7 AN ASYMMETRIC PERSPECTIVE ON TAX BUOYANCY: EVIDENCE FROM TÜRKIYE

Caner DEMIR[1]*
Pelin Mastar ÖZCAN[2]
Güngör ÖZCAN[3]

Abstract

This study aims to investigate the tax buoyancy hypothesis in an asymmetrical framework. Increasing levels of gross domestic product (GDP) cause higher levels of tax revenue for economies. However, the magnitude of this impact varies from country to country, or year by year. Some countries transfer more from GDP to tax revenue, while others transfer less. From this perspective, in the present study, the tax buoyancy is estimated for the Turkish economy over the 2006Q1-2022Q3 period by considering the asymmetrical effects. The results obtained from the nonlinear autoregressive distributed lag model suggest that tax buoyancy is valid for the personal income tax while for tax on goods and services, and for corporate income tax there is no evidence favoring tax buoyancy. In other saying, the discretionary changes are effective only for personal income tax. Moreover, the positive and negative shocks affect tax revenues at different rates, and in some cases, even insignificant impacts were observed for the negative shocks. The findings may simply guide policymakers in two ways; first, personal income tax is the only tax type causing to tax buoyancy; second, the positive and negative GDP shocks affect tax buoyancy at different rates.

Keywords: *Tax buoyancy, Turkish economy, asymmetric effects, time series analysis*

JEL Codes: E62, C22, H21
https://doi.org/10.55991/j.rjef.74761

1. Introduction

Although the concepts of tax buoyancy and elasticity similarly express the sensitivity of changes in tax revenues to changes in national income, there is a difference between them. The buoyancy of a tax system measures the overall response of tax revenues to changes in national income and to discretionary changes in tax policy over time. Tax elasticity measures the sensitivity of tax revenue to changes in GDP. All other parameters (including tax legislation) are held constant (Dudine & Jalles, 2017).

[1] *Manisa Celal Bayar University, Department of Economics, Bes Eylul Kampusu, Salihli-Manisa, 45300, Türkiye. *Corresponding author. E-mail: caner.demir@cbu.edu.tr*

[2] *Manisa Celal Bayar University, Department of Public Finance, Sehit Prof. Dr. İlhan Varank Campus, Muradiye-Manisa, 45000, Türkiye. E-mail: pelin.mastar@cbu.edu.tr*

[3] *Manisa Celal Bayar University, Department of Public Finance, Bes Eylul Kampusu, Salihli-Manisa, 45300, Türkiye. E-mail: gungor.ozcan@cbu.edu.tr*

In other words, tax buoyancy measures the extent to which tax revenues change as a result of changes in national income and voluntary changes in the tax system, and the extent to which tax revenues are affected by these changes. Interpreting changes in tax revenue solely in terms of tax elasticity reflects a narrow perspective. The measurement of the response of the tax system to policy decisions is important for the sustainability of tax policies (Lagravinese, vd. 2020). When the elasticity of base taxes is low (e.g., due to the narrowness of the tax base or the existence of tax evasion and/or avoidance), governments try to increase tax revenue by introducing tax measures (e.g. incentives, tax amnesties, etc.). In this case, the increase in tax revenue is due to tax buoyancy rather than high elasticity. Tax buoyancy can be measured for all taxes or each tax in particular. In terms of tax tariffs, generally decreasing rates and special taxes show low buoyancy. Buoyancy is higher in taxes with a broad base and progressive rates (Akar & Uysal Şahin, 2015). Tax buoyancy is generally measured by the proportional change of total tax revenues in national income and is shown in the equation.

$$BTY = \frac{\Delta T/T}{\Delta Y/Y} \text{ or } BTY = \frac{\Delta T}{\Delta Y} \times \frac{Y}{T}$$

Based on this equation, when the tax buoyancy is less than 1, it indicates that the growth in tax revenues is less than the GDP growth, in other words, tax buoyancy, and discretionary changes are inefficient in increasing tax revenues. The increase in GDP and the increase in tax revenue are compatible when tax buoyancy is 1. A tax buoyancy value greater than one indicates that the results of discretionary changes are favorable, in other words, the tax system responds to the decisions taken (Akar & Uysal Şahin, 2015).

The calculation of tax buoyancy is important for 3 reasons. These reasons are (Dudine & Jalles, 2017):

i. The calculation of tax buoyancy shows that in the long run fiscal sustainability is not ensured, while in the short run, taxes fail to fulfill their role as automatic stabilizers.
ii. It enables the estimation of country-specific tax mobility. In this way, the strengths and weaknesses of the tax system are identified.
iii. By identifying the structural factors that influence tax buoyancy, it is possible to predict what outcomes may occur as the economy evolves.

It is expected that tax flexibility and tax buoyancy are high. The increase in tax revenue, together with the increase in GDP, is important for financing public expenditure. However, it should be noted that tax buoyancy and tax flexibility do not always move in the same direction. This is so because not every administrative decision that is taken leads to an increase in tax revenue. Although the decision is in essence an incentive to pay taxes, tax revenues may not increase as a result of the reaction of taxpayers. At this point, tax elasticity may be higher than tax buoyancy.

High tax revenues are important for all countries. But they are even more important for developing countries. In developing countries, it is observed that the tax system is intervened more frequently through discretionary policies. Therefore, an accurate determination of tax buoyancy in these countries is important for the determination of the tax policies to be implemented.

The present study provides some novel findings to the existing literature on tax buoyancy. To the best of our knowledge, this is the first study dealing with the tax buoyancy hypothesis from an asymmetrical perspective. Since the existence of nonlinearities causes biased and inconsistent results, time series analyses focusing on such important cases affecting the fiscal policies of countries should consider this fact.

While numerous empirical studies have extensively investigated the relationship between economic growth and tax revenues, they predominantly rely on linear frameworks that implicitly assume a symmetric response. What distinguishes this study from the extensive existing literature and what makes it particularly interesting is its fundamental premise: the reaction of tax revenues to economic expansion is inherently different from its reaction to economic contraction. By employing a Nonlinear Autoregressive Distributed Lag (NARDL) framework, this study departs from traditional symmetric models to introduce an asymmetric perspective to the tax buoyancy hypothesis. This novel approach reveals hidden cyclical dynamics and downward rigidities in tax collection that conventional studies completely obscure. Within this purpose, in the following section, the existing literature will be presented; then a basic description of the data and the empirical methodology of the study will be expressed; and lastly, the novel empirical findings will be presented and discussed.

2. Literature Review

A review of the literature reveals that there are studies on tax buoyancy covering many countries and using different methods. Mansfield's (1972) study measuring tax elasticity and tax buoyancy in Paraguay is the most important of these studies. In this study, the elasticity and buoyancy of the tax system in Paraguay between 1962 and 1970 were analyzed with the double logarithmic method. The analysis shows that the discretionary changes in Paraguay during the period in question (e.g. the adoption of the new sales tax, and the increase in the rates of indirect taxes) resulted in a buoyancy of 1.69 in total tax revenue receipts. This ratio is also higher than the tax elasticity measured for that period.

Gillani (1986) analyzed the Divisa Index Method and Proportional Adjustment Method in the short and long run in 1971-1972 and 1982-83 and concluded that, except for a few exceptional cases, changes in tax revenues are not due to discretionary changes. Moreover, Akbar and Ahmed (1997) used the Prest Method in their study on the 1973-1990 period and concluded that tax buoyancy is low in indirect taxes and high in income. Another study measuring tax elasticity in Pakistan was conducted by Mukarram (2001) for the period 1981-2001 using Chain Indexing Methods. In the study, the coefficient of tax buoyancy for all taxes is found to exceed the tax elasticity, and it is concluded that tax reforms increase tax revenues. Contrary to Mukarram, Bilquees (2004) analyzed the 1974/1975 - 2003/2004 period using the Divisa Index Method and found that the coefficient of tax buoyancy is less than 1. Additionally, the study concluded that tax reforms did not increase tax revenues in Pakistan. Rasheed (2006) measured tax buoyancy by using the Divisa Index and proportional adjustment methods between 1975-2002 and concluded that the tax regime in Pakistan needs to be improved.

Belinga *et al*. (2014); in their study covering the period 1965-2012 for OECD countries, short and long-term tax buoyancy is estimated with the Vector Error Correction Model. The results show that the coefficient of short-term tax buoyancy in terms of total tax revenues is broadly similar in most countries; tax buoyancy has been increasing since the late 1980s so tax systems have generally become better automatic stabilizers. In the short and long run, corporate taxes generate the highest tax collections, while consumption taxes and property taxes generate the lowest tax collections. Moreover, the tax buoyancy coefficient is higher than 1 in 14 OECD member countries. While the average short-term tax buoyancy of countries is 1.01, it is 1.06 in the long term.

