition of the required documents for bureaucratic processes into electronic format can contribute to waste reduction, resulting in a positive environmental impact.

On the other hand, reweighting these variables to calculate the index can make the I-DESI more advanced than the current version. This modification can explain economic growth more properly. Nevertheless, these findings can be considered in a policy decision about which investment is feasible or needed and which project should have priority.

Lastly, since the I-DESI is a thoroughly current calculated index, the data contains only four years, from 2015 to 2018. In this context, the present paper can be qualified to lead future research, which may be more inclusive.

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RESEARCH ARTICLE

Relationship between Organic Agriculture And GDP Per Capita, Economic Growth, and Unemployment: Panel Data Analysis

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ABSTRACT

The increase in the world population recently has also increased the need for agricultural products. The need for food products has made it necessary to obtain more products per unit area. At this point, producers have focussed on the use of hormones, chemicals, and fertilisers to increase productivity and meet the demand for cheap food, and the process that increases production in the short term has become a threat to human health in the long term. Over time, the negative effects of chemicals on humans and the environment were observed, forcing producers to seek new methods. This process has led to independent studies on organic agriculture in every country. In this study, the effects of organic agriculture on some economic variables were revealed. In this context, the analyses focus now the variables of area allocated to organic agriculture on a regional basis, production amount and number of producers affected GDP per capita, economic growth, and unemployment in Turkey between 2003 and 2021. The scientific dimension of the study was prepared using data obtained from domestic and foreign literature and the electronic database of the Ministry of Food, Agriculture and Livestock. In this study, in which panel data analysis was used, EViews 12 programme was employed. For the variables used in the study, the geographical region cross-section dependence was determined, and the stationarity of the series was examined with the CIPS (Cross-Sectionally Augmented IPS) unit root test. As a result of the study, it was determined that organic production amount, number of organic farmers, and organic production area did not have a significant effect on economic growth and unemployment. Organic production area and the number of organic farmers had a positive and significant effect on GDP per capita, but the amount of organic production did not have a significant relationship.

Keywords: Organic agriculture, Economic growth, Unemployment, Turkiye
JEL Classification: Q13, Q16, Q17

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1. Introduction

The growth in the world population has increased the demand for food products. The need for food products has necessitated obtaining more yield from each unit of land. In this context, producers have turned to artificial supplements such as hormones, chemical fertilisers, and pesticides to increase efficiency and meet the demand for affordable food. The shift in production and consumption models in the name of economic growth, along with the extensive use of additives, has escalated environmental pollution and posed risks to human health. Over time, the negative effects of these chemicals on humans and the environment have become evident, prompting producers to seek new methods (Anaç and Çiçekli, 2012, p. 45). This has generated an agricultural production process that questions the techniques and inputs used in farming and is sensitive to escalating environmental issues. This process has fostered independent studies on organic farming in many countries (İlter, Aksoy and Altındışli, 2012, p. 4).

Organic farming is defined as certified products that are inspected throughout all stages from production to consumption, adopting an environmentally friendly and human-centric production system, devoid of any chemical inputs harmful to the ecosystem, and ensuring the continuity of soil fertility (Hutchins and Greenhalgh 1997; Ak, 2004; Honkanen, Veerplanken and Olsen, 2006; Er and Başalma, 2008, p. 13). Organic farming aims to produce healthy foods that serve the purpose of maintaining natural balance and advocates for production through natural fertilisation (Atiker, 2004, p. 1; Merdan, 2014, p. 7). While there are numerous definitions of organic farming that are similar or closely related, a common characterisation is that organic farming encompasses production systems friendly to all living beings and the environment, disallowing the use of harmful antibiotics, chemical drugs, and fertilisers. Organic farming is not merely limited to soil cultivation; it upholds sustainable principles extending from packaging to marketing. In addition, organic farming significantly contributes to the natural order, especially in conserving biological diversity, minimising factors leading to climate change, and preventing toxic substances (Demir and Gül, 2004, p. 1).

Organic farming practises protect both human and environmental health and to practise sustainable production that does not harm the organic structure of the soil. In organic farming activities, less yield is obtained per unit area compared with other farming methods (Demirci et al., 2002; Karabaş and Gürler, 2011; Eryılmaz and Kılıç, 2018). Indeed, because chemical inputs are not used in organic farming, there are greater yield losses, and practitioners face various technical challenges. This situation results in organic product prices being higher than those of traditional products.

Organic farming activities create new employment opportunities at every stage from production to consumption. In this context, producers are provided with both financial and social support in rural areas. Organic farming offers opportunities to rural economies at various scales in line with sustainable development goals. The objectives aligned with sustainable development include eradicating poverty in all its forms, promoting economic growth, and strengthening sustainable farming (Özbağ, 2010, p. 2).

This study reveals the relationship among organic farming, economic growth, gross domestic product (GDP), and unemployment. The necessary data to present organic farming in Turkey within the framework of economic discipline were obtained from the electronic database of the Ministry of Agriculture and Forestry (GTHB). The EViews 12 programme has been used for the analysis of the obtained data. Geographic cross-sectional dependence has been identified for the variables used in the study, and the stationarity of the series has been examined with the CIPS (Cross-Sectionally Augmented IPS) unit root test. There are limited studies in the literature regarding the relationship between organic farming and economic concepts in Turkey. This study also addresses gaps in the literature.

2. Organic Farming in Turkey

In the globalising world, advancements in agricultural production techniques and applications within the market economy have led to rapid industrialisation based on science and new technology. At this juncture, industrialised countries have started using developed organic farming techniques to mitigate the destruction caused by traditional farming methods and to render agricultural production systems sustainable. This emerging situation has facilitated the development of organic farming activities in Turkey, a country significant for its farming (Merdan, 2014, p. 67). While farmers have pioneered the advancement of organic farming in the United States and many European countries, in Turkey, the introduction and adoption of organic farming have been driven by specialised European organic farming companies (Demiryürek, 2004).

In developing countries, organic products are produced for export based on the demand from abroad. A similar situation applies to Turkey. In Turkey, the production of organic agricultural products, initially starting with seedless raisins and dried figs in the Aegean Region in the 1980s, aimed to create export potential. From the 2000s onwards, with the formation of local demand, the production of organic farming has shifted towards meeting domestic market needs (Atış, 2005, p. 172; Fidan, 2017, p. 1). To this end, initiatives have been undertaken to increase local demand, and particularly supermarket-based efforts have been made to present such products to consumers. However, these initiatives have fallen short of expectations because of the higher prices of organic agricultural products compared to conventional ones. Subsequently, stores specialising in the sale and marketing of organic products have been established in major cities and regions with a high concentration of foreign population (Aksoy, 2001, pp. 14-16).

The inception of organic farming activities in the Aegean Region of Turkey has influenced the establishment of all related organisations, such as organic product enterprises, control, and certification companies, in İzmir (Aksoy and Altındişli, 1997). The Aegean Exporters' Association has been authorised to facilitate the export of organic products and to consolidate export-related information under one roof (Aksoy, 2001, p. 4). The Ministry of Food, Agriculture and Livestock and the Ecological Agriculture Organisation Association (ETO) are also among the authorised institutions contributing to the development of organic farming (Yürüdür, Kara, and Arıbaş, 2010, p. 405).

3. Conceptual Framework Regarding the Economic Dimension of Organic Farming in Turkey

Following the acceleration of organic farming in Turkey in the 1990s, academics began conducting economically oriented studies on organic farming. Akgüngör (1996) conducted the first domestic study in this area in the Salihli district of Manisa and the Kemalpaşa district of İzmir. This study examined the yield values obtained in the production of organic seedless dried grapes. The findings suggested that in Kemalpaşa, both yield and production costs were high, whereas in Salehi, yield was low and production costs were high. The second study, conducted in Manisa by Olhan (1997), included 59 producers. Merdan and Kaya (2013) authored the third study. The economic analysis of organic agriculture was conducted in this study. The analysis revealed that Turkey has highly fertile areas and significant potential for organic agriculture. Durmaz (2010) conducted another study. The economic analysis of organic agriculture in Turkey in general and the role of organic agriculture in the economy of Adana province, in particular, are discussed in this study. The analysis shows that organic agriculture in Turkey does not receive the attention it deserves and that its production is export-oriented. Çınaroğlu and Akçacı (2019) o-authored study. The economic dimension of the market for organic agricultural products in Turkey in general and in Kilis province in particular was evaluated in this study. The assessment reveals that Turkey, especially the Kilis province, has not sufficiently utilised its organic agriculture potential and has not yet been able to mobilise its organic agriculture advantages. Considering these facts, it is recommended that awareness of organic agriculture should be improved in the minds of producers and consumers.

The study found that after transitioning to organic production, yield decreased, but income increased. Most of the studies conducted for economic analysis have concluded that the yield is generally lower in organic farming. However, some studies have also found that depending on the type of crop, yield could be higher in organic farming. In the context of production costs, varying outcomes have been reported. While some studies an increase in the costs associated with organic farming, others indicate a decrease. The most significant and common finding identified in these studies is that the prices of organic products are considerably high, resulting in greater profits for producers engaged in organic farming (Table 1).

Studies that highlight the organic contribution to the national economy have been conducted by Turhan et al. (2008), Yazıcı et al. (2011), Erkoyuncu (2008), Engindeniz and Yücel (2003), Tanrvermiş et al., (2004), Olgun et al., (2008), Bülbül and Tanrıvermiş (2002), and Tanrıvermiş et al., (2004). The common point of the studies in the literature is that the efficiency obtained from organic agriculture is quite low and the costs are high. Low productivity values and high labour costs also increase product prices. In this case, the net income from organic products decreases. According to a study conducted by Demirci et al. (2002), the yield of some organic products (seedless raisins, olives, cotton, barley and wheat) is 5-20% lower than that of conventional products, and their sales prices are 10-15% higher. In the research, it was stated that the price advantage in organic products does not always compensate for yield losses, and the net profit loss due to low yield and high unit costs is 25-60%. The evaluation results regarding the economy of organic agriculture in Turkey according to yield, cost, price, and net income are summarised in Table 1. In studies conducted on the yield values of organic agriculture in Turkey, it is seen that all products except hazelnuts, olives, dried figs, and filtered flower honey have negative values. In terms of cost values, only peaches, hazelnuts, tomatoes, greenhouse cucumbers, and seedless raisins have negative costs. In terms of price evaluation, tomato and flower honey have the highest value in the market (Table 1).

Table 1: Findings of studies conducted on the economics of organic farming in Turkey

Researchers	Field of Study	Investigated Product	Yield (%)	Cost (%)	Price (%)	Net Income (%)
Bülbül and Tanrvermiş (2002)	Ordu-Samsun	Hazelnut	24.20	-15.20	-	20.00
Engindeniz and Yücel, (2003)	İzmir-Menderes	Greenhouse Cucumber	-30.86	-9.63	50.00	28.16
Tanrıvermiş et al.., (2004)	Afyon-Konya	Cherry	-22.80	22.60	15.71	11.85

Table 1: Continued

Tanrıvermiş et al.., (2004)	Konya-Akçaşehir	Strawberry	-21.70	1.25	10.60	27.93
Bektaş and Miran, (2005)	Aydın	Dried Fig	0.26	19.53 (*)	5.69	0.73 (**)
Bektaş and Miran (2006)	İzmir-Manisa	Seedless Dried Grape	-4.76 -	-1.45 (*)	6.89	4.04 (**)
Birinci and Er, (2006)	Bursa-Karacabey	Peach	-40.98	-31.74	41.03	-
Erkoyuncu, (2008)	Ankara-Beypazarı	Tomato	-27.74	-8.98	50.00	36.53
Turhan et al., (2008)	Çanakkale	Tomato	-55.96	82.11	128.15	167.38
Olgun et al., (2008)	İzmir-Aydın-Çanakkale	Olive	34.38	0.84	28.03	15.11
Adanacıoğlu, (2009)	İzmir-Aydın-Manisa	Cotton	-11.39	22.31	11.69	-40.91
Yazıcı et al., (2011)	Antalya	Pomegranate	-15.61	-	-	50.37
Şahin et al., (2011)	Malatya	Apricot	-25.35	-	-	-7.35
Saner et al., (2012)	İzmir-Kemalpaşa	Strained Flower Honey	2.71	-	100.00	-
Çınaroğlu and Akçacı (2019)	Kilis	Olive, Grape	-	-	-	-

Note: (*) variable costs, (**) calculated considering gross margin.

