

The Statistical Relationship between Defense Spending and Economic Growth in Ukraine: a Comparative Regression Analysis

Статистичний зв'язок між оборонними видатками та економічним зростанням України: порівняльний регресійний аналіз

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Purpose. To identify and quantitatively interpret the statistical relationship between defence expenditure and economic growth in Ukraine amidst ongoing security challenges, as well as to clarify the specific characteristics of the Ukrainian case through comparison with Turkey and Georgia.

Method: This is an empirical study. The data set comprises World Bank statistics for 2014–2023 on military expenditure and real gross domestic product for Ukraine, Turkey and Georgia. The study employs methods of generalisation, comparison, dynamic analysis, linear regression and analysis of the residuals of the regression model.

Findings. For Ukraine, a strong inverse statistical relationship has been established between defence expenditure and real gross domestic product. The correlation coefficient is -0.897, and the coefficient of determination is 0.804. A comparative analysis showed that Turkey is characterised by a weak positive relationship, whilst Georgia is characterised by a strong positive relationship.

Theoretical implications. The study deepens the scientific understanding of the context-dependent relationship between defence expenditure and economic growth in developing countries.

Practical implications. The findings can be used as an analytical basis for further research into the macroeconomic consequences of defence funding in conditions of security instability.

Value. The originality of the work lies in combining regression analysis of the Ukrainian case with a comparative analysis of Turkey and Georgia.

Limitations / directions for further research. The limitations of the study include the use of simple linear regression and a limited time period. Further research should focus on expanding the sample, including additional macroeconomic variables, and applying more complex econometric models.

Paper type. Empirical.

Мета дослідження. Виявлення та кількісна інтерпретація статистичного зв'язку між оборонними видатками та економічним зростанням України в умовах тривалих безпекових викликів, а також уточнення специфіки українського випадку шляхом порівняння з Туреччиною та Грузією.

Методи дослідження. Дослідження має емпіричний характер. Інформаційну базу становлять статистичні дані Світового банку за 2014 – 2023 роки щодо військових видатків і реального валового внутрішнього продукту України, Туреччини та Грузії. У роботі використано методи узагальнення, порівняння, динамічного аналізу, лінійної регресії та аналізу залишків регресійної моделі.

Результати дослідження. Для України встановлено сильний обернений статистичний зв'язок між оборонними видатками та реальним валовим внутрішнім продуктом. Коефіцієнт кореляції становить -0,897, а коефіцієнт детермінації - 0,804. Порівняльний аналіз показав, що для Туреччини характерний слабкий прямий зв'язок, тоді як для Грузії — сильний прямий зв'язок.

Теоретична цінність дослідження. Дослідження поглиблює наукове розуміння контекстної залежності взаємозв'язку між оборонними видатками та економічним зростанням у країнах, що розвиваються.

Практична цінність дослідження. Отримані результати можуть бути використані як аналітична основа для подальшого вивчення макроекономічних наслідків оборонного фінансування в умовах безпекової нестабільності.

Оригінальність/цінність дослідження. Оригінальність роботи полягає у поєднанні регресійного аналізу українського випадку з порівняльним аналізом Туреччини та Грузії.

Обмеження/напрями подальших досліджень. Обмеженням дослідження є використання простої лінійної регресії та обмеженого часового періоду. Подальші дослідження доцільно спрямувати на розширення вибірки, включення додаткових макроекономічних змінних і застосування складніших економетричних моделей.

Тип дослідження: емпіричне.

Key words: Defence Spending; Real Gross Domestic Product; Regression Model; Security Challenges; Macroeconomic Instability; Developing Countries.

Ключові слова: оборонне фінансування; реальний валовий внутрішній продукт; регресійна модель; безпекові виклики; макроекономічна нестабільність; країни, що розвиваються.

Introduction

In today's world, economic growth is increasingly shaped not only by traditional macroeconomic factors, but also by security challenges that alter the structure of public finances, budgetary priorities and the general conditions under which national economies operate. Rising geopolitical instability is increasing the role of defence spending, making the relationship between defence expenditure and economic growth a key issue in contemporary economic analysis.

In the academic literature, the relationship between defence expenditure and economic growth is interpreted in various ways. On the one hand, defence expenditure can be viewed as a component of government demand that supports production, employment and the functioning of strategically important sectors of the economy. On the other hand, an increase in defence funding may exacerbate the fiscal burden and limit resources for investment, the social sector and long-term development. This duality of impact is evident in studies devoted to the theoretical and empirical aspects of defence spending and economic growth (Aydın, 2021; Becker & Dunne, 2023; Carter et al., 2021).

This issue is of particular relevance to developing countries, as the increase in their defence burden occurs against a backdrop of limited financial resources, high vulnerability to external shocks and unstable economic dynamics. Deger and Sen (1995) emphasised that, for such countries, defence expenditure cannot be assessed in isolation from development challenges, resource constraints and structural transformation. This means that the statistical relationship between defence expenditure and economic growth should be examined with due regard to the specific national context.

For Ukraine, this issue is of particular significance. Since 2014, the national economy has been operating amid prolonged security challenges, accompanied by an increased role of the defence sector, the transformation of public finances and significant volatility in macroeconomic dynamics. In 2022–2023, this problem became even more acute, as a sharp increase in the defence burden occurred simultaneously with severe economic losses caused by full-scale war. The Ukrainian macroeconomic context during this period was characterised by a combination of war shock, the destruction of productive capacity, budgetary pressure and changes in the conditions of economic activity (Koval, 2023; Pukhyr & Yurkiv, 2023; Rosola et al., 2023).