Dudine and Jalles (2017) calculated tax elasticity and buoyancy for 107 countries. Of the countries included in the analysis, 31 are developed countries, 38 are developing countries, and 38 are less developed. In the study, total tax revenues and revenues from income tax, corporate tax, taxes on goods and services, and social security contributions are included in the calculation. Parameters were evaluated on a country basis and then generalizations were made. In the long run, tax buoyancy is high in all country groups. In the short run, tax buoyancy is lower than in the long run for all country groups and ranges between 0.96 and 1.24. In addition, the study found that the long-run tax buoyancy is higher for corporate tax in developed countries, income tax in developing countries, and social security contributions in low-income countries.

Lagravinese *et al* (2020) analyzed the data from 35 OECD countries between 1995 and 2016 using panel data analysis and the Error Correction Model (ECM). There are two special reasons for choosing this period in the study. The first of these is the implementation of the Maastricht Criteria in this period. The second is the crises of 2007 and 2013, the impact of which differs from country to country, and the introduction of Keynesian fiscal policies that involve market intervention to combat these crises. As a result of the analysis, tax buoyancy is calculated as 0.76 for total tax revenue. This situation shows that the fiscal policy measures implemented have not been successful in increasing tax revenues.

Audi *et al*. (2021) used cross-sectional and time series in selected countries (Bangladesh, India, Pakistan, and Sri Lanka) included in the South Asian Regional Cooperation and supported their study with the OLS model (Common Constant Method). The study, which covers the years 1990-2019, finds that tax buoyancy is high in income and sales taxes and that these taxes act as automatic stabilizers. Another conclusion reached in the study is also interesting. In income and sales taxes with high tax buoyancy, policies were formulated in line with national priorities. In taxes with low tax buoyancy, such as special consumption tax and customs tax, policies were formulated in line with the directives of international organizations such as the World Bank and the World Trade Organization.

Pascale, Fiore, & Conto (2021) aimed to analyze both short-term and long-term environmental taxes in terms of tax buoyancy for 28 EU countries between 2000-2018. According to the results of the analysis, tax buoyancy for total environmental taxes is 1.19 in the short run, 2.26 in the long run, and 2.11 for transport taxes. These results imply that these taxes act as automatic stabilizers in 28 EU countries. In Türkiye, the Atabey *et al*. 2009 study is one of the leading studies on tax buoyancy.

In Türkiye, Atabey *et al*. 2009 study is one of the leading studies on tax buoyancy. In this study, the coefficient of tax buoyancy was estimated by regression analysis using total tax revenues, corporate tax revenues, value-added tax revenues, and GDP data for the period 1981-2006 in Türkiye. As a result of the analysis, it is observed that a one-unit increase in GDP increases total tax revenues, Corporate Tax revenues, and value-added tax revenues. However, since the coefficient of tax buoyancy is less than 1 for the taxes analyzed in the said period, it is determined that these taxes are not buoyant.

In another study, Şimşek (2013) used the regional panel data method. The study analyses total tax revenues, corporate tax, income tax, and value-added tax revenues for the period 2004-2008. In this study, tax buoyancy for total tax revenues is estimated as 0.83 based on the model including only the constant term (intercept coefficient) dummy. In the case of corporate tax, tax buoyancy increased in the period when Law No. 5520 entered into force. From this point of view, it is possible to say that Law No. 5220 has made a positive contribution to tax buoyancy, albeit to a lesser extent.

Akar and Uysal Şahin (2015) analyzed the data on taxes included in the central government budget between January 2005 and June 2014 and the Industrial Production Index. The reason for starting the dataset from 2005 onwards is explained as Law No. 5018, which entered into force in 2003, changed the method of calculating budget tax revenues. As a result of the study, the tax buoyancy coefficient in Türkiye is found to be less than 1 in the short run and closer to 1 in the long run.

Topal & Şentürk (2019) estimated the efficiency of the Turkish tax system by using the PAA approach and ARDL method between 1965-2016 in Türkiye. When the main results of the research are evaluated, the tax elasticity and buoyancy of the Turkish tax system is estimated to be approximately 1.06 in the analyzed period, and it is determined that Türkiye does not have an effective tax system for fiscal sustainability. However, short-term tax buoyancy (=0.947) is found to be higher than tax elasticity (=0.825). This result supports that it is a rational choice for governments to make frequent tax adjustments in order to ensure budget discipline in Türkiye. However, the fact that both measures are less than 1 indicates that tax regulations without reforms cannot have a function of ensuring fiscal stability. When the evaluations made in terms of indirect taxes are analyzed in the study, it is found that the Value Added Tax reform, although it decreases the short-run tax buoyancy, does not significantly increase the long-run tax buoyancy, short and long-run tax elasticity. The Special Consumption Tax reform was also found to have no significant effect on the short and long-run tax elasticity and long-run tax buoyancy, while it decreased the short-run tax buoyancy.

In the study of Kaya & Gürler Hazman (2022), tax buoyancy hypothesis was investigated for six incentive regions by taking into account Decree No. 2012/3305 on State Aids in Investments for the period 2004-2019, which was determined separately using panel data analysis. The voluntary adjustments made in 2006 were taken into account in the analysis to estimate the tax buoyancy in income tax. These regulations are the introduction of a new income tax tariff and the elimination of the segregation theory for non-wage earners. The model estimated tax buoyancy as 0.29. When this coefficient is analyzed, it is seen that the effect of voluntary regulations is low.

Pascale *et al* (2021) analyzed annual data collected in 28 European countries from 2000 to 2018, they ran the dynamic common correlated effects estimator to calculate the short- and long-run buoyancy of environmental taxes. The results provide evidence of short-run rigidity for energy tax revenues, but long-run buoyancy for total tax revenues, which are mainly driven by transport taxes. This suggests that the environmental tax system acts as a good stabilizer for the economy (Pascale, Fiore, & Contò, 2021).

Shahzada *et al* (2016) used The Engel-Granger Test and Error Correction Mechanism to calculate the long and short-run buoyancies and elasticity for the period 1979-2015 Time Series Data in Pakistan. Results show that the long-run buoyancy for total tax revenue is 0.984 and the short-run buoyancy for total tax revenue is 0.973, which shows that the tax system is not buoyant and is inelastic and inefficient in the short run as well as in the long run. The long-run elasticity is 0.994, which is also less than one. The long-run elasticity of total tax revenue is greater than the long-run buoyancy. This shows that the reforms are ineffective in raising revenue, even though the tax reforms have a negative impact on the tax. The base to GDP elasticity (1.017) is greater than the tax to base elasticity (0.967). This shows that as the GDP increases, the base increases but the tax revenue does not increase (Shahzada, Siddique, Kiran, Hussain, & Abbasi, 2016).

Jalles (2017) examined estimates of tax buoyancy in the short and long run for 37 countries in sub-Saharan Africa over the period 1990 to 2015. He used time series and panel data techniques, he empirically examined the short- and long-run tax buoyancy of 37 sub-Saharan African countries between 1990 and 2015. Using mean group estimators, he found that the standard deviation of long-run buoyancy estimates is much larger than that of short-run buoyancy estimates. In 19 out of 37 countries, the long-run tax buoyancy is statistically significantly higher than one. This means that for these countries, growth has improved fiscal sustainability over time (Tovar Jalles, 2017).

Khadan (2020) found that although the buoyancy coefficients for total tax revenues are greater than one, there are significant differences between broad tax categories and between the pre-crisis and post-crisis periods. In terms of the composition of tax revenues, indirect taxes account for more than three-fifths of tax revenues and have a relatively lower long-run buoyancy coefficient than direct taxes. Moreover, while the short-run buoyancy is low for both tax categories, it is relatively higher for indirect taxes than for direct taxes. It was also found that the long-run buoyancy of taxes has weakened in the post-crisis period compared to the pre-crisis period, implying a diminishing influence of the tax system in supporting long-term fiscal sustainability (Khadan, 2020).

Krushna (2015) found that in India the change in tax revenue for each decade resulting from a one percent increase in GDP. Notably, tax revenue increased by 1.7 percent from the 1950s to the 1960s, but only by 0.6 percent from the 1960s to the 1970s. The increase in tax revenue then declined significantly by 2.2 percent from the 1970s to the 1980s. From that point onwards, the tax revenue began to decline, although the decrease was not significant. Another important implication of the positive regression coefficient was that the growth rate of tax revenue was higher than that of national income. The regression analysis showed that tax buoyancy has been higher than national income for all five decades, with particularly high levels in the 1960s and 1970s. From the 1980s to the 2000s, tax buoyancy remained relatively constant (Krushna, 2015).

Dudine and Jalles (2018) provided short-run and long-run tax buoyancy estimates for 107 countries, including advanced, emerging, and low-income countries, for the period 1980-2014. They used fully modified ordinary least squares (OLS) and pooled mean group estimators. The study found that, on average, the long-run buoyancy of total revenue is not different from 1 in all country groups. In advanced economies, short-run buoyancy is not statistically different from 1. However, in emerging markets and low-income countries, it is generally statistically larger than 1. This suggests that revenue works better as an automatic stabilizer in the latter group of countries (Dudine & Jalles, 2018).