In the domestic literature, there is only one study titled "panel data analysis on economic variables of organic farming." In a study by Ateş in 2020, the relationship between organic farming and GDP was analysed. Because of the analysis, it was observed that the increase in the number of organic producers and the area allocated to organic farming positively affected agricultural GDP. In the foreign literature, there are several studies on the economic variables of organic agriculture. Zanoli, Gambelli and Solfanelli (2023) addressed the first study in the literature (2013) from the UK perspective. Panel data analysis was used in their study, and the years 2007-2009 were taken as the basis. The tendency of farmers to comply with the rules of organic agriculture was discussed in the study, and it was determined that the tendency of animal producers to comply with the rules was higher than that of plant producers. The second of these studies was by Viitaharju, Kujala and Törmä (2017) in Finland. This study analyzes the impact of organic agriculture on GDP and unemployment. The study concluded that organic agricultural activities positively affected GDP, whereas unemployment rates decreased slightly because of the decrease in traditional agricultural activities.

The third study in the literature is Rehman et al. (2017) in Pakistan. This study analysed the impact of organic livestock activity on agricultural GDP. The study results indicated that milk, egg, fat, and mutton variables positively affected agricultural GDP.

4. The Place of Organic Farming in the Economy of Turkey

In this study, the role of organic farming in the Turkish economy is examined in terms of production, consumption, and foreign trade. In the study, efforts have been made to provide the most up-to-date data, and the year 2019, which contains the latest data, has been used as the base.

4.1. Production Dimension of Organic Farming

In the early years of organic farming in Turkey, traditional export products such as dried figs and grapes began to be produced. Over time, the number of products has rapidly increased, and hazelnuts, apricots, walnuts, pistachios, apples, cotton, lentils, olives, tomatoes, strawberries, cherries, peppers, chickpeas, onions, wheat, medicinal, and aromatic plants have also been added to the list (Merdan, 2014, p. 69). This number has continuously increased and, as of 2020, has reached 248.

Organic farming, considered one of the most significant elements of agricultural development in Turkey, has entered an upward trend recently. In Turkey, organic farming has shown significant growth in recent years because of the increase in production amount, the number of producers, and the number of products. When analysing the long-term change, it is observed that the number of producers engaged in organic farming activities has increased by 4.23 times over the 18 years from 2002 to 2020, while the amount of production has increased by 5.26 times. The number of products, which was 150 in 2002, has increased by 1.65 times, reaching 248 different products in 2020 (Table 2). Based on these findings and considering the number of producers, production amount, and number of products in Turkey, it is possible to say that the organic market, which has gained importance in line with consumer demands, is growing.

Table 2: Statistics on Turkey's Number of Organic Farmers, Amount of Production, and Number of Products (2002-2020)

Years	Number of Producers	Amount of Production (Tonnes)	Number of Products
2002	12.428	310.125	150
2003	14.798	323.981	179
2004	12.806	378.803	174
2005	14.401	421.934	205
2006	14.256	458.095	203
2007	16.276	568.128	201
2008	14.926	530.225	247
2009	35.565	983.715	212
2010	42.097	1.343.737	216
2011	42.460	1.659.543	225
2012	54.635	1.750.127	204
2013	60.797	1.620.387	213
2014	71.472	1.642.235	208
2015	69.967	1.829.291	197
2016	67.878	2.473.600	225
2017	75.067	2.406.606	214
2018	79.563	2.371.612	213
2019	74.545	2.030.465	213
2020	52.590	1.630.252	248

Source: www.tarimorman.gov.tr.

4.2. Consumption Dimension of Organic Farming

While the consumption of organic food is increasing day by day in high-income countries, in less developed and developing countries, producers engaging in export-oriented organic farming activities due to high profitability negatively affect organic consumption. The findings obtained from the conducted studies reveal that the price consumers in Turkey are willing to pay for organic products is considerably higher than that for the alternatives.

Two significant conclusions have been reached in the studies conducted on organic product consumption. The first is the identification of the potential demand for organic products, and the second is consumers being informed about organic products. At this juncture, the action required is either to boost demand or to reduce supply. Since the objective is not to cut supply, necessary precautions should be taken to develop policies aimed at increasing demand. When examining factors that influence demand, an increase in consumer income, along with shifts in consumer tastes and preferences in favour of the producer, can contribute to increased demand. Moreover, through effective advertising and marketing strategies, organic product makers can shape the demand for organic products (Merdan, 2014, p. 82).

Looking at Turkey as a whole, it has been observed that excluding some developed regions like Istanbul, Ankara, and Izmir, the habit of purchasing organic products is not widespread among consumers. This situation can be attributed to the high prices of organic products and consumers not having sufficient knowledge about organic farming (Aydın, Emir, and Demiryürek, 2015: 202). In studies focussed on consumer tendencies, emphasis is generally placed on taste, price, absence of additives, and lack of Genetically Modified Organisms (GMO) in organic products. (Turan and Demircan, 2021, p. 154; Kekeç and Seçer, 2021, p. 87; İnan, Bekar, and Urlu, 2021, p. 220).

4.3. Trade of Organic Agricultural Products in Turkey

In the early 1980s, organic production in Turkey, which was initially focussed solely on exports, evolved in response to foreign demand, leading to changes in both the amount and variety of organic products. Foreign individuals and organisations provided during the initial years of organic production, consultancy, inspection, and certification services. Starting in the 1990s, although in limited numbers, Turkish experts began to emerge in the field of organic farming, eventually becoming representatives of foreign companies in Turkey (İslam, 2013).

A significant portion of organically produced products in Turkey are sold in foreign markets; some are used in the production of processed goods, and others are directly consumed (Emeksiz et al., 2005). In recent years, with the increase in domestic consumption demand and consumer awareness, the domestic market has shown a rising trend, although not as rapidly as the foreign market. The distribution of organic products in the domestic market is facilitated through a specific marketing network that connects producers to supermarkets or directly to consumers (Tetik, 2012: 51).

4.3.1. Organic Product Export

The majority of organically produced products in Turkey are exported. Foreign demand, with a focus on order-based production networks primarily driven organic production quantities in Turkey (Kırmacı, 2003). While export values in Turkey have fluctuated from 2002 to 2020, they have consistently shown an upward trend. The export amount, which was 19,183 tonnes in 2002, reached 75,904 tonnes in 2019. Similarly, the export value of organic products has shown a fluctuating but increasing trend. In 2002, the generated amount was $30,877, while in 2019, it reached $203,142 (Table 3). In the context of this study, organic products that were initially exported as raw materials have been increasingly exported as processed goods in recent years, contributing to the growth of organic export revenue.

Table 3: Export Values in Turkey Over the Years

Years	Amount (Tonnes)	Amount (Thousand dollars)
2002	19.183	30.877
2003	21.083	36.933
2004	16.093	33.076
2005	9.319	26.230
2006	10.374	28.237
2007	9.347	29.359
2008	8.629	27.260
2009	7.566	27.505
2010	3.593	15.880
2011	3.371	15.529
2012	6.258	24.704
2013	10.495	46.020
2014	15.553	78.780
2015	13.549	69.230
2016	16.819	77.831
2017	61.989	215.288
2018	111.691	361.129
2019	75.904	203.142

Source: www.tarimorman.gov.tr.

A list of the most exported organic plant products in Turkey in 2019 is provided in Table 4. Wheat ranks first among the exported organic plant products, with 31,194.53 tonnes and revenue of $11,913,987.26. Fruits, grapes, figs, hazelnuts, and apricots, in that order followed (Table 4).

Table 4: The most exported organic plant products in Turkey (2019)

Product Name	Amount (Tonnes)	Amount ($)
Wheat	31,194.53	11,913,987.26
Fruits	16,733.92	65,242,625.00
Grape	9,536.31	27,895,275.66
Fig	6,895.86	40,306,275.00
Hazelnut	4,440.76	31,964,563.27
Apricot	3,744.10	14,727,473.00
Vegetable	1,146.61	1,694,270.52
Others	850.03	2,198,960.80
Corn	815.38	2,983,475.42
Olive	178.22	394,232.08
Spices	137.75	1,850,383.93
Pistachio	85.87	1,566,455.26
Total	**75,798.79**	**202,7377,977.2**

Source: www.tarimorman.gov.tr.

4.3.2. Importation of Organic Products

In Turkey, the importation of organic products is steadily increasing, and the range of products is expanding. A variety of products are imported, including soybeans and flour, coffee, chocolate, beeswax, liquorice root, coconut, flaxseed, dates, sunflower oil, walnuts, chickpeas, cotton, and dried fruits, among others (Merdan, 2014, p. 77).

When examining Turkey's import activities on a product basis, according to the data for 2019, soybeans take the first place with 1,518 tonnes. Soybeans are primarily imported from Ethiopia. In the second place, with 716 tonnes, liquorice root is observed. Liquorice root is imported from Georgia and Kazakhstan. In third place, date palms rank with 598 tonnes. This plant is imported to Turkey from countries such as the United States, France, the Netherlands, the United Kingdom, Germany, Algeria, Israel, Iran, Pakistan, Tunisia, and Saudi Arabia. Following the dates, the subsequent products in order are flaxseeds, dried apples, sesame seeds, coconuts, dried apricots, banana puree, and apple vinegar (Table 5).

Table 5: Turkey's organic import values for 2019 (top ten products)

Product Name	Quantity (Tonnes)	Imported Country
Soybean	1.518	Ethiopia
Liquorice	716	Georgia, Kazakhstan
Date	598	USA, France, Germany, Pakistan, Saudi Arabia, Tunisia, Algeria, Netherlands, UK, Iran, and Israel
Linseed	276	Kazakhstan
Dried Apple	137	Kyrgyzstan
Sesame Seed (Raw)	112	Uganda
Coconut	89	Netherlands, Germany, Sri Lanka,
Dried Plums	63.7	England, Argentina, and France
Banana Puree and Flake	42	Ecuador, France
Apple Cider Vinegar	40	Germany

Source: www.tarimorman.gov.tr.

5. Methodology

5.1. Subject and Purpose of the Study

This study examines the effects of organic farming on certain economic variables. The study analysed how variables related to the area allocated to organic farming, organic production amount, and the number of producers engaged in organic farming between 2003 and 2021 at a regional level in Turkey influenced gross domestic product (GDP), economic growth, and unemployment. Panel data analysis was employed in this study, utilising the EViews 12 software. Geographical region cross-sectional dependence was assessed for the variables used in the study, and the stationarity of the series was examined using the CIPS (Cross-Sectionally Augmented IPS) unit root test.

