Şengül / Journal of Economics and Administrative Sciences, 26(2): 257-268, 2025
DOI: 10.37880/cumuiibf.1608768

Journal of Economics and Administrative Sciences

| esjournal.cumhuriyet.edu.tr | Founded: 2000 Available online, ISSN: 1303-1279 Publisher: Sivas Cumhuriyet Üniversitesi

Economic and Demographic Effects of Public Pension Expenditures: The Case of Türkiye

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Research Article

History

Received: 28/12/2024
Accepted: 28/02/2025

JEL Codes: *H55, J14, E21*

ABSTRACT

This study investigates the economic and demographic factors affecting public pension expenditures in Türkiye and provides significantinformation about the sustainability of the country's social security system. Using annual data from 1980 to 2019, the study employed the ARDL bounds testing approach to examine the short and long-run effects of GDP per capita, public debt, tax revenues, and the elderly dependency ratio on pension expenditures. The 2001 economic crisis led to a structural break, which is modeled by adding a dummy variable. The results show that GDP per capita reduces pension expenditures in the long run, reflecting the mitigating effect of economic growth on fiscal pressure. In contrast, public debt exerts a notably positive impact, highlighting the fiscal burden of pension financing through borrowing. Tax revenues show a limited but positive effect, while the elderly dependency ratio emerges as the most influential determinant, highlighting the challenges posed by the demographic transition. The short-run analysis confirms a rapid return to equilibrium, pointing to a robust error correction mechanism. The findings underscore the need for social security reforms, including measures to raise the retirement age, increase private pension participation, and address demographic challenges. Despite its contributions, the study is limited by not including variables such as health expenditures and labor market dynamics. Nevertheless, it provides a valuable framework for policymakers to develop growth-oriented policies, ensure fiscal discipline, and promote sustainable social security systems. These insights are relevant not only for Türkiye but also for other countries facing similar demographic and economic pressures, making this study an important contribution to the ongoing debate on pension system reforms.

Keywords: Public Pension Expenditures, Social Security System, Economic Growth, Elderly Dependency Ratio, ARDL Analysis

Kamu Emeklilik Harcamalarının Ekonomik ve Demografik Etkileri: Türkiye Örneği

ÖZET

Bu çalışma, Türkiye'de kamu emeklilik harcamalarını etkileyen ekonomik ve demografik faktörleri araştırmakta ve ülkenin sosyal güvenlik sisteminin sürdürülebilirliği hakkında önemli bilgiler sunmaktadır. Analizde, ARDL yöntemi ile 1980-2019 aralığında, kişi başına düşen GSYH, kamu borcu, vergi gelirleri ve yaşlı bağımlılık oranının emeklilik harcamaları üzerindeki kısa ve uzun vadeli etkileri araştırılmıştır. 2001 yılında yaşanan ekonomik kriz sonucunda yapısal kırılma yaşanmış, bu durum kukla değişkeni eklenerek modellenmiştir. Sonuçlar, ekonomik büyümenin mali baskı üzerindeki hafifletici etkisini yansıtacak şekilde, kişi başına düşen GSYH'nin uzun vadede emeklilik harcamalarını azalttığını göstermektedir. Buna karşılık, kamu borcu önemli bir pozitif etkiye sahiptir ve borçlanma yoluyla emeklilik finansmanının mali yükünü vurgulamaktadır. Vergi gelirleri sınırlı ancak olumlu bir etki gösterirken, yaşlı bağımlılık oranı en etkili belirleyici olarak ortaya çıkmakta ve demografik dönüşümün yarattığı zorlukları vurgulamaktadır. Kısa dönem analizi, sağlam bir hata düzeltme mekanizmasına işaret ederek dengeye hızlı bir şekilde geri dönüldüğünü doğrulamaktadır. Bulgular, emeklilik yaşının yükseltilmesi, özel emeklilik katılımının artırılması ve demografik zorlukların ele alınmasına yönelik tedbirler de dahil olmak üzere sosyal güvenlik reformlarının gerekliliğinin altını çizmektedir. Katkılarına rağmen çalışma, sağlık harcamaları ve işgücü piyasası dinamikleri gibi değişkenleri içermemesi nedeniyle sınırlıdır. Bununla birlikte, politika yapıcılara büyüme odaklı politikalar geliştirmeleri, mali disiplini sağlamaları ve sürdürülebilir sosyal güvenlik sistemlerini teşvik etmeleri için değerli bir çerçeve sunmaktadır. Bu görüşler sadece Türkiye için değil, benzer demografik ve ekonomik baskılarla boğuşan diğer ülkeler için de geçerli olup, bu çalışmayı emeklilik sistemi reformları konusunda süregelen tartışmalara önemli bir katkı haline getirmektedir.

Süreç

Geliş: 28/12/2024
Kabul: 28/02/2025

Jel Kodları: *H55, J14, E21*

Anahtar Kelimeler: Kamu Emeklilik Harcamaları, Sosyal Güvenlik Sistemi, Ekonomik Büyüme, Yaşlı Bağımlılık Oranı, ARDL Analizi

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Introduction

As a key element of Türkiye's social security system, the pension system stands out as a critical mechanism affecting social welfare and economic stability. Pension systems around the world are facing growing pressure from demographic and economic shifts, highlighting the need for a comprehensive theoretical framework to assess their sustainability. Broadly, pension systems can be categorized into defined benefit (DB) plans, where retirees receive predetermined payments, and defined contribution (DC) plans, where benefits depend on contributions and investment performance. Additionally, the pay-as-you-go (PAYGO) model, prevalent in many countries, finances current retirees through the contributions of current workers, while private pension systems (PPS) rely on individual savings and investments for future retirement income.