Within the Ukrainian academic context, Koval's (2023) work is significant, as it examines the theoretical and econometric aspects of the relationship between military spending and economic growth. The researcher draws on the 'guns versus butter' model, which is used in economic theory to explain the state's distributional choice between military needs and civilian welfare. In this logic, an increase in defence spending is viewed not only as a security issue but also as a manifestation of resource constraints, since defence funding takes place within the limits of the state's overall economic and budgetary capacity.

At the same time, the Ukrainian case in 2014–2023 requires a broader interpretation, as in the context of a full-scale war, defence spending cannot be viewed merely as one aspect of budgetary choice. It serves to safeguard the state's basic conditions of existence, whilst economic dynamics determine the feasibility of sustaining such a burden over the long term. In this study, this interrelationship is proposed to be interpreted through the authors' metaphor of 'armour on the economic engine': defence expenditure forms the necessary protective framework of the state, whilst real gross domestic product is the economic engine, upon the state of which depends the

country's ability to sustain defence funding, maintain macroeconomic stability and ensure the conditions for further recovery.

The relevance of this article stems from the need to quantitatively assess the statistical relationship between defence expenditure and economic growth in Ukraine amidst ongoing security challenges. To this end, it is not sufficient merely to describe the trends in defence funding or changes in macroeconomic indicators. It is important to apply formalised tools that allow us to determine the direction, strength and explanatory power of the relationship between the indicators under study. In this article, such a tool is linear regression.

The aim of the article is to identify and quantitatively interpret the statistical relationship between defence expenditure and economic growth in Ukraine in 2014–2023 using linear regression, as well as to clarify the specifics of the Ukrainian case by comparing it with Turkey and Georgia.

To achieve this objective, the following tasks have been defined: to summarise academic approaches to interpreting the relationship between defence expenditure and economic growth; to justify the choice of data set, time period and research methods; to analyse the dynamics of defence expenditure and Ukraine's real gross domestic product in 2014–2023; to construct a linear regression model for Ukraine and evaluate its main parameters; to analyse the model's residuals; to compare the results of the Ukrainian model with the regression models of Turkey and Georgia; to determine the limits of interpretation of the results obtained.

The scientific novelty of this study lies in clarifying the nature of the statistical relationship between defence expenditure and economic growth in Ukraine amidst persistent security challenges, by combining linear regression, residual analysis and a comparative approach. Unlike a general description of the dynamics of defence funding, the proposed approach allows for a quantitative assessment of the specifics of the Ukrainian case and a comparison with models from other developing countries.

Literature review

The issue of the relationship between defence expenditure and economic growth is a subject of debate in economic science, as defence funding combines security, budgetary and macroeconomic functions. In the academic literature, defence expenditure is viewed not only as expenditure on national security, but also as a factor that can influence aggregate demand, investment activity, productivity, public finances and long-term economic dynamics.

One of the classic approaches to analysing this issue is the study by Deger and Sen (1995), in which the military expenditure of developing countries is examined through the prism of resource constraints, structural transformation and security needs. The authors emphasise that the impact of defence funding cannot be unequivocally positive or negative, as it depends on the level of economic development, the state's institutional capacity, the nature of external threats and the structure of budget resource allocation. This approach is important for this article, as Ukraine is analysed as a country whose economic dynamics in 2014–2023 were shaped by prolonged security challenges.

The theoretical duality of the impact of defence expenditure is systematised by Aydın (2021). Within the Keynesian approach, defence funding can support economic activity through government demand, employment and the development of specific sectors. By contrast, within the neoclassical approach, the emphasis is on the risks of crowding out investment, the fiscal burden and the inefficient reallocation of resources. For this study, such a distinction is important because it allows us to avoid a simplistic interpretation of defence spending as merely a stimulus or merely a constraint on economic growth.

The issue of trade-offs between defence and civilian needs is explored by Carter, Ondercin and Palmer (2021), who re-examine the implications of military expenditure within the broader context of government choices between security, social spending and economic development. This approach is relevant to the study of Ukraine; however, in wartime conditions, it requires cautious

application, as defence expenditure during a full-scale war is not merely one of several budgetary options, but serves to ensure the basic conditions for the state's existence.

Empirical studies also confirm the ambiguous relationship between military expenditure and economic growth. Alptekin and Levine (2012), based on a meta-analysis, showed that the results of previous studies depend significantly on the choice of countries, the period, the methodology and the specification of the models. A similar conclusion is reached by Aizenman and Glick (2006), who link the effects of military expenditure to the level of external threats and the country's security environment. Antonakis (1997), using Greece as an example, shows that the relationship between military expenditure and economic growth may be specific to countries with a heightened security burden. This confirms that an analysis of the defence burden must take into account not only the volume of expenditure itself, but also the conditions under which it is incurred.

A separate strand of the literature focuses on the structure of defence expenditure. Becker and Dunne (2023) emphasise that the economic impact of military funding depends on where resources are directed: personnel, equipment, infrastructure, research and development, or day-to-day operations. This point is of particular significance for Ukraine, as in wartime a significant portion of defence funding is directed towards urgent security needs, which may limit the potential long-term investment impact of such expenditure.

Recent review articles also indicate a growing interest in this issue. Mutumba (2025) systematises the international literature on the relationship between military expenditure and economic growth and shows that studies present varying conclusions: a positive impact, a negative impact, a bidirectional relationship, or the absence of a statistically significant link. Such heterogeneity in results confirms the need for empirical testing for specific countries, rather than the mechanical application of general conclusions to the Ukrainian case.