In the data preparation phase, it is essential for all series to be included in the model to be stationary. Unit root tests were conducted to assess the stationarity of the series. After conducting unit root tests, the study model was constructed. This study determines the economic effects of organic farming in Turkey and to provide guidance for researchers who intend to conduct similar studies in the future.

5.2. Data Collection Technique of the Study

In the preparation of this study, scientific and periodical publications were reviewed, and the gathered information and documents were compiled in accordance with scientific research methods. The scientific data for this study were obtained from the electronic database of the Ministry of Food, Agriculture, and Livestock (GTHB).

5.3. Scope and Data Set of the Study

The data used in the research covers the years 2003–2021 and includes a regional assessment from a geographical perspective. EViews 12 software was utilised in this study, and panel data analysis was conducted. The variables used in the analysis and their descriptions are presented in Table 6.

Table 6: Variables Used in the Analysis and Their Descriptions

Variable Code	Purpose of Use	Variable Name
GROWTH	Dependent variable	Economic Growth (%)
GDP	Dependent variable	GDP (USD)
UNEMPLOYMENT	Dependent variable	Unemployment (%)
AOP	Independent Variable	Amount of Organic Production
NOF	Independent Variable	Number of Organic Farmers
AOF	Independent Variable	Area of Organic Farming

Panel data analysis is widely used in various fields, including economics, sociology, political science, health research, psychology, and education. It is particularly valuable in microeconomic studies where there are a substantial number of units (e.g., regions, countries, companies) In studies that examine the activities of countries over time, macroeconomic panel data analysis is often employed (Baltagi, 2006).

A normality test based on the p-values of the Jarque-Bera test statistic was conducted. Jarque-Bera test is a goodness-of-fit measure used to assess deviations from a normal distribution, which is derived from the transformation of kurtosis and skewness measurements. The null hypothesis (H_0) in this test assumes that the errors follow a normal distribution. When $p < 0.05$, the null hypothesis is rejected, indicating that the data do not follow a normal distribution.

Table 7: Descriptive Statistics for the Variables

Variables	Min.	Max.	Mean	SD	J-B	p
GROWTH	-4.70	11.00	4.61	3.71	3.16	0.206
GDP	4684	12488	9564.89	2021.74	2.12[1]	0.344
UNEMPLOYMENT	9.20	14.00	11.07	1.29	5.60[3]	0.061
AOP	12140	1081655	195480	252916	5.48[3]	0.064
NOF	91	29852	6707.90	7897.09	1.07[2]	0.586
AOF	2831	379373	64107.69	76101.99	2.18[2]	0.335

[1]: Square root transformation
[2]: Logarithmic transformation
[3]: Inverse transformation

When examining the Jarque-Bera test statistics in Table 7, it was determined that the variables GDP, UNEMPLOYMENT, OPA, NOF, and OPA have a normal distribution after appropriate transformations ($p > 0.05$).
To determine the direction of the relationships between the variables used in the study, correlation coefficients were calculated. The Pearson correlation coefficients obtained from the analysis of the variables are shown in Table 8.

Table 8: Correlation Coefficients between Variables

Variables	1	2	3	4	5	6
GROWTH	1	-0.160*	-0.348**	-0.099	-0.137	-0.129
GDP		1	-0.382**	0.266**	0.292**	0.351**
UNEMPLOYMENT			1	0.108	0.091	0.030
AOP				1	0.645**	0.760**
NOF					1	0.656**
AOF						1

Note: *: p<0.05; **: p<0.01

In the correlation method, where the degree of correlation between independent variables is considered, it can be said that in the literature, correlations of 80% or lower are in line with common practise. When examining

Table 8, it can be observed that the correlation between pairs of independent variables is less than 0.80. It was determined that among the dependent variables, only the GDP variable has a relationship with the independent variables.

When cross-sectional dependence is present in series, the Breusch and Pagan (1980) and Pesaran (2004) tests are employed. The second-generation unit root tests used to detect cross-sectional dependence include Breusch and Pagan (1980) LM, Bias-corrected scaled LM test, Pesaran (2004) CD, and Pesaran (2004) scaled LM test. The use of these tests is determined by examining the relative situation of the cross-sectional dimension "N" and the time dimension "T." Accordingly, it is stated in the literature that it would be more appropriate to use the Pesaran (2004) CD test when N>T and the Breusch and Pagan (1980) LM test when T>N.

In practise, since our cross-sectional dataset consists of regions (N=7) and our time-dependent dataset is determined by the number of periods (T=19), the Pesaran (2004) CD test, which is considered appropriate for cases where T>N, is more suitable for testing cross-sectional dependence. The null hypothesis H_0 used for the cross-sectional dependence test is "there is no dependence between the sections." If the probability values obtained from the analysis are p<0.05, H_0 will be rejected. In this case, it is concluded that there is cross-sectional dependence among the variables that constitute the panel data analysis. Therefore, cross-sectional dependence will be considered in the selection of unit root tests to be applied.

Table 9: Cross-Sectional Dependence Test Results

	Model 1			**Model 2**			**Model 3**		
Variables	**sd**	**Value**	**p**	**sd**	**Value**	**p**	**sd**	**Value**	**p**
Breusch-Pagan LM	21	379.31	0.000	21	271.86	0.000	21	383.82	0.000
Pesaranscaled LM		54.21	0.000		37.63	0.000		54.90	0.000
Bias-Correctedscaled LM		54.01	0.000		37.43	0.000		54.71	0.000
Pesaran CD		19.47	0.000		16.31	0.000		19.59	0.000

Note: *p<0.05; **p<0.01
(Dependent Variable: Economic Growth), Model 2 (Dependent Variable: GDP), and Model 3 (Dependent Variable: Unemployment)

Upon examining Table 9, it is observed that the p-value corresponding to the test statistic obtained in the Pesaran CD test is less than 0.05 ($p<0.05$) in all three models. In other words, there is cross-sectional dependence in the series. This result indicates that a change occurring in any of the variables included in the model also affects the other variables. Considering the findings obtained, second-generation panel unit root tests will be utilised within the empirical model in which panel data analysis is employed.

5.4. Findings and Remarks

The fact that panel unit root tests take into account both the time and cross-sectional dimensions of the data reveals that they are statistically more robust than time series unit root tests that consider only the time dimension (Hadri, 2000; Levin, Lin & Chu, 2002; Im, Pesaran, & Shin, 2003; Pesaran 2007).

In this study, geographical region cross-sectional dependence was identified for the variables used in the panel data. The stationarity of the series was tested by performing a unit root test using the CIPS (Cross-Sectionally Augmented IPS) test, a second-generation unit root test (Pesaran, 2007). The CIPS test allows for conducting a unit root test among the series included in the panel. The null hypothesis (H_0) suggests that they contain a unit root (i.e., they are not stationary), and when $p<0.05$, the hypothesis is rejected, indicating that they do not contain a unit root (i.e., they are stationary). The results of the unit root test conducted for the variables are shown in Table 10.

Table 10: CIPS Pesaran Unit Root Test Results

		Level		First difference	
Variables	**Lag**	**t**	**p**	**t**	**p**
GROWTH[1]	1	-6.190	0.000	-6.802	0.000
GDP[1]	1	-2.101	0.018	-6.494	0.000
UNEMPLOYMENT[1]	1	-4.155	0.000	-6.346	0.000
AOP	1	-2.941	0.000	-5.192	0.000
NOF	1	-3.068	0.000	-4.991	0.000
AOF	1	-2.662	0.000	-4.766	0.000

Note: [1]A singular unit root test was conducted.

According to the results in Table 10, it has been determined that the variables do not contain a unit root at level and are stationary at level. Consequently, there was no need to consider the first difference in the series.

5.4.1. Model Specification

In this study, the likelihood ratio (LR) test is used to test the fixed-effects model against the random-effects model. The H_0 hypothesis is expressed as "a fixed-effects model is not necessary" (Tatoğlu, 2018). The Lagrange Multiplier (LM) test was conducted to detect random effects. In the test examining random effects over cross-sections, time, and cross-section/time, the H_0 hypothesis (no effect) is tested (Breusch and Pagan, 1980). In the model's application, considering our variables, the Hausman test statistics with an X^2 distribution are used to determine the appropriate model. The test results related to the selection between fixed- and random-effects models are shown in Table 11.

Table 11. Fixed Effect/Random Effect Test Results

LR test	**Model-1[1]**	**Model-2[2]**	**Model-3[3]**
F (6; 123) / p	0.663/0.679	4.848/0.000	0.300/0.935
X2 (6) / p	4.237/0.645	28.233/0.000	1.932/0.925
	Random	Fixed	Random
LM test			
Unit	2.667	0.001	121.78**
Time	386.41**	330.21**	14.03**
Unit and Time	389.07**	330.21**	132.81**
	Fixed/Random	Fixed/Random	Random
Hausman test			
X^2	3.981	29.089	1.800
sd	3	3	3
p	0.263	0.000	0.614
	Random	Fixed	Random

Note: *p<0.05; **p<0.01
(Dependent Variable: Economic Growth), Model 2 (Dependent Variable: GDP), and Model 3 (Dependent Variable: Unemployment)

Based on the likelihood ratio (LR) test results used to test the fixed effects model against the random effects model, the hypothesis "a fixed effects model is not necessary" has been accepted for Models 1 and 3 but rejected for Model 2. Accordingly, the LR test results a random-effects model for Models 1 and 3 and a fixed-effects model for Model 2. In the LM test, according to the Breusch-Pagan statistic, the hypothesis of no random effects was accepted for Models 1 and 2, whereas the hypothesis "there is no random effect in time and cross-section" has been rejected. In Model 3, the hypothesis "there is no random effect in cross-section, time, and cross-section/time" has been rejected. According to the X2 test statistic obtained in the Hausman test, a random effects model is suitable for Models 1 and 3, while a fixed effects model is suitable for Model 2.

In models, the presence of heteroskedasticity, inter-unit correlation, or autocorrelation affects the validity of F and t statistics, R^2, and confidence intervals (Tatoğlu, 2018). Since the GLS method offers weighting and covariance error corrections, it is a more efficient method than OLS under varying variance or autocorrelation (Baltagi, 2005; Greene, 2003). Cross-section weights, White Diagonal, White Cross-Section weights, and the Swamy-Arora (SA) estimator are preferred estimators when the sample size is small (Baltagi & Song, 2006).

Table 12: Model Autocorrelation, Heteroscedasticity, and Cross-sectional Correlation

Condition Examined	Test	Model-1[1]	Model-2[2]	Model-3[3]
Autocorrelation	Durbin-Watson	1.766	0.772	0.985
Cross-sectional Autocorrelation	Pesaran CD	19.893**	16.314**	19.590**
Heteroscedasticity	Wald	1.581	-5.341**	-16.884**

Note: *p<0.05; **p<0.01
(Dependent Variable: Economic Growth), Model 2 (Dependent Variable: GDP), and Model 3 (Dependent Variable: Unemployment)

5.4.2. Model Testing

In Model 1, within the random effects model, there is no issue of heteroscedasticity, and while there is no autocorrelation within the units, a problem of cross-sectional autocorrelation is present, as indicated in Table 12. To address this, the Period SUR (PCSE) method has been used to adjust the panel standard errors, and subsequently, the Swamy-Arora weighted Panel EGLS was applied.

In Model 2, within the fixed effects model, there is an issue of heteroscedasticity as well as problems of autocorrelation both within and between the units, as illustrated in Table 12. To rectify this, the White Diagonal method was employed to correct the panel standard errors, followed by the application of Cross-Section Weights Panel EGLS (Greene, 2003; Kyriazis and Anastassis, 2007).