In Türkiye, the pension system comprises both the PAYGO model and the PPS. The PAYGO model operates through the Social Security Institution (SGK), established in 2006 by merging various social security bodies to streamline and strengthen the system. The PPS, introduced to complement the public system, is based on voluntary participation and long-term savings. However, the PPS has faced criticism for its limited capacity to boost national savings rates and its high operational costs (Demirci & Sancak, 2012; Özel & Yalçın, 2013).

Comparatively, Türkiye's pension system transformation mirrors trends in OECD countries, where demographic aging and financial sustainability have prompted significant reforms. For instance, while many OECD nations have increased retirement ages and adjusted benefit formulas to maintain fiscal balance, Türkiye implemented key reforms post-2000, including the gradual increase of the retirement age and the introduction of the PPS with state contributions starting in 2013 (Bayar, 2017; OECD, 2018). Despite these efforts, Türkiye faces unique challenges such as a relatively younger population transitioning rapidly towards aging, and lower participation rates in the PPS compared to OECD averages.

Globally, pension systems in both developed and developing countries grapple with structural challenges like aging populations, increasing life expectancy, and fiscal deficits. Developed countries such as Japan and Germany experience severe aging, necessitating continuous reforms to balance pension expenditures and revenues. Developing countries, while younger demographically, are beginning to face similar pressures as life expectancy rises and fertility rates decline. Financial deficits in pension systems often lead to increased public debt or reduced benefits, sparking debates on the adequacy and sustainability of retirement income (Lee, 2024).

The historical development of Türkiye's pension system reflects these global trends. Before 2000, Türkiye's system was fragmented, with multiple institutions serving different occupational groups. The 2006 establishment of the SGK marked a significant milestone, unifying these systems to improve efficiency and coverage. Subsequent reforms focused on raising the retirement age, adjusting benefit calculations, and integrating the PPS with state incentives to enhance participation. These changes aimed to address the growing fiscal burden, as evidenced by the increasing ratio of pension expenditures to GDP, which reached approximately 7.6% in recent years, highlighting the system's strain on the national budget. Furthermore, the ratio of retirees to active workers has been declining, exacerbating the financial pressure on the PAYGO model.

This study contributes to the existing literature by providing a detailed econometric analysis of the economic and demographic determinants of public pension expenditures in Türkiye. While previous studies have explored individual factors such as economic growth or demographic changes, this research integrates multiple variables—GDP growth rate, public debt, tax revenues, and the elderly dependency ratio—to offer a comprehensive view of their combined impact on pension sustainability. The use of the Autoregressive Distributed Lag (ARDL) bounds testing approach allows for a nuanced understanding of both short- and long-term dynamics, filling a gap in empirical research on Türkiye's pension system.

The independent variables selected for this study are grounded in the extensive literature on the economic and demographic influences on public expenditures and social security systems. The GDP growth rate assesses the impact of economic expansion on social security expenditures, with mixed findings in existing studies regarding its alleviating or exacerbating effects. The public debt to GDP ratio highlights the role of government finances in sustaining pension obligations, while the tax revenues to GDP ratio evaluates the capacity of fiscal resources to support social security. The elderly dependency ratio serves as a critical indicator of demographic pressure on pension systems, with rising ratios signaling increased fiscal strain.

By analyzing these factors, the study aims to provide actionable recommendations for policymakers to enhance the financial sustainability of Türkiye's pension system. The interaction of public pension expenditures with macroeconomic indicators will be scrutinized to propose reforms that balance social and economic objectives. This research not only extends theoretical insights but also offers practical implications for countries facing similar demographic and fiscal challenges.

Literature Review

Pension systems have a critical role in ensuring the economic security of individuals and maintaining the macroeconomic balance of countries. In the literature, the main factors affecting pension expenditures are economic growth, public debt, tax revenues, and the elderly dependency ratio. The theoretical and empirical impacts of these factors on pension expenditures have been extensively explored, and this study seeks to analyze these effects more comprehensively within the context of Turkey.

The role of economic growth in ensuring the sustainability of pension systems has been extensively examined in the literature. Modigliani (1970) and Schmidt-Hebbel, Servén (1997), and Carroll and Well (1993) argue that economic growth supports pension systems by increasing savings rates. Romer (1986) and Lucas (1988), on the other hand, argue that economic growth encourages capital accumulation, which has positive effects on pension systems in the long run. However, Grigoli et al. (2014) argue that these effects of growth may weaken during periods of economic recession. In the Turkish context, how economic growth shapes public pension expenditures is a topic that requires further research, especially given macroeconomic shocks and economic fluctuations.

Public debt exerts considerable pressure on the financial sustainability of pension systems. An increase in public debt can jeopardize the sustainability of these systems by restricting the financial resources allocated to social security. Verbič and Spruk (2014) argue that a rise in public debt might reduce social expenditures, with particularly serious consequences for PAYGO systems. Garcia and Ferreira (2023a) highlight the importance of addressing the long-term implications of public debt comprehensively. While research on the effects of public debt on public pension expenditures in Türkiye remains scarce, this study seeks to bridge that gap.

Tax revenues are one of the main sources of financing for the sustainability of pension systems. While an increase in tax revenues facilitates the financing of social security systems, a decrease in revenues may widen the deficits of these systems. Garcia and Lopes (2009) examine the contribution of tax revenues to social security systems and emphasize that these revenues are indispensable for sustainable pension systems. In the Turkish context, the effects of recent reforms and tax policy changes on the pension system have been understudied in the literature, and this research aims to shed further light on this relationship.

The aging of the population and the elderly dependency rate are other critical factors affecting pension expenditures. A rise in the elderly dependency rate increases the financial burden on pension systems and complicates their sustainability. Bayar (2017) and Lee (2024) comprehensively addressed how the increase in the elderly population affects social security systems and stated that this trend may have serious consequences, especially in developing countries. Modigliani (1970) highlights the adverse effects of demographic shifts on savings rates, emphasizing that the growing elderly population threatens the fiscal sustainability of pension systems. In Türkiye, the impact of the increase in the elderly dependency ratio on public pension expenditures continues to be an important policy issue.

