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Quality versus Quantity of Defence Expenditure and Its Impact on Economic Growth: Evidence from the Feder-Ram Model

Abstract. *This study examines the relationship between defence expenditure and economic growth in Türkiye from 1974 to 2023, employing the Feder-Ram model within a three-sector framework. By incorporating technological change and externalities, the research aims to provide a more detailed understanding of this economic relationship. The calculated elasticity coefficients indicate that an increase in defence expenditure has a negative impact on economic growth in Türkiye. Accordingly, the positive externalities and feedback effects on production appear insufficient to offset the negative effects of defence expenditure on economic growth in Türkiye. The study highlights the necessity of shifting defence investments from quantity to quality to optimise economic benefits. It can be said that the qualitative increase in defence spending in Türkiye does not support a quantitative increase. The paper offers policy recommendations for improving the efficiency of defence expenditure in Türkiye.*

Keywords: *defence expenditure, technological change, economic growth, externalities, Feder-Ram model.*

JEL Classification: O38, O33, O47.

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1. Introduction

National defence has historically been the most important issue for every nation state, but it is even more important today. Trump has asserted that no part of the world is completely safe and that all nations, including NATO members, must bear some costs. These statements have forced many countries, particularly those within the European Union (EU), to reassess their defence policies and, as a result, their defence budgets during the second Trump Administration (Fabbrini, 2025). Recent studies also highlight that the economic implications of rising defence expenditures differ significantly between NATO and non-NATO alliances, suggesting that institutional and security commitments shape the growth impact of military spending (Dimitriou, et al., 2024). The plan aims to mobilise approximately €800 billion over

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the next four years, with funding derived from EU member states' increased national expenditures on defence and security. This is leading to a reallocation of national resources, prioritising defence spending. A key economic concern arising from this development is the potential impact of increased defence expenditure on economic growth. Where national defence used to be determined in a hostile but stable environment, today it is formed in an environment characterised by a high degree of complexity and asymmetry. Therefore, countries allocate more resources to defence as part of national security. The question of how much resources will be allocated to national defence is related to the assessment of the willingness of the country's citizens to accept the importance of national security (Qari et al., 2024). The primary economic concern that stems from this development is the potential impact of increased defence spending on economic growth. For addressing this concern requires striking a balance between the quantity and quality of defence expenditure. The basic building blocks in the construction of national defence are based on the acquisition of appropriate defence materials and human resources.

The costs that must be incurred to have defence capabilities vary according to the geopolitical and geostrategic positions of the countries. Geopolitically, Türkiye is located in the middle of zones of peace and danger, and geostrategically, it has the only waterway that connects three continents by land and provides passage from the Black Sea to the Mediterranean and other major seas. These strategic advantages make Türkiye unique in the world. However, these privileges also bring with them a number of threats and dangers. The problem of terrorism is at the forefront of these threats, and Türkiye has been fighting terrorism for more than four decades. In addition, the civil unrest in Syria, Iraq, and other Middle Eastern countries, as well as the war between Russia and Ukraine, two countries with ports on the Black Sea, are some of the external threats Türkiye faces (Aras & Kardaş, 2021; Tüysüzoğlu, 2023). The Ukraine war has also reshaped regional defence strategies, reducing Russia’s military effectiveness in certain domains such as the Arctic, while simultaneously intensifying NATO’s strategic posture (Limon & Gürdal Limon, 2024). These developments have revived debates on European defence integration, where scholars underline both opportunities and institutional challenges in building a coherent European security framework (Hartley, 2024). Therefore, Türkiye is obliged to keep its defence capability up to date, to closely follow the developments in defence technologies, and to integrate these developments into its national defence system. A possible defence weakness can cause heavy costs to the country and its economy. Although the importance of military modernisation is indisputable, economic constraints limit defence expenditures.

Considering all these factors, economic growth and defence expenditure are of great importance for national security and the Türkiye economy. Evaluating the relationship between defence expenditure and economic growth in Türkiye has significant international implications, given the country's geostrategic and geopolitical importance in the Euro-Asian region. An increase in defence spending that stimulates economic growth could offer a dual benefit: strengthening the security apparatus while enhancing economic prosperity. As a regional powerhouse, Türkiye's defence and economic policies have direct implications for the Eurozone and regional security collaborations. Moreover, these policies generate spillover effects on regional politics. A financially stronger Türkiye, supported by robust defence investments, would be better positioned to negotiate from a stance of strength in international forums, potentially reshaping both global and regional political dynamics. In this context, the effects of defence expenditures on the economy are an important issue worthy of research and discussion for Türkiye. Although it is considered worthy of research and discussion in the field of economics, the effect of defence expenditure on economic growth is not yet a field on which consensus has been reached.

The aim of this study is to analyse the long- and short-term relationships, as well as the causality, between defence expenditures and economic growth in Türkiye within the framework of a three-sector Feder-Ram-based defence-growth model, incorporating technological change and externalities. This study makes two key contributions to the literature. First, it identifies the direction and magnitude of the externality effects of defence expenditure on economic growth in Türkiye. Second, it examines the potential impact of defence expenditure on economic growth through technological change.