The issue of causality represents another significant limitation in the study of defence expenditure and economic growth. Saeed (2024) emphasises that a simple statistical comparison of military expenditure and macroeconomic indicators does not always allow us to determine the actual direction of causality, as there may be feedback loops and endogeneity between them. This is of fundamental importance for this article: linear regression is used not to prove a direct causal relationship, but to quantitatively interpret the statistical link within the selected sample.

Studies focusing on different countries and groups of countries also highlight the context-dependence of the results. Kollias and Paleologou (2018) analyse the relationship between military expenditure, economic growth and investment, taking into account differences between groups of countries in terms of income levels. Elgin, Elveren, Özgür and Dertli (2022) examine military expenditure in relation to sustainable development, extending the analysis beyond short-term macroeconomic effects. Gönül-Sezer and Demirel (2023) investigate the impact of military expenditure on economic productivity, whilst Tao, Glonț, Li, Lobonț and Guzun (2020) analyse the dynamic causality between military expenditure and sustainable economic growth using Romania as a case study. Mohanty, Panda and Bhuyan (2020) focus on the importance of the composition of defence expenditure for economic growth, whilst Rudy (2022) examines the two-way effects between the military economy and economic growth in the transition economies of Eurasia. This confirms the multi-layered nature of the issue under investigation.

Of particular relevance to the Ukrainian academic context is the work by Koval (2023), which examines the theoretical and econometric aspects of the relationship between military expenditure and economic growth. The author draws on the 'guns versus butter' model, which is used to explain the state's distributional choice between military needs and civilian welfare. Within the scope of this article, this approach is important as a theoretical backdrop for understanding resource constraints; however, the main focus shifts to a statistical assessment of the relationship between defence expenditure and Ukraine's real gross domestic product in the context of a war shock.

The macroeconomic consequences of the war for Ukraine are discussed in the works of Rosola, Hladynets and Petrichko (2023), as well as Pukhyr and Yurkiv (2023). These studies show that Ukraine's economic dynamics in the context of full-scale war are shaped not only by fiscal reallocation, but also by the destruction of productive capacity, changes in investment activity, migration processes, inflationary risks and external financial support. Institutional assessments also confirm the scale of the war's economic consequences. In particular, the World Bank (2025) and the International Monetary Fund (2025) examine the impact of the war shock on macroeconomic stability and the conditions for economic recovery, whilst the National Bank of Ukraine (2025) and the Ministry of Finance of Ukraine (2025) detail the fiscal and budgetary aspects of the economy's functioning under wartime conditions. This is precisely why the results of the regression analysis of the Ukrainian case require cautious interpretation and cannot be reduced to a direct assertion of the independent impact of defence expenditure on real gross domestic product.

Thus, a review of the literature reveals three main approaches to interpreting the relationship between defence spending and economic growth. The first approach views defence spending as a potential stimulus for government demand. The second approach focuses on the risks of fiscal burden and the crowding out of resources from civilian sectors. The third approach assumes that outcomes depend on the specific economic, institutional and security context. It is this third approach that is most suitable for this article, as it allows Ukraine to be considered not in isolation but in comparison with other developing countries, whilst maintaining a focus on the specificities of the wartime period.

Thus, the literature confirms that the relationship between defence expenditure and economic growth is not universal. This justifies the use of regression analysis for Ukraine and a comparative analysis with Turkey and Georgia, which allows us to clarify which features of the Ukrainian model are specific and which correspond to broader patterns of economic development in the context of security challenges.

Materials and Methods

This study is empirical in nature and aims to quantitatively assess the statistical relationship between defence expenditure and economic growth in Ukraine. To clarify the specifics of the Ukrainian case, a comparative approach is used, drawing on the examples of Turkey and Georgia. These countries were selected as comparators because they belong to the group of developing countries, yet differ in terms of the size of their economies, the level of defence expenditure and the nature of their macroeconomic dynamics.

The study is based on World Bank statistics for the period 2014–2023. The same time frame has been used for all three countries to ensure the comparability of the results. The choice of the 2014–2023 period is due to the fact that, for Ukraine, it covers a phase of prolonged security challenges, structural economic changes, a pandemic-induced recession and full-scale war. Data on military expenditure are based on the indicator "Military expenditure, % of gross domestic product", whilst data on economic dynamics are based on the indicator "gross domestic product in constant 2015 prices" (World Bank, 2026a, 2026b). The military expenditure indicator in the World Bank database is compiled using data from the Stockholm International Peace Research Institute; therefore, to verify the content of this indicator, the methodological framework of SIPRI and reviews of global military expenditure have also been taken into account (SIPRI, 2025; Liang et al., 2025; Liang et al., 2026).

The study utilises two main variables. The independent variable is defined as military expenditure as a percentage of gross domestic product. This indicator characterizes the level of the defence burden on the economy and allows for comparisons between countries with different-sized economies. The dependent variable is defined as real gross domestic product at constant 2015 prices, expressed in US dollars. Within the empirical section, this indicator is used to operationalise

economic growth, as it reflects changes in economic performance in real terms and reduces the impact of price fluctuations.

The choice of real gross domestic product as the dependent variable is also consistent with broader economic growth theory, within which long-term economic dynamics are linked to the productive base, capital accumulation, productivity and institutional conditions for development. In this context, real gross domestic product at constant 2015 prices is used as a summary measure of economic performance rather than as a complete explanation of all factors of growth (Barro & Sala-i-Martin, 2004; Mankiw et al., 1992).

At the same time, this methodological choice sets the limits for interpreting the results. Real gross domestic product at constant 2015 prices reflects the level of economic performance, whereas the rate of economic growth is a separate macroeconomic indicator. Therefore, in this article, the concept of economic growth is used in an empirical sense as the dynamics of real gross domestic product, which directly corresponds to the chosen dependent variable.