In Model 3, which utilises the random effects model, there is heteroscedasticity and inter-unit autocorrelation but no intra-unit autocorrelation, as indicated in Table 12. To address these issues, the White Cross-Section method was applied to correct the panel standard errors, subsequently leading to the implementation of Swamy-Arora Weighted Panel EGLS (Wooldridge, 2002; Arellano, 1987).
The results of the Panel EGLS are presented in Table 13.

Table 13: Model Results

Model	Independent Variables	Dependent Variables	Coefficients	Standard Error	t	Probability (p)	VIF
1	C	GROWTH	10.419	4.998	2.084	0.039	
	AOP		47176.46	156611.5	0.301	0.763	4.522
	NOF		-0.303	0.373	-0.810	0.419	4.291
	AOF		-0.294	0.451	-0.654	0.514	4.969
	F=0.965; p=0.965; R^2=0.021; ΔR^2=0.001						
2	C	GDP	-221.889	41.538	-5.341	0.000	
	AOP		-821818.3	1338426.0	-0.614	0.540	3.149
	NOF		6.552	2.937	2.230	**0.027**	2.388
	AOF		10.893	3.082	3.533	**0.000**	2.491
	F=6.315; p=0.000; R^2=0.316; ΔR^2=0.266						
3	C	UNEMPLOYMENT	-1.508	0.071	-20.982	0.000	
	AOP		3106.49	2499.83	1.242	0.216	2.564
	NOF		0.003	0.004	0.667	0.505	1.915
	AOF		-0.006	0.006	-1.095	0.275	2.613
	F=0.947; p=0.419; R^2=0.021; ΔR^2=0.001						

Examining Model 1, where economic growth is the dependent variable, it is observed that the F-test is not significant (p>0.05), the explained variance is at 0%, and no variable has a significant impact on economic growth (p>0.5). In other words, it was determined that the amount of organic production, the number of organic farmers, and the area of organic production do not have a significant effect on economic growth.

In Model 2, where the dependent variable is per capita income, the F-test was found to be significant ($F=6.31$; $p<0.05$), indicating the model's validity. The variables of organic production, number of farmers, and area of production account for approximately 27% ($R^2=0.316$) of the variation in per capita income. Examining the t-values for coefficient significance reveals that both the area under organic production ($t=2.23$; $p<0.05$) and the number of organic farmers ($t=3.53$; $p<0.05$) exert a positive and statistically significant impact on per capita income, while the amount of organic production does not have a significant impact ($p>0.05$).

When examining Model 3, in which unemployment is the dependent variable, it's found that the F-test is not significant ($p>0.05$), the explained variance is at the 0% level, and none of the variables have a significant impact on unemployment ($p>0.5$). In other words, it was determined that the amount of organic production, the number of organic farmers, and the area of organic production do not have a significant effect on unemployment.

Conclusion and Evaluation

Turkey is an agricultural country with a vast range of products. In recent years, the demand for organic products has rapidly increased with the controlled and certified production and presentation of agricultural products healthily. Nowadays, many consumers are willing to pay a higher price for products they believe are reliable and of high quality. In this context, increasing organic farming activities with the objective of safeguarding the environment and promoting the well-being of humans, plants, and animals will yield positive results.

In addition to its positive outcomes, organic farming has several negative consequences, particularly for developing countries like Turkey. The shift from traditional farming, which involves excessive use of synthetic fertilisers and pesticides, to organic farming leads to a decrease in yield as conventional methods are completely abandoned. Along with this drawback, there is a certain transition period in organic farming, which demands advanced farm management skills. In this context, for less developed and developing countries, producing an adequate amount of organic products to meet the continuously increasing demands of the population might not be easily achievable in the near future.

Organic farming, considered one of the most significant elements of agricultural development in Turkey, has been on a rising trend recently. Organic farming in Turkey has shown significant progress because of increases in the amount of production, the number of products, and the number of producers. When examining the long-term transformation over the 18 years from 2002 to 2020, the number of producers engaging in organic farming activities increased by 4.23 times, the amount of production grew by 5.26 times, and the variety of products rose by 1.65 times.

In Turkey, a significant portion of organically produced products are sold in foreign markets, some are used in the mixtures of manufactured products, and some are consumed directly. With the recent increase in domestic consumption demand and consumer awareness, there is a growing trend in the domestic market, albeit not as rapid as that in the foreign market. The introduction of organic products to the domestic market is carried out either through a specific marketing network from producers to supermarkets or directly from producers to consumers.

This study examined organic farming activities within the framework of economic policy. In summary, the findings indicate that the amount of organic production, the number of organic farmers, and the area of production have a significant impact on economic growth. It might be assumed that organic farming, which yields fewer products per unit compared with conventional farming, could impede economic growth. On the other hand, it is observed that the area of organic production ($t=2,23$; $p<0,05$) and the number of organic farmers ($t=3,53$;

p<0,05) have a positive and significant influence on per capita income, whereas the amount of organic production does not have a (p>0,05) significant effect. Furthermore, it has been established that the amount of organic production, the number of organic farmers, and the organic production area does not significantly affect unemployment.

Within the scope of the findings obtained in the study, although the positive aspects of organic agriculture in terms of human and environmental health are recognised, it is considered that the continuation of this activity does not benefit the discipline of economics in terms of economic growth and unemployment but only has a positive effect on per capita income.

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RESEARCH ARTICLE

Exploring the Impact of Behavioural Factors and Personality Traits on Private Pension System Participation: A Machine Learning Approach*

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ABSTRACT
This study aims to investigate the effects of personality traits, in addition to basic financial literacy, private pension literacy and behavioural factors on Private Pension System (PPS) participation using machine learning algorithms. The PPS participation model was trained using both random forest and LightGBM algorithms, and the contributions of model inputs in the prediction of pension participation were interpreted using the Tree SHAP algorithms with swarmplots. The data employed in the empirical analysis is survey data collected from the Şırnak province of Türkiye with a sample size of 449. The findings of the study shows that: (i) PPS participation is more likely for females and middle-aged people; (ii) High basic financial literacy has a negative impact on PPS participation; (iii) Extraversion is the key personality trait affecting PPS participation; (iv) Advanced pension literacy has more impact on participation than simple pension literacy: (v) Present-fatalistic tendency is key behavioural factor and it negatively affects PPS; (vi) Present-hedonistic, conscientiousness, future-time orientation, and locus of control tendencies increase PPS participation. Furthermore, the distribution of colours in LightGBM has a greater degree of uniformity in both directions compared with the random forest algorithm. Finally, to increase PPS participation, the results of the study suggest the implementation of the following policy measures: Tailored pension literacy programmes can help to increase pension participation rates. Incentives should be created to prevent narrow-minded behaviour and establish a sense of protection and control around PPS, targeting middle-aged individuals and women.

Keywords: Private pension system, Behavioural factors, Personality traits, Machine learning algorithms, Tree SHAP
JEL Classification: C60, G41, J32

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Introduction

For many reasons, increasing social security expenditures has caused social security system-related government budget deficits to increase over time. Since the 1980s, governments have striven to transform their social security systems into a market-based structure as well as establishing the Private Pension System (PPS) to cope with the burden of the system on government budgets.

Chile was the pioneering country that devised its social security system as a two-pillar structure through the establishment of the PPS in 1981. Within this two-pillar pension system, the first pillar corresponds to the public social security system, while the second pillar entails the PPS. The PPS converts the Social Security System into a market-oriented framework and aids in alleviating the social security burden via the implementation of its three primary functions: (i) the augmentation of savings in the economy by means of collecting pension contributions and channelling the under-pillow savings towards the PPS. In the PPS, the more participants are encompassed within the system, the greater the accumulation of pension contributions; (ii) the promotion of investment by directing the pension contributions towards the capital markets; (iii) PPS also leads to the conversion of investment returns to benefits. Consequently, in addition to social security benefits, PPS participants enjoy supplementary advantages. The benefit is computed by subtracting the expenses and management fees of the private pension company from the investment returns. As such, all these aspects underscore the direct correlation between PPS and savings as well as investment, thus underscoring its pivotal role in mitigating the social security burden. Because of these reasons, numerous governments perceive the PPS as a valuable policy instrument for generating funds for financial markets and savings, which in turn leads to its expanding prevalence and encouragement.

The establishment of the Turkish PPS in 2003 aimed to capitalise on the advantages of PPS. Its formation closely mirrored that of its counterparts in developed countries: it incorporated tax incentives and a 25% state contribution and adopted the Automatic Enrollment System (AES). However, the Turkish PPS has failed to attain satisfactory growth in the contribution per participant and has faced challenges in attaining the necessary level of funding since its establishment (Ertuğrul, Gebeşoğlu, & Atasoy, 2018). Moreover, it cannot reach enough participants compared with the working population (see appendix for details). Consequently, additional effective policy measures and institutional changes must be implemented to realise the anticipated benefits of PPS in Türkiye.

Although a limited number of studies are available, several examine the underlying factors that contribute to the low levels of participation and the observed failure in establishing a strong PPS in Türkiye (Türkmen, & Kılıç, 2022; Canöz, & Baş, 2020; Özbek, 2020; Özer, & Çınar, 2012). A concise analysis of the existing literature reveals significant aspects related to the determinants of the Turkish PPS. Firstly, behavioural factors and personality traits are utilised as determinants of private pension participation. However, these factors only address certain dimensions of behavioural factors and personality traits, such as risk and future considerations. Second, there is a noticeable lack of studies that explore the relationship between PPS participation and private pension literacy in Türkiye. Third, there is also a scarcity of studies that thoroughly examine the determinants of PPS participation, considering basic financial literacy, private pension literacy, behavioural factors, and personality traits, utilising machine learning algorithms. Fourth, none of the studies reviewed employ machine learning algorithms to analyse the impact of behavioural factors, personality traits, pension literacy, and basic financial literacy on PPS. Finally, a limited number of studies compare the performance of the random forest and light gradient boosting machine (LightGBM) algorithms in training their models.

Considering these facts, this study aims to analyse and evaluate the determinants of private pension participation using survey data collected from the Şırnak province of Türkiye. Pension participation is modelled as a function of financial literacy, private pension literacy, behavioural factors, and personality traits and analysed using machine learning algorithms. This study contributes to the existing literature mainly in two ways. First, in addition to basic financial literacy, the private pension participation model includes pension financial literacy, many personality traits, and behavioural factors such as the Big Five personality traits, pessimism, procrastination, time perspective, compulsive buying, and locus of control in the analysis. Second, it employs random forest, LightGBM, and Tree SHAP, which is a variant of SHapley Additive exPlanation (SHAP), as a machine learning algorithm to estimate the importance of the variables subject to empirical analysis and to interpret and compare the estimated results.

The rest of the study is organised as follows. A theoretical literature review of pension participation is presented in Section 2. Section 3 reviews the empirical literature on pension participation and its determinants. Section 4 introduces the dataset and the methodology. The results obtained from the empirical analysis of the data are given in Section 5. Section 6 concludes the study with policy recommendations.

1. Review of the Theoretical Literature on the Determinants of Pension Participation

This section provides the theoretical basis for the determinants of private pension participation. Individuals have a growing desire for greater economic security in their old age, leading to an increasing interest in private complementary provident arrangements (Barr, & Diamond, 2009; Holzmann, & Hinz, 2005). In other words, they accumulate savings from their incomes to ensure economic security in the future. This viewpoint asserts that the factors influencing savings are identical to those influencing retirement savings (or participation in private pension systems). A brief review of the theoretical discussions on the subject shows that the theoretical factors that make people participate in a PPS involve income, institutional factors, behavioural factors, and personal traits.