The remainder of the article is structured as follows: the next section presents the literature review, followed by an explanation of the methodology, including both the theoretical and empirical frameworks. Subsequently, the data, analyses, and findings are reported. The final section provides the conclusion and recommendations.

2. Literature review

There are two main theoretical perspectives on the complex relationship between defence expenditures and economic performance or growth: Military Keynesianism and the Neoclassical approach. Military Keynesianism posits that defence expenditures can positively contribute to economic development by increasing aggregate demand. According to this view, defence spending stimulates economic activity and job creation, leading to higher consumer spending and investment (Treddenick, 1985). In contrast, the Neoclassical approach argues that defence expenditures can negatively impact economic growth by crowding out and reducing private investment. This perspective suggests that government spending on defence diverts resources from more productive sectors, thus hindering overall economic expansion (Khan et al., 2024).

A long-standing debate exists between two models based on the Neoclassical approach: the multi-sector Feder-Ram-based defence-growth model (Atesoglu and Mueller, 1990) and the augmented Solow defence-growth model (Dunne et al., 2005). Both models take a supply-side approach. The Feder-Ram model is based on the neoclassical production function and is static, while the augmented Solow model relies on the Cobb-Douglas production function and is dynamic (Mankiw et al., 1992).

With the end of the Cold War in 1989, two key concepts gained prominence among defence economists analysing the defence-growth nexus from a supply-side perspective: the direct or indirect link and externality. Huang and Mintz's (1990) direct or indirect link approach constructs and estimates multiple equations to assess both the static and dynamic effects of defence expenditures (Huang & Mintz, 1990; Mintz & Huang, 1991). Conversely, the concept of externality, introduced by Feder (1983) and later expanded by Ram (1986), provides a framework for understanding the short-term effects of defence expenditures on economic growth. Huang & Mintz (1991), who applied the neoclassical economic approach to the defence-growth relationship, and Mueller & Atesoglu (1993), who developed a nonlinear model incorporating technological progress, brought greater attention to the externality effects of defence expenditures. Their work spurred numerous empirical studies on externalities, both at the country-specific level (Atesoglu & Mueller, 1990; Augier et al., 2017; DeRouen, 2000; Huang and Mintz, 1991; Mueller & Atesoglu, 1993) and through panel data analyses (Heo, 1998; Heo & DeRouen, 1998).

Theoretically, defence expenditure has a complex relationship with economic growth, influenced by factors such as economic development, political and social context, and government policies and strategies. Although theoretical models provide varying perspectives on this relationship, the empirical literature on this topic is rich and diverse. The reviewed studies can be categorised under two main headings: the methodologies employed and the research findings. Regarding the former, the literature employs various methodological approaches, including ARDL (autoregressive distributed lag) (Dimitraki & Emmanouilidis, 2024; Emmanouilidis, 2024; Akume & Akadiri, 2025), OLS (ordinary least squares) (Augier, M., 2017), VAR (vector autoregression) (Saba & Ngepah, 2022; Wang, et al., 2023), VECM (vector error correction model) (Zhao, et al., 2017), SVAR (structural VAR) (Ahmed et al., 2022), SAR (spatial autoregressive) (Yildirim & Öcal, 2016), and GMM (generalised method of moments) (Khalid & Noor, 2015). While most studies analyse Granger (symmetric) causality (Zhao et al., 2017; Gbadebo et al., 2024), some studies examine asymmetric causality (Hatemi-J. et al., 2018; Yolcu Karadam et al., 2023; Tsitouras & Tsounis, 2024). In addition, some studies examine the interdependence between defence spending and economic growth using integrated frameworks that include other economic factors and variables. Concerning the second, empirical evidence varies depending on the countries analysed and the methodologies applied. Most studies suggest that defence spending contributes to economic growth (Derouen, 2000; Raifu & Aminu, 2023; Hanson & Jeon, 2024; Gnidehou & Faton, 2025). An alternative perspective contends that defence spending negatively impacts growth, identifying an inverse correlation between the two variables (Heo et al.,1998; Desli & Gkoulgkoutsika, 2021; Becker & Dunne, 2023; Saeed, 2025). A third perspective supports the growth neutrality hypothesis, asserting that no causal relationship exists between defence spending and economic growth (Kollias & Makrydakis, 2000).

3. Methodology

This study employs two complementary methodologies. The first is the theoretical framework, which explains the three-sector Feder-Ram model based on the neoclassical production function. This framework provides the study's foundation and informs the selection of variables and the research hypothesis. The second is the empirical framework, which outlines the econometric techniques used to analyse the relationship between defence expenditure and economic growth in Türkiye.

3.1 Theoretical Framework

Despite these contrasting perspectives, the relationship between economic growth and defence expenditure is modelled using the neoclassical production function. The Feder-Ram model uses an aggregate production function approach to estimate the transmission mechanism from defence spending to economic growth. The Feder (1983) and Ram (1986) models incorporate inter-sectoral productivity differentials and externalities. Mintz and Huang (1991) adapted the model developed by Feder and Ram to the defence sector. In this adapted model, government expenditures are divided into military and non-military expenditures. They also assumed that these expenditures affect the private sector through externalities. Mueller and Atesoglu (1993) included technological change as an input to production in the model. Finally, the three-sector model compiled by Heo and DeRouen (1998) provides an opportunity to distinguish between the externality effects of defence and non-defence government spending.