A simple linear regression model has been constructed for each country:

$$y = a + bx, \quad (1)$$

- where
- y – is real gross domestic product at constant 2015 prices;
 - x – is military expenditure as a percentage of gross domestic product; a is the intercept of the regression equation;
 - b – is the regression coefficient, which reflects the direction and average change in the dependent variable when the independent variable changes by one unit.

The use of simple linear regression is appropriate for the purpose of this study, as the article aims to provide an initial quantitative assessment of the direction and strength of the statistical relationship between the selected variables. Methodologically, this approach is based on the fundamental principles of econometric analysis, according to which a regression model allows for the estimation of the average change in the dependent variable as the independent variable changes, but does not automatically eliminate the problem of endogeneity or omitted variables (Gujarati & Porter, 2009; Stock & Watson, 2020; Wooldridge, 2020).

During the analysis, the correlation coefficient, coefficient of determination, regression coefficient, intercept, mean values of the variables, standard error of the estimate and model residuals were calculated. The correlation coefficient was used to determine the direction and strength of the statistical relationship between the variables under study. The coefficient of determination was used to assess the proportion of variation in the dependent variable that is explained by changes in the independent variable within the constructed model. The residuals of the regression model were used to identify the years in which the actual values of real gross domestic product deviated most significantly from the estimated values.

The calculations have been carried out separately for Ukraine, Turkey and Georgia. The main focus is on the Ukrainian model, whilst the results for Turkey and Georgia are used for comparative analysis. This approach allows us to assess not only the parameters of the specific model for Ukraine, but also how its results differ from those of other countries in terms of the direction of the relationship, the strength of the relationship and explanatory power.

The linear regression method is not used in this article as a tool to prove a direct causal relationship between defence expenditure and economic growth. Its purpose is to identify and quantitatively interpret the statistical relationship between the selected variables within the sample under study. This is important given that Ukraine's economic dynamics in 2014–2023 were shaped by many factors, including the war shock, changes in public finances, external financial support, investment activity and losses in productive capacity.

A limitation of the study is the use of simple linear regression and a limited time period. The model does not include additional macroeconomic variables, in particular investment, inflation, public debt, the volume of foreign aid, demographic changes and infrastructure destruction. Therefore, the results obtained should be interpreted as a preliminary quantitative assessment of the statistical relationship, rather than as an exhaustive explanation of all of Ukraine's macroeconomic dynamics.

Results

Analysis of the raw data revealed a significant change in the relationship between military expenditure as a percentage of gross domestic product and Ukraine's real gross domestic product between 2014 and 2023. Between 2014 and 2021, military expenditure remained relatively moderate, fluctuating between 2.97 % and 4.40 % of gross domestic product. However, in 2022 this figure rose to 25.88 %, and in 2023 to 36.65 %. This increase indicates a sharp rise in defence expenditure over the last two years of the period under review.

The trend in Ukraine's real gross domestic product at constant 2015 prices took a different course. Between 2014 and 2021, the figure fluctuated between US\$91.03 billion and US\$101.94 billion. The highest value of the indicator was recorded in 2019, whilst in 2022 real gross domestic product fell to US\$72.31 billion, and in 2023 stood at US\$76.31 billion. The initial trends in the indicators are shown in Table 1 and Figure 1.

Table 1: Dynamics of Military Expenditure and Real Gross Domestic Product of Ukraine in 2014–2023

Year	Military expenditure, % of gross domestic product	Real gross domestic product, billion US dollars, constant 2015 prices
2023	36.65	76.31
2022	25.88	72.31
2021	3.43	101.50
2020	4.40	98.12
2019	4.07	101.94
2018	3.64	98.78
2017	3.24	95.45
2016	3.67	93.25
2015	3.85	91.03
2014	2.97	100.89

Source: compiled by the authors based on World Bank data (2026a, 2026b).

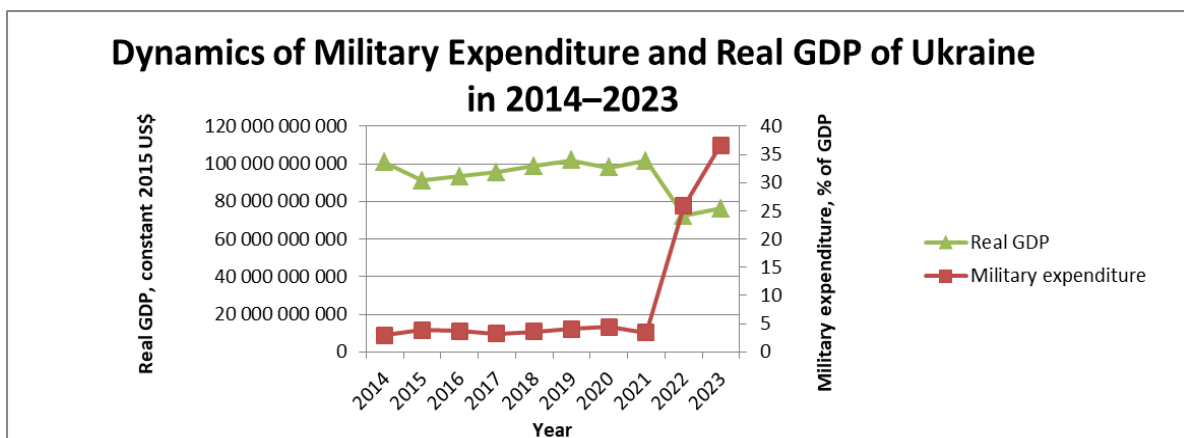


Figure 1: Dynamics of Military Expenditure and Real Gross Domestic Product of Ukraine in 2014–2023

Source: compiled by the authors based on World Bank data (2026a, 2026b).