Gupta *et al*. (2022) estimated the short- and long-term tax buoyancies of 44 Sub-Saharan African (SSA) countries between 1980 and 2017 using both time series and panel data techniques. The short-term buoyancy of PIT is significantly less than one, which could be due to wage rigidity in the formal sector. The estimated long-term buoyancy suggests that most taxes are progressive, except for those on trade. Overall, the robustness checks indicate that tax buoyancy remains neutral to discretionary tax changes. Additionally, there has been an increase in long-term buoyancy in the more recent period, reflecting tax reforms implemented by SSA countries (Gupta, Jalles, & Liu, 2022).

Ahmed and Mohammed (2010) conducted a study to determine the tax buoyancy of developing countries. They analyzed cross-sectional data from 25 countries between 1998 and 2008 using the pooled least squares method. The results indicate that tax buoyancy is positively influenced by imports, the manufacturing and services sectors, monetization, and budget deficits, while growth in grants has a negative impact on tax buoyancy. The impact of the agriculture sector's growth on tax buoyancy in developing countries is insignificant due to their low taxation or under-taxation (Masood Ahmed & Mohammed, 2010).

While the existing literature has extensively investigated the tax buoyancy hypothesis, a critical gap remains. Previous studies implicitly assume a symmetric relationship between economic growth and tax revenues. This conventional approach assumes that tax revenues respond with the same magnitude to both economic expansions and contractions. However, fiscal policies, particularly in developing nations, are highly asymmetric. During economic downturns, governments frequently intervene through tax amnesties, temporary exemptions, and restructuring laws, which distort the conventional buoyancy expectations. Therefore, the primary motivation of this study is to bridge this gap by exploring the tax buoyancy hypothesis through an asymmetrical framework, which, to the best of our knowledge, has not been empirically addressed in the prior literature.

Türkiye provides a uniquely compelling laboratory to explore this gap. Rather than conducting a heterogeneous panel study (such as BRICS or OECD countries) where unique, country-specific administrative behaviors are averaged out and lost in cross-sectional dynamics, a single-country time-series approach is essential for asymmetric analysis. Türkiye is characterized by highly volatile growth cycles accompanied by frequent discretionary tax interventions, particularly recurring tax amnesties and sudden indirect tax adjustments. By focusing specifically on Türkiye, this study isolates these profound structural anomalies, providing clear empirical evidence on how positive and negative economic shocks uniquely dictate tax buoyancy -insights that would otherwise be obscured in a multi-country panel analysis.

3. Data and Methodology

The selection of Türkiye and the specific sample period (2006Q1–2022Q3) is highly motivated by several structural and historical particularities. First, from a structural perspective, the Turkish tax system is heavily reliant on indirect taxes (such as VAT and excise duties), which makes tax revenues exceptionally sensitive to cyclical fluctuations in consumption and economic growth. Furthermore, during economic downturns, policymakers in Türkiye frequently resort to discretionary fiscal interventions, most notably periodic "tax amnesties" (wealth restructuring laws) and temporary tax rate reductions. These idiosyncratic interventions create profound asymmetries in tax buoyancy that symmetric models fail to capture. Second, the starting point of the sample, 2006, represents a critical structural break in Turkish public finance. It marks the period following the full implementation of the Public Financial Management and Control Law (Law No. 5018), which fundamentally changed the calculation and classification methods of budget tax revenues. Additionally, 2006 saw the introduction of a new income tax tariff. Over the subsequent years, the Turkish economy experienced severe macroeconomic volatilities, including the spillover effects of the 2008 Global Financial Crisis, the 2018 domestic currency shock, and the 2020 COVID-19 pandemic. These consecutive boom-and-bust cycles, combined with the administrative characteristics of the tax system, render Türkiye an optimal and compelling case study for testing the asymmetric tax buoyancy hypothesis.

In the empirical analysis of the study, we used personal income tax (PIT), corporate income tax (CIT), tax on goods and services (TGS), and gross domestic product (GDP). All the tax data were obtained from the Republic of Türkiye Ministry of Treasury and Finance. The GDP data was obtained from the Central Bank of the Republic of Türkiye. Since the excise duty on consumption has a widespread impact on many goods and services, we decided to consider tax on goods and services as a sum of value-added tax (VAT) and excise duty on consumption. The data set covers 2006Q1-2022Q3 period. To avoid the deceptive seasonal impacts, all the data were seasonally adjusted. In the empirical analysis, the variables were used in their natural logarithm. The descriptive statistics of the raw data are presented in Table 1.

Table 1. Descriptive Statistics

	GDP	PIT	CIT	TGS
Mean	752,171,624	24,426,355	17,005,535	40,139,907
Max.	4,258,167,547	99,183,722	160,146,904	162,796,443
Min.	162,557,040	5,836,201	1,679,474	11,891,089
Std. Dev.	744,484,956	18,604,935	26,291,528	29,432,287
Observations	67	67	67	67

Note: The table presents raw data. In the analysis, all the data were used as seasonally adjusted.

The empirical part of the study consists of two subsections. In the first subsection, a linear time series analysis will be applied to present the preliminary findings on the case. In the second subsection, a nonlinear time series analysis will be applied to present the main findings of the study. In the linear analysis, first, the unit root tests will be applied to check the stationarity of the series. For this purpose, the Augmented Dickey-Fuller (ADF) test developed by Dickey and Fuller (1979) and the Phillips-Perron (PP) test developed by Phillips and Perron (1988) were used. After checking the series in terms of stationarity, the potential cointegrated relationships between the tax variables and GDP will be tested via the linear Autoregressive Distributed Lag (ARDL) Bounds Test developed by Pesaran and Shin (1999) and Pesaran *et al*. (2001). The main advantage of the ARDL model is that it does not require the variables in the model to be stationary at the same level. Additionally, as Panopoulou and Pittis (2004) and Baek and Kim (2013) stated, the estimated coefficients are more consistent in relatively small samples. The ARDL model presents a holistic framework since it produces the estimation results for a co-integration model, error correction model, and long-run coefficients.

The null hypothesis of the bounds test is that there is no cointegrated relationship. The linear ARDL models for the TGS, PIT, and CIT models might be formed as below;

$$\Delta TGS = \alpha_0 + \sum_{i=1}^{p} \alpha_1 \Delta TGS_{t-i} + \sum_{i=0}^{q} \alpha_2 \Delta GDP_{t-i} + \lambda_1 TGS_{t-1} + \lambda_2 GDP_{t-1} + \varepsilon_t \quad (1)$$

$$\Delta PIT = \alpha_0 + \sum_{i=1}^{p} \alpha_1 \Delta PIT_{t-i} + \sum_{i=0}^{q} \alpha_2 \Delta GDP_{t-i} + \lambda_1 PIT_{t-1} + \lambda_2 GDP_{t-1} + \varepsilon_t \quad (2)$$

$$\Delta CIT = \alpha_0 + \sum_{i=1}^{p} \alpha_1 \Delta CIT_{t-i} + \sum_{i=0}^{q} \alpha_2 \Delta GDP_{t-} + \lambda_1 CIT_{t-1} + \lambda_2 GDP_{t-1} + \varepsilon_t \quad (3)$$

The models above consist of both short-run and long-run parameters which are shown as α and λ respectively. The ARDL model also estimates the long-run coefficients of the cointegrated model via an error correction mechanism. The error correction forms of the TGS, PIT, and CIT models are as below;

$$\Delta TGS = \gamma_0 + \sum_{i=1}^{p} \gamma_1 \Delta TGS_{t-i} + \sum_{i=0}^{q} \gamma_2 \Delta GDP_{t-i} + \mu ECT_{t-1} + u_t \quad (4)$$

$$\Delta PIT = \gamma_0 + \sum_{i=1}^{p} \gamma_1 \Delta PIT_{t-i} + \sum_{i=0}^{q} \gamma_2 \Delta GDP_{t-i} + \mu ECT_{t-1} + u_t \quad (5)$$

$$\Delta CIT = \gamma_0 + \sum_{i=1}^{p} \gamma_1 \Delta CIT_{t-i} + \sum_{i=0}^{q} \gamma_2 \Delta GDP_{t-i} + \mu ECT_{t-1} + u_t \quad (6)$$

The μ parameter which is the estimated coefficient of the error correction term (ECT) stands for the speed of adjustment. If the parameter is statistically significant and less than zero, then one may suggest that the mechanism converges to the equilibrium path.

