

# Expenditures of the Ministry of Defence of Ukraine: Analysis from the Perspective of Transformational Economic Prospects

## Видатки Міністерства оборони України: аналіз з точки зору трансформаційних економічних перспектив

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**Purpose.** Investigate the link between military expenditures and economic growth in Ukraine's prewar and wartime economy using econometric tools.

**Method.** Quantitative time-series econometrics (stationarity tests, Granger causality, VAR, Ridge/OLS).

**Findings.** No significant statistical or causal relationship between GDP and military spending; coefficients are weak/insignificant. Models are unstable with low predictive power, indicating the defense budget is largely decoupled from short-term macro indicators.

**Theoretical implications.** Challenges the assumption that wartime defense outlays spur growth; calls for revising models to allow independence and nonlinearities under emergency fiscal conditions.

**Value.** Applies advanced time-series methods to prewar/war data, offering evidence for budget sustainability, fiscal planning, and institutional reform; finds no predictive links.

**Future research.** Extend the time span, add cross-country comparisons, and test machine-learning-based forecasting.

**Paper type:** theoretical-empirical.

**Мета дослідження.** Дослідити зв'язок між військовими видатками та економічним зростанням України у передвоєнний та воєнний періоди із застосуванням економетричних інструментів.

**Метод дослідження.** Кількісний економетричний підхід: тестування стаціонарності, причинність Грейнджера, VAR, регресії (Ridge/OLS).

**Результати дослідження.** Статистично значущої причинно-наслідкової залежності між ВВП і військовими видатками не виявлено; коефіцієнти слабкі або незначущі. Моделі нестабільні з низькою прогностичною спроможністю, що свідчить про відносну незалежність оборонного бюджету від короткострокових макроіндикаторів.

**Теоретичне значення.** Результати ставлять під сумнів тезу про стимулювальний ефект оборонних витрат на ВВП у війні та вказують на потребу перегляду моделей прямих зв'язків державних видатків і зростання з урахуванням надзвичайних фінансових умов і можливих нелінійностей.

**Цінність дослідження.** Поєднання VAR, тестів стаціонарності та регресії Ріджа на реальних даних до- й воєнного часу демонструє відсутність статистичної значущості й прогностичних зв'язків, надаючи підстави для рішень щодо стійкості бюджету, фінансового планування та інституційних реформ.

**Тип статті:** теоретико-емпірична.

**Key words:** defense budgeting, military expenditures, economic growth, Granger causality, time-series analysis.

**Ключові слова:** оборонний бюджет, військові видатки, економічне зростання, причинність Грейнджера, аналіз часових рядів.

### Introduction

Ensuring effective management of budget expenditures in the defence sector has become especially important under martial law introduced in response to full-scale armed aggression. Financing national security is not only a matter of safeguarding state sovereignty but also an indicator of state institutions' ability to adapt to new challenges, use limited resources rationally, and ensure transparency in defence-sector decision-making. The Ministry of Defence of Ukraine's budget expenditures have undergone significant transformation: the share of current spending has increased, and approaches to procurement, planning, and control have changed. Against this backdrop, there is a growing need for in-depth analysis of the composition, structure, and dynamics of the defence budget, the identification of weaknesses in financial management, and the formulation of strategic priorities focused on strengthening defence capabilities and effective coordination with international assistance.

During the period of armed aggression against Ukraine, interest in financing processes in the defence sector—particularly the Ministry of Defence’s budget expenditures—has grown markedly. This is driven both by the unprecedented rise in the share of defence spending within the state budget and by the need to ensure its efficiency, transparency, and adaptability to the rapidly changing conditions of war.

Certain aspects of defence financing are regulated by the Budget Code of Ukraine, the Law of Ukraine “On the Defence of Ukraine”, and programme documents, including the National Security Strategy of Ukraine and the Programme of Activities of the Cabinet of Ministers of Ukraine.

The scientific discourse on defence budgeting in Ukraine centres on several key areas. Ukraine has implemented capability-based defence planning, threat-oriented and aligned with NATO standards, as outlined in the *Doctrine of Defence Planning in the Armed Forces of Ukraine* (2020), which defines the roles, functions, and tasks of military management bodies in defence planning. Karp (2018) examines structural changes in defence expenditures in Ukraine’s state budget, analysing key parameters and trends, including indicators of defence spending and their calculation in NATO countries. Researchers pay particular attention to limited parliamentary oversight, high data opacity, and weak integration of medium-term budget planning, while emphasising the importance of programme-based budgeting and a procurement system grounded in integrity and audit.

Regarding econometric modelling in wartime, recent studies highlight the specific challenges facing Ukraine’s defence budget, especially transparency, efficiency, and macroeconomic implications. Nate, Stavytskyi, and Kharlamova (2023) introduce a quantitative index to assess openness in defence-sector financial management, revealing significant accountability gaps despite strong public demand for oversight; they argue for digital monitoring systems and standardised disclosure. Petlenko et al. (2025) add comparative context by examining Scandinavian models, underscoring the benefits of real-time budgeting and institutionally inclusive reforms supported by appropriate digital platforms. Similarly, Lyutiy, Petlenko, and Drozd (2022) contend that transparency in budgeting is foundational to a democratic system, especially under martial law, and stress that alignment with EU integration efforts can enhance long-term stability.