Following an analysis of the trends in the indicators, a linear regression model was constructed for Ukraine. The results indicated a strong inverse statistical relationship between military expenditure as a percentage of gross domestic product and real gross domestic product at constant 2015 prices. The main parameters of the model are presented in Table 2.

Table 2: Main Parameters of the Linear Regression Model for Ukraine

Indicator	Value
Correlation coefficient	-0.897
Coefficient of determination	0.804
Regression coefficient	-0.789 billion US dollars
Intercept	100.20 billion US dollars
Mean value of x	9.18
Mean value of y	92.96 billion US dollars
Standard error of estimate	4.92 billion US dollars

Source: calculated by the authors based on World Bank data (2026a, 2026b).

The correlation coefficient is -0.897, indicating a strong inverse statistical relationship between the variables under study. The coefficient of determination is 0.804, meaning that 80.4% of the variation in real gross domestic product within the constructed model is explained by changes in military expenditure as a percentage of gross domestic product. The regression coefficient is -0.789 billion US dollars, which, within the model, reflects a negative relationship between the independent and dependent variables.

A graphical representation of the model confirms the downward slope of the regression line for Ukraine. This means that, in the sample under study, an increase in military expenditure as a percentage of gross domestic product was statistically associated with a decline in real gross domestic product at constant 2015 prices.

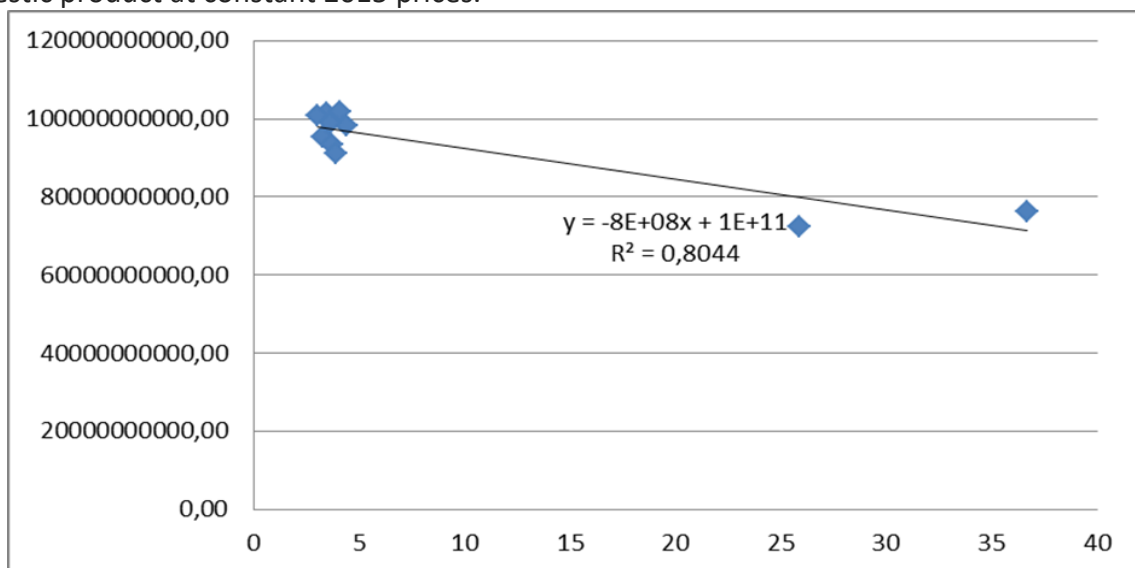


Figure 2: Linear Regression between Military Expenditure and Real Gross Domestic Product of Ukraine

Source: calculated by the authors based on World Bank data (2026a, 2026b).

To further assess the quality of the model's fit to the actual data, the residuals of the regression model were analysed. Table 3 presents the actual figures for real gross domestic product, the predicted values, the residuals and the squared residuals for Ukraine. The residuals represent the difference between the actual and predicted values of the dependent variable.

Table 3. Actual, Predicted Values and Residuals of the Regression Model for Ukraine

Year	Actual value, US dollars	Predicted value, US dollars	Residuals, US dollars	Squared residuals
2023	76311548883.90	130259652075.74	-53948103192	2910397837997730000000.00
2022	72309415409.67	92061604629.37	-19752189220	390148978970699000000.00
2021	101499127457.56	12445623868.83	89053503589	7930526501427850000000.00
2020	98118341608.39	15902019392.43	82216322216	6759523638717380000000.00
2019	101944118786.82	14723521448.53	87220597338	7607432600048060000000.00
2018	98783535744.14	13189058096.50	85594477648	7326414603773980000000.00
2017	95453762636.02	11793224625.03	83660538011	6999085620287540000000.00
2016	93253017277.09	13307666960.13	79945350317	6391259037301800000000.00
2015	91030967789.07	13943158792.54	77087808997	5942530295885310000000.00
2014	100891035818.55	10821270206.85	90069765612	8112562677346830000000.00

Source: calculated by the authors based on World Bank data (2026a, 2026b).

An analysis of the residuals shows that the model does not fit all years of the study period equally well. In 2014–2021, the residuals are positive, whereas in 2022–2023 they turn negative. This means that in 2022–2023, the actual values of real gross domestic product were lower than the model's estimated values. The dynamics of the residuals are shown in Figure 3.