The impact of private pension systems on economic growth, savings rates, and financial sustainability has also been extensively discussed in the literature. Grigoli et al. (2014) argue that private pension funds support economic growth by providing long-term resources to capital markets. Schmidt-Hebbel and Servén (1997) argue that private pension funds positively affect not only economic growth but also macroeconomic stability. In the Turkish context, Özel and Yalçın (2013) argue that private pension systems have a limited effect on increasing savings rates due to their high operating costs and voluntary nature. However, Karabacak and Küçükçaylı (2020) and Meral and Arıcan (2020) emphasize that the automatic enrollment system is an important tool to increase individual savings and that the system should be optimized to attract more participants. However, it is emphasized that the performance of the system has not yet reached its full potential and that special policies should be developed to ensure that more participants are retained in the system (Akgiray et al., 2020). These studies suggest that private pension reforms can not only ease the social security burden but also contribute to economic development (Meral and Şener, 2021; Akın, 2016).

Research on social security systems in Türkiye and around the world extensively examines their impact on economic growth and fiscal sustainability. Ertuğrul and Gebesoğlu (2020) examine the impact of the private pension system on savings in Türkiye and find that this system plays an important role in increasing national savings rates. Doğan and Kabayel (2017) examine the historical development of social security expenditures and draw attention to the fiscal pressures and reform requirements especially after the 1973 Oil Crisis. Arpa and Kolçak (2017) compare social security expenditures in Türkiye and OECD countries and emphasize that Türkiye has lower expenditures relative to GDP and the pressures this may create on the sustainability of the social security system. Ünal and Afşar (2021) examined the impact of social security expenditures on economic growth in Türkiye and found that these expenditures stimulate growth but do not create a reverse causality relationship.

Berkay (2013) examined the development of social security expenditures in Türkiye during the 1980-2010 period and analyzed the effects of neo-liberal policies implemented during this period on social expenditures. Verbič and Spruk (2014) discuss the pressures of the aging population on public pension systems and emphasize the importance of increasing the retirement age and raising fertility rates for fiscal sustainability. Teleş et al. (2021) evaluated the efficiency

of social security expenditures of OECD countries with the Malmquist Total Factor Productivity Index and revealed Türkiye's comparative situation with other countries in terms of efficiency. These studies provide an important framework to better understand the effects of Türkiye's policies on the social security system on economic growth, fiscal sustainability and social welfare.

Although studies on pension systems have a large place in the literature, analyses of the financial sustainability and macroeconomic effects of these systems in the Turkish context are limited. This study aims to fill this gap by analyzing the association between public pension expenditures and economic growth, public debt, tax revenues, and the elderly dependency ratio in Türkiye. Although the effects of these variables on pension systems have been examined independently in the literature, there is no comprehensive model that analyzes these variables together in the Turkish context. In this respect, this study makes an innovative contribution both theoretically and empirically.

First of all, the model of this study analyzes the impact of variables such as GDP growth rate, public debt, tax revenues, and elderly dependency rate on public pension expenditures in an integrated framework. In the case of Türkiye, there is a limited number of studies that thoroughly examine the impact of public debt and tax revenues on pension expenditures (Garcia & Ferreira, 2023b; Demirci & Sancak, 2012). Within this framework, this study is among the first to empirically examine the dynamic effects of these variables in evaluating the financial sustainability of pension systems.

Moreover, it is a rare approach in the literature to examine the association between the private pension system (PPS) and the public pension system (PAYGO) in Türkiye in a holistic manner in the context of macroeconomic indicators. Although studies such as Özel and Yalçın (2013) have addressed the individual dimensions and limitations of these systems, there are gaps in analyzing the interaction of these two systems with macroeconomic balances. However, it is emphasized that the PAYGO system in Türkiye is increasingly burdening the budget due to the increasing elderly dependency ratio and low fertility rates (Yılmaz, 2017; World Bank, 1994). This study aims to fill this literature gap by analyzing the dynamics of the PPS and PAYGO systems with macroeconomic indicators.

Another key contribution is that the study addresses the effects of demographic changes (e.g. the elderly dependency ratio) on public pension expenditures within a more comprehensive theoretical and empirical framework. Studies such as Modigliani (1970), Impavido et al. (2003), and Bayar (2017) have theoretically addressed the positive effects of the elderly dependency rate on pension systems. However, in the Turkish context, studies analyzing the impact of this variable together with other macroeconomic indicators are quite limited. The current study addresses this gap by analyzing the effect of the elderly dependency rate on public expenditures.

Finally, this study not only extends the empirical findings in the literature but also provides original recommendations for policymakers regarding Türkiye's pension systems. In the Turkish context, the sustainability implications of reform proposals such as reducing public debt, increasing tax revenues, and increasing participantion in the private pension system are evaluated in detail. In this respect, the study makes both an academic and an applied contribution.

In this context, compared to previous studies on Türkiye's current pension system, the innovative aspects of this study stand out with its examination of the dynamic effects of multiple variables, the breadth of its theoretical framework, and the applicability of its policy recommendations. Addressing these gaps in the literature is a valuable guide for Türkiye and other countries facing similar structural problems.

Data and Methodology

This study analyzes the determinants of public pension expenditures in Türkiye for the period 1980-2019. The data used in the study are obtained from Eurostat. In the analysis, the ratio of public pension expenditures to GDP is used as the dependent variable. The independent variables include GDP growth rate, public debt to GDP ratio, tax revenues to GDP ratio, and elderly dependency ratio. These variables were selected to explore the relationship between public pension expenditures and both economic and demographic dynamics. The analytical approach of the study is structured by using appropriate methods to address stationarity issues and possible cointegration relationships between variables, which are often encountered in time series data.