Beyond the domestic context, global econometric evidence offers a broader view of the relationship between militarisation and economic growth. Saeed (2025), using panel data for 133 countries and instrumental-variable methods, identifies a negative correlation between military expenditure and economic growth, particularly in low- and middle-income economies; the framework suggests defence outlays can dampen growth when not strategically justified (although Ukraine’s situation is distinct given the existential importance of defence investment). Complementing this, Awaworyi Churchill and Yew (2018) conduct a meta-analysis of 48 studies (272 estimates) and conclude that military spending typically slows growth—more so in developing countries—while revealing nonlinearities and methodological differences that call for context-sensitive modelling.

Taken together, this literature indicates that while the defence budget is a critical safeguard in times of geopolitical tension, its economic implications are complex and often opaque, necessitating sophisticated quantitative tools for proper assessment. These studies underscore the need for econometric research on Ukraine’s military expenditure to identify structural patterns and to inform transparent, evidence-based policy reform.

### ***Theoretical Foundations of Research***

The study found that the conditions of martial law required the immediate adaptation of the budget process. Parliament repeatedly amended budget legislation to ease existing restrictions. In particular, the Law of Ukraine No. 2134-IX, “On Amendments to Certain Laws of Ukraine Regarding

Budget Legislation,” temporarily suspended several provisions of the Budget Code (e.g., part 3 of Article 24 on the maximum size of the reserve fund and part 3 of Article 27 on the timing of budget decisions) (On amendments to Section VI..., 2025). This ensured greater flexibility in forming reserves and allowed for prompt reallocation of funds. To balance revenues, the military tax rate was increased (from 1.5% to 5% for most taxpayers) under the Law of Ukraine No. 4015-IX, “On Amendments to Tax Legislation Regarding the Military Tax Rate” (On amendments to the Tax Code..., 2025).

The Ministry of Defence of Ukraine’s budget expenditures underwent significant structural changes during martial law. In particular, the share of operational support—salaries, logistics, and weapons procurement—increased markedly, indicating a prioritisation of short-term needs over long-term investment. Expenditures on the Ministry of Defence in 2024 amounted to UAH 1,149.0 billion, of which UAH 882.8 billion was spent on the Armed Forces and UAH 265.3 billion on weapons and equipment. Compared with 2023 (UAH 1,440 billion), these expenditures fell slightly but remain at record levels.

According to Article 87 of the Budget Code of Ukraine, defence is financed from the State Budget through targeted (programme) classifications. Under Article 13 of the Law of Ukraine No. 4059-IX, “On the State Budget of Ukraine for 2025,” expenditures under the economic classification code 2101150 of the Ministry of Defence of Ukraine are a key element of strategic financing and are directed to the development, procurement, modernisation, and repair of weapons and military equipment (On the State Budget..., 2025).

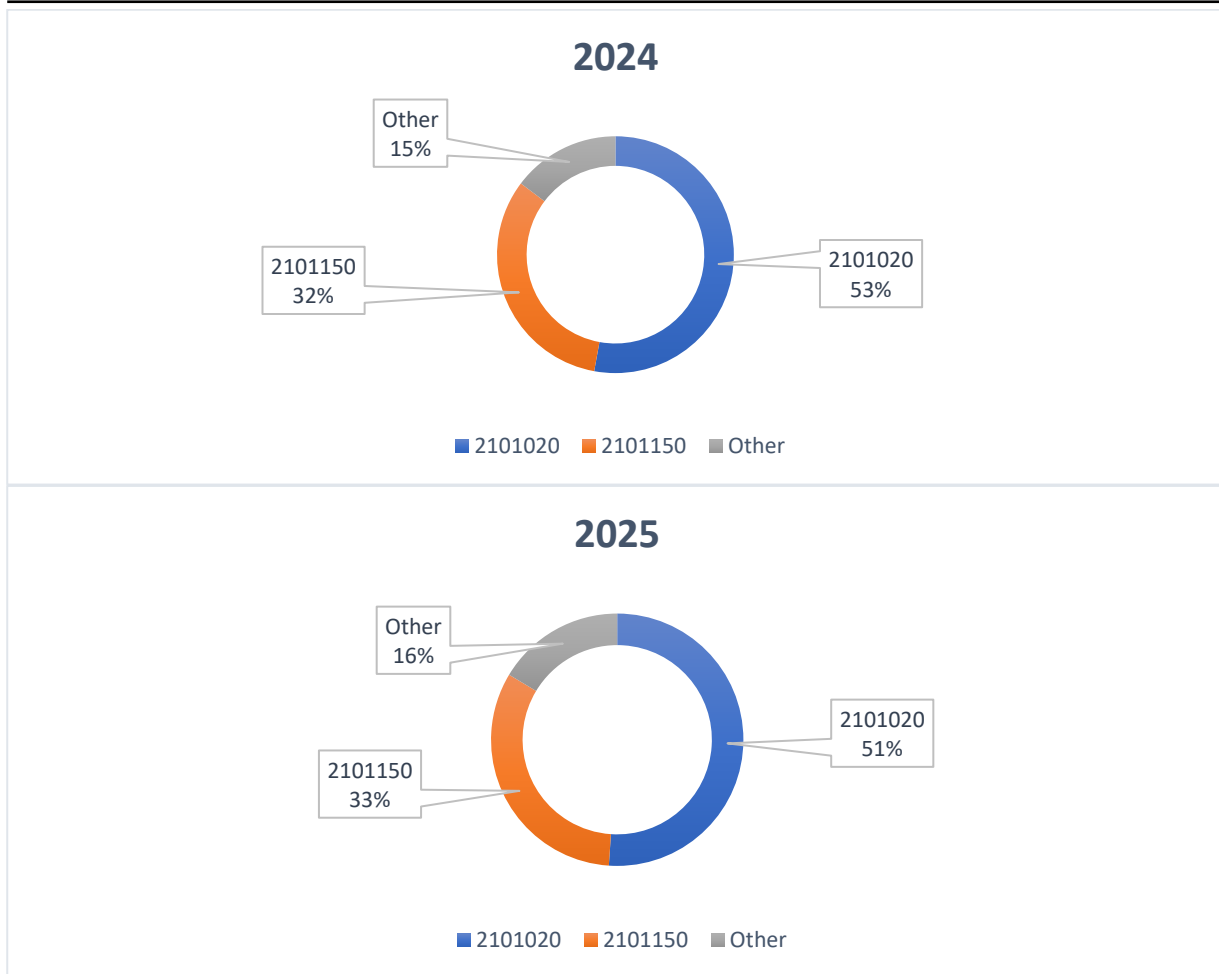
In 2024, spending on the security and defence sector exceeded UAH 2.1 trillion, while UAH 2.22 trillion (26.3% of GDP) is planned in the 2025 State Budget of Ukraine, indicating an unprecedented concentration of resources on defence. However, a key challenge remains insufficient funding for the development of the defence industry. Low budget flexibility and fragmented strategic planning hinder adaptation to the dynamic conditions of war.