This improved model is presented below:

$$M = A_{(t)}F(L_m, K_m)$$

$$N = B_{(t)}G(L_n, K_n)$$

$$P = C_{(t)}H(L_P, K_P, M, N)$$

And let the total output of the economy be as follows;

$$Y = M + N + P$$

In these equations, Y represents total output, M represents defence expenditures, N represents non-defence government expenditures, and P represents the private sector. L, labour, and K, capital, in the equations, are the standard inputs for each sector in the model. $A_{(t)}$, $B_{(t)}$, and $C_{(t)}$ denote Hicks neutral technical change in the respective sectors (Mueller and Atesoglu, 1993).

Although the technical changes in the sectors are different from each other, it is assumed that there is a proportionality between them. Therefore, the technical change between sectors can be shown as follows:

$$A_{(t)} / C_{(t)} = 1 + \phi_m$$

$$B_{(t)} / C_{(t)} = 1 + \phi_n$$

where ϕ_m and ϕ_n are unknown constants.

Labour and capital productivity may differ across sectors. Assuming that the marginal productivity of factors used in the public sector is $(1+\delta_i)$ times the marginal productivity of factors in the private sector;

$$F_l/H_l = F_k/H_k = 1+\delta_m$$

$$G_l/H_l = G_k/H_k = 1+\delta_n$$

where Fi, Gi, and Hi (i = l, k, m, and n) represent the marginal products of labor and capital for the three sectors. The term δ, the factor productivity differential, is an unknown constant.

Total inputs are as follows;

$$L = L_m + L_n + L_p$$

$$K = K_m + K_n + K_p$$

Using all the above equations, we can derive the following equation for estimation (see Heo and DeRouen, 1998 for the derivation equation).

$$dY/Y = \lambda + e^{\lambda t}\psi_l\left(dL/L\right) + e^{\lambda t}\psi_k\left(I/Y\right) + \left[\pi_m\left(M/Y\right) + e^{\lambda t}\psi_m\right]\left(dM/M\right) + \left[\pi_n\left(N/Y\right) + e^{\lambda t}\psi_n\right]\left(dN/N\right) + \lambda\pi_m\left(M/Y\right) + \lambda\pi_n\left(N/Y\right)$$

Where dL/L is the growth rate of the labor force; I/Y is the share of investment in GDP; dM/M is the growth rate of defence expenditure; M/Y is the share of defence expenditure in GDP; dN/N is the growth rate of non-military public expenditure and N/Y is the share of non-military public expenditure in GDP. π_i (where $i = m, n$) is the combined effect of technological progress and productivity changes on economic growth, and ψ_i is the effect of externalities. Thus, ψ_l is labor; ψ_k is capital; π_m is the combined effect (technology and productivity) of defence expenditure; π_n is the combined effect (technology and productivity) of non-defence public expenditure; ψ_m is the defence externality and ψ_n is the non-defence externality. The technological change factor is represented by the term $e^{\lambda t}$ (DeRouen, 2000).

3.2 Empirical Framework

Theoretical models provide a foundation for understanding the relationship between defence spending and economic growth. To empirically examine this relationship, this study employs the ARDL bounds test. The ARDL test examines both the long- and short-run relationships among variables under study. Unlike other methods, the ARDL bounds testing approach does not require pre-testing for non-stationarity; however, none of the variables should be integrated of order two I(2) (Nkoro and Uko, 2016). Therefore, the stationarity degrees of the variables must be tested. The augmented Dickey-Fuller (ADF), Phillips-Peron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests are used to test the stationarity levels. This approach was selected because it mitigates correlation issues through appropriate lag selection, reduces endogeneity problems, and facilitates a better understanding of long-term coefficients (Menegaki, 2019).

The ARDL bounds test analysis is conducted using the level values of the series. This analysis incorporates key economic indicators, including technology, labour growth rate, the share of investment in GDP, defence expenditure growth rate, the percentage change in non-defence public expenditure, and the shares of defence and non-defence public expenditure in GDP. This approach enables a more detailed examination of the impact of defence expenditure on economic growth.

The long-run relationship under the ARDL model is as follows:

$$\left({dY}/{Y}\right)_t = \alpha_0 + \sum_{i=1}^{a} \alpha_{1i} \left({dY}/{Y}\right)_{t-i} + \sum_{i=0}^{b} \alpha_{2i}\, \lambda_{t-i} + \sum_{i=0}^{c} \alpha_{3i} \left({dL}/{L}\right)_{t-i} + \sum_{i=0}^{d} \alpha_{4i} \left({I}/{Y}\right)_{t-i} + \sum_{i=0}^{e} \alpha_{5i} \left({dM}/{M}\right)_{t-i} + \sum_{i=0}^{f} \alpha_{6i} \left({dN}/{N}\right)_{t-i} + \sum_{i=0}^{g} \alpha_{7i} \left({M}/{Y}\right)_{t-i} + \sum_{i=0}^{h} \alpha_{8i} \left({N}/{Y}\right)_{t-i} + \varepsilon_{1t}$$