Income: Income seems to be the most obvious and well-known factor that determines private pension participation and the size of pension contributions. The importance of income factor in pension participation can be explained by referring to theories on savings. The larger the income, the more people save, and these people are more reluctant to participate in PPS because it provides an alternative institutional framework for saving. Numerous economic theories assert that saving behaviour is contingent on income and consumption patterns, with an increase in income levels leading to a higher propensity to save. Consequently, it can be contended that a higher income level positively influences the rates of participation in PPS.

Keynes (1936) defines saving as the proportion of income that exceeds the portion allocated to consumption. However, Friedman (1957) posits in his permanent income hypothesis that the primary determinant of savings is permanent income. Consequently, he concludes that the age of the population has significant implications for consumption and saving, prioritising it over temporary income. The life cycle hypothesis, developed by Modigliani and Brumberg (1954), postulates that long-term income is the main driver of saving. In contrast to the permanent income hypothesis, this theory recognises the longevity of life and advocates the consideration of life resources and current income. Like the permanent income hypothesis, the life cycle hypothesis acknowledges the influence of individual age on consumption and saving, while also asserting that consumption is contingent on long-term income. Duesenberry (1967) elucidates saving behaviour through the lens of the relative income hypothesis. According to this hypothesis, households make consumption decisions based on their relative income. Consequently, current consumption is influenced by past savings. Thus, an increase in income triggers a more substantial change in consumption than a decrease in income. In contrast to other savings theories, the relative income hypothesis assumes a correlation between income distribution and savings. It posits that savings are influenced by interest rates, the relationship between current and expected future incomes, income distribution, age distribution of the population, and income growth (Duesenberry, 1967).

Institutional Factors: Theories regarding institutional saving posit that both individuals and institutional processes impact households' savings. Consequently, individual behaviour is influenced by social institutions. As stated by Sherraden (1991), the mechanisms of institution encompass rules, incentives, implicit connections, and subsidies. He refers to the incentives within the PPS as institutional subsidies. Accordingly, individuals accumulate wealth through the incentives provided by the PPS.

Behavioural Factors: A limited range of behavioural theories examine the determinants of savings. Behavioural savings theories differ from economic theories in their assumptions about preferences for saving and consumption. Unlike economic theories, behavioural savings theories posit that saving and consumption preferences, as well as individual economic behaviours, are not influenced by preferences and economic resources (Beverly, 1997). These theories propose that individuals are subject to behavioural constraints and incentives. One well-known behavioural savings theory is the behavioural life-cycle hypothesis (Shefrin, & Thaler, 1988). According to this theory, individuals can be categorised as either planners or doers. Planners and doers make different decisions regarding saving and consumption on the basis of the time periods they consider. While planners base their consumption and savings decisions on lifetime utility, doers make economic decisions for a single period (Thaler, & Shefrin, 1981). However, if the preferences and incentives of doers change and become more restricted, they will exhibit greater self-control. According to this theory, individuals often accept rules that limit their behaviour as doers. Therefore, it is concluded that planners are more inclined to participate in PPS than doers. Furthermore, a mandatory pension plan could increase overall savings (Thaler, & Shefrin, 1981).

This study considers procrastination, locus of control, time perspective, pessimism, and compulsive buying as behavioural variables. Procrastination is defined as the voluntary postponement of an intended event that is expected to have negative consequences (Piotrowska, 2019). Locus of control is a psychological notion that includes individuals' beliefs regarding the degree to which they can control the events that impact them. Time perspective is examined under three subheadings: future (expectations), present-hedonistic, and present-fatalistic. Present-hedonistic individuals avoid long-term work and focus on pleasure in their lives. Present-fatalistic individuals believe that an external force is dominant in their lives and not in their actions. Pessimism is defined as the negative bias of expectations and perceptions in life (Burke, Joyner, Czech and Wilson, 2000). Compulsive buying is the uncontrollable urge to buy or use a substance or activity (O'Guinn, & Faber, 1989).

Behavioural factors play a pivotal role in determining savings. Hence, they have a close association with PPS. The relationship between pessimism and retirement savings is mediated through various channels. Individuals with a pessimistic outlook tend to have shorter life expectancies, resulting in negative decisions regarding retirement savings (O'Dea, & Sturrock, 2019). Furthermore, pessimism may interact with retirement savings through other behavioural factors, such as locus of control and procrastination (Burke et al., 2000; Piotrowska, 2019). Procrastination, due to its consequences such as anxiety, depression, and stress, exhibits a positive correlation with pessimism (Van Eerde, 2003). Pessimists, owing to their external locus of control (such as fate), display a lack of motivation to save for retirement (Piotrowska, 2019). Nevertheless, pessimism can have a positive impact on retirement savings, as it is positively associated with individualism, thereby positively influencing financial comfort (Bengtson, Biblarz, & Roberts, 2002). Consequently, it encourages individuals to consider their financial conditions during retirement, leading to increased retirement savings. According to Personality Plus (Littauer, 1995), pessimists possess a unique ability to identify problems that optimists may overlook. This phenomenon is known as defensive pessimism, which involves preparing for negative outcomes and harbouring negative expectations (Burke et al., 2000). Consequently, pessimism may positively influence savings through this mechanism. Procrastination exhibits a negative relationship with retirement planning, as it prioritises short-term actions over long-term consequences and is prone to postponement (Piotrowska, 2019). The locus of control is closely linked to self-control, which in turn has a positive impact on savings. Hence, it is a critical behavioural factor in the context of retirement savings.

According to the theory of planned behaviour (Ajzen, 1991), future time perspective can influence retirement savings by affecting the attitudes, subjective norms, and perceived behavioural control of individuals regarding saving and investing for retirement. Individuals who have a strong future time perspective may have more positive attitudes towards saving and investing for retirement because they value the long-term benefits and consequences of their actions. Empirical evidence is scarce on the causality of compulsive buying, future (expectations), present-fatalistic, and present-hedonistic to retirement savings. However, some studies have suggested a negative relationship between compulsive buying and retirement savings. For example, Asebedo and Browning (2020) found that compulsive buyers had lower levels of retirement saving adequacy than non-compulsive buyers. They also found that compulsive buyers had lower levels of future time perspective than non-compulsive buyers. Another study by Donnelly, Iyer, and Howell (2012) found that compulsive buyers had lower levels of financial well-being than non-compulsive buyers. They also found that compulsive buyers had higher levels of present-hedonistic time perspective than non-compulsive buyers. The causal factor behind compulsive buying is theoretically attributed to hedonism, as posited by O'Guinn and Faber (1989). Piotrowska (2019) deduced that hedonism, fatalism, and present-fatalistic and present-hedonistic tendencies manifest a positive influence on compulsive buying. Moreover, she contends that the impact of compulsive buying on retirement savings can be elucidated through the mechanisms of status consumption and a deficiency in self-assurance. Finally, it is determined that the indirect consequence of present-fatalistic attitudes, mediated through procrastination, has a detrimental effect on retirement savings.

Personality traits play a crucial role in determining retirement savings, making them closely linked to PPS. This investigation focuses on the Big Five personality traits, which were established by Costa and McCrae (1992) and serve as the foundation for identifying personality traits (Piotrowska, 2019). The Big Five encompasses extraversion, agreeableness, conscientiousness, neuroticism, and openness. Extraversion is a personality trait that is responsive to rewards, socially oriented, positive, and willing to take risks (Balasuriya, & Yang, 2019). Agreeableness is defined as a personality trait that is cooperative, friendly, inclined towards volunteering, and nonviolent (Rentfrow, Jokela, & Lamb, 2015). Conscientiousness can be described as a personality trait that is oriented towards success and characterised by diligence (Piotrowska, 2019). Neuroticism encompasses anxiety, aversion to risk, depression, instability, and avoidance of harm (Rentfrow, Jokela, & Lamb, 2015; Balasuriya, & Yang, 2019). Lastly, openness is a personality trait associated with being receptive to new experiences and ideas (Costa, & McCrae, 1992).

The life span theory of control can explain how personality traits influence retirement savings by affecting the level of perceived control over financial outcomes. For example, individuals who score high on conscientiousness may have a higher sense of control over their finances because they are more organised, disciplined, and responsible. They may also have more positive attitudes towards saving and investing for retirement and may be more likely to follow a financial plan (Heckhausen, & Schulz, 1995). Individuals with high extraversion have greater net worth (wealth) levels and may have an increased ability to adjust to retirement (Asebedo, & Browning, 2020). Conversely, individuals who score high on neuroticism may have a lower sense of control over their finances because they are more anxious, worried, and emotional. They may also have more negative attitudes towards saving and investing for retirement and may be more likely to avoid or procrastinate financial decisions (Heckhausen, & Schulz, 1995). The theory of planned behaviour can explain how personality traits influence retirement savings by affecting the three factors that shape behavioural intentions. For example, individuals who score high on openness to experience may have more positive attitudes towards saving and investing for retirement because they are more curious, creative, and adventurous (Ajzen & Schmidt, 2020). Conversely, individuals who score low on agreeableness may have more negative attitudes towards saving and investing for retirement because they are more competitive, selfish, and distrustful (Asebedo & Browning, 2020).

2. Empirical Review of the Literature on the Determinants of PPS Participation

Having reviewed the theoretical literature above, this section reviews the findings of the empirical studies on the factors that affect private pension participation rates. Numerous studies empirically explore the causal relationship between PPS participation and its determinants, personality traits, behavioural factors, pension literacy, and so on. They usually conclude that personality traits, financial literacy, pension literacy, behavioural factors, and demographic variables affect participation in PPS. Furthermore, several other studies employ variables such as retirement preparation, participation probability in pension plans, and participation in pension plans as explanatory variables of PPS participation.

Niu, Zhou, and Gan (2020) investigated the correlation between financial literacy and retirement preparation in China. They utilised a longitudinal dataset and applied multivariate regression analysis. The findings reveal a positive association between financial literacy and retirement preparation. In a similar vein, Brown and Graf (2013) explored the link between financial literacy and retirement planning. Their study employs the probit model and utilises survey data from 1500 households in Switzerland. The results demonstrate a robust relationship between financial literacy and voluntary retirement savings. Unlike Niu, Zhou, and Gan (2020), Fornero and Monticone (2011) incorporate the possibility of participating in retirement plans as a dependent variable. They analysed the relationship between financial literacy and retirement plan participation in Italy in 2006 using SHIW survey data (covering 7,768 households and 19,551 individuals in the year 2015) and OLS and IV estimators. The findings indicate that financial literacy positively impacts the probability of participating in retirement plans.

Furthermore, few international studies analyse the causality between financial literacy and PPS based on savings. Landerretche and Martínez (2013) tested the relationship between retirement financial literacy and voluntary retirement savings in Chile using cross-sectional data analysis and a probit model. The analysis results show that employees with higher retirement literacy participate more in the retirement system. Diaz, Ruiz, and Tapia (2021) concentrate on Chile, employing clustering algorithms and probit regression to analyse the impact of pension literacy on voluntary pension and banking savings. They discovered a positive and significant connection between pension literacy and voluntary pension savings. Furthermore, a higher level of pension literacy positively influences the likelihood of voluntary banking savings, with conscientiousness emerging as a significant predictor of voluntary banking savings.