Table 1. Descriptive statistics for annual data from 1980 to 2019.
Çizelge *1. 1980-2019 yıllı veri seti için tanımlayıcı istatistikler*

Variables	Min	Max	Mean	Std. Dev.
Pension	0.2490	7.6370	3.4478	3.1280
GDP Growth	-7.1383	9.5799	2.8149	4.2299
Public Debt	22.368	77.936	40.189	12.236
Tax Revenue	10.407	25.706	19.675	5.1006
Dependency Ratio	0.3508	0.7279	0.5079	0.1181

Table 1 summarizes the overall distribution of Türkiye's key economic and demographic indicators such as pension expenditures, economic growth, public debt, tax revenues, and the elderly dependency ratio. The average value of pension expenditures is 3.45, indicating a significant expenditure burden compared to total economic output. The standard deviation of 3.13 indicates that pension expenditures fluctuate significantly between years and in some years may constitute a higher budget burden.

The average GDP growth rate (GDP Growth) is calculated as 2.81. However, the minimum value of -7.13 and the maximum value of 9.57 indicate that growth rates in the Turkish economy have been subject to significant fluctuations over the years. This points to the importance of analyzing the effects of economic instability on pension expenditures and other macroeconomic indicators. The average public debt (Public Debt) is 40.19. This indicates that public debt is a moderate burden relative to GDP and that borrowing is used as a significant resource of public financing. The standard deviation of 12.23 indicates that public debt varies across periods.

Tax revenue is calculated as 19.67 on average. This ratio expresses the share of Türkiye's public revenues in economic production. The standard deviation of 5.10 indicates that tax revenues have varied over the years. This indicates the impact of fluctuations in economic growth and public policies on tax revenues. The elderly dependency rate (Dependency Ratio) expresses the ratio of the elderly population to the labor force and has an average value of 0.50. This implies that there are approximately 5 elderly people for every 10 working people. The standard deviation is 0.11, indicating a relatively low fluctuation in the elderly dependency ratio over the years. This data is important for understanding the impact of demographic pressure on pension systems.

Overall, these descriptive statistics offer a solid foundation for an in-depth analysis of Türkiye's pension system and macroeconomic indicators. The dynamic relationships between indicators such as pension expenditures, public debt and the elderly dependence rate are critical to understanding the sustainability and economic stability of the system.

After explaining the descriptive statistics, firstly unit root tests are applied to evaluate the stationarity levels of the time series data. In this context, the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests are employed. The ADF test assesses the stationarity of variables by accounting for the autocorrelation of error terms, while the PP test considers both autocorrelation and variance in its analysis of stationarity. These tests complement each other in determining whether the variables are stationary at level or after differencing. Unit root tests are crucial for selecting the appropriate analytical methods, as the modeling approach is determined based on the stationarity properties of the variables.

The results of the stationarity analysis indicate that the Autoregressive Distributed Lag (ARDL) model is the appropriate choice for examining the short- and long-run relationships between the dependent and independent variables. The ARDL model is a suitable method for this study as it offers the flexibility to analyze both I(0) and I(1) level stationary variables in the same model. With the ARDL model, firstly, the existence of a long-run cointegration relationship between the variables is tested. In this context, the ARDL bounds test is used to determine whether the variables are in a long-run equilibrium relationship. If a cointegration relationship is found, the long-run coefficients of the model are interpreted, and the error correction model (ECM) is estimated to explain the short-run dynamics. The ARDL approach provides a comprehensive analysis by offering the advantage of estimating both long-run coefficients and short-run dynamics in the same model.

The ADF test is an extended Dickey-Fuller test used to determine whether time series are stationary. Stationarity means that the mean and variance of the series do not change over time. The ADF test provides more reliable results by considering whether there is autocorrelation in the series (Dickey & Fuller, 1979). The ADF test is expressed by the following regression model:

$$\Delta y_t = \alpha + \beta t + \gamma y_{t-1} + \sum_{i=1}^{p} \delta_i \Delta y_{t-i} + \epsilon_t \quad (1)$$

where γy_{t-1} is lagged variable tested for stationarity and δ_i shows lag terms added to remove autocorrelation.

The Phillips-Perron test tests for unit roots similar to the ADF test, but corrects for autocorrelation and heteroskedasticity directly in the error terms (Phillips & Perron, 1988). This makes the PP test more flexible. Unlike the ADF test, the PP test corrects for autocorrelation and variance problems with Newey-West corrections. Therefore, it corrects the test statistics based on the error terms without the need to add lag terms. The PP test is expressed by the following regression model:

$$\Delta y_t = \alpha + \beta t + \gamma y_{t-1} + \epsilon_t \quad (2)$$

The Zivot-Andrews test tests stationarity by assuming an unknown structural break point in the time series. Events such as economic crises, reforms, or natural disasters can cause structural breaks in time series (Zivot & Andrews, 1992). While the classical ADF and PP tests do not take such breaks into account, the Zivot-Andrews test addresses this problem.

$$\Delta y_t = \mu + \beta t + \alpha y_{t-1} + \sum_{i=1}^{k} c_i \Delta y_{t-i} + \theta DU_t(\lambda) + \epsilon_t \quad (3)$$

where $DU_t(\lambda)$ indicates post-structural break constant term (0 before break, 1 after break). The Zivot-Andrews test automatically identifies break points and provides more accurate results by changing the structure of the model at these

points. According to the test results, structural breaks detected in the variables are taken into account by adding dummy variables to the model.