where a, b, c, d, e, f, g and h are the optimal lag length of each variable based on the AIC. The short-run parameters are obtained applying the error correction model (ECM) which is presented as follows:

$$\Delta\left({dY}/{Y}\right)_t = \beta_0 + \sum_{i=1}^{a} \beta_{1i}\, \Delta\left({dY}/{Y}\right)_{t-i} + \sum_{i=0}^{b} \beta_{2i}\, \Delta\lambda_{t-i} + \sum_{i=0}^{c} \beta_{3i}\, \Delta\left({dL}/{L}\right)_{t-i} + \sum_{i=0}^{d} \beta_{4i}\, \Delta\left({I}/{Y}\right)_{t-i} + \sum_{i=0}^{e} \beta_{5i}\, \Delta\left({dM}/{M}\right)_{t-i} + \sum_{i=0}^{f} \beta_{6i}\, \Delta\left({dN}/{N}\right)_{t-i} + \sum_{i=0}^{g} \beta_{7i}\, \Delta\left({M}/{Y}\right)_{t-i} + \sum_{i=0}^{h} \beta_{8i}\, \Delta\left({N}/{Y}\right)_{t-i} + \delta_0\left({dY}/{Y}\right)_{t-1} + \delta_1\lambda_{t-1} + \delta_2\left({dL}/{L}\right)_{t-1} + \delta_3\left({I}/{Y}\right)_{t-1} + \delta_4\left({dM}/{M}\right)_{t-1} + \delta_5\left({dN}/{N}\right)_{t-1} + \delta_6\left({M}/{Y}\right)_{t-1} + \delta_7\left({N}/{Y}\right)_{t-1} + \varepsilon_{1t}$$

In this equation, β_0 , is the constant term. $\beta_{1,2,3,4,5,6,7\,,8}$ and $\delta_{1,2,3,4,5,6,7}$ coefficients. Here, the null hypothesis is formulated as H_0: $\delta_0 = \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = \delta_7 = 0$. According to these results, if the null hypothesis is accepted, there is no cointegration relationship. The alternative hypothesis is H_1: $\delta_0 \neq \delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq \delta_5 \neq \delta_6 \neq \delta_7 \neq 0$. Acceptance of H_1 confirms the existence of cointegration among the series. The ECM measures the speed at which short-run disequilibrium adjusts toward long-run equilibrium. It also integrates short-run and long-run coefficients without omitting long-run information.

In the ARDL approach, the presence of short- and long-term relationships between variables is examined; however, it does not establish a causal link between them. Therefore, the results of the cointegration test should be validated through causality analysis (Rahman and Kashem, 2017). The Toda-Yamamoto causality analysis aims to determine the direction of causality among variables and serves as a robustness check for the ARDL bounds test. Accordingly, the final step in our empirical methodology involves the application of the Toda-Yamamoto causality test.

The Toda-Yamamoto causality test is used to examine the presence of linear causal relationships. Compared to the standard Granger non-causality test, the Toda-Yamamoto procedure offers several advan tages, most notably its applicability regardless of the integration and cointegration properties of the variables. In contrast, the standard Granger causality test requires a preliminary assessment of the series' properties, and errors in integration or cointegration analysis may lead to incorrect causality conclusions. The Toda-Yamamoto test addresses these limitations by eliminating the need for prior inspection. It is a modified Wald test for restrictions on the parameters of the vector autoregressive $VAR(k)$ model. Toda and Yamamoto (1995) emphasise that the correct lag order of the system k should be augmented by the maximum order of integration (d_{max}) to ensure valid inference. Asymptotically, the degrees of freedom for the modified Wald test should correspond to the number of time lags $(k + d_{max})$, which follows a Chi-square (χ^2) distribution. When applying the Toda–Yamamoto causality test, it is crucial to ensure that the order of integration in the process, d_{max}, does not exceed the true lag length, k, of the model. The VAR models of Toda and Yamamoto causality are as follows:

$$Y_t = \mu_1 + \sum_{i=1}^{k} \alpha_{1i} Y_{t-i} + \sum_{i=1}^{k+d_{max}} \alpha_{1i} Y_{t-i} + \sum_{i=1}^{k} \varphi_{1i} X_{t-i} \sum_{i=1}^{k+d_{max}} \varphi_{1i} X_{t-i} + \varepsilon_t$$

$$X_t = \vartheta_1 + \sum_{i=1}^{k} \beta_{1i} X_{t-i} + \sum_{i=1}^{k+d_{max}} \beta_{1i} X_{t-i} + \sum_{i=1}^{k} \delta_{1i} Y_{t-i} + \varepsilon_{2t} \sum_{i=1}^{k+d_{max}} \delta_{1i} Y_{t-i} + \eta_t$$

In the above equations, the optimal lag length is denoted by k; The symbols ε_t and η_t represent error terms; d_{max} represents the maximum order of integration of the time series variables. μ; α; φ; θ; β; δ are coefficients.

4. Data Analysis and Results

Following the 1974 Cyprus Peace Operation and the subsequent restriction on the use of weapons and ammunition provided by allied countries, it was decided that the Turkish Armed Forces' weapons and ammunition needs would be met by domestic defence industry companies (TSKGV, 2021). As a result, the research covers the period from 1974 to 2023. Although data on total factor productivity, labour force, and investment were last published in 2019, the series estimated using the ARIMA method has been updated to 2023.