Salleh, Wahab, Karim, and Lim (2022) centred their study on the level of preparedness exhibited by employees in relation to a fully Defined Contribution Retirement scheme. Their findings highlight the importance of higher financial literacy and positive behavioural, normative, and controlled beliefs in informed financial decision-making, particularly concerning retirement savings, within a sample of 350. In a similar vein, Fang, Hao, and Reyers (2022) investigated the effects of financial advice, financial literacy, and social interaction on the decisions made by households regarding retirement savings in New Zealand. Analysing data from the 2018–2019 wave of the Financial Capability Barometer survey with a probit model, they determined that financial advice and financial literacy complemented each other, jointly leading to improved retirement savings decisions among 3,629 individuals. Finally, Tomar, Baker, Kumar, and Hoffman (2021) delved into how the interplay between financial literacy and psychological traits such as retirement goal clarity, future time perspective, attitude towards retirement, risk tolerance, and social group support influenced women's retirement planning behaviour in India. Using partial least squares regression with multi group analysis on a sample of 485, they found positive associations between future time perspective, retirement goal clarity, and social group support with retirement planning behaviour, moderated by financial literacy.

In previous studies, the effect of personality and behavioural factors on PPS is usually analysed by variables such as purchase decision, purchase intention, PPS savings level, and PPS participation level as dependent variables. Dragos, Dragos, and Muresan (2020) studied the effect of behavioural and socio-demographic factors on purchasing private pension plans in Romania by using a logit regression and sampling 1579 individuals. The results indicate that the decision to purchase PPS is positively affected by investing through specialised institutions and seeking financial consultancy, while perceiving PPS as an investment and viewing the public pension system as adequate are negatively associated with the decision to purchase PPS. The findings suggest that behavioural factors and knowledge about private pensions are associated with the purchase decision but not with the purchase intention. Piotrowska (2019) investigated retirement savings behaviours among 826 participants aged 25-45 in Poland, employing logistic, multiple, and mediation models to examine the influence of personality and behavioural constraints. The results show that procrastination negatively impacts retirement savings, whereas compulsive buying is positively associated with retirement savings. Furthermore, introversion, undirectedness, locus of control, and future orientation positively affect participation in private pension plans.

Balasuriya and Yang (2019) explored the relationship between personal traits and retirement decisions in England using longitudinal data analysis and several statistical models, including Ordinary Least Squares (OLS), probit, and random-effects models. The findings reveal that extraversion and openness exhibit a negative association with participation in PPS, whereas conscientiousness positively impacts both participation in PPS and the amount contributed. Moreover, agreeableness and extraversion are negatively associated with the PPS contribution amount. Previous studies include retirement expectations as an explanatory variable. Bottazzi, Japelli, and Padula (2006) investigated the influence of Italian reform on retirement wealth accumulation and household expectations on retirement outcomes. The results show that the reforms revise workers' retirement expectations and that more knowledgeable workers increase their retirement wealth savings through the reforms.

Many studies have investigated the correlation between PPS and financial literacy, personality traits and behavioural factors in Türkiye. They concluded that financial knowledge, individual characteristics, and behavioural aspects are commonly linked to PPS. Furthermore, the analysis incorporates participation, withdrawal, and fund preferences in PPS as dependent variables. These studies typically identify basic financial knowledge as an explanatory variable for financial literacy, as well as risk factors, future anxiety, and security as representations of personality traits and behavioural factors. In contrast to studies conducted in other countries, limited attention is given to personality traits, behavioural factors, pension literacy, and the big five personality traits as explanatory variables. Doğan (2016) examined the association between investment fund preferences in PPS and behavioural finance tendency by including 400 bank personnel in the analysis. The study employed ANOVA, Chi-square, T-test, and correlation methods. The findings indicate that risk perception, risk-taking attitude, emotional intelligence, and basic and advanced financial literacy levels significantly impact individual pension fund preferences.

Canöz and Baş (2020) studied participation factors in private pension plans using the binary logit model. The findings demonstrate that saving habits and investment, financial literacy, future anxiety and security, gender, and tenure affect the decisions to enter PPS for state university academicians. According to the results for foundation university academicians, savings and investment habits, financial literacy level, and age affect academicians' participation decision for PPS. Özbek (2020) analysed whether the financial literacy level of individuals, depending on their financial attitudes and behaviours affect their participation in the PPS by using randomly selected 405 participants as a sample and the Structural Equation Model. The findings indicate that financial literacy has a positive effect on participation in PPS.

Bayar, Gündüz, Öztürk, and Şaşmaz (2020) investigated the effect of financial literacy on participation in the private pension system in a sample of Uşak University personnel using factor analysis and logistic regression. The results indicate that basic and medium levels of financial literacy do not significantly influence participation in PPS. However, advanced financial literacy has a negative effect. Similarly, Türkmen and Kılıc (2022) examined the role of financial literacy and perceived consumer risks in elucidating the ownership of individual pension plans among workers in Türkiye. The study employs T-tests, ANOVA, and Chi-Square tests on a sample of 651 individuals. The findings reveal that financial literacy does not exhibit a significant correlation with involvement in the individual pension system, whereas perceived consumer risks vary depending on the ownership of individual pension plans.

In the existing studies, numerous studies have been undertaken with the aim of examining the correlation between demographic factors and PPS in Türkiye. These investigations consistently reveal that demographic indicators are usually associated with PPS. One such study by Özer and Çınar (2012) surveyed 289 faculty members from a foundation university to determine their perspectives on PPS. The findings demonstrate a notable relationship between various variables such as age, gender, length of employment, income level, and individuals' perspective on PPS. Similarly, Yemez and Akdoğan (2019) analyse the impact of demographic factors on the purchasing behaviour of private pensions. In this particular study, a survey was administered to 430 bank customers aged 18 and above in Sivas city, employing the t-test and One-way ANOVA tests for the subsequent analysis. In contrast to the findings of Özer and Çınar (2012), the results indicate that variables such as age, education level, average monthly income, gender, and marital status were not significantly important in the decision to purchase a private pension plan. Instead, private pension purchasing behaviour increases in tandem with higher income levels. Furthermore, the type of bank is discovered to have an impact on purchasing behaviour. Interestingly, it is observed that the intention to purchase a private pension plan does not affect the actual decision to purchase, while the behaviour surrounding private pension plans varies according to an individual's occupation.

Some studies have tested the views and reasons for leaving the Turkish PPS. Şataf and Yıldırım (2019) studied the awareness of PPS and the opinions of individuals about it in Ordu by a randomly selected sample of 371 people in the workforce. Participants think they need a lower retirement age, and they do not fully trust PPS. Moreover, most registered participants are in the 25-44 age range, at least a university graduate, and have a high monthly income. Kocabıyık and Küçükçakal (2018) investigated the reasons for leaving and staying in the Automatic Enrollment System in Isparta by surveying 463 public and private sector employees and the Crosstabs Test. The results demonstrate that state contribution is the most important factor in the Automatic Enrollment System. Other ideas include receiving lump sum money in the future and the usefulness of AES. The main reasons for leaving are that the 10-year period is too long, 3% of the earnings are deducted, and the savings are directed to other investment instruments.

To summarise, previous studies employing various methodologies arrive at a consensus that a connection exists between personality traits, financial literacy, pension literacy, behavioural factors, demographic variables, and PPS. This study aims to address the gaps in the existing literature identified earlier by examining the factors that determine participation in PPS under the constraints of financial literacy, private pension literacy, behavioural factors, and personality traits. In addition, we employ random forest, LightGBM, and Tree SHAP as machine learning algorithms. Moreover, we compare the performance of the random forest algorithm and the light gradient boosting machine (LightGBM) to address another gap in the existing literature.

3. Dataset, Methodology, and Model

3.1. Dataset

The data employed in the empirical analysis is survey data independently collected from the Şırnak province of Türkiye, involving 449 participants, without being tied to any project or funding. In this context, the survey consists of 33 questions (see appendix for details). Advanced pension literacy and big five personality traits consist of multiple items; therefore, the empirical counterpart of these variables is obtained by aggregating these items. The sample consists of the working age (and mostly employed) population, between the ages of 15 and 52. During the data collection process, a face-to-face survey is conducted. Similar to previous studies, Rentfrow et al. (2015) (the personality scale consists of 44 items (The Big Five Inventory)), Piotrowska (2019) (the 10-item question set adapted from Gosling, Rentfrow and Swan Jr (2003)), and Oishi et al. (2015) (which use the 25-item scale from Brody and Ehrlichman (1998)) are applied as personality trait survey sets. We utilise a personality trait survey set from Rentfrow et al. (2015) personality inventory (The Big Five Inventory) in the analysis because the scope of the question set is wider in this study. Furthermore, we adapted a behavioural factor survey set from Piotrowska (2019). A 7-point Likert scale ((1) strongly disagree-… - strongly agree (7)) is employed in the personality scale and behavioural factor question sets. The questions by Dragos, Dragos, and Muresan (2020) are used to assess PPS perceptions and the adequacy of the public pension system. Finally, the pension literacy question set is provided by Landerretche and Martínez (2013), and the question sets by Lusardi and Mitchell (2011) are applied to measure basic financial literacy.

3.2. Model and Methodology

To investigate the determinants of PPS participation, we employed basic financial literacy, private pension literacy, behavioural factors, and personality traits as independent variables in the empirical model of PPS participation. The model is also extended with sociodemographic variables (individuals' age, gender, income, education level). Details of variables are presented in the Appendix.

In the empirical analysis of the participation model, this study uses machine learning algorithms utilising Python programming language. Moreover, the dataset is randomly separated into 80% and 20% as the training and testing datasets, respectively, because this ratio is a common heuristic in the field, supported by its alignment with the Pareto principle (Joseph, 2022). In recent years, the importance of machine learning algorithms has sharply increased in empirical analysis. This is because it has been argued that traditional methodologies used in empirical analyses can lead to arbitrary and non-robust estimation and might not be efficient for non-linear situations (Salas-Rojo, & Rodríguez, 2022). Biases and model selection problems limit parameter-based analyses, and non-parametric tests have inefficiencies due to arbitrary segmentation (Han, 2022). Tree classification algorithms are bias-free and have no model selection problems. Thus, machine learning algorithms are preferred to solve the inefficiencies observed in traditional methodologies.[1]

[1] The methodology and terminology of machine learning models differ from those of econometric models. As the relationship between dependent and independent variables is estimated in econometrics, the relationships between the inputs and outputs of ML models are found by training the ML model using optimisation techniques and model evaluation criteria (Mullainathan, & Spiess, 2017).

Machine learning algorithms used in this study include random forest, LightGBM, and Tree SHAP, which are variants of SHAP. Random forest and LightGBM regressors are employed in the dataset training process. After the model is trained, the Tree SHAP is used to interpret the contributions of the inputs of the model (determinants of pension participation-features, inputs of the model) in predicting the output of the model (pension participation variable-output of the model).[2] The random forest algorithm is a technique of machine learning that uses numerous decision trees to perform classification or regression tasks. It is founded on the concept of ensemble learning, in which the predictions of numerous models are combined to enhance the overall precision and diminish the possibility of overfitting (Breiman, 2001).

The random forest algorithm consists of the following steps:

Bootstrap sampling: A random sample of the original dataset is drawn with replacement, meaning that some observations may be repeated. This process is repeated several times to create different bootstrap samples, each of which will be used to train a separate decision tree (Schonlau, & Zou, 2020).

Feature selection: For each split in the decision tree, a random subset of features (or predictors) is selected as candidates. This adds randomness and diversity to the tree because different features may be used in different trees. The optimal feature for each split is selected on the basis of criterion, such as Gini impurity, information gain, or mean squared error (Savargiv, Masoumi, & Keyvanpour, 2021).

Tree construction: Each bootstrap sample is used to grow a fully developed decision tree without pruning or regularisation. The trees are allowed to reach their maximum depth, which may vary depending on the data (Schonlau, & Zou, 2020).