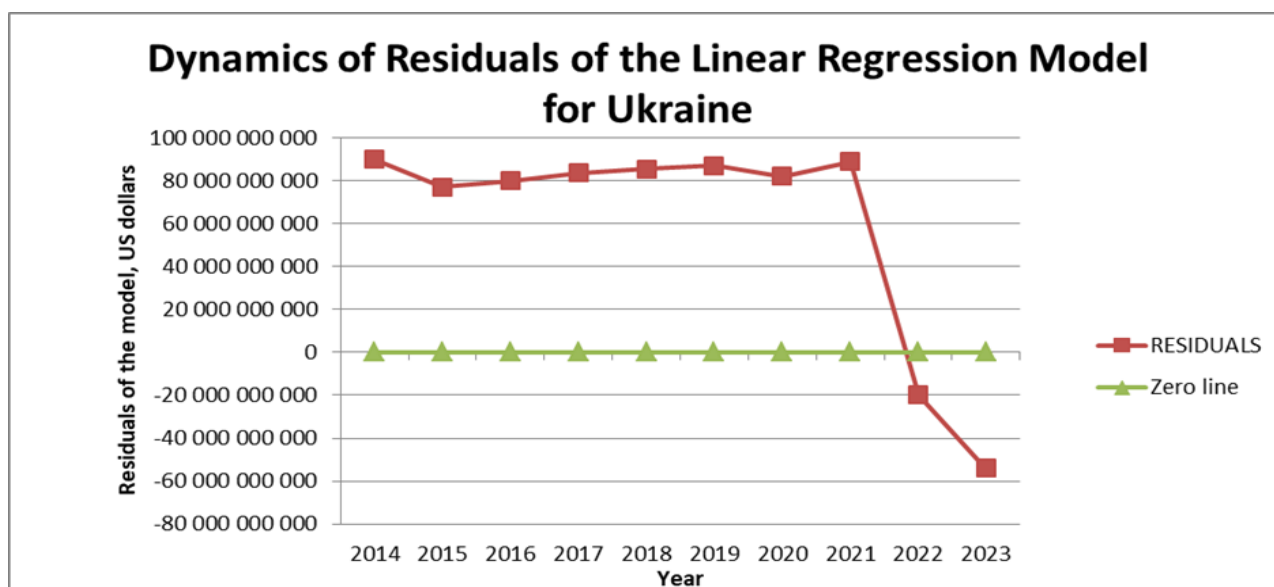


Figure 3: Dynamics of Residuals of the Linear Regression Model for Ukraine

Source: calculated by the authors based on World Bank data (2026a, 2026b).

To clarify the specific features of the Ukrainian case, the results of the regression model were compared with the corresponding models for Turkey and Georgia. A comparison of the key parameters showed that the same methodological approach yields different results for the three countries. This applies to both the direction of the relationship and its strength and explanatory power.

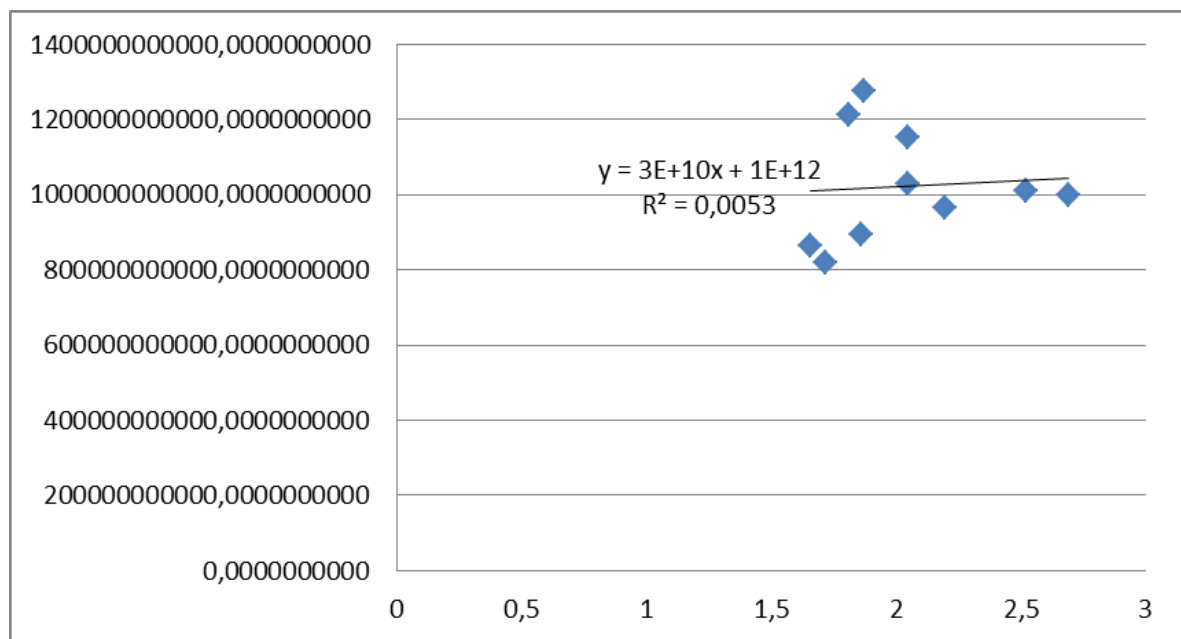
Table 4: Comparison of the Main Parameters of Regression Models for Ukraine, Turkey and Georgia

Indicator	Ukraine	Turkey	Georgia
Correlation coefficient	-0.897	0.073	0.916
Coefficient of determination	0.804	0.005	0.839
Regression coefficient, billion US dollars	-0.789	32.208	10.894
Intercept, billion US dollars	100.20	955.80	-2.28
Mean value of x	9.18	2.04	1.85
Mean value of y, billion US dollars	92.96	1021.65	17.91
Standard error of estimate, billion US dollars	4.92	158.91	1.13

Source: calculated by the authors based on World Bank data (2026a, 2026b).