The analytical framework of this study is based on a three-sector Feder-Ram model, which also incorporates technological change in its analysis. This inclusion distinguishes the findings of this research from previous studies on Turkey. The ARDL bounds test approach was selected to test the research hypothesis. This method was chosen due to its ability to be applied regardless of the degree of stationarity, its capacity to avoid correlation through appropriate lag selection, and its effectiveness in addressing the endogeneity problem (Menegaki, 2019).

Table 1. Description of Variables

Variables	Symbol	Period	Source
Dependent variable			
dY/Y	Economic growth	1974-2023	World Bank
Independent variable			
λ	Total factor productivity	1974-2023	World Bank
dL/L	Labor force growth rate	1974-2023	World Bank
I/Y	Share of investment in GDP	1974-2023	IMF
dM/M	Defence expenditure growth rate	1974-2023	World Bank
dN/N	Non-defence government expenditures growth rate	1974-2023	World Bank
M/Y	Share of defence expenditure in GDP	1974-2023	World Bank
N/Y	Share of non-defence government expenditure in GDP	1974-2023	World Bank

Source: Authors' processing.

Table 2 shows the descriptive statistics of the series used in the ARDL analysis. According to Table 2, the mean and median values are close to each other, and therefore the series are reported to have a symmetric distribution. λ, dL/L, I/Y, M/Y exhibit low volatility. dY/Y, dM/M, dN/N and N/Y have higher volatility.

Table 2. Descriptive Statistics

Variables	Mean	Std. Dev.	Min.	Median	Max.
dY/Y	4,62	4,15	-5,74	5,09	11,35
λ	1,04	0,07	0,91	1,03	1,18
dL/L	0,18	0,22	-0,51	0,19	0,78
I/Y	0,62	0,05	0,53	0,62	0,76
dM/M	3,38	15,16	-36,90	2,77	71,83
dN/N	5,91	10,98	-19,18	5,85	32,73
M/Y	3,14	0,94	1,23	3,31	5,11
N/Y	8,92	2,68	3,95	8,87	13,16

Source: Authors' processing.

In time series analysis, unit root tests are initially applied to assess the stationarity of the data. If any variable exhibits an order of integration greater than one – such as an I(2) variable – the critical bounds provided by Pesaran et al. (2001)

and Narayan (2005) become invalid, as they are derived under the assumption that variables are either I(0) or I(1). Therefore, it is crucial to conduct unit root tests to ensure that all variables satisfy the underlying assumptions of the ARDL bounds testing approach for cointegration before proceeding to the estimation stage. For this purpose, the Augmented Dickey-Fuller (ADF), Phillips-Perron (PP), and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests are employed. The results of these tests are presented in Table 3.

Table 3. Unit Root Tests

	ADF		PP		KPSS		
Variables	Level	1st Difference	Level	1st Difference	Level	1st Difference	Integration order, I(d)
dY/Y	0,40	-6,71***	0,69	-6,78***	0,92	0,10***	I(1)
λ	7,78***	---	7,78***	---	0,20***	---	I(0)
dL/L	-0,82	6,01***	-0,80	6,06***	0,90	0,08***	I(1)
I/Y	-2,32	-7,13***	-2,58	-7,13***	0,95	0,05***	I(1)
dM/M	-5,97***	---	-5,82***	---	0,13***	---	I(0)
dN/N	-4,62***	---	-4,63***	---	0,08***	---	I(0)
M/Y	-1,21	9,19***	-1,17	-9,37***	1,10	0,10***	I(1)
N/Y	-0,88	-5,87***	-0,98	-5,87***	1,09	0,08***	I(1)

Note: The abbreviations ADF, PP, and KPSS stand for Extended Dickey-Fuller, Phillips-Perron, and Kwiatkowski-Phillips-Schmidt-Shin respectively.
Source: Authors' processing.

According to the unit root test results shown in Table 3, most of the variables contain a unit root at the I(0) level and become stationary at the first difference. The fact that a significant portion of the variables are stationary at the I(1) level allows the cointegration test to be performed. However, in the selection of the analysis method, the fact that some of the variables are stationary at the I(0) level was taken into consideration, and the ARDL bounds test was deemed appropriate.

Table 4. The Result of Model Diagnostic Inspections

Diagnostic Test Results	
Normal Distribution (JB):	2,25 [0,32]
Breusch Godfrey Otokor. LM:	3,53 [0,16]
Heteroscedasticity (ARCH):	0,28 [0,59]
Heteroscedasticity (White):	8,95 [0,97]
Heteroscedasticity (BreuschPagan-Godfrey):	13,53 [0,80]
Ramsey RESET:	1,03 [0,31]
F- Statistic:	8225,58 [0,00]
R2 :	0,99

Note: Prob. values are included in "[]".
Source: Authors' processing.