Prediction: For classification tasks, the random forest predicts the class that receives the majority vote from the individual trees. For regression tasks, the random forest predicts the average or median of the individual trees' predictions (Breiman, 2001).

2 We employ Tree SHAP because machine learning algorithms are not directly interpreted for causal inference.

The random forest algorithm has several advantages over single decision trees. First, it reduces the variance and improves the generalisation ability of the model, as it averages out the errors and biases of the individual trees (Breiman, 2001). Second, it handles high-dimensional and complex data well, as it can capture non-linear and interactive effects among features (Schonlau, & Zou, 2020). Third, it is robust to outliers and noise because it relies on multiple samples and features (Savargiv, Masoumi, & Keyvanpour, 2021). Finally, it provides measures of variable importance and feature selection, as it can rank features based on how often they are used in splits or how much they decrease the error (Breiman, 2001).

However, the random forest algorithm also has some limitations and challenges: It may still overfit or underperform in some cases, depending on the data characteristics and hyperparameters, such as the number of trees, the number of features, and the splitting criterion (Breiman, 2001). It may lose some interpretability and transparency compared with single decision trees, as it is harder to visualise and explain the logic behind many trees (Savargiv, Masoumi, & Keyvanpour, 2021). It requires more computational resources and time than single decision trees because it involves building and storing many trees (Schonlau, & Zou, 2020). The random forest algorithm can be described as follows (Breiman, 2001):

$$\hat{f}_B(x) = \frac{1}{B}\sum_{b=1}^{B} T_b(x).$$

where $\hat{f}_B(x)$ is the predicted output of the random forest for input x;B is the number of trees in the random forest; $T_b(x)$ is the predicted output of the b-th tree for input x. The idea behind this formula is that by averaging the predictions of many trees, we can reduce the variance and noise of each tree and obtain a more stable and accurate prediction.

LightGBM (Light Gradient Boosting Machine) is a framework for gradient boosting that employs algorithms for learning based on trees. Given a dataset $D = \{(x_i, y_i)\}_{i=1}^{n}$ of n instances with p features and one target variable, the objective function of LightGBM is as follows (Ke et al., 2017):

$$\mathcal{L}(\phi) = \sum_{i=1}^{n} l(y_i, \phi(x_i)) + \sum_{j=1}^{J} \Omega(f_j)$$

where $\phi(x) = \sum_{j=1}^{J} f_j(x)$ is the prediction score for *x*, *l* is a differentiable loss function, f_j is a decision tree, and $\Omega(f_j)$ is a regularisation term for the complexity of the tree. LightGBM possesses several advantages over random forest and other decision tree algorithms. These advantages include faster training speed and higher efficiency, lower memory usage, better accuracy, support of parallel and distributed and GPU learning, and the capability to handle large-scale data (Ke et al., 2017).

SHAP (Shapley Additive Explanations) is a machine learning method that is used to explain the output from different machine learning models. Tree SHAP is specially designed to explain the outputs of tree-based models. SHAP is consistent for estimating the importance degree of variables, and its results can be easily interpreted. It has a similar concept to the Shapley value approach (Han, 2022). It is proposed by Lundberg and Lee (2017) and provides interpretable estimation results. The explanation model consists of a linear function of a binary variable as follows:

$$g(z') = \phi_0 + \sum_{i=1}^{M} \phi_i \, z_i' \qquad (1)$$

g(z') is a defined local surrogate model that enables interpretation of the original model under condition $z' = \{0,1\}^M$. M represents the number of independent variables and $\phi \in R$ (Han, 2022). z_i' takes the value of 1 in the observed variable and the other conditions take the value of 0. The estimation equation is as follows:

$$\Phi i = \sum_{S \subseteq N \setminus \{i\}} \frac{|S|!(M - |S| - 1)!}{M!} \left(f_x\,(S \cup \{i\}) - f_x\,(S)\right) \qquad (2)$$

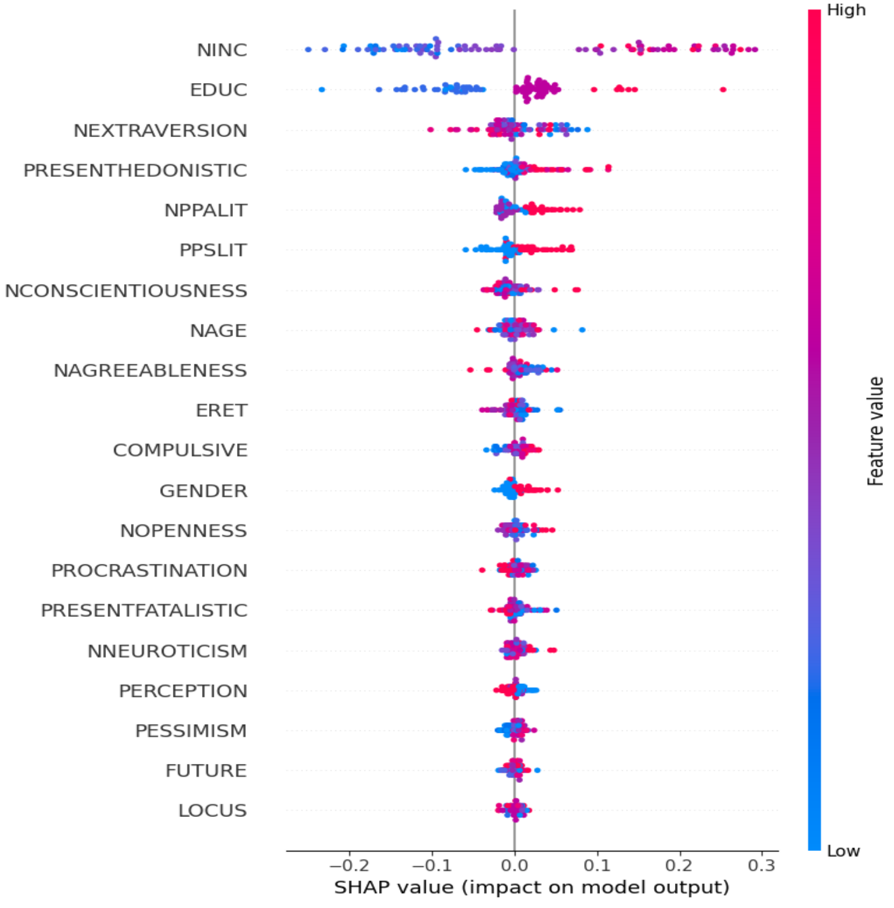
where N is a set of independent variables; S is a subset of variables from N, S⊂N, excluding i; (|S|!(M — |S| — 1)!)/M! is a weighting factor; $f_x(S)$ is the expected output of subset S.

4. Results

This section presents the findings derived from the empirical analysis of the PPS participation model using machine learning algorithms. Initially, the estimation results of the random forest and LightGBM are illustrated and interpreted, followed by an analysis of the significance of the variables. The SHAP summary plot displayed in Figure 1 shows the estimated results of the random forest algorithm. In Figure 1, the SHAP values are represented on the horizontal axis (x-axis), whereas the determinants of PPS participation features are presented on the vertical axis (y-axis). As the model output variable (PPS participation) assumes a value of one for participation and zero for non-participation, positive SHAP values correspond to participation, whereas negative SHAP values correspond to non-participation. In Figure 1, blue (red) signifies low (high) values of participation features. Leveraging this information, we interpret Figure 1 as follows. A decrease in income level decreases the SHAP value. This suggests a positive correlation between private participation and income levels. Similarly, higher values of EDUC, PRESENTHEDONISTIC, NPPALIT, PPSLIT, and GENDER (females) are associated with high SHAP values, indicating that these features contribute to the prediction of pension participation. Conversely, higher values of PERCEPTION and GENDER (males) correspond to negative SHAP values, implying that an increase in the values of these variables increases the likelihood of non-participation.

However, as seen in Fig. 1, it is difficult to clearly distinguish between the variables. This makes it difficult to interpret and analyse the results in the random forest SHAP plot (Fig. 1). This is due to the unstable nature of the decision tree algorithm, which limits interpretation. To clarify the effects of features on the model output of PPS, the PPS model is also trained with LightGBM. The following SHAP summary plot in Fig. Figure 2 shows the estimated results of LightGBM.

Figure 1: Random Forest SHAP summary plot

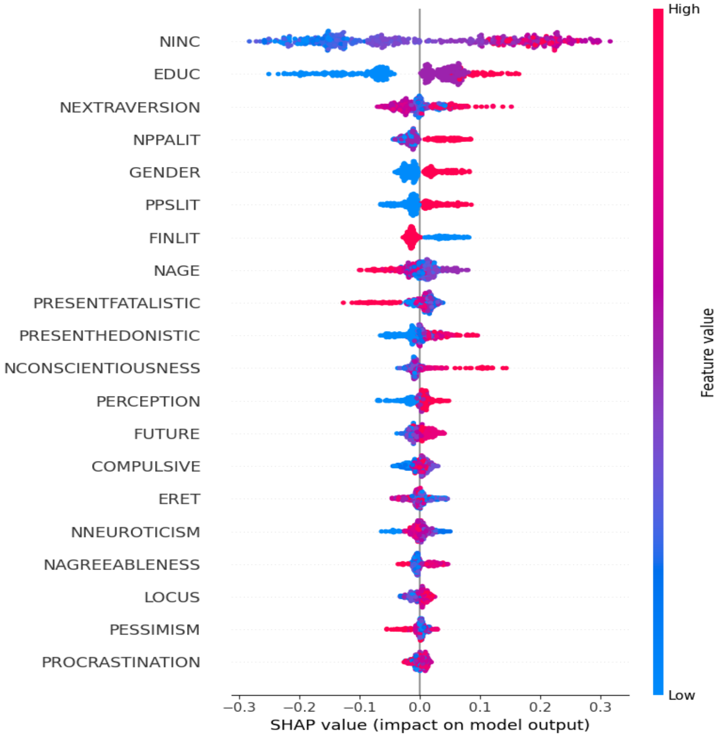


Note: (1) The vertical order signifies the relative significance of the variable. (2) The red colour denotes a high value, while the blue colour signifies a low value of the variable. (3) The horizontal axis represents the influence of the variable's value on the output. (4) The density exhibited by the dots displays their intensity. (5) The output (dependent) variable, PPS Participation (PPS), is accompanied by several independent variables. These include PPS Perception (PERCEPTION), which reflects an individual's view of PPS; Financial literacy (FINLIT), representing basic financial literacy; Normalised pension literacy (NPPALIT); Normalised monthly individual income (NINC); Gender (GENDER); Education level (EDUC); and Normalised age (NAGE). Additionally, ERET measures the adequacy of the Public Pension System. Personality traits encompass normalised extraversion (NEXTRAVERSION), agreeableness (NAGREEABLENESS), conscientiousness (NCONSCIENTIOUSNESS), neuroticism (NNEUROCRITICISM), and openness (NOPENNESS). Behavioural factors include procrastination (PROCRASTINATION), time preferences such as future orientation (FUTURE), present-hedonistic (PRESENTHEDONISTIC), and present-fatalistic (PRESENTFATALISTIC) attitudes, locus of control (LOCUS), pessimism (PESSIMISM), and compulsive buying (COMPULSIVE).