For Ukraine, the correlation coefficient is -0.897, indicating a strong inverse relationship. For Turkey, this figure is 0.073, meaning the relationship is very weak and direct. The coefficient of determination for Turkey is only 0.005, indicating that the model has almost no explanatory power. For Georgia, by contrast, the correlation coefficient is 0.916 and the coefficient of determination is 0.839, indicating a strong direct statistical relationship between military expenditure as a percentage of gross domestic product and real gross domestic product.

The graphs of the regression models for Turkey and Georgia visually confirm the difference in results. For Turkey, the regression line has a weak positive slope, whereas for Georgia it is clearly upward-sloping. This distinguishes both models from the Ukrainian one, where the regression line is downward-sloping.

**Figure 4:** Linear Regression between Military Expenditure and Real Gross Domestic Product of Turkey

Source: calculated by the authors based on World Bank data (2026a, 2026b).

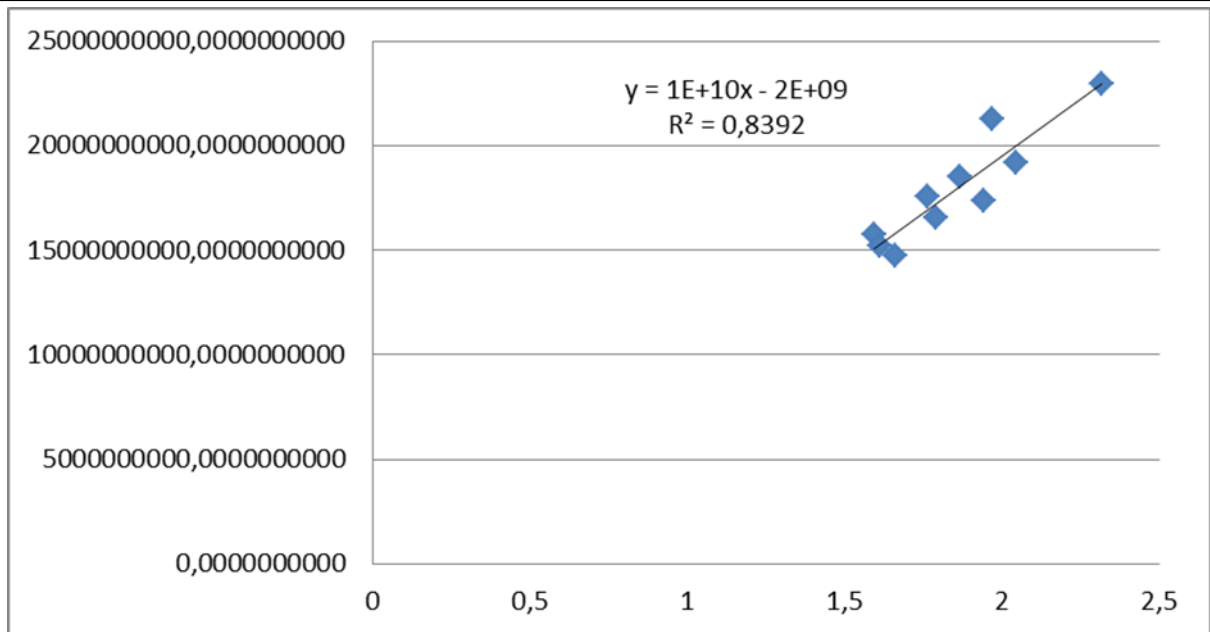


Figure 5: Linear Regression between Military Expenditure and Real Gross Domestic Product of Georgia

Source: calculated by the authors based on World Bank data (2026a, 2026b).

Thus, the results of the regression analysis allow us to identify three distinct types of statistical relationship. Ukraine shows a strong inverse relationship, Turkey a very weak positive relationship, and Georgia a strong positive relationship. At this stage, the results record precisely the statistical difference between the models; a substantive interpretation of the reasons for such differences is presented in the ‘Discussion’ section.

Discussion

The results confirm that the statistical relationship between military expenditure as a percentage of gross domestic product and real gross domestic product at constant 2015 prices is not universal. The same methodological approach applied to Ukraine, Turkey and Georgia yielded different results in terms of the direction, strength and explanatory power of the relationship. This is consistent with approaches that emphasise the context-dependence of the impact of defence expenditure on economic dynamics (Aizenman & Glick, 2006; Alptekin & Levine, 2012; Kollias & Paleologou, 2018).

A strong inverse statistical correlation has been identified for Ukraine. This result should not be interpreted as evidence that the increase in defence spending in itself caused a decline in real gross domestic product. It is more accurate to view it as a statistical reflection of a situation in which a sharp rise in defence expenditure coincided with a severe war-induced economic shock. In 2022–2023, defence expenditure as a percentage of gross domestic product rose significantly, whilst real gross domestic product remained at a considerably lower level compared to the pre-war period.

This result can be explained within the framework of the metaphor of ‘armour on the economic engine’ proposed in the article. In the context of full-scale war, defence expenditure serves as the state’s protective armour; however, the ability to sustain such protection over the long term depends on the state of the economic engine—real gross domestic product, the industrial base, fiscal sustainability and overall macroeconomic capacity. In the case of Ukraine in 2022–2023, the strengthening of the defence “armour” occurred simultaneously with the weakening of the economic “engine”, which gave rise to the inverse nature of the statistical relationship in the constructed model.