The second subsection of the empirical analysis considers the potential nonlinearities of the series and models. To test whether the series are nonlinear, firstly, the linearity tests developed by Harvey and Leybourne (2007) and Harvey *et al*. (2008) were applied. The null hypothesis of both tests is that the series is linear. After applying these tests, the Fourier-KPSS unit root test developed by Becker *et al*. (2006) was used. The Fourier-KPSS unit root test produces robust statistics in the case of nonlinearities.

Shin *et al*. (2014) transformed the linear ARDL model to an asymmetrical form by decomposing the positive and negative shocks into two separate variables. Within this transformation, the nonlinear ARDL (NARDL) form of the previous models will be as follows;

$$\Delta TGS = \alpha_0 + \sum_{i=1}^{p-1} \alpha_1 \Delta TGS_{t-i} + \sum_{i=0}^{q-1} (\beta_i^+ \Delta GDP_{t-i}^+ + \beta_i^- \Delta GDP_{t-i}^-) + \lambda_1 TGS_{t-1} + \lambda^+ GDP_{t-1}^+ + \lambda^- GDP_{t-1}^- + \varepsilon_t \quad (7)$$

$$\Delta PIT = \alpha_0 + \sum_{i=1}^{p-1} \alpha_1 \Delta PIT_{t-i} + \sum_{i=0}^{q-1} (\beta_i^+ \Delta GDP_{t-i}^+ + \beta_i^- \Delta GDP_{t-i}^-) + \lambda_1 PIT_{t-1} + \lambda^+ GDP_{t-1}^+ + \lambda^- GDP_{t-1}^- + \varepsilon_t \quad (8)$$

$$\Delta CIT = \alpha_0 + \sum_{i=1}^{p-1} \alpha_1 \Delta CIT_{t-i} + \sum_{i=0}^{q-1} (\beta_i^+ \Delta GDP_{t-i}^+ + \beta_i^- \Delta GDP_{t-i}^-) + \lambda_1 CIT_{t-1} + \lambda^+ GDP_{t-1}^+ + \lambda^- GDP_{t-1}^- + \varepsilon_t \quad (9)$$

As seen in the models, by estimating the ARDL model in a nonlinear form, observing the impacts of positive and negative GDP shocks will be possible. In accordance with the foundational framework of Shin *et al*. (2014), a single error correction term (ECT) is maintained to test the convergence to a unified long-run equilibrium, rather than decomposing it into regime-specific components. Similar to the ARDL model, the NARDL model provides a holistic approach by presenting findings on cointegrated relationships, long and short-run coefficients, and error correction process. Nevertheless, we decided to check the robustness of the co-integration relationship by applying a Fourier-based co-integration test developed by Tsong *et al*. (2016).

4. Empirical Findings

In the empirical part of the paper, we first present some preliminary findings obtained from a nonlinear analysis. After conducting the ADF and PP unit root tests, ARDL bounds test, and estimating the long-run and short-run coefficients, we will go on with the nonlinear analysis, which is the main contribution of the study. In the second subsection of the section, firstly, the linearity of the series will be tested, then the nonlinear unit root test, the Tsong *et al*. (2016) co-integration test, and the Nonlinear ARDL bounds test will be applied; and lastly, the coefficients will be estimated via the nonlinear model.

Preliminary Results – Linear Analysis

Since the posterior tests and estimation techniques should be chosen according to the stationarity of the series, this is a must-step for time-series analyses. Table 2 shows the results of the ADF and PP unit root tests. The ADF test results imply that all the variables include unit root at level according both to the model with intercept and the model with intercept and trend. The same test results suggest TGS, PIT, and CIT variables do not include unit root (is stationary) at their first difference while GDP still include unit root (is not stationary) for both models. The PP test results, on the other hand, imply that all the variables include unit root at level but not at their first difference. Since the co-integration tests apart from the ARDL Bounds Test, require stationarity at the same level, the existence of unit root in the GDP series poses a problem according to the ADF test results. Nevertheless, the PP test results suggest that all the series are stationary at the same level.

Table 2. Unit Root Tests: ADF and PP

Augmented Dickey-Fuller Unit Root Test				
	With Intercept		With Trend and Intercept	
Variable	Level	First difference	Level	First difference
TGS	1.446	-2.766*	-2.199	-3.121
PIT	1.649	-8.085***	-0.244	-8.433***
CIT	1.819	-10.501***	-2.263	-10.960***
GDP	4.661	-2.027	4.046	-0.016
Phillips-Perron Unit Root Test				
	With Intercept		With Trend and Intercept	
Variable	Level	First difference	Level	First difference
TGS	1.461	-6.837***	-1.741	-7.034***
PIT	1.649	-8.109***	-0.054	-8.435***
CIT	1.601	-10.522***	-2.003	-11.363***
GDP	3.542	-5.517***	4.459	-6.441***

*Notes: All variables were used in their natural logarithm. ***, **, and * denote statistical significance at 1%, 5%, and 10% respectively. The null hypothesis of both tests is that the series include unit root.*

After carrying out the unit root tests, we can now continue with the ARDL Bounds Test to examine whether the series are cointegrated. According to the results in Table 3, all three tax variables are cointegrated with GDP separately at 1% significance level. The long and short-run estimation results in Table 4, on the other hand, will provide information on tax buoyancy. The estimated long-run coefficients show that the coefficient of PIT is less than 1 while the coefficients of TGS and CIT are greater than 1. This implies that the tax buoyancy hypothesis is valid for TGS and CIT, but not for PIT. In other words, the discretionary changes are effective only for TGS and CIT. For all three models, the coefficients of error correction terms are negative and between 0 and -1, which implies that the system converges to the equilibrium path by following a monotonic process.

Table 3. ARDL Bounds Tests

Model: F(TGS | GDP)					
Optimal Lag Length		ARDL (7, 6)			
F-statistic		8.487***			
Critical Values					
10%		5%		1%	
I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
3.127	3.65	3.803	4.363	5.383	6.033

Model: F(PIT | GDP)					
Optimal Lag Length		ARDL (1, 3)			
F-statistic		10.773***			
Critical Values					
10%		5%		1%	
I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
3.127	3.65	3.803	4.363	5.383	6.033

Model: F(CIT | GDP)					
Optimal Lag Length		ARDL (1, 6)			
F-statistic		11.897***			
Critical Values					
10%		5%		1%	
I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
3.127	3.65	3.803	4.363	5.383	6.033

*Notes: All variables were used in their natural logarithm. ***, **, and * denote the significance at 1%, 5%, and 10% levels, respectively. The optimal lag selections were chosen according to the Akaike information criteria.*

Table 4. ARDL Estimation Results

Long Run Coefficients			
Variables			
	TGS	*PIT*	*CIT*
GDP	1.022 (0.103)***	0.972 (0.027)***	1.094 (0.071)***
Constant	-2.826 (1.946)	-2.739 (0.528)***	-5.833 (1.375)***

Error Correction Model					
TGS		*PIT*		*CIT*	
Variables	*Coefficients*	*Variables*	*Coefficients*	*Variables*	*Coefficients*
$\Delta TGS(-1)$	0.060 (0.129)	ΔGDP	0.582*** (0.128)	ΔGDP	0.409 (0.432)
$\Delta TGS(-2)$	-0.189 (0.123)	$\Delta GDP(-1)$	-0.355** (0.135)	$\Delta GDP(-1)$	0.106 (0.398)
$\Delta TGS(-3)$	-0.223 (0.137)	$\Delta GDP(-2)$	-0.269* (0.137)	$\Delta GDP(-2)$	0.661 (0.424)
$\Delta TGS(-4)$	-0.332** (0.139)			$\Delta GDP(-3)$	-0.454 (0.470)
$\Delta TGS(-5)$	0.172 (0.134)			$\Delta GDP(-4)$	-0.082 (0.473)
$\Delta TGS(-6)$	0.277** (0.119)			$\Delta GDP(-5)$	-1.516*** (0.486)
ΔGDP	0.806*** (0.178)				
$\Delta GDP(-1)$	-0.325 (0.201)				
$\Delta GDP(-2)$	-0.220 (0.226)				
$\Delta GDP(-3)$	-0.081 (0.237)				
$\Delta GDP(-4)$	-0.379 (0.292)				
$\Delta GDP(-5)$	-0.930*** (0.271)				
ECT(-1)	-0.206*** (0.039)	*ECT(-1)*	-0.641*** (0.111)	*ECT(-1)*	-0.605*** (0.099)

*Notes: All variables were used in their natural logarithm. Standard errors are in parantheses. ***, **, and * denote the significance at 1%, 5%, and 10% levels, respectively.*

The Nonlinear Analysis

While the linear analysis provides some implications, it is also necessary to evaluate the series in terms of nonlinearity. If such a circumstance is present, the selection of stages in the time series analysis should be based on methodologies that are robust to nonlinearity. In the case of nonlinearity, linear unit root tests, co-integration tests, and coefficient estimators will give biased results. For this purpose, two different linearity tests, which are reported in Table 5, were applied. According to the W_λ Statistics proposed by Harvey *et al*. (2008), the null hypothesis of linearity was rejected for the PIT, CIT, and GDP variables, while according to the Harvey and Leybourne (2007) test results, the null hypothesis of linearity was rejected for the PIT variable at 10%, for the CIT and GDP variables at 1%. The TGS variable, on the other hand, seems linear according to all four tests. One may suggest at this point that a linear model for TGS will fulfill the need. However, it should be noted that the motivation of the study is based on the association between the tax types and GDP. Since the GDP variable seems as nonlinear according to the results in Table 5, the estimated model reflecting the relationship between TGS and GDP might be nonlinear.