As seen in the diagnostic test results in Table 4, according to the Breusch Godfrey LM test, there is no autocorrelation in the model. ARCH and Breusch-

Pagan-Godfrey tests, there is no problem of heteroscedasticity, and according to Ramsey RESET test, there is no functional form problems. Finally, the Jarque-Bera test shows that the error terms are normally distributed.

Following the model estimations, a bounds test analysis was conducted to determine the long-run equilibrium relationship, and the bounds test results of the ARDL model are presented in Table 5.

Table 5. ARDL Bounds Test Results

Critical Bound	Critical value at 1% significance level	Critical value at 5% significance level	Critical value at 10% significance level
Ho: Long run relationship does not occur amid study variables			
F-Test Bound Values			
Lower Bound	3,07	2,5	2,22
Upper Bound	4,23	3,5	3,17
Estimated Value of Long Run F- Statistics	**39,91**		

Source: Authors' processing.

According to the ARDL F-bound test results reported in Table 5, the F statistic (39,91) in absolute value is greater than the Pesaran et al. (2001), Narayan (2005) values. These results in the null hypothesis being rejected and indicate the existence of a long-run equilibrium relationship between the variables used in the ARDL model.

In the event of a deviation in the long-run equilibrium due to any shock, the short-run error correction regression estimation results should be analysed to find out whether the error correction mechanism, which shows how long it takes to return to equilibrium, works or not. The ARDL model short-run error correction regression estimation results are presented in Table 6.

Table 6. ARDL Model Short Run Error Correction Regression Estimation Results

Variables	Coefficient	Std. Error	t-Statistic
D(λ)	0.005724***	0.000451	12.69820
D(dL/L)	0.083794	0.072274	1.159405
D(dL/L (-1))	0.315481***	0.072665	4.341608
D(dL/L (-2))	-0.371870***	0.068261	-5.447767
D(dN/N)	0.002280***	0.000233	9.803313
D(N/Y)	-0.032978***	0.003133	-10.52541
D(N/Y (-1))	0.017721***	0.003004	5.899325
D(N/Y (-2))	-0.012548***	0.002064	-6.080727
DUMC1	0.006362	0.010239	0.621292
DUMC2	0.014962	0.008921	1.677156
C	0.584627	0.026309	22.22185
CointEq(-1)	-0.145940†, ***	0.007001	-20.84417

Note: *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively. † denotes the significance of the t-bound test at the 1% significance level.
Source: Authors' processing.

The error correction term (ECT) in Table 6 is statistically significant and negative. According to this result, the ECM operates in the ARDL model and will return to equilibrium with a possible deviation in about 7 periods (years).

Structural changes in the years subject to the study led to structural breaks. In order to test both structural breaks and the reliability of the findings, CUSUM and CUSUM of Squares structural break tests were applied. Figure 1 shows the CUSUM test result on the left side and the CUSUM of Squares test result on the right side. According to both test results, the test statistics are within the 5% confidence interval. This underscores the model's appropriateness for making forecasts. Figure 1 shows the CUSUM and CUSUM of Squares test results for the first model.

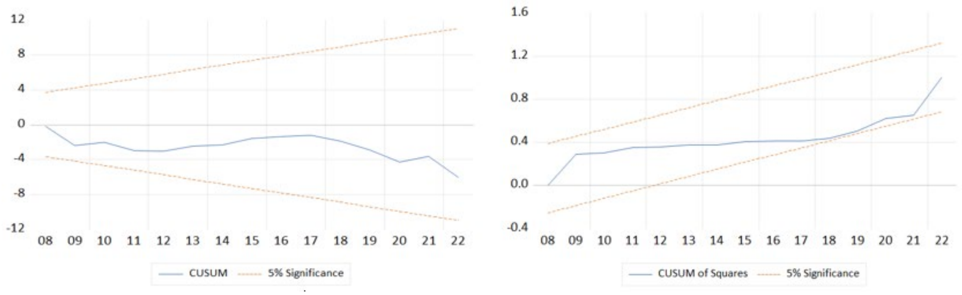

Figure 1. CUSUM and CUSUM of Squares Test Results for ARDL

Source: Taken from Eviews program.

In order to determine the impact of defence expenditure on economic growth directly and through externalities, the long-run coefficients of both models were examined. Table 7 presents these coefficients.

Table 7. ARDL Long-Run Coefficient Estimation and Elasticities in Türkiye (1974–2023)

Variables	Coefficient	Std. Error	t-Statistic
λ	0.073279***	0.021340	3.433933
dL/L	1.334273**	0.491356	2.715493
I/Y	-0.628900**	0.279359	-2.251222
dM/M	0.006465**	0.002398	2.695704
dN/N	0.009612**	0.003445	2.790280
M/Y	-0.112618**	0.050280	-2.239807
N/Y	0.045615***	0.011776	3.873559
Elasticities			**Coefficient**
Defence size effect (λπm)			0,0004
Non-defence size effect (λπn)			0.0006
Defence growth effect [πm(M/Y) + eλtΨm]			-0,65
Non-defence growth effect [πn(N/Y) + eλtΨn]			0,23

Note: *, **, and *** denote statistical significance at 10%, 5%, and 1% levels, respectively.

Source: Authors' processing.