A key advantage of the ARDL method is its ability to operate with an unrestricted error correction model (UECM), which often yields more reliable results compared to other cointegration tests. The unrestricted error correction model equation is employed for the ARDL bounds test. Thanks to these features, the ARDL method stands out as an effective and flexible tool for detecting cointegration relationships.

$$\Delta\text{Pension}_t = a_0 + a_{1t+} \sum_{i=1}^{m} a_{2i}\Delta\text{Pension}_{t-i} + \sum_{i=0}^{m} a_{3i}\,\Delta\text{GDP Growth}_{t-i} + \sum_{i=0}^{m} a_{4i}\,\Delta\text{Public Debt}_{t-i} + \sum_{i=0}^{m} a_{5i}\,\Delta\text{Tax Revenue}_{t-i} + \sum_{i=0}^{m} a_{6i}\,\Delta\text{Dependency}_{t-i} + a_7\text{Pension}_{t-1} + a_8\text{GDP Growth}_{t-1} + a_9\text{Public Debt}_{t-1} + a_{10}\text{Tax Revenue}_{t-1} + a_{11}\text{Dependency}_{t-1} + \varepsilon_t \quad (4)$$

Various diagnostic tests were applied to increase the reliability of the analysis and to guarantee the model's reliability. The Breusch-Godfrey test for autocorrelation, the Breusch-Pagan-Godfrey test for heteroskedasticity, and the Jarque-Bera test for normal distribution of the error terms are checked. Furthermore, the Ramsey RESET test is used to assess whether the model contains specification errors. These tests are critical to improve the validity of the model and the reliability of the estimated results. The results of the diagnostic tests are interpreted to support the robustness and accuracy of the model.

Finally, CUSUM and CUSUMSQ tests are conducted to evaluate the stability of the model. They provide graphs that visualize whether the coefficients change over time and whether the model contains a structural break. The CUSUM test assesses the stability of the coefficients over time, while the CUSUM of Squares test confirms this stability more robustly. Stability analysis results are crucial for ensuring the consistency of the model's estimated values and coefficients over the long term.

Empirical Analysis

In the analysis section, aligning with the study's objectives, the stationarity levels of the series are initially examined using unit root tests. It is known that stationarity problems of time series data due to trend or seasonal effects may affect the accuracy of econometric models. Therefore, firstly, Extended Dickey Fuller (ADF) and Phillips-Perron (PP) unit root tests are applied to determine whether the series are stationary at level or difference. The results of both tests determine the level of integration at which the series are stationary and the suitability of the ARDL model is assessed. The optimal lag lengths were used according to the Schwarz information criterion in the ADF test and the Newey-West Bandwidth method in the PP test. Tables 2 and 3 present the ADF and PP unit root test results for the stationarity levels of the variables.

Table 2. ADF Unit Root Test Results
Çizelge *2. ADF Birim Kök Test Sonuçları*

	None		Intercept		Trend and Intercept	
Variables	**I(0)**	**I(1)**	**I(0)**	**I(1)**	**I(0)**	**I(1)**
Pension	0.9594	0.0000	0.9311	0.0000	0.6871	0.0003
GDP Growth	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Public Debt	0.5567	0.0000	0.2715	0.0000	0.6637	0.0001
Tax Revenue	0.9409	0.0029	0.6944	0.0001	0.9553	0.0005
Dependency Ratio	0.0121	0.2883	0.0176	0.7353	0.9995	0.0009

Table 3. Philips Peron Unit Root Test Results
Çizelge *3. Philips Peron Birim Kök Test Sonuçları*

	None		Intercept		Trend and Intercept	
Variables	**I(0)**	**I(1)**	**I(0)**	**I(1)**	**I(0)**	**I(1)**
Pension	0.9202	0.0000	0.9187	0.0000	0.6156	0.0003
GDP Growth	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
Public Debt	0.5332	0.0000	0.1762	0.0000	0.5181	0.0001
Tax Revenue	0.9409	0.0000	0.6917	0.0001	0.9553	0.0004
Dependency Ratio	0.0000	0.2912	0.0000	0.8935	0.9998	0.0684

The ADF and Phillips-Perron unit root test results shown in Tables 2 and 3 indicate that there are significant differences in the stationarity levels of the variables. In both ADF and Phillips-Perron tests, while some variables are non-stationary at the level, they become stationary when first differences are taken. In particular, pension expenditures,

which is the dependent variable, and independent variables such as public debt and tax revenues are non-stationary at level, but become stationary when first differenced. This situation reveals that there are different levels of integration among the variables and indicates that care should be taken in model selection.

The fact that the variables are stationary both at level and at first difference supports the applicability of the ARDL model. However, since there are crises experienced by Türkiye over the years of the dataset, it is necessary to examine whether there is a structural break. Therefore, the Zivot Andrews unit root test with structural breaks is applied.

Table 4. Zivot-Andrews Unit Root Test Results
Çizelge *4.* Zivot-Andrews *Birim Kök Test Sonuçları*

Variables	t-stat	Probability	Chosen break point
Pension	-8.984	0.0002	2001
GDP Growth	-7.208	0.0503	2002
Public Debt	-3.643	0.0048	2000
Tax Revenue	-2.921	0.0007	1999
Dependency Ratio	1.045	0.1673	-

The Zivot-Andrews unit root test results (for intercept) shown in Table 4 reveal the presence of significant structural breaks in the dependent variable, pension expenditures, and some independent variables. The break points in pension expenditures in 2001, economic growth in 2002, public debt in 2000, and tax revenues in 1999 can be associated with the crisis and reform processes experienced by the Turkish economy during this period. Especially 2001 stands out as a period of radical changes in both macroeconomic balances and social security expenditures. Accordingly, the fact that the breakpoints of all variables are concentrated close to 2001 makes it necessary to take this year into account in the modeling process. Therefore, the ARDL model will be estimated by adding a structural break dummy variable representing the year 2001. This approach will make the model more sensitive to structural changes and increase the reliability of the results.