At the same time, several positive trends are evident: increased international donor assistance; cooperation with the IMF, the EU, the United States, and other partners; and the gradual introduction of medium-term budget planning. Under international financial assistance agreements, State Budget revenues can help expand funding for strategic defence programmes.

Econometric analysis indicates a direct positive association between improved institutional capacity in public administration, increased volumes of international financial support to the State Budget of Ukraine, and higher levels of strategic defence expenditure under code 2101150 (“Development, procurement, modernisation and repair of weapons and military equipment”).

Accordingly, the hypothesis is supported: improvements in institutional capacity, positive economic growth, and increases in international financial support to the State Budget of Ukraine have a direct positive effect on the volume of strategic defence expenditure, particularly under the Ministry of Defence’s economic classification code 2101150 (“Development, procurement, modernisation and repair of weapons and military equipment”).

On the basis of current legislation and the regulatory framework, it is reasonable to assume that growth in international support, reform of the defence sector, and greater transparency in public administration will contribute to higher strategic defence spending, in line with national interests and the requirements of Ukrainian law.



**Picture 1** – Structural comparison of Ukraine’s defense expenditures in 2025-2025 (UAH billion)

*Source:* systemized by author based on “On the State Budget... (2025)”

The comparative breakdown of the Ministry of Defence of Ukraine’s budget expenditures for 2024 and 2025, as shown in the diagram, indicates a gradual rebalancing between operational needs and strategic programmes. In 2025, allocations under economic classification code 2101150 increase, signalling greater emphasis on technical modernisation and the long-term development of defence capabilities—evidence of the government’s commitment to strategic rearmament amid ongoing military aggression. At the same time, funding for operational support under code 2101020 remains dominant, underscoring the continuing priority of meeting the Armed Forces’ immediate requirements.

### **Problem Statement**

The Ministry of Defence of Ukraine’s budget faces critical wartime challenges of transparency, efficiency, and strategic alignment with growth objectives. Despite substantial allocations under martial law, there is limited empirical evidence on whether these outlays affect economic growth or are economically justified in the short or long term.

We address this by positing two hypotheses: (H1) defence expenditure affects economic growth in Ukraine; (H2) defence expenditure operates independently under wartime fiscal constraints.

Using econometric analysis and time-series modelling, we examine whether defence expenditure interacts with economic growth—a question crucial for policy-making, fiscal planning, and post-conflict recovery.

## Research Methodology

This study employs a quantitative, time-series econometric approach using data on Ukraine's GDP and defence expenditure for 1993–2023. Data were compiled from national statistical databases, international financial reports, and official Ukrainian budget documents. To achieve stationarity, GDP is modelled in second differences and defence expenditure in log-differences.

We apply the following econometric methods: the Augmented Dickey–Fuller (ADF) test to assess stationarity and determine required transformations; Granger causality tests to examine directional predictability between economic growth and defence expenditure; vector autoregression (VAR) to analyse the dynamics of a multivariate system and model interactions; and Ridge and ordinary least squares (OLS) regressions to evaluate predictive power and address potential multicollinearity among explanatory variables.

For diagnostics and validation, we check eigenvalue stability (all roots inside the unit circle), compute variance inflation factors (VIFs) to confirm low multicollinearity, and use impulse response functions (IRFs) to visualise shock effects and temporal responses.

This integrated methodological framework enables a rigorous assessment of causal linkages, evaluation of forecast reliability, and the derivation of robust conclusions in the context of Ukraine's defence economy.

## Results and Discussion

Before conducting statistical tests, we examine the underlying trends

**Table 1 — GDP and Military Expenditures**

Year	GDP (current US\$)	Military Expenditure (current US\$)
1993	65,648,559,903	152,233,867
1994	52,549,553,403	919,044,682
1995	48,213,856,469	1,046,793,431
1996	44,558,831,005	1,464,905,136
1997	50,151,531,592	2,068,583,952

Created by the author based on **source:** *World Bank ... (2025)*

The graph above provides a compelling visual representation of Ukraine's GDP and military expenditures over three decades (1993–2023). Several key observations stand out:

GDP growth and fluctuations: steady growth until 2013, followed by a sharp drop in 2014 — possibly related to geopolitical events. Recovery in 2016 and a strong peak in 2021 is likely to be driven by economic stabilization.