Table 5. Linearity Tests

	W_λ	W_{10}	W_5	W_1
TGS	1.49	2.00	2.03	2.10
PIT	12.08***	9.21*	9.28	9.40
CIT	6.47**	23.82*	23.96**	24.22***
GDP	62.16***	46.95*	47.19**	47.61***

*Notes: All variables were used in their natural logarithm. ***, **, and * denote statistical significance at 1%, 5%, and 10% respectively. The linearity tests were developed by Harvey and Leybourne (2007) and Harvey et al. (2008). The null hypothesis of both tests is that the series is linear. The critical values for W_λ (see Harvey et al., 2008) are 9.21, 5.99, and 4.6 while the critical value for W_{10}, W_5 and W_1 are 7.77, 9.48, and 13.27 (see Harvey and Leybourne, 2007).*

Since three of the four variables were observed as nonlinear according to the applied linearity tests, it became necessary to test the variables with nonlinear unit root tests. Table 6 shows the Fourier KPSS unit root test results. In line with the previous unit root test results, the TGS, PIT, and CIT variables are not stationary at level, but stationary at their first difference. However, the GDP variable is stationary both at the level and at its first difference. Nevertheless, one may suggest that all the variables are stationary at their first difference (I(1)).

Table 6. Nonlinear Unit Root Test: Fourier KPSS

	Break in Level		**Break in Level and Trend**	
Variable	**Level**	**First difference**	**Level**	**First difference**
TGS	2.206***	0.126	0.288***	0.019
PIT	2.260***	0.329	0.156***	0.090
CIT	2.173***	0.064	0.105***	0.011
GDP	2.253***	1.185***	0.241***	0.082***

*Notes: All variables were used in their natural logarithm. ***, **, and * denote the significance at 1%, 5%, and 10% levels, respectively. The null hypothesis of the test corresponds to stationarity.*

After carrying out the unit root tests, we can now continue with the NARDL Bounds Test to examine whether the series are cointegrated. According to the results in Table 7, PIT and CIT are separately cointegrated with GDP at 1% significance level, while TGS is cointegrated with GDP at 5% significance. To check the robustness of the nonlinear ARDL Bounds test results, an alternative nonlinear co-integration test developed by Tsong *et al*. (2016) was used. The test provides four different statistics, the cross combinations of the break in level model, and the break in level and trend model with the OLS and the DOLS estimators. The results of this test are shown in Table 8. According to the break in level models, the null hypothesis of co-integration was not rejected for TGS, PIT, and CIT, which means that these variables are separately cointegrated with GDP. The break in level and trend models, on the other hand, show that the null hypothesis of co-integration was rejected for the OLS models of TGS and PIT. However, the null hypothesis was not rejected for the DOLS model of TGS, PIT, CIT, and the OLS model of CIT. Although the obtained twelve test results in this method did not yield a uniform implication, the majority of the tests favor the co-integration of the tax types with GDP.

Table 7. Nonlinear ARDL Bounds Tests

Model: F(TGS | GDP_P, GDP_N)					
Optimal Lag Length		ARDL (8, 6)			
F-statistic		5.335**			
Critical Values					
10%		5%		1%	
I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
2.738	3.465	3.288	4.07	4.558	5.59

Model: F(PIT | GDP_P, GDP_N)					
Optimal Lag Length		ARDL (1, 4)			
F-statistic		12.007***			
Critical Values					
10%		5%		1%	
I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
2.74	3.455	3.285	4.07	4.538	5.475

Model: F(CIT | GDP_P, GDP_N)					
Optimal Lag Length		ARDL (1, 2)			
F-statistic		13.648***			
Critical Values					
10%		5%		1%	
I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
2.74	3.455	3.285	4.07	4.538	5.475

*Notes: All variables were used in their natural logarithm. ***, **, and * denote the significance at 1%, 5%, and 10% levels, respectively. The P and N indices for the variables denote the decomposed positive and negative effects of the variables in the nonlinear ARDL model. The optimal lag selections were chosen according to the Akaike information criteria.*

Table 8. Tsong *et al*. (2016) Co-integration Test Results

Model	Break Type	OLS		DOLS		Critical Values		
		F-Stat	CI_f	F-Stat	CI_f	1%	5%	10%
Tax on goods and services (TGS)	Break in Level	22.333	0.084	28.965	0.058	0.198	0.124	0.095
	Break in Level and Trend	12.703	0.374***	16.733	0.055	0.163	0.099	0.078
Personal income tax (PIT)	Break in Level	28.034	0.158	8.332	0.060	0.473	0.276	0.200
	Break in Level and Trend	9.166	0.273***	8.091	0.038	0.163	0.099	0.078
Corporate income tax (CIT)	Break in Level	16.261	0.046	16.507	0.049	0.473	0.276	0.200
	Break in Level and Trend	10.043	0.037	19.434	0.015	0.163	0.099	0.078

Notes: All variables were used in their natural logarithm. The null hypothesis of the test is co-integration. For each model, the co-integration test is based on the relationship between the indicated tax type and gross domestic product.

Since we have observed that all three tax types are separately cointegrated with GDP, also according to the nonlinear-based co-integration tests, now we are able to estimate the tax buoyancy hypothesis via a nonlinear estimator. The results in Table 9 show the nonlinear ARDL estimations. The long-run coefficients on the top of the table suggest that the positive shocks of GDP are statistically significant for all the models, but the negative shock of GDP is statistically significant only for PIT. It should be noted that the negative point estimates for GDP_N in TGS and CIT models are statistically insignificant, implying that these coefficients are effectively zero. This indicates that negative income shocks do not have a statistically discernible long-run impact on these tax types, likely due to the structural characteristics of the Turkish tax administration. When we closely focus on the coefficients, it is seen that for the TGS model, a 1% increase in GDP raises TGS by 0.755%, PIT by 1.066%, and CIT by 0.902%. This means that in an asymmetrical perspective, for positive GDP shocks, the discretionary changes are effective only for PIT. For negative GDP shocks, on the other hand, the findings suggest that a 1% decrease in GDP reduces PIT by 2.613%. As we stated above, the estimated coefficients of negative GDP shocks in the TGS and CIT models are insignificant. Thus, we may suggest again that also for negative GDP shocks, the discretionary changes are effective only for PIT. Moreover, in the PIT models, the estimated coefficient of the negative shocks is greater than the estimated coefficient of the positive shocks. When GDP increases by 1%, personal income tax revenues will increase by 1.066%. But when GDP decreases by 1%, personal income tax revenues will decrease by 2.613%. In such a situation, policymakers should always monitor the possible recessions in the economy to be on guard against a potential budget deficit. For all three nonlinear models here, the coefficients of the error correction terms are negative. However, the magnitude of the coefficient is between 0 and -1 for TGS and CIT models, while it is even less than -1 for the PIT model. In other words, for TGS and CIT models, the system converges to the equilibrium path by following a monotonic process, while it converges to the equilibrium path by fluctuating around the estimated long-run coefficient for the PIT model. Nevertheless, as Narayan and Smyth (2006) stated, both cases are acceptable since they are statistically significant and have negative signs; briefly, all the error correction terms imply a converging process.