According to Table 7, all variables in both models are significant at the 10%, 5%, and 1% levels. The real effects of defence and non-defence government expenditures on economic growth are calculated using ARDL estimation results (DeRouen, 2000). The defence expenditure externality (Ψm) is negative, while the non-defence expenditure externality (Ψn) is positive. Similarly, the combined effect of defence expenditure (πm), and the combined effect of non-defence expenditure (πn) are positive and significant. However, the combined effect of technological progress and productivity in the defence and non-defence government sectors does not contribute significantly to growth.

The elasticities presented at the bottom of Table 7 indicate that a 1% increase in defence spending in Türkiye would lead to a 0.65% decline in economic growth, whereas a 1% increase in the defence share of GDP (defence burden) would have a negligible impact (0.0004%). Similarly, a 1% increase in non-defence government expenditure would raise economic growth by 0.023%, while a 1% increase in non-defence government expenditure as a share of GDP would have only a minimal effect (0.0006%).

Cointegration test results demonstrate initial evidence of a long-run equilibrium relationship between the observed variables, indicating a causal relationship. Therefore, the Toda–Yamamoto causality test was performed. Table 8 depicts various criteria for selecting optimal lag length for further empirical analysis. The optimal lag length is chosen as 3 according to AIC, being the minimum value among all other values. The analysis performed the Toda-Yamamoto long-run non-Granger causality test using VAR with 4 lags (k = 3 and dmax = 1).

Table 8. VAR lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-454.1149	NA	0.073460	20.09195	20.40998	20.21109
1	-75.44659	609.1621*	8.75e-08*	6.410721	9.272942*	7.482926*
2	-20.30562	69.52557	1.66e-07	6.795896	12.20231	8.821173
3	60.58058	73.85270	1.69e-07	6.061710*	14.01232	9.040058

Note: * Indicates lag order selected by the criterion. LR: Sequential modified LR test statistic; FPE: final prediction error; AIC: Akaike information criterion; SC: Schwarz information criterion; HQ: Hannan–Quinn information criterion; and NA: not applicable
Source: Authors’ processing.

Table 9 contains the results of the Toda-Yamamoto Granger causality test. Only the results of the Toda-Yamamoto Granger causality test, which are relevant to the hypothesis of the study, are included in the table. The Toda-Yamamoto Granger non-causality test results, presented in Table 9, indicate a statistically significant bidirectional causal relationship between defence expenditure growth and economic growth at the 5% significance level. Similarly, the test results reveal a bidirectional causal relationship between the share of defence expenditure in GDP and economic growth. Additionally, a statistically significant bidirectional relationship is observed between defence expenditure growth and total factor productivity. Finally, the results confirm a bidirectional causal relationship between the share of defence expenditure in GDP and total factor productivity, also at the 5% significance level.

Table 9. Results of the Toda– Yamamoto Granger non-causality test

Null hypothesis	Modified Wald statistic	*p*- value	Direction of causality
λ does not Granger cause dY/Y	42.04316***	0.0000	$\lambda \to dY/Y$
dY/Y does not Granger cause λ	25.70891***	0.0000	$dY/Y \to \lambda$
dM/M does not Granger cause dY/Y	19.77354***	0.0000	$dM/M \to dY/Y$
dY/Y does not Granger cause dM/M	109.4954***	0.0000	$dY/Y \to dM/M$
dN/N does not Granger cause dY/Y	5.118499*	0.0698	$dN/N \to dY/Y$
dY/Y does not Granger cause dN/N	29.02811***	0.0000	$dY/Y \to dN/N$
M/Y does not Granger cause dY/Y	26.62135***	0.0000	$M/Y \to dY/Y$
dY/Y does not Granger cause M/Y	53.91720***	0.0000	$dY/Y \to M/Y$
N/Y does not Granger cause dY/Y	28.16957***	0.0000	$N/Y \to dY/Y$
dY/Y does not Granger cause N/Y	31.99088***	0.0000	$dY/Y \to N/Y$
dM/M does not Granger cause λ	9.425048**	0.0241	$dM/M \to \lambda$
λ does not Granger cause dM/M	164.8886***	0.0000	$\lambda \to dM/M$
dN/N does not Granger cause λ	21.05144***	0.0000	$dN/N \to \lambda$
λ does not Granger cause dN/N	22.68559***	0.0000	$\lambda \to dN/N$
M/Y does not Granger cause λ	8.929906**	0.0302	$M/Y \to \lambda$
λ does not Granger cause M/Y	83.85297***	0.0000	$\lambda \to M/Y$
N/Y does not Granger cause λ	23.51987***	0.0000	$N/Y \to \lambda$
λ does not Granger cause N/Y	4.126474	0.1029	None
dN/N does not Granger cause dM/M	30.52545***	0.0000	$dN/N \to dM/M$
dM/M does not Granger cause dN/N	24.13838***	0.0000	$dM/M \to dN/N$
M/Y does not Granger cause dM/M	39.86686***	0.0000	$M/Y \to dM/M$
dM/M does not Granger cause M/Y	55.31753***	0.0000	$dM/M \to M/Y$
N/Y does not Granger cause dM/M	21.12514***	0.0000	$N/Y \to dM/M$
dM/M does not Granger cause N/Y	9.276539**	0.0258	$dM/M \to N/Y$
M/Y does not Granger cause dN/N	23.59721***	0.0000	$M/Y \to dN/N$
dN/N does not Granger cause M/Y	48.11707***	0.0000	$dN/N \to M/Y$
N/Y does not Granger cause dN/N	35.98851***	0.0000	$N/Y \to dN/N$
dN/N does not Granger cause N/Y	14.29475***	0.0025	$dN/N \to N/Y$
N/Y does not Granger cause M/Y	15.95900***	0.0000	$N/Y \to M/Y$
M/Y does not Granger cause N/Y	16.62598***	0.0000	$M/Y \to N/Y$

Notes: *, **, ***Indicate rejection of the null hypothesis at the 10, 5 and 1% significance level.
Source: Authors' processing.