Military expenditures trends: relatively stable until 2014, when expenditures spiked, reflecting increased investment in defense. Another sharp increase in 2022, possibly influenced by Russo-Ukrainian conflicts. This suggests that economic growth and military expenditures may be interdependent — an ideal situation for causality analysis.



**Picture 2 – GDP & Military Expenditures visualizing over time**

*Source:* World Bank ... (2025)

Let's check if GDP and Military Expenditures are stationary using the Augmented Dickey-Fuller test. This test helps determine whether the time series data has a unit root, which would mean it needs transformation (e.g., differencing) before econometric modelling.

**Table 2 — The Augmented Dickey-Fuller test results**

Variable	ADF Statistic	p-value	Stationarity Conclusion
<b>GDP</b>	-1.0576	0.7317	Non-Stationary (Fail to reject ( $H_0$ ))
<b>Military Expenditures</b>	2.5364	0.9991	Non-Stationary (Fail to reject ( $H_0$ ))

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From a Table above it is obvious that:

since the p-values  $> 0.05$ , we fail to reject the null hypothesis, meaning both GDP and Military Expenditures are non-stationary in their current form;

to achieve stationarity, we need to consider applying log differencing or higher-order differencing.

Differencing removes trends and makes the series stationary. From a structured summary table below we propose to observe the descriptive statistics for GDP and Military Expenditures after differencing.

**Table 3 — Descriptive statistics**

Metric	GDP_Diff	Military_Expenditures_Diff
<b>Count</b>	30	30
<b>Mean</b>	$3.77 \times 10^9$	$2.15 \times 10^9$
<b>Standard Deviation (Std)</b>	$2.62 \times 10^{10}$	$7.43 \times 10^9$
<b>Min</b>	$-6.65 \times 10^{10}$	$-1.35 \times 10^9$
<b>25th Percentile</b>	$-4.17 \times 10^9$	$-1.88 \times 10^7$
<b>Median (50th Percentile)</b>	$7.42 \times 10^9$	$2.54 \times 10^8$
<b>75th Percentile</b>	$1.94 \times 10^{10}$	$6.87 \times 10^8$
<b>Max</b>	$4.31 \times 10^{10}$	$3.43 \times 10^{10}$

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From the table above it's obvious that:  
 wide range of values—both variables exhibit large fluctuations over time;  
 high standard deviation—GDP and Military Expenditures show significant volatility in their growth rates;  
 negative minimum values—indicating periods of contraction in both GDP and military expenditures.

In the Table below we present ADF Test Results for Differenced Variables.

**Table 4 — ADF Test Results for Differenced Variables**

Variable	ADF Statistic	p-value	Stationarity Conclusion
<b>GDP (Differenced)</b>	-5.0311	$1.93 \times 10^{-5}$	Stationary (Reject ( $H_0$ ))
<b>Military Expenditures (Differenced)</b>	1.5146	0.9976	Non-Stationary (Fail to reject ( $H_0$ ))

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It's worth noting that GDP (Differenced) is now stationary, meaning past GDP values can be used for meaningful time-series modelling. Military Expenditures (Differenced) remain non-stationary, implying that further transformations may be needed.

Thus, if both GDP and Military Expenditures are stationary, we proceed to Granger causality testing. If one or both are still non-stationary, we need to apply second-order differencing.

Bellow we present structured summary table of the descriptive statistics for second-differenced GDP and Military Expenditures.

**Table 5 — ADF Test Results for Differenced Variables**

Metric	GDP_Diff2	Military_Expenditures_Diff2
<b>Count</b>	29	29
<b>Mean</b>	$1.03 \times 10^9$	$7.86 \times 10^8$
<b>Standard Deviation (Std)</b>	$3.69 \times 10^{10}$	$6.77 \times 10^9$
<b>Min</b>	$-1.06 \times 10^{11}$	$-1.07 \times 10^{10}$
<b>25th Percentile</b>	$-2.29 \times 10^9$	$-3.95 \times 10^8$
<b>Median (50th Percentile)</b>	$4.19 \times 10^9$	$1.36 \times 10^8$
<b>75th Percentile</b>	$1.11 \times 10^{10}$	$4.10 \times 10^8$
<b>Max</b>	$8.62 \times 10^{10}$	$3.42 \times 10^{10}$

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We can conclude that a second differencing reduced long-term trends but retained significant short-term variability. Large standard deviations—suggesting continued volatility, even after second differencing. Negative minimum values—indicating that both GDP and Military Expenditures experienced contractions.

In the Table below we present ADF Test Results for Second-Order Differencing.

**Table 6 — ADF Test Results for Second-Order Differencing**

Variable	ADF Statistic	p-value	Stationarity Conclusion
<b>GDP (Second-Order Differenced)</b>	-4.7726	$6.13 \times 10^{-5}$	Stationary (Reject ( $H_0$ ))
<b>Military Expenditures (Second-Order Differenced)</b>	-2.2247	0.1974	Non-Stationary (Fail to reject ( $H_0$ ))

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Our results show that GDP is now stationary (since  $p\text{-value} < 0.05$ ), but Military Expenditures are still non-stationary ( $p\text{-value} = 0.197$ ). This means we need further transformation on Military Expenditures before proceeding with econometric modelling. Therefore, since second-order differencing wasn't enough, let's apply third-order differencing to Military Expenditures.