Table 9. Nonlinear Estimation Results

Long Run Coefficients			
Variables	*TGS*	*PIT*	*CIT*
GDP_P	0.755 (0.175)***	1.066 (0.034)***	0.902 (0.094)***
GDP_N	-5.355 (4.616)	2.613 (0.448)***	-1.167 (1.251)
Constant	16.581 (0.202)***	15.810 (0.018)***	14.811 (0.044)***

Error Correction Model					
TGS		*PIT*		*CIT*	
Variables	*Coefficients*	*Variables*	*Coefficients*	*Variables*	*Coefficients*
$\Delta TGS(-1)$	0.064 (0.146)	ΔGDP_P	0.254 (0.197)	ΔGDP_P	3.392*** (0.511)
$\Delta TGS(-2)$	-0.109 (0.222)	ΔGDP_N	2.288** (0.448)	ΔGDP_N	-3.372** (1.280)
$\Delta TGS(-3)$	-0.223 (0.146)	ΔGDP_P*(-1)*	-0.638** (0.257)	ΔGDP_P*(-1)*	-0.121 (0.477)
$\Delta TGS(-4)$	-0.163 (0.139)	ΔGDP_N*(-1)*	-1.615*** (0.584)	ΔGDP_N*(-1)*	5.544*** (1.654)
$\Delta TGS(-5)$	0.214 (0.148)	ΔGDP_P*(-2)*	-0.829*** (0.261)		
$\Delta TGS(-6)$	0.275** (0.125)	ΔGDP_N*(-2)*	-1.172* (0.625)		
$\Delta TGS(-7)$	0.390*** (0.134)	ΔGDP_P*(-3)*	-0.034 (0.181)		
ΔGDP_P	0.464 (0.395)	ΔGDP_N*(-3)*	-2.151*** (0.615)		
ΔGDP_N	-0.255 (0.584)				
$\Delta GDP_P(-1)$	-0.382 (0.373)				
$\Delta GDP_N(-1)$	0.683 (0.798)				
$\Delta GDP_P(-2)$	-0.107 (0.342)				
$\Delta GDP_N(-2)$	2.082** (0.940)				
$\Delta GDP_P(-3)$	-1.304*** (0.401)				
$\Delta GDP_N(-3)$	3.715*** (0.961)				
$\Delta GDP_P(-4)$	-1.327*** (0.441)				
$\Delta GDP_N(-4)$	0.368 (0.890)				
$\Delta GDP_P(-5)$	-1.530*** (0.379)				
$\Delta GDP_N(-5)$	0.540 (0.863)				
ECT(-1)	-0.375*** (0.077)	*ECT(-1)*	-1.022*** (0.142)	*ECT(-1)*	-755*** (0.099)

*Notes: All variables were used in their natural logarithm. Standard errors are in parantheses. ***, **, and * denote the significance at 1%, 5%, and 10% levels, respectively. The P and N indices for the variables denote the decomposed positive and negative effects of the variables in the nonlinear ARDL model.*

The asymmetry tests in Table 10 present the long-run, short-run, and joint test results for each model. The results imply that the null hypothesis of symmetry was rejected for all the models according to the joint test. When the long and short-run tests were separately applied, the null hypothesis of symmetry was rejected again for all the models. However, the short-run symmetry tests suggest that the TGS model is asymmetric, while the PIT and CIT models are symmetric. Nevertheless, since in the present study, the tax buoyancy hypothesis is being investigated in a long-run period, one may consider asymmetry evidence for the long-run models.

Moving beyond a purely descriptive analysis of the coefficients, the significant short-run dynamic parameters of the lagged GDP variables (e.g., up to 5 quarters in the NARDL specifications) offer crucial economic insights. These lagged dynamics empirically illustrate how economic growth from previous periods is incrementally captured as actual tax revenue in subsequent quarters. In the context of Türkiye, the drivers of this delayed revenue capture are primarily administrative and legislative. First, the Turkish direct tax system heavily relies on provisional tax declarations, where corporate and business income taxes are assessed quarterly but reconciled and finalized in the subsequent fiscal year. This creates an inherent administrative lag between economic value creation and actual cash collection. Second, structural features of indirect taxation, such as VAT carry-forwards, dictate that an initial surge in consumption (GDP growth) might first absorb accumulated tax credits before translating into tangible tax revenue in later quarters. Finally, the frequent implementation of tax restructuring laws allows taxpayers to pay accrued liabilities from past economic activities in installments over several future quarters. Consequently, the complex short-run dynamic coefficients observed in our models mathematically trace this administrative absorption and collection process, highlighting that buoyancy in Türkiye is a prolonged, multi-quarter phenomenon rather than an instantaneous reaction.

Table 10. Asymmetry Tests

	Models		
	TGS	**PIT**	**CIT**
Long-run	7.84***	7.48***	2.71*
Short-run	4.01**	0.37	0.34
Joint test (Long-run & short-run)	8.03**	10.59***	4.88*

*Notes: The null hypothesis of the tests is the coefficient estimated in the model is symmetric. The rejection of the null implies that there is an asymmetric relationship in the model. ***, **, and * denote the significance at 1%, 5%, and 10% levels, respectively.*

Robustness Check: Dynamic Multiplier Analysis

To further validate the robustness of our empirical findings and to gain deeper insights into the asymmetry patterns, this section presents a cumulative dynamic multiplier analysis. While the estimated NARDL coefficients and asymmetry tests provide robust evidence of long-run asymmetric relationships, dynamic multipliers are essential for mapping the precise adjustment paths and evaluating the imbalance durations following a unit positive or negative shock in GDP. By visualizing these trajectories, we can dynamically assess the speed of adjustment towards the new steady-state equilibrium for each tax category (TGS, PIT, and CIT). Furthermore, plotting these multipliers along with their 95% confidence interval bands allows for a rigorous visual confirmation of the statistical significance of the asymmetric responses over a multi-year horizon, thereby demonstrating the structural stability and dynamic reliability of the estimated models.

Figure 1. Cumulative Dynamic Multiplier: GDP on TGS Shock Evolution

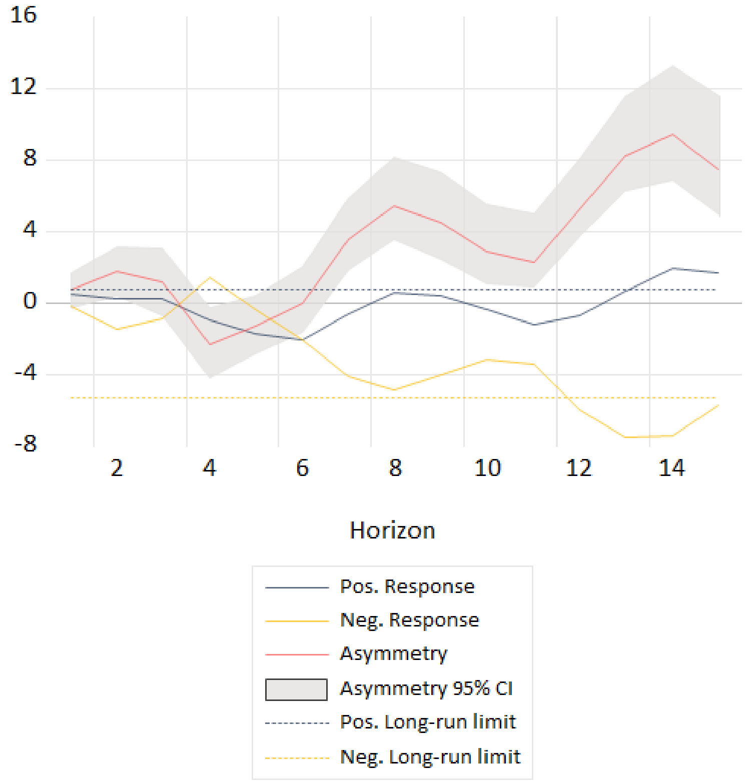


Figure 1 illustrates the cumulative dynamic multipliers and the adjustment path of responses to GDP shocks for the Tax on Goods and Services (TGS) model. The horizontal dashed lines in the graph represent the long-run coefficient limits estimated from the NARDL framework. The volatile trajectory followed by the solid blue (positive response) and yellow (negative response) lines visually corroborates the long lag structure determined by the information criteria (ARDL 8, 6) and the relatively slow speed of error correction (ECT = -0.375). Reaching a new long-run equilibrium in this model requires a prolonged adjustment process extending up to 15 quarters. Examining the statistical significance of the asymmetry, it is observed that the 95% confidence interval (gray shaded area) around the red asymmetry line encompasses the zero axis for the first 6 quarters, indicating that the asymmetry between shocks is statistically insignificant in the short run. However, from the 7th horizon onwards, the confidence interval completely detaches from the zero line, definitively proving the existence of long-run asymmetry. Furthermore, the high volatility of responses to negative shocks supports the finding that the long-run impact of negative shocks in the TGS model is statistically insignificant (a "statistical zero"), visually reflecting downward rigidity within the Turkish tax administration.

Figure 2 presents the cumulative dynamic multipliers and the adjustment path of responses to GDP shocks for the Personal Income Tax (PIT) model. The horizontal dashed lines represent the estimated long-run coefficient limits from the NARDL framework. The multiplier paths visually confirm the study's core finding: the magnitude of the response to a negative shock (the yellow line, stabilizing around 2.6) is significantly larger than that to a positive shock (the solid blue line, stabilizing near 1.0). This explicitly shows that an economic contraction pulls PIT revenues downward to a much larger extent than the revenue increase generated by equivalent economic growth. Furthermore, the rapid flattening of these trajectories by the 5th horizon visually corroborates the high speed of adjustment (ECT = -1.022) estimated in the model, demonstrating an oscillatory but swift convergence to the new steady-state. Examining the statistical significance of the asymmetry, the 95% confidence interval (gray shaded area) around the red asymmetry line encompasses the zero axis during the first four quarters, implying that the asymmetry is statistically insignificant in the short run. However, strictly from the 5th horizon onwards, the confidence interval completely detaches from the zero line, definitively proving the existence of long-run asymmetry.