Examination of Figure 1 reveals that income (NINC) plays the most crucial role in determining private pension participation, while the variable of PROCRASTINATION appears to be the least influential. In the case of INC, similar to the random forest algorithm, INC's impact on the output and degree of intensity is much greater than that of the other variables. In other words, the individuals 'income contribute the most in participating in PPS. Regarding all variables, the division of colour in LightGBM is more uniform in both directions compared with the random forest algorithm. It is worth mentioning again that positive SHAP values correspond to participation, while negative SHAP values represent non-participation in the pension system. High education works in a strongly positive direction, whereas low education levels work in a strongly negative direction. This implies that the more educated person prefers to participate in pension more. The other variables can be interpreted in the same way.

Table 1 presents the evaluation results based on the evaluation metrics for each model. Upon comparing the two models, the evaluation values exhibit a significant increase in all evaluation metrics for LightGBM compared with the random forest algorithm. The interpretation and analysis of the SHAP are summarised as follows: For the random forest algorithm, although the importance of variables can be estimated through the SHAP, it is difficult to interpret the results accurately because of the unstable characteristics of the algorithm. Conversely, LightGBM demonstrated greater stability by sequentially updating multiple classification learners, as evident in the SHAP summary plot and evaluation results. Consequently, LightGBM appears to be more reliable and appropriate for the interpretation and analysis of variables of importance.

Figure 2. LightGBM SHAP summary plot.



Note: (1) The vertical order signifies the relative significance of the variable. (2) The red colour denotes a high value, while the blue colour signifies a low value of the variable. (3) The horizontal axis represents the influence of the variable's value on the output. (4) The density exhibited by the dots displays their intensity. (5) The output (dependent) variable, PPS Participation (PPS), is accompanied by several independent variables. These include PPS Perception (PERCEPTION), which reflects an individual's view of PPS; Financial literacy (FINLIT), representing basic financial literacy; Normalised pension literacy (NPPALIT); Normalised monthly individual income (NINC); Gender (GENDER); Education level (EDUC); and Normalised age (NAGE). Additionally, ERET measures the adequacy of the Public Pension System. Personality traits encompass normalised extraversion (NEXTRAVERSION), agreeableness (NAGREEABLENESS), conscientiousness (NCONSCIENTIOUSNESS), neuroticism (NNEUROCRITICISM), and openness (NOPENNESS). Behavioural factors include procrastination (PROCRASTINATION), time preferences such as future orientation (FUTURE), present-hedonistic (PRESENTHEDONISTIC), and present-fatalistic (PRESENTFATALISTIC) attitudes, locus of control (LOCUS), pessimism (PESSIMISM), and compulsive buying (COMPULSIVE).

Table 1: Evaluation results[3,4]

	Evaluation Metrics				
Algorithms	**Accurate**	**Precision**	**Recall**	**F1**	**ROC-AUC**
Random Forest	0.7667	0.7500	0.5455	0.6316	0.8570
LightGBM	0.9111	0.9310	0.8182	0.8710	0.9830

The findings of the Tree SHAP offer support for various methodologies that elucidate the correlation between participation in PPS, personality traits, behavioural factors, pension financial literacy, and sociodemographic variables. Extraversion emerges as the preeminent personality trait with a significant impact on participation, suggesting that individuals with higher net worth are more inclined to engage in PPS. Advanced pension literacy holds more sway than simple pension literacy, indicating that comprehensive knowledge of pension systems plays a pivotal role. Present-fatalistic tendencies exert a negative influence on participation as the most important behavioural factor, potentially indicating a connection with procrastination. Among sociodemographic groups, females and middle-aged individuals demonstrated a greater propensity to participate in PPS. High levels of basic financial literacy negatively affect PPS participation, possibly because financially literate individuals perceive PPS as an investment opportunity rather than a tool for retirement savings. Present-hedonistic tendencies are associated with an increased likelihood of participation, potentially because of compulsive buying behaviours. The trait of conscientiousness manifests as a favourable impact, which corresponds to the theory of planned behaviour. This suggests that individuals possessing a strong sense of responsibility and self-control are more likely to engage in participation. Individuals with a strong future-time orientation demonstrate a greater likelihood of engaging in PPS, which aligns with the theory of planned behaviour. Individuals with a heightened locus of control, indicating a sense of self-control, are more inclined to participate in PPS.

[3] The hyperparameters for the LightGBM classifier are as follows: the number of leaves is 8, the learning rate is 0.05, and the number of estimators is 100. For the Random Forest classifier, the maximum depth is 10 and the number of estimators is 50.

[4] The LightGBM and Random Forest algorithms are trained using various hyperparameters and yield comparable results.

This implies that fostering a sense of personal responsibility and control over one's financial future can foster participation. Perception of protection emerges as a pivotal factor in PPS participation. Individuals who view PPS as a means of financial security are more likely to participate. Finally, when comparing machine learning algorithms, LightGBM proves to be a more robust and dependable algorithm for interpreting variable importance compared to the random forest algorithm.

5. Conclusions and Policy Recommendations

This study investigates the determinants of participation in PPS under various sociodemographic, personality traits, behavioural factors, pension literacy, and basic financial literacy constraints and provides valuable insights into the factors influencing individuals' decisions to participate in PPS. These findings have several significant conclusions and implications for economic policy makers. Individual income is identified as the most critical sociodemographic factor influencing PPS participation. Extraversion stands out as the most crucial personality trait that affects participation, indicating that individuals with higher net worth (wealth) levels are more likely to participate. Advanced pension literacy is more influential than simple pension literacy, suggesting that knowledge about pension systems plays a pivotal role. Present-fatalistic tendencies have a negative impact on participation as the most crucial behavioural factor, suggesting a potential link with procrastination. Among the sociodemographic groups, females and middle-aged individuals exhibit a higher likelihood of participating in PPS. This suggests that targeted policies and marketing efforts should focus on these demographics to increase participation rates. High basic financial literacy has a negative impact on PPS participation, possibly because financially literate individuals are aware of alternative investment tools for accumulating savings. This finding implies the need for tailored financial education efforts to clarify the role of PPS in retirement planning. Present-hedonistic tendencies are associated with an increased likelihood of participation, potentially due to compulsive buying behaviours. Conscientiousness exerts a favourable impact that coincides with the theory of planned behaviour, suggesting that individuals possessing a strong sense of responsibility and self-control tend to be more inclined to engage. Individuals with a strong future-time orientation are more likely to participate in PPS, which aligns with the theory of planned behaviour. This suggests that promoting a long-term perspective and emphasising the benefits of saving for retirement may boost participation. Individuals with a higher locus of control, indicating a sense of self-control, are more likely to participate in PPS. This implies that promoting a sense of personal responsibility and control over one's financial future can encourage participation. Protection perception is a crucial factor in PPS participation. Individuals who perceive PPS as a means of financial protection are more likely to participate. This highlights the importance of government incentives and marketing campaigns that emphasise the protective aspects of PPS. Finally, this study compares machine learning algorithms and demonstrates that LightGBM is a more stable and reliable machine learning algorithm for interpreting variable importance compared with the random forest algorithm.

Policymakers should consider these findings when designing strategies to promote PPS participation. Tailored financial education programmes, especially for those with high basic financial literacy, can help individuals better understand the benefits of PPS as a retirement saving tool. They should create incentives to act less present-oriented or by establishing rules that prevent narrow-minded behaviour. These incentives should yield benefits for participants in PPS in the long term and should encompass a wide array of personality traits and behavioural factors. In addition, efforts should be made to create a sense of protection and control around PPS, targeting middle-aged individuals and women as potential participants.

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Appendix

Table 2: Comparison of PPS participants and working age population

Year	PPS Participants (% of population)	Working Age Population (% of population)
2004	0.47	65.63
2005	0.97	66.03
2006	1.49	66.38
2007	1.96	66.67
2008	2.28	66.70
2009	2.53	66.95
2010	2.83	67.09
2011	3.20	67.27
2012	3.70	67.47
2013	4.83	67.64
2014	5.80	67.74
2015	6.75	67.76
2016	7.33	67.86
2017	11.02	67.93
2018	12.47	67.88
2019	12.99	67.83
2020	13.34	67.75
2021	18.4	67.77
2022	20.34	67.99

Source: OECD; www.egm.org.tr

Table 3: Measures of variables

Variable	**Items**
Dependent variable	
PPS: PPS participation	Are you a member of the PPS? (Yes = 1 or No = 0)
Independent variables	
PERCEPTION: PPS perception by Dragos, Dragos, and Muresan (2020)	What do you think of PPS? 0. None 1. Investment (to provide a more secure financial future) 2. Protection (financial support in case of need, unexpected events) 3. Investment and Protection (Both financial support and investment for the future)
FINLIT: Basic financial literacy by Lusardi and Mitchell (2011)	Suppose you have 100 Turkish Lira (TL) in a saving account and the interest rate is 2% per year. How much do you think you will have in your account after 5 years? (1= More than 102 TL 0=102 TL 0= Less than 102 TL)
PPSLIT: Simple pension literacy by Landerretche and Martínez (2013)	What percentage of government contribution is added to your PPS contribution? (0= 15% 0= 20% 0= 25% 1= 30%)
NPPALIT: (Normalised) Advanced pension literacy by Landerretche and Martínez (2013)	How often can the PPS fund basket be changed? (0= 3 times a year 0= 6 times a year 0= 9 times a year 1= 12 times a year) There is an option to receive monthly payments for life when I retire from PPS. (1= True 0= False)
NINC: (Normalised) Income (Monthly)	What is your average monthly net income in TL? (.........................TL)
GENDER: Gender	1 = Male 2 = Female
EDUC: Education level	1 = Primary school 2 = Middle school 3 = High school 4 = University 5 = Master's / Doctorate
NAGE: (Normalised) Age	15-52 years
The questions about personality traits by Rentfrow et al. (2015)- seven point Likert scale of 1 = strongly disagree . . . 7 = strongly agree	I see myself as someone who:
NEXTRAVERSION: (Normalised) Extraversion	• Enthuse others • Is quiet • Outgoing and sociable
NAGREEABLENESS: (Normalised) Agreeableness	• Tend to find fault with others (reverse score) • Starts quarrelling with others (reverse score) • Is considerate and kind to almost everyone

Table 3: Continued

NCONSCIENTIOUSNESS: (Normalised) Conscientiousness	• Tends to be disorganised (reverse score) • perseveres until the task is completed • Easily distracted (reverse score)
NNEUROCRITICISM: (Normalised) Neuroticism	• Is anxious • Is emotionally stable and not easily upset (reverse score) • Remains calm in tense situations (reverse score) • Gets nervous easily
NOPENNESS: (Normalised) Openness	• Is curious about different things • prefers work that is routine (reverse score)
Behavioural Factors by adapted from Piotrowska (2019)	
1. PROCRASTINATION: Procrastination -seven point Likert scale 1 = strongly disagree . . . 7 = strongly agree	• I delay making difficult decisions
2. Time preferences -seven point Likert scale 1 = strongly disagree . . . 7 = strongly agree	
a) FUTURE: *Future*	• When I want to achieve something, I set goals and think of specific ways to achieve them.
b) PRESENTHEDONISTIC: *Present-Hedonistic*	• I like to play games of chance (lottery, six-horse racing, etc.) when I have money
c) PRESENTFATALISTIC: *Present-Fatalistic*	• There is no point in worrying about the future because there is nothing to do.
3. LOCUS: Locus of control	• I often feel that I have very little influence over what happens to me.
4. PESSIMISM: Pessimism	• I see myself as pessimistic.
5. COMPULSIVE: Compulsive buying	• You continue to buy things despite the financial and family problems caused by your purchases.
ERET: Adequacy of the Public Pension System—seven-point Likert scale 1 = strongly disagree . . . 7 = strongly agree	• The public pension system meets my financial needs

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