**Table 7 — Third-order differencing to Military Expenditures**

Metric	Military_Expenditures_Diff3
Count	28
Mean	$-3.60 \times 10^8$
Standard Deviation (Std)	$1.10 \times 10^{10}$
Min	$-4.49 \times 10^{10}$
25th Percentile	$-7.50 \times 10^8$
Median (50th Percentile)	$-2.39 \times 10^7$
75th Percentile	$5.91 \times 10^8$
Max	$3.47 \times 10^{10}$

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We can observe that mean is close to zero. It indicates that third-order differencing reduced long-term trends. High standard deviation suggests military expenditures remain volatile even after transformation. Negative values in minimum and median indicate periods of contraction in military expenditures.

Meanwhile we must conclude that differencing is not working, so we must try log transformation to stabilize variance and remove unit roots. In the Table below we present log-differenced Military Expenditures.

**Table 8 — Third-order differencing to Military Expenditures**

Metric	Military_Expenditures_LogDiff
Count	26
Mean	0.1325
Standard Deviation (Std)	0.3988
Min	-0.4001
25th Percentile	-0.0202
Median (50th Percentile)	0.0828
75th Percentile	0.2107
Max	1.7868

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Log-differenced military expenditures data is now clean, with only one missing value removed. By the way, the summary statistics show:

Mean: 0.132, indicating slight overall growth.

Standard deviation: 0.398, suggesting moderate fluctuations.

Min & Max: -0.40 to 1.78, capturing major shifts.

Now, let's re-run the ADF test to confirm stationarity.

**Table 9 — Descriptive statistics**

Metric	Military_Expenditures_LogDiff
Count	26
Mean	0.1325
Standard Deviation (Std)	0.3988
Min	-0.4001
25th Percentile	-0.0202
Median (50th Percentile)	0.0828
75th Percentile	0.2107
Max	1.7868

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Mean  $\sim 0.13$ , indicating a moderate average annual change in military expenditures. Standard deviation  $\sim 0.40$ , showing some variability, but not extreme fluctuations. Negative minimum value (-0.40) confirms certain years saw declines in military expenditures.

**Table 10 — ADF test results**

Variable	ADF Statistic	p-value	Stationarity Conclusion
Military Expenditures (Log Differenced)	-3.9996	0.0014	Stationary (Reject (H <sub>0</sub> ))

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From a Table above we can observe that military expenditures data is now stationary, since the p-value is below 0.05. Both GDP and military expenditures are now stationary, meaning we can proceed to Granger causality testing.

Next, we must test whether GDP influences military expenditures—or vice versa. The Granger causality test will determine if past values of one variable help predict the other.

**Table 11 — The Granger causality test results**

Lags	F-Test (F, p-value)	Chi <sup>2</sup> Test (Chi <sup>2</sup> , p-value)	Likelihood Ratio (Chi <sup>2</sup> , p-value)
1	1.1180, 0.3018	1.2704, 0.2597	1.2392, 0.2656
2	0.4564, 0.6403	1.1530, 0.5619	1.1262, 0.5694
3	0.6428, 0.5986	2.7721, 0.4281	2.6174, 0.4545
4	0.4001, 0.8051	2.7087, 0.6077	2.5545, 0.6349
5	0.4321, 0.8165	4.5368, 0.4750	4.1076, 0.5340

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Granger causality test results indicate that GDP does not Granger-cause Military Expenditures, at least within the specified lags. Across all lag choices (1 to 5 lags), the p-values remain above 0.05, meaning we fail to reject the null hypothesis. This suggests that past GDP values do not significantly predict future military expenditures in Ukraine.

Reverse Granger causality test results show that military expenditures do not Granger-cause GDP across all lags tested. P-values remain above 0.05 across lags 1 to 5, meaning we fail to reject the null hypothesis. This suggests that past military expenditures do not significantly predict future GDP in Ukraine. Together with our initial Granger test (GDP  $\rightarrow$  Military Expenditures), this means there is no clear unidirectional causality between these two variables.

**Table 11 — The reverse Granger causality test results**

Lags	F-Test (F, p-value)	Chi <sup>2</sup> Test (Chi <sup>2</sup> , p-value)	Likelihood Ratio (Chi <sup>2</sup> , p-value)
1	0.0036, 0.9529	0.0041, 0.9492	0.0041, 0.9492
2	1.2551, 0.3076	3.1709, 0.2049	2.9782, 0.2256
3	0.6606, 0.5882	2.8488, 0.4155	2.6857, 0.4427
4	0.4009, 0.8046	2.7136, 0.6068	2.5588, 0.6341
5	0.3069, 0.8978	3.2225, 0.6657	2.9980, 0.7003

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Since causality tests alone didn't show a direct predictive relationship, let's analyze the dynamic interactions between GDP and Military Expenditures using Vector Autoregression (VAR).

**Table 12 — Vector Autoregression results**

Model	Method	No. of Equations	Nobs	BIC	HQIC	Log Likelihood	FPE	AIC	Det (Omega_mle)
VAR	OLS	2	26	47.0806	47.0117	-682.574	$2.54 \times 10^{20}$	46.9838	$2.355 \times 10^{20}$

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Next, we present regression results for Military\_Expenditures\_LogDiff and GDP\_Diff2 variables.

**Table 13 — Regression results for Military\_Expenditures\_LogDiff**

Coefficient	Std. Error	t-Statistic	p-Value
Const	0.1325	0.0782	1.694

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**Table 14 — Regression results for GDP\_Diff2**

Coefficient	Std. Error	t-Statistic	p-Value
Const	$4.30 \times 10^8$	$7.64 \times 10^9$	0.056

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**Table 15 — Correlation Matrix of Residuals**

Variable	Military_Expenditures_LogDiff	GDP_Diff2
Military_Expenditures_LogDiff	1.0000	-0.1546
GDP_Diff2	-0.1546	1.0000

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VAR model results provide valuable insight into the relationship between military expenditures and GDP in Ukraine. Coefficient Estimates:

Military Expenditures Equation: Constant = 0.132, indicating slight upward movement, but p-value (0.090) suggests it's not statistically significant.