Figure 2. Cumulative Dynamic Multiplier: GDP on PIT Shock Evolution

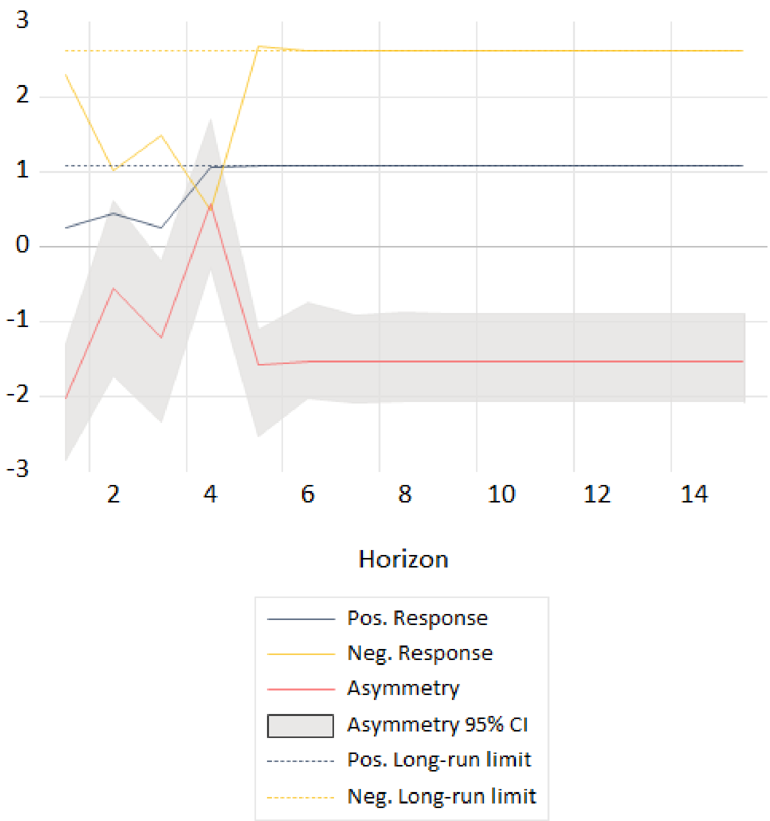
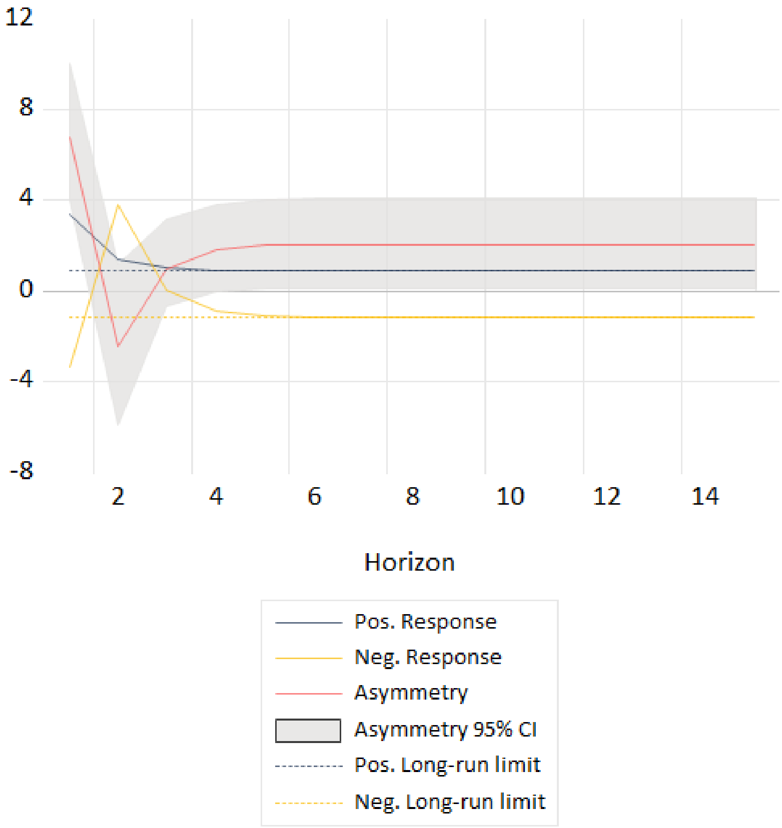


Figure 3 illustrates the cumulative dynamic multipliers and the adjustment path of responses to GDP shocks for the Corporate Income Tax (CIT) model. The horizontal dashed lines represent the long-run limits estimated from the NARDL framework. The most striking feature of this graph is the extremely rapid stabilization of the multiplier paths. Both the positive (solid blue line) and negative (solid yellow line) responses fluctuate briefly but flatten out entirely by the 3rd and 4th quarters. This visual evidence perfectly corroborates the short lag structure (ARDL 1, 2) and the highly significant, rapid speed of adjustment (ECT = -0.755) estimated in the model. It indicates that corporate tax revenues absorb economic shocks and reach a new steady-state much faster than consumption or personal income taxes.

Regarding the statistical significance of the asymmetry, the 95% confidence interval (gray shaded area) stabilizes with its lower bound resting marginally on the zero axis. This visual behavior is highly consistent with our empirical findings (Table 10), which show that the long-run asymmetry in the CIT model is statistically significant at the 10% level. Consequently, while a distinct long-run asymmetric limit exists, the rapid and almost immediate equilibration is the defining dynamic of the corporate income tax response in Türkiye.

Figure 3. Cumulative Dynamic Multiplier: GDP on CIT Shock Evolution



From a theoretical standpoint, these asymmetric findings challenge the traditional Keynesian assumption of symmetric automatic stabilizers. According to standard macroeconomic theory, tax systems are expected to smooth economic cycles by proportionally expanding during booms and contracting during recessions. However, our empirical results deviate significantly from this mechanical expectation. The pronounced collapse in Personal Income Tax (PIT) during negative shocks (GDP_N~2.613) can be theoretically explained through the lens of labor market dynamics and the shadow economy. During economic downturns in emerging markets like Türkiye, rigidities in the formal labor market often lead to rapid shifts toward informal employment, causing tax evasion to rise and income tax revenues to decline faster than overall GDP. Conversely, the downward rigidity observed in Corporate Income Tax (CIT) and Tax on Goods and Services (TGS), where negative shocks yield statistically insignificant impacts, aligns closely with Institutional Economics and Public Choice Theory. Rather than allowing revenues to fall mechanically, the government frequently deploys discretionary institutional interventions, such as massive tax amnesties and temporary exemptions during economic contractions to prevent corporate insolvencies and sustain aggregate consumption. Consequently, these institutional policy choices theoretically neutralize the expected mechanical decline in revenues, demonstrating that tax buoyancy in Türkiye is driven by cycle-dependent, asymmetric fiscal behavior rather than pure income elasticity.

Conclusion

The tax revenue-raising effect of GDP, which is called "tax buoyancy," is a crucial topic in public finance. It is expected that higher economic growth will result in higher tax revenue. But if the growth rate of tax revenues is less than the growth rate of GDP, then the budget balance might be deteriorated. From this point of view, policymakers should investigate countries' tax revenue-GDP elasticities to maintain the budget balance. Since the economic characteristics of countries differ greatly from each other, the evidence obtained from country-specific time-series analyses can provide effective information to policymakers.

In the present study, the tax buoyancy hypothesis was investigated for Türkiye by conducting a comprehensive time-series analysis over the 2006Q1-2022Q3 period. In the existing literature, it is seen that none of the previous studies dealt with the subject by considering potential asymmetrical effects. Thus, the main motivation of the study is to reveal how the asymmetrical assumptions change the results of symmetrical models. For this purpose, following the results of the linear ARDL model, the nonlinear ARDL model's results were presented. The results of the linear ARDL model suggest that tax buoyancy is valid for TGS and CIT but not for PIT. In other words, the discretionary changes are not effective for PIT, contrary to TGS and CIT.

The results of the nonlinear ARDL model, which reflects asymmetrical assumptions, suggest that tax buoyancy is valid only for PIT. Briefly, the discretionary changes are only effective for PIT but not TGS and CIT. Moreover, the positive and negative shocks of GDP affect tax revenues at different rates. In TGS and CIT cases, even insignificant impacts were observed for the negative shocks. This means that when the economy grows, the tax revenues caused by TGS and CIT also grow. However, the magnitudes of the revenue growth rates are less than the GDP growth rates in these cases. On the other hand, when the economy shrinks, there is no statistically significant impact on TGS and CIT. The main reason of this finding is the tax exemptions, which cause decreases in tax collection. For the PIT case, it is observed that tax buoyancy is valid both for positive and negative shocks. However, the magnitude of the negative shocks is greater than the magnitude of the positive shocks. This implies that the decline in PIT revenue when GDP shrinks is greater than the increase in PIT revenue when GDP grows. All of these asymmetrical findings were also proven by the applied asymmetry tests. The findings may simply guide policymakers in two ways: first, personal income tax is the only tax type causing tax buoyancy; second, the positive and negative GDP shocks affect tax buoyancy at different rates. The latter is most important for the PIT case since the impact of the negative shocks is greater than the impact of positive shocks. In recessions or shrinkage periods, the budget balance may significantly deteriorate.