5. Conclusions and recommendations

The role of defence spending in the economy – its share, growth rate, external effects, and broader impact on national economic performance – remains a focal point for policymakers and scholars. The ongoing debate largely stems from the persistent lack of consensus on whether defence expenditures influence economic growth and, if so, whether their effects are positive, negative, or unidirectional. This uncertainty is further exacerbated by methodological, theoretical, and empirical inconsistencies in the literature, complicating efforts to synthesise existing evidence. With the potential for a second Trump administration, global defence spending is expected to rise. Additionally, China's planned expansion of its defence budget, the European Union's pursuit of independent defence capabilities, and the broader dynamics between defence expenditures and economic growth – including both their quantitative and qualitative dimensions – remain critical areas for further investigation. This study contributes to this ongoing discourse. Although this study focuses on Türkiye, the findings carry implications for other emerging and middle-income economies that allocate substantial resources to defence. Lessons regarding the prioritisation of quality over quantity in defence spending, management of technological integration, and mitigation of negative externalities are applicable in broader contexts

In our research, the relationship between defence expenditure and economic growth in Türkiye from 1974 to 2023 was modelled as a three-sector model built on the neoclassical production function. Technological change and externality effects were also measured through this model. Through unit root tests and cointegration analysis supported by the ARDL bounds test method a long-term relationship were determined between defence expenditures and economic growth. Our long-term estimation results show that defence expenditures have a negative effect on economic growth. According to this result, it shows that quantitative increases in defence expenditures in Türkiye do not translate into economic growth. In addition, according to our findings, the negative effect of the opportunity cost advocated by the Neoclassical Approach is more dominant than the positive feedback and production effects emphasised by the Military Keynesian Approach. This is because an increase in the share of defence expenditures in GDP negatively affects economic growth through externalities. While defence expenditures can potentially positively affect economic growth through technological change and productivity, this positive effect is relatively small compared to the negative externality effects. Although Türkiye has made significant technological advances in the defence sector in the last two decades and is trying to integrate a large number of companies into the defence industry as subcontractors, significant improvements and reforms regarding the sector are inevitably necessary. These findings indicate the necessity of transferring resources from quantity to quality when planning and programming defence expenditures.

These findings indicate the necessity of transferring resources from quantity to quality when planning and programming defence expenditures. Based on the research findings, the following policy recommendations are proposed. To support economic growth in Türkiye, defence expenditures should prioritise quality over quantity. Investments must be strategically allocated to enhance sectoral competitiveness and sustainability, foster the development of future technologies using national resources, and strengthen institutional capacity. Achieving these objectives requires a focus on increasing defence-related exports, promoting civil-defence collaboration through dual-use technologies, and improving financial planning within defence budgets. Additionally, expenditures should be directed toward initiatives that advance domestic and national projects while reinforcing the defence supply ecosystem. Particular emphasis should be placed on breakthrough technologies that drive innovation and long-term growth. In this context, greater integration between the Turkish defence industry and the private sector is critical. A more organic collaboration between the defence sector and other industries – where the private sector assumes a leading role as the prime contractor – could generate positive externalities by leveraging R&D activities and fostering innovation-driven competition. These results reinforce the theoretical insight that the net impact of defence expenditures on growth depends critically on resource allocation and governance, providing internationally relevant lessons on balancing military priorities with economic efficiency. However, given that private-sector firms operate with profit-maximisation objectives and the defence market is often constrained by national regulations and export controls, participation may be limited. To address this challenge, the government should implement targeted incentives to enhance private sector engagement while maintaining strict regulatory oversight to mitigate potential security risks. By highlighting strategies such as dual-use technology development and private-sector integration, the policy recommendations derived from the Türkiye case can serve as a reference framework for other countries seeking to leverage defence spending for innovation-driven growth while minimising opportunity costs.

The main limitation of this research is the inability to select the most appropriate analytical techniques and data. Given this limitation, future researchers are advised to: (1) analyse cybersecurity spending and R&D expenditure as distinct variables within overall defence spending to gain more precise insights into their economic impact; (2) examine the long-term effects of defence expenditure using dynamic panel models for comparative analysis; (3) evaluate how the composition of the defence budget (e.g., R&D and personnel spending) affects productivity by including subcomponents of defence expenditure; (4) conduct revision studies that include nonlinear causality tests to capture asymmetric relationships; and (5) use advanced analytical methods, including alternative machine learning techniques, to increase analytical rigour.

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