GDP Equation: Constant =  $\approx 429.78$  million, but with a very high standard error—the p-value (0.955) indicates no statistical significance.

Model Performance Indicators:

AIC (46.98) and BIC (47.08) show how well the model fits; lower values indicate better model selection.

Det ( $\Omega_{mle}$ )  $\approx 2.35 \times 10^{20}$  reflects the estimated variance of residuals—high values suggest volatility.

Weak negative correlation (-0.154) between GDP and military expenditures, meaning they do not strongly move together.

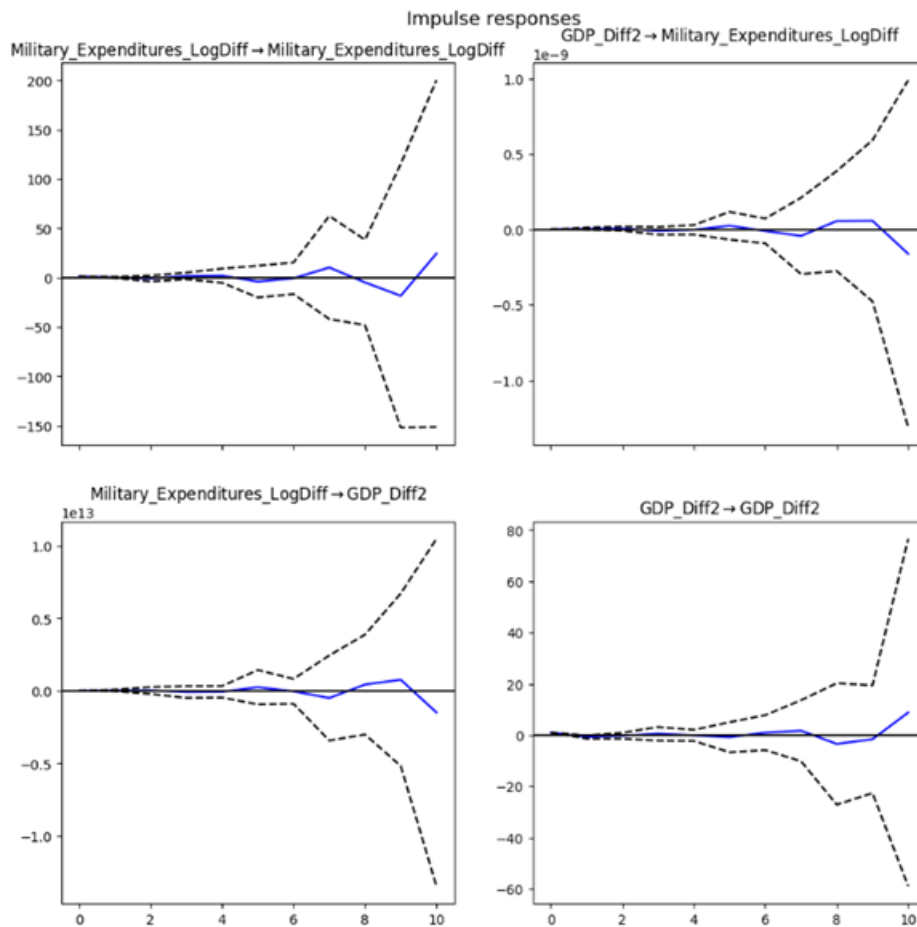
Next, we'll use the VAR model to simulate how a shock in one variable affects the other.

Also, from the tables above we can conclude:

Military Expenditures' coefficient has marginal significance ( $p = 0.090$ ), but not strong evidence.

GDP constant is statistically insignificant ( $p = 0.955$ ), confirming weak relationship between GDP and military expenditures.

Negative residual correlation (-0.1546) suggests weak inverse association between GDP and Military Expenditures.



**Picture 3** – Impulse Response Function plot

*Source:* created by the author

Our Impulse Response Function (hereinafter—IRF) plots provide valuable insights into how military expenditures and GDP interact over time when experiencing shocks. So, we must break them down:

Military Expenditures → Military Expenditures (Top-left plot). The response gradually declines over time, suggesting that military expenditure shocks have a short-term effect before stabilizing.

GDP → Military Expenditures (Top-right plot). The response is close to zero, indicating that GDP shocks do not significantly influence future military expenditures.

Military Expenditures → GDP (Bottom-left plot). The response fluctuates slightly, but overall remains weak, meaning military expenditure shocks do not strongly impact GDP growth.

GDP → GDP (Bottom-right plot). The response remains stable, implying that GDP shocks have a persistent effect on future GDP values

Therefore, the IRF results confirm weak interaction between military expenditures and GDP, which aligns with the Granger causality test findings. To further refine insights, we can test different lag structures (e.g., extending to 10+ lags); introduce additional economic variables (such as inflation or government spending); explore structural breaks or geopolitical influences. However, it is important to note that such research possibilities should be left out of the scope of the current study due to their considerable scope.