Table 5. Bound Test Results
Çizelge *5. Sınır Testi Sonuçları*

Model	k	F	Signif	I(0)	I(1)
(4, 3, 4, 1, 0)	4	15.2475*	1%	5.376	7.092
			5%.	3.958	5.226
			10%	3.334	4.438

(k) shows the number of explanatory variables, (*) indicates 1% significance level.

Table 5 proves that the model contains a cointegration relationship according to the F-statistics. This demonstrates the presence of a long-run relationship between the dependent variable and the independent variables. Notably, when compared with the critical values corresponding to various significance levels, the test results confirm cointegration even at the highest significance level of 1%.

This result suggests that the ARDL model provides an appropriate framework for analyzing both short-run dynamics and long-run equilibrium. The cointegration relationship obtained reveals that public pension expenditures are consistently affected by the independent variables in the long run. The bounds test findings support the theoretical background of the study and show that the model can produce reliable and robust results. Thus, the necessary conditions for interpreting short and long-run relationships are provided in the analysis.

The results of the ARDL model which is given in Table 6 provide remarkable findings in terms of both long-run and short-run relationships and the overall dynamics of the model. An analysis of the long-run relationships reveals that the rate of economic growth has a negative and statistically significant effect on pension expenditures. This suggests that growth reduces the fiscal pressure on social security systems because economic expansion supports the financial sustainability of the system by increasing employment and thus premium revenues. Although the effect of public debt on pension expenditures is positive, it is marginal at the significance level. This indicates that the effect of public debt on social security expenditures may be limited or indirect. The tax revenues variable, on the other hand, shows a positive and strong effect, suggesting that increased tax revenues play a critical role in financing social security expenditures. The old-age dependency ratio has one of the most significant effects, clearly reflecting the effect of demographic pressure on pension expenditures.

Table 6. General Results of ARDL Model

ARDL (4, 3, 4, 1, 0)[1]				
Long-Run Relations	**Coefficient**	**Std. Error**	**t-Statistics**	**Probability**
GDP Growth	-0.339914	0.076274	-4.456499	0.0003
Public Debt (PD)	0.044431	0.022116	2.008984	0.0607
Tax Revenue (TR)	0.476307	0.116441	4.090549	0.0008
Dependency Ratio (DR)	46.74223	11.91467	3.923081	0.0011
Short-Run Relations	**Coefficient**	**Std. Error**	**t-Statistics**	**Probability**
C	-33.98777	0.030044	-9.735634	0.0000
D(PPS(-1))	-1.333071	0.180538	-6.638234	0.0000
D(PPS(-2))	-1.576367	0.181951	-8.731505	0.0001
D(PPS(-3))	-0.946902	0.013615	-5.204148	0.1137
D(GDP)	-0.022707	0.027292	-1.667739	0.0000
D(GDP(-1))	0.195379	0.018899	7.158937	0.0015
D(GDP(-2))	0.071367	0.011170	3.776215	0.2858
D(PD)	-0.012309	0.012029	-1.102037	0.5453
D(PD(-1))	-0.007423	0.011047	-0.617144	0.0036
D(PD(-2))	-0.037234	0.013610	-3.370465	0.0006
D(PD(-3))	-0.056856	0.056102	-4.177510	0.0524
D(TAX)	0.117029	0.581615	2.086003	0.0000
DUMMY	4.571828	0.092009	7.860580	0.0000
CointEq(-1)*	-0.892893	0.030044	-9.704413	0.0000
Specification Tests for ARDL (4, 3, 4, 1, 0)				
Tests			**Probability**	
Serial Correlation LM test (Breusch–Godfrey)			0.2861	
Heteroscedasticity test (Breusch–Pagan–Godfrey)			0.2049	
Jargue–Bera Normality test			0.4336	
Ramsey Reset Test			0.7848	

In terms of short-run relationships, the differences in pension expenditures in the previous period (D(PSS)) and two periods ago (D(PSS(-2))) are statistically significant and show negative effects. This indicates that fluctuations in pension expenditures in the short run have corrective effects in the following period and the system tends to reach a certain equilibrium. While the difference in economic growth (D(GDP)) did not show a significant effect in the short run, the difference in growth two periods ago (D(GDP(-2))) showed a positive and significant effect. This suggests that the effect of growth on social security expenditures emerges with a lag. Public debt differences are not significant in general, but the third-period difference (D(PD(-3))) has a negative and significant effect. Changes in tax revenues, on the other hand, have a significant and positive effect in the short run, confirming the rapid impact of tax revenues on pension expenditures.

The error correction coefficient of the model (Cointeq(-1))[2] is -0.89, which is highly significant. This implies that when there is an imbalance in the system, about 89% of it will be corrected in the next period and the model returns to equilibrium quickly. The magnitude of the error correction coefficient indicates the speed of the return to equilibrium, while a negative coefficient of less than one confirms that the model is stable. This value indicates that equilibrium will

[1] The optimal lag lengths of the model were determined using the Akaike Information Criterion (AIC), Schwarz Information Criterion (SIC) and Hannan-Quinn (HQ) criteria. The maximum lag length is restricted to four and the ARDL(4,3,4,1,0) model with the lowest SIC value according to the information criteria is selected. Moreover, the appropriateness of the selected model is verified by Ramsey RESET test and autocorrelation tests. Different lag structures are compared and the selected model is evaluated as the most appropriate structure in line with the information criteria and diagnostic test results.

[2] Based on the magnitude of the error correction coefficient, the time to return to equilibrium is calculated using the half-life formula. This calculation is a standard method used to determine the number of periods in which half of the imbalance is corrected, and the achievement of equilibrium in about one quarter indicates that deviations in social security expenditures quickly stabilize in response to macroeconomic variables and contribute to the sustainability of the system.

be achieved within one to two periods, which implies that the system is highly sensitive to short-term shocks and responds quickly.