To explicitly address the broader economic consequences of these findings, our results carry profound implications for fiscal sustainability and budget planning in Türkiye. The main result of this paper is that the Turkish tax system does not act as a symmetric automatic stabilizer across economic cycles. The most critical economic consequence stems from the asymmetric behavior of the Personal Income Tax (PIT); because PIT revenues contract significantly more during economic downturns than they expand during growth periods, the government faces a disproportionate revenue collapse precisely when expansionary fiscal policy and public spending are most needed. Furthermore, the statistical insignificance of negative shocks on corporate and consumption taxes (CIT and TGS) highlights a structural downward rigidity, largely driven by frequent tax amnesties and exemptions during recessions. Therefore, answering the crucial "so what?" question: if policymakers continue to rely on traditional, symmetric tax buoyancy assumptions, they risk dangerously overestimating tax revenues during economic recovery phases and facing severe, unanticipated budget deficits during contractions. To achieve long-term fiscal stability, policymakers must preemptively account for this asymmetric revenue loss and prioritize structural reforms that broaden the tax base, rather than relying on cyclical tax amnesties that inherently distort the revenue-generation mechanism.

Finally, this study focuses strictly on the concept of tax buoyancy, which inherently captures the effects of discretionary policy changes and nominal price movements. Due to the frequent and complex nature of tax legislation changes in Türkiye, constructing an adjusted tax series to estimate tax elasticity was beyond the scope of this paper. Future research could expand upon this framework by employing data-cleansing techniques (such as the Proportional Adjustment Method) to isolate discretionary changes and introduce inflation as a control variable, thereby investigating whether the asymmetric patterns observed in buoyancy persist in tax elasticity.

References

Akar, S. and Uysal Şahin, Ö., 2015. Türkiye'de Vergi Canlılığının Analizi. Journal of Economics (in Turkish). *Finance & Accounting*, 2(1), pp.29-43.

Akbar, M. and Ahmed, Q.M., 1997. Elasticity and Buoyancy Revenues and Expenditure of Federal Goverment. *Pakistan Ekonomic and Social Review*, 35(1), pp.43-56.

Audi, M., Ali, A. and Roussel, Y., 2021. Measuring the Tax Buoyancy: Empirics from South Asian Association for Regional Cooperation (SAARC). *MPRA Paper*.

Baek, Jungho, and Hyun Seok Kim. 2013. Is Economic Growth Good or Bad for the Environment? Empirical Evidence from Korea. *Energy Economics,* 36, pp.744–49. https://doi.org/10.1016/j.eneco.2012.11.020.

Becker, R., Enders, W. and Lee, J., 2006). A stationarity test in the presence of an unknown number of smooth breaks. *Journal of Time Series Analysis*, 27(3), pp.381-409.

Belinga, V., Benedek, D., Mooij, R. and Norregaard, J., 2014. Tax Buoyancy in OECD Countries. IMF.

Bilquees, F., 2004. Elasticity nad Buoyancy of the Tax System in Pakistan. *Pakistan Development Review*, 43(1), pp.73-91.

Dickey, D. A. and Fuller, W. A., 1979. Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American statistical association*, 74(366a), pp.427-431.

Dudine, P. and Jalles, J., 2017. How Buoyant is the Tax System? New Evidence from a LArge Heterogeneous Panel. *IMF Working Paper*.

Dudine, P. and Jalles, J., 2018. How Buoyant Is the Tax System. *Journal of International Development*, 30, pp.961-991

Ertürk Atabey, S., Avşar, T. and Bulut, M., 2009. Türkiye Verilerine Göre Vergi canlılığı ve Esnekliğinin Tahmin Edilmesi. Ekonomik Yaklaşım (in Turkish), 20(71), pp.109-119.

Gillani, S., 1986. Elasticity and Buoyancy of Federeal Taxes in Pakistan. *Pakistan Development Review*, 15, pp.163-174.

Gupta, S., Jalles, J. and Liu, J., 2022. Tax Buoyancy in Sub Saharan Africa and its Determinants. *International Tax and Public Finance*, pp. 890-921.

Harvey, D.I. and Leybourne, S.J., 2007. Testing for time series linearity. *Econometrics Journal*, 10, pp.149–165.

Harvey, D.I., Leybourne, S.J. and Xiao, B., 2008. A powerful test for linearity when the order of integration is unknown. *Studies in Nonlinear Dynamics and Econometrics*, 12.

Kaya, P.B. and Gürler Hazman, G., 2022. Türkiye'de Dolaysız Vergilerin Kaldıraç Etkisi (in Turkish). *Gümrük ve Ticaret Dergisi*, (29), pp.12-29.

Khadan, J., 2020). Long and short-run tax buoyancies in small states. *Economics Bulletin*, 40(1), pp.821-827.

Krushna, V., 2015. Tax Buoyancy of India. *International Journal of Research in Management, Economics & Commerce*, 5(12), 46-55.

Lagravinese, R., Liberati, P. and Sacchi, A., 2020. Tax Buoyancy in OECD Countries: New Empirical Evidence. *Journal of Macroeconomics*, 63, pp.1-20.

Mansfield, C. Y., 1972. Elasticity and Buoyancy of a Tax System: A Method Applied to Paraguay. *IMF Staff PApers*, 19(2), pp.425-446.

Masood Ahmed, Q. and Mohammed, S., 2010. Determinant of Tax Buoyancy: Empirical Evidence from Developing Countries. *European Journal of Social Sciences*, 13(3).

Mukarram, F., 2001. Elastıcıty and Buoyancy of Major Taxes in Pakıstan. *Pakıstan Economic and Socıal Review*, 39(1), pp.75-86.

Panopoulou, Ekaterini, and Nikitas Pittis. 2004. A comparison of autoregressive distributed lag and dynamic OLS co-integration estimators in the case of a serially correlated co-integration error. *The Econometrics Journal,* 7, pp.585–617.

Pascale, G., Fiore, M. and Conto, F., 2021. Short and long run environmental tax buoyancy in EU-28: a panel study. *International Economics*, (168), pp.1-9.

Pesaran, M. Hashem, and Yongcheol Shin. 1999. An Autoregressive Distributed Lag Modelling Approach to Co-integration Analysis. In: Steinar Strøm, ed., Econometrics and Economic Theory in the 20th Century The Ragnar Frisch Centennial Symposium. Cambridge: Cambridge University Press, pp.371–413.

Pesaran, M. Hashem, Yongcheol Shin, and Richard J. Smith., 2001. Bounds Testing Approaches to the Analysis of Level Relationships. *Journal of Applied Econometrics*, 16, pp.289–326.

Phillips, P.C. and Perron, P., 1988. Testing for a unit root in time series regression. *Biometrika*, 75(2), pp.335-346.

Rasheed, F., 2006. Ananalysis of Tax Buoyancy Rates in Pakistan. MPRA.

Shahzada, N., Siddique, M., Kiran , M., Hussain, A. and Abbasi, M., 2016. Buoyancy, Elasticity and Stability of Total Tax Revenues: Evidence from Pakistan. *Abasyn Journal of Social Sciences* – Special Issue, pp.1-14.

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

Şimşek, D., 2013. Türkiye'de Bölge Düzeyinde Vergi Esnekliği, Vergi Canlılığı, Vergi Kapasitesi ve Vergi Gayreti (in Turkish). Ankara: TC Gazi Üniversitesi Sosyal Bilimler Enstitüsü Yayımlanmamış Yüksek Lisans Tezi.

Topal, M.H. and Şentürk, S.H., 2019. Dolaylı Vergi nın Türk Vergi Sisteminin Esnekliği ve Canlılığı Üzerindeki Etkisi (in Turkish). A. Güner, A. Yılmaz, & B. Doğrusöz içinde, Güncel Maliye Araştırmaları- I (s. 189-222). Ankara: Seçkin Yayınları.

Tovar Jalles, J., 2017. Tax Buoyancy in Sub-Saharan Africa: An Empirical Exploration. *African Development Review*, 29(1), pp.1-15.

Tsong, C. C., Lee, C. F., Tsai, L. J. and Hu, T. C., 2016. The Fourier approximation and testing for the null of co-integration. *Empirical Economics*, 51(3), pp.1085-1113.