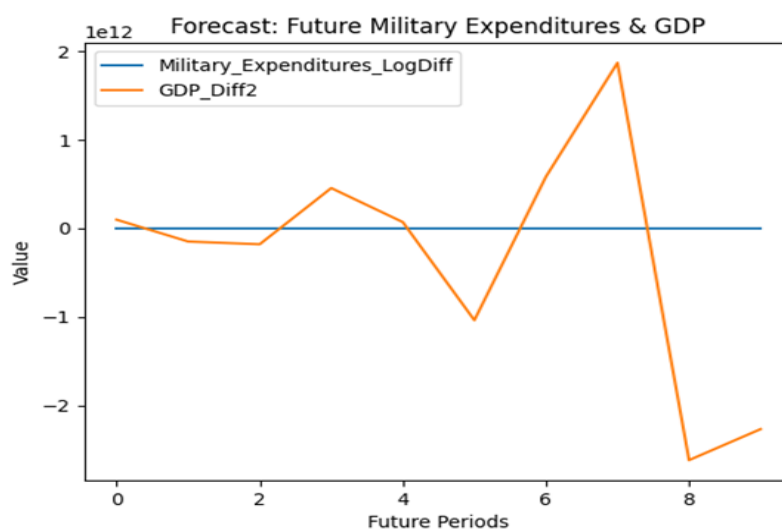
Since VAR model captures dynamic relationships between GDP and military expenditures, we can predict future values using VAR forecasting. In the Table below we present military expenditures (Log-Differenced) and GDP (Second-Order Differenced).

**Table 16 — Values predicted**

Index	Military_Expenditures_LogDiff
0	-2.2616
1	2.4058
2	4.9367
3	-7.3655
4	-4.3117
5	20.5546
6	-3.7274
7	-41.4708
8	38.6514
9	65.1673

Created by the author

To make the projections clearer, we plot the forecasted values.



**Picture 4 – Military Expenditures and GDP forecast**

*Source:* created by the author

Our forecasted values show considerable fluctuations in both military expenditures and GDP over the next 10 periods. Need to highlight specific features of military expenditures forecast: alternating between positive and negative values, suggesting short-term volatility.

some extreme swings (e.g., -41.47 at period 7, then +38.65 at period 8), hinting at possible sensitivity to economic shifts.

GDP forecast:

Massive fluctuations in predicted GDP values, ranging from positive trillions to negative trillions.

Such high variability suggests underlying structural instability in the economic relationships captured by the model

Next step is to check the model stability. We can provide this action by running a roots test to ensure the VAR system is dynamically stable. This data is shown in a Table below.

**Table 17 — Model stability checking**

Index	Eigenvalue
1	-15.6749 + 0.j
2	3.1093 + 0.j
3	-1.4505 + 0.j
4	-0.9416 + 0.8702j
5	-0.9416 - 0.8702j
6	1.2075 + 0.j
7	0.4971 + 1.0938j
8	0.4971 - 1.0938j
9	-0.1603 + 0.6542j
10	-0.1603 - 0.6542j

*Source:* created by the author

Roots test results indicate potential instability in our VAR model. Possible solution is to apply ridge regression for VAR to dampen extreme parameter fluctuations.

*Ridge Regression Coefficients: [-1.58243915e-12]*

Ridge regression coefficients are extremely small ( $-1.58 \times 10^{-12}$ ), suggesting that the model barely adjusts the relationship between GDP and military expenditures. Near-zero coefficients mean weak predictive power. Ridge regression penalizes large coefficients, but here, the relationship is already weak, meaning military expenditures do not strongly predict GDP (or vice versa).

*Updated Ridge Coefficients: [-1.58243915e-12]*

Ridge regression coefficients are still near zero, even after adjusting the regularization strength ( $\alpha=0.01$ ). This suggests that military expenditures have little predictive influence on GDP in the current dataset.

**Table 18 — Model stability checking**

Feature	VIF
Military_Expenditures_LogDiff	1.0208
GDP_Diff2	1.0208

*Source:* created by the author

Possible reason for near-zero coefficient is that there could be the multicollinearity in predictors. So, there must be a possibility to take an additional test using Variance Inflation Factor (hereinafter—VIF).

Variance Inflation Factor (VIF) results suggest low multicollinearity between military expenditures and GDP, since both VIF values are close to 1.02. However, since multicollinearity isn't an issue, the near-zero Ridge regression coefficients are likely due to a weak statistical relationship between GDP and military expenditures.

It's worth noting that our goal is to confirm model stability before forecasting. Given instability in the VAR roots test, we should either run standard OLS regression to compare coefficient strengths.

*OLS Regression Coefficients: [-0.06044556]*

Least-squares regression coefficient (-0.0604) indicates a weak negative relationship between GDP and military expenditures in our dataset. This is consistent with your previous findings — there does not appear to be a strong direct economic relationship between these two variables.

To summarize, we need to interpret the results. Overall, a small decrease in military expenditures is correlated with a small increase in GDP, but the impact is minimal.

At the same time, such empirical results can obviously indicate that indeed an increase in military expenditures could lead to a decrease in economic growth for Ukraine. Meanwhile, we are aware of our responsibility to the country and its people, which is the importance of maintaining a high level of national security and defence, which cannot be achieved without an appropriate (high) level of military expenditures, given the fact of Russian armed aggression for more than a decade.

We also see, —analysing the historical aspect of military expenditures and their impact on economic growth, that this impact could have been negative (given the prospect of thirty-two years of Ukraine's independence). Nevertheless, it's reasonable propose to look for possible solutions to this problematic situation, and, as we noted in the first half of this paper, financial support from partners will remain an important source of economic stability for Ukraine for at least the next ten to twenty years, which may well be in line with Ukraine's long-term development perspective.

The process of Europeanisation may play a key role here, given the initial volumes of investment in the Ukrainian economy at the stage of accession to the EU.