The structural break dummy variable (DUMMY) added to the model is highly statistically significant and has a positive effect. Coinciding with 2001, this structural break reveals that Türkiye's economic crisis and the subsequent social security reforms had a significant impact on pension expenditures. The fact that this variable is significant in the model indicates that structural breaks significantly affect the overall dynamics of the model and that taking such exogenous shocks into account increases the accuracy of the model.

Robustness tests conducted for the general validity of the model also support the reliability of the model. The results of Breusch-Godfrey autocorrelation test and the Breusch-Pagan-Godfrey heteroskedasticity test indicate that the model does not suffer from autocorrelation and heteroskedasticity problems. The Jarque-Bera normality test confirms that the error terms are normally distributed, while the Ramsey RESET test confirms that the model is correctly specified.

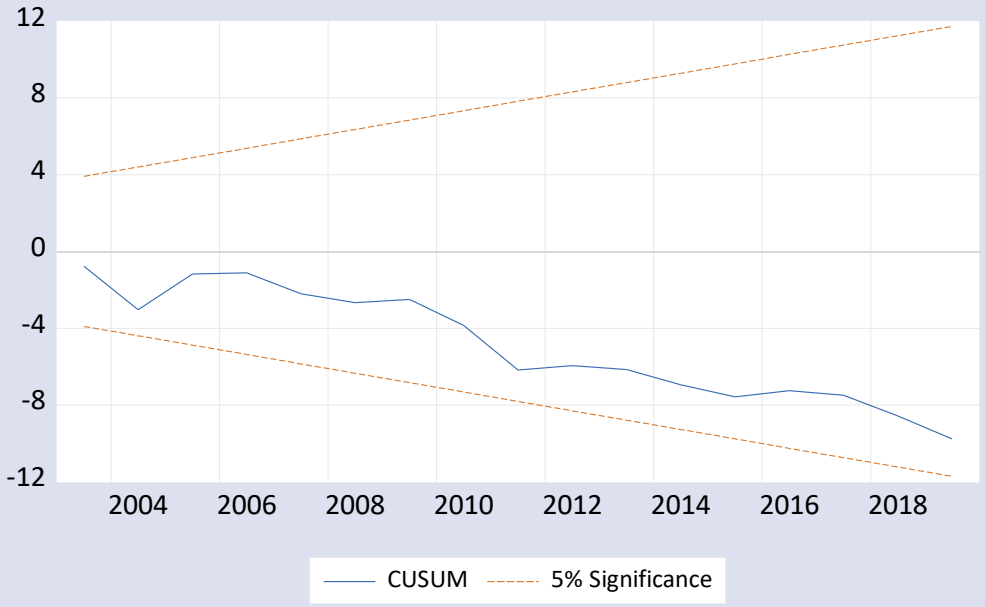

Figure 1. CUSUM
Resim 1. CUSUM

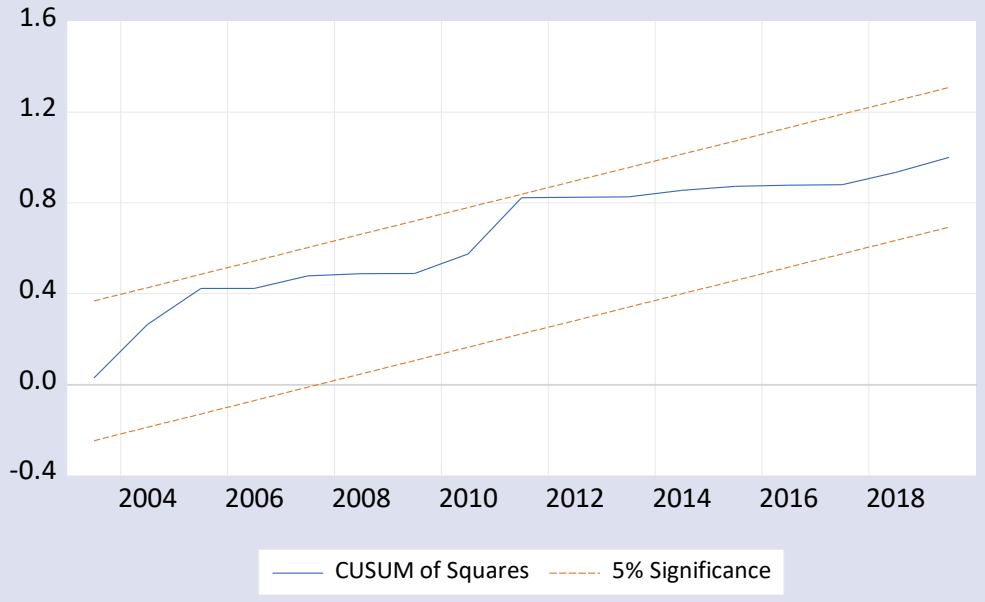

Figure 2. CUSUM of Square
Resim 2. CUSUM Kare

The CUSUM and CUSUM of Squares plots for the ARDL model (4, 3, 4, 1, 0) shown in Figures 1 and 2 are used to assess whether the coefficients of the model are stable over time. The statistical limits (5% Significance) are an important reference point for the interpretation of the graphs. The CUSUM graph shows that the model coefficients do not change over time and remain within the boundary lines. This indicates that the model has not experienced a structural break over time and the estimated results are reliable. The CUSUM of Squares plot, on the other hand, is evaluated based on the sum of squares of the coefficients and also remains within the boundary lines. This result supports the overall stability of the model and reveals that the model is reliable in both short and long run analyses.

These graphs prove that the ARDL model used in this study is stable over time and that the dynamic structure of the model does not contain any structural breaks that would invalidate the estimated results. The findings from the stability analysis once again confirm the reliability of the econometric approach used and show that the model provides a robust framework for understanding the determinants of public pension expenditures.