At the same time, the study’s findings do not deny the importance of defence spending for maintaining the basic conditions for the functioning of the state. On the contrary, in a state of war,

defence funding is a prerequisite for security, without which economic recovery itself becomes impossible. However, from a macroeconomic perspective, a sharp increase in the defence burden against a backdrop of falling real gross domestic product creates resource constraints that require careful analytical interpretation. This logic is consistent with studies in which defence expenditure is viewed simultaneously as a factor of security and as a potential source of budgetary and investment constraints (Becker & Dunne, 2023; Carter et al., 2021; Elgin et al., 2022).

A comparison with Turkey and Georgia shows that the direction of the relationship between the indicators under study depends on the specific economic situation of the country. In Turkey, the relationship between military expenditure as a percentage of gross domestic product and real gross domestic product proved to be very weak. This may indicate that, within the period under study, changes in the defence burden were not significantly linked to the dynamics of the country's real gross domestic product. A larger economy, a different production structure and a broader set of macroeconomic factors may have reduced the visibility of such a relationship within a simple linear model.

This finding should also be viewed within the broader context of research showing that, in countries with smaller economies, simultaneous changes in defence spending and real gross domestic product can give rise to a strong statistical correlation even in the absence of a direct causal link. Similar conclusions emerge from studies emphasising the need to account for the size of the economy, income levels, expenditure structure and the macroeconomic environment when analysing military expenditure (Antonakis, 1997; Mohanty et al., 2020; Rudy, 2022).

The results also confirm the importance of caveats regarding causality. As Saeed (2024) notes, a simple comparison of military expenditure and macroeconomic indicators does not always allow one to determine the actual direction of influence. This is particularly important for Ukraine, where the increase in defence expenditure was a response to an external military threat, rather than a routine element of budgetary policy under stable conditions. Therefore, the linear regression model in this article should be viewed as a tool for quantitatively capturing the relationship, rather than as proof of a causal link.

An analysis of the model's residuals further revealed that simple linear regression does not uniformly describe individual years within the period under study. The most noticeable change in the nature of the residuals occurred in 2022–2023, when actual real gross domestic product figures were lower than the model's projected values. This confirms that it was precisely the years of full-scale war that significantly influenced the overall nature of the Ukrainian regression model.

The practical significance of the results obtained lies in the fact that they allow the specific nature of the Ukrainian case to be quantified. The strong inverse relationship between military expenditure as a percentage of gross domestic product and real gross domestic product does not constitute a universal conclusion about the negative impact of defence on the economy. It reflects a specific situation in which the defence burden rose sharply amid a severe war-induced economic shock.

Consequently, the findings of this study should be interpreted within the specific historical, security and macroeconomic context. The Ukrainian model differs from those of Turkey and Georgia not only in the direction of the statistical relationship, but also in the conditions under which it arises. This confirms the need for further research involving an expanded set of variables and the use of more complex econometric models, which allow for the multifactorial nature of economic growth and possible feedback loops between defence expenditure and macroeconomic dynamics (Gujarati & Porter, 2009; Stock & Watson, 2020; Wooldridge, 2020).

Conclusion

This article provides a quantitative assessment of the statistical relationship between defence expenditure and economic growth in Ukraine, based on a comparative regression analysis. The research was based on World Bank data for 2014–2023 on military expenditure as a percentage of

gross domestic product and real gross domestic product at constant 2015 prices for Ukraine, Turkey and Georgia.

The results of the regression analysis showed that, for Ukraine during the period under study, a strong inverse statistical relationship emerged between military expenditure as a percentage of gross domestic product and real gross domestic product. The correlation coefficient is -0.897, and the coefficient of determination is 0.804. This indicates a strong relationship between the indicators under study within the constructed model.

At the same time, the results should not be interpreted as evidence of a direct causal link between defence spending and economic growth. The Ukrainian model reflects a specific macroeconomic situation in which a sharp increase in the defence burden in 2022–2023 was combined with a severe war-induced economic shock and a decline in real gross domestic product compared to previous years.

A comparative analysis showed that the results for Ukraine differ significantly from the models for Turkey and Georgia. For Turkey, a very weak direct link was found between the indicators under study, whereas for Georgia, a strong direct statistical link was found. This confirms that the relationship between defence expenditure and economic growth is not universal and depends on the specific economic, security and institutional context.

The scientific value of the study lies in clarifying the specifics of the Ukrainian case by combining linear regression, residual analysis and a comparative approach. The proposed interpretation, using the metaphor of 'armour on the economic engine', allows defence expenditure to be viewed not merely as a budgetary burden, but as a protective element of the state, the maintenance of which depends on the state of the economic base.

The practical significance of the findings lies in their potential use as an analytical basis for further study of the macroeconomic implications of defence spending in the context of prolonged security challenges. The findings may be useful in developing a more comprehensive approach to assessing the defence burden, one that takes into account not only the level of military expenditure but also the overall resilience of the economy.

Prospects for further research should be linked to extending the time series, incorporating additional macroeconomic variables, and applying more complex econometric models. In particular, further analysis could take into account investment, inflation, public debt, external financial assistance, demographic changes, losses to productive infrastructure, and other factors influencing a country's economic dynamics in wartime.

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Competing interests

The authors declare that they have no competing interests.

Use of Artificial Intelligence

Artificial intelligence tools were used for language editing, technical checking of text structure and consistency of wording. The authors bear full responsibility for the content of the manuscript

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