Discussion and Conclusion

This study provides significant findings on the sustainability of Türkiye's social security system and analyzes the effects of public pension expenditures on economic and demographic variables. The findings of this study make noteworthy contributions to the field by highlighting both the similarities and differences compared to existing studies in the literature. In particular, the relationship between public pension expenditures and economic growth, public debt, tax revenues, and the elderly dependency ratio has been revealed both theoretically and empirically, providing guidance for policymakers.

The negative effect of GDP per capita on public pension expenditures suggests that economic growth reduces the fiscal pressure on the social security system. This finding is consistent with the views of studies such as Modigliani (1970) and Schmidt-Hebbel and Servén (1997) that savings rates increase with economic growth and thus support social security systems. However, as noted in studies such as Grigoli et al. (2014), this relationship may weaken during periods of economic recession. In the case of Türkiye, this finding suggests that growth-oriented policies can contribute to the social security system, but these policies should be resilient to economic fluctuations. This is in line with the findings of Önal and Afşar (2021), who also find that social security expenditures stimulate economic growth, but no reverse causality is observed.

The positive effect of public debt on public pension expenditures emphasizes the burden of the social security system on the budget and the role of public borrowing in meeting this burden. This finding highlights the risks to fiscal sustainability of the borrowing strategies used to finance the social security system, as noted in studies such as Verbič and Spruk (2014) and Garcia and Ferreira (2023a). In the case of Türkiye, the impact of public debt is limited and indirect, which suggests the need to ensure budget discipline and prioritize expenditures.

The positive contribution of tax revenues on public pension expenditures emphasizes the importance of these revenues in financing the social security system. However, as emphasized in the literature (Grigoli et al., 2014; Garcia & Lopes, 2009), this effect is more limited compared to other variables. In Türkiye, expanding the tax base and reducing the informal economy may allow more resources to be allocated to the social security system. In particular, transferring tax revenues directly to social security funds and increasing the efficiency of tax collection can make the financing of public pension expenditures more sustainable.

The strong positive effect of the elderly dependency ratio on public pension expenditures clearly reveals the effects of demographic transformations on the social security system. This finding suggests that the increase in the elderly population imposes a long-term burden on the social security system, as also noted in studies such as Bayar (2017) and Lee (2024). In Türkiye, there is a need to gradually increase the retirement age, encourage participation in private pension systems, and strengthen health services to meet the needs of the elderly population. These findings support the financial pressures of the social security system and the demographic transformation as reported in the national literature such as Arpa and Kolçak (2017) and Berkay (2013). Therefore, it is revealed that demographic and fiscal reforms should be carried out together to ensure the sustainability of the social security system in Türkiye.

The impact of social security reforms implemented in this period on the variables analyzed is also noteworthy. In particular, reforms implemented in the 2000s, such as raising the retirement age and increasing the state contribution to the private pension system, alleviated the financial pressure on the social security system. However, it is understood that the effects of these reforms are limited, and more comprehensive steps need to be taken for the sustainability of the system. For instance, high operating costs in the private pension system and the limitations caused by the voluntary participation principle necessitate more effective incentive policies to increase the number of participants. Expanding the scope of the automatic enrollment system and offering more attractive incentives may increase interest in the private pension system and provide additional financing to the social security system.

As for the limitations of the study, the analysis covers only the period 1980-2019, which limits the examination of the effects of more recent economic and demographic changes. Moreover, although the variables used in the model are chosen based on the literature, the scope of the analysis is narrowed by not considering factors such as health expenditures, labor market dynamics, and technological transformation.

By addressing such shortcomings, future studies can provide a broader analytical framework and examine the sustainability of social security systems from different perspectives. Moreover, conducting international comparative analyses can increase the impact of policy recommendations by revealing the similarities and differences of Türkiye's social security system with other countries.

In conclusion, this study contributes to the literature by analyzing the economic and demographic determinants of Türkiye's social security system. The findings of this study provide valuable insights not only for Türkiye but also for other countries facing similar demographic and economic challenges. Policy recommendations for the sustainability of the social security system are critical to alleviate fiscal pressures and achieve a long-term balance.

Katkı Oranları ve Çıkar Çatışması / Contribution Rates and Conflicts of Interest

Etik Beyan	Bu çalışmanın hazırlanma sürecinde bilimsel ve etik ilkelere uyulduğu ve yararlanılan tüm çalışmaların kaynakçada belirtildiği beyan olunur.	**Ethical Statement**	It is declared that scientific and ethical principles have been followed while carrying out and writing this study and that all the sources used have been properly cited
Yazar Katkıları	Çalışmanın Tasarlanması: SŞ (%100) Veri Toplanması: SŞ (%100) Veri Analizi: SŞ (%100) Makalenin Yazımı: SŞ (%100) Makale Gönderimi ve Revizyonu: SŞ (%100)	**Author Contributions**	Research Design: SŞ (%100) Data Collection: SŞ (%100) Data Analysis: SŞ (%100) Writing the Article: SŞ (%100) Article Submission and Revision: SŞ (%100)
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Çıkar Çatışması	Çıkar çatışması beyan edilmemiştir.	**Conflicts of Interest**	The author(s) has no conflict of interest to declare.
Finansman	Bu araştırmayı desteklemek için dış fon kullanılmamıştır.	**Grant Support**	The author(s) acknowledge that they received no external funding in support of this research.
Telif Hakkı & Lisans	Yazarlar dergide yayınlanan çalışmalarının telif hakkına sahiptirler ve çalışmaları **CC BY-NC 4.0** lisansı altında yayımlanmaktadır.	**Copyright & License**	Authors publishing with the journal retain the copyright to their work licensed under the **CC BY-NC 4.0**

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