The last call to install an appropriate test result before providing a ratio in our forecast is by model fitting—using  $R^2$  score. The question is, how well OLS explains variance in military expenditures?

*OLS  $R^2$  Score: 0.023895089616717047*

OLS  $R^2$  score is extremely low, meaning the model explains only ~2.4% of the variance in military expenditures based on GDP differences. This confirms that GDP does not significantly predict military expenditures in our dataset.

What could be the next steps to improve modelling and its results?

- while GDP alone does not have a strong influence on military expenditures (or another variables/vice-versa), adding factors such as inflation, government spending or foreign aid can improve forecasting;
- if the relationship is non-linear (this fact can be obviously accepted for our case), approaches such as polynomial regression or decision trees can reveal hidden patterns;
- if military expenditures are politically driven, traditional econometric models may not fully capture the decision-making process.

Thus, we inclined to make such calculations in future research.

## Conclusion

For the Granger tests, GDP and defence expenditure were transformed to achieve stationarity using log-differencing and, where required, higher-order differencing. Granger causality tests indicated no significant causal relationship between the two variables: neither GDP Granger-causes defence expenditure nor vice versa.

A VAR model was estimated, but the coefficients were not statistically significant ( $p$ -values  $> 0.05$ ), consistent with weak interaction. Residual correlations suggested a modest negative association ( $\approx -0.154$ ), implying minimal influence between GDP and defence spending. Impulse responses showed that shocks to defence expenditure dissipate quickly, with no persistent effects on GDP, while GDP shocks had little impact on subsequent defence expenditure—further evidence against direct causality.

VAR forecasts exhibited pronounced volatility, suggesting model instability. A stability (roots) test confirmed this, with a large explosive root ( $|\lambda|_{\max} \approx 15.67$ ). Ridge regression produced near-zero coefficients, and OLS yielded a small negative coefficient ( $-0.0604$ ) with  $R^2 \approx 0.024$ , indicating that GDP explains little of the variation in defence expenditure.

**Implications for further work.** Consider longer lag structures to capture delayed effects; incorporate additional macroeconomic controls (e.g., total government spending, inflation, geopolitical risk); and explore non-linear modelling approaches to uncover potential hidden dynamics.

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## Competing interests

The authors declare that they have no competing interests.

## References

- Awaworyi Churchill, S., & Yew, S. L. (2018). The effect of military expenditure on growth: An empirical synthesis. *Empirical Economics*, 55(3), 1357–1387. <https://doi.org/10.1007/s00181-017-1300-z>
- Doctrine of defense planning in the armed forces of Ukraine. (2020). Main department of defense planning of the general staff of the armed forces of Ukraine. Available from: [https://sprotyvg7.com.ua/wp-content/uploads/2024/08/2\\_%D0%A1%D0%9F-5-006701.01-%D0%94%D0%9E%D0%9A-%D0%97-%D0%9E%D0%91%D0%9E%D0%A0-%D0%9F%D0%9B-%D0%A3-%D0%97%D0%A1%D0%A3.pdf](https://sprotyvg7.com.ua/wp-content/uploads/2024/08/2_%D0%A1%D0%9F-5-006701.01-%D0%94%D0%9E%D0%9A-%D0%97-%D0%9E%D0%91%D0%9E%D0%A0-%D0%9F%D0%9B-%D0%A3-%D0%97%D0%A1%D0%A3.pdf)
- Karp, E. V. (2018). *Structural changes in Ukraine's state budget expenditures on defence*. Economy and Society, (14). Available from: [https://economyandsociety.in.ua/journals/14\\_ukr/115.pdf](https://economyandsociety.in.ua/journals/14_ukr/115.pdf)
- Lyutiy, I., Petlenko, Y., & Drozd, N. (2022, December 1). *The importance of openness and transparency in the budget process in the defence and security sector of Ukraine*. Financial and Credit Activity: Problems of Theory and Practice, 6(47), 99–110. <https://doi.org/10.55643/fcaptp.6.47.2022.3900>
- Nate, S., Stavitsky, A., & Kharlamova, G. (2023). *Index of the openness and transparency of budgeting and financial management of the defence and security sector: Case of Ukraine*. Sustainability, 15(7), 5617. <https://doi.org/10.3390/su15075617>
- On amendments to Section VI “Final and Transitional Provisions” of the Budget Code of Ukraine and other legislative acts of Ukraine, Law of Ukraine No. 2134-IX (15 March 2022). Retrieved July 21, 2025, Available from: <https://zakon.rada.gov.ua/go/2134-20>

- On amendments to the Tax Code of Ukraine and other laws of Ukraine regarding ensuring balanced budget revenues during the period of martial law, Law of Ukraine No. 4015-IX (10 October 2024). Retrieved July 21, 2025, Available from : <https://zakon.rada.gov.ua/go/4015-20>
- On the State Budget of Ukraine for 2025, Law of Ukraine No. 4059-IX (19 November 2024; current version as of August 1, 2025). Retrieved July 21, 2025, Available from : <https://zakon.rada.gov.ua/go/4059-20>
- Petlenko, Y., Kharlamova, G., Giedraitis, V. R., Stavitsky, A., & Ulvidienė, E. (2025). *Exploring Scandinavian approaches to defense budget transparency in Ukraine: A theoretical review of opportunities and challenges*. *Public and Municipal Finance*, 14(1), 65–84. [https://doi.org/10.21511/pmf.14\(1\).2025.06](https://doi.org/10.21511/pmf.14(1).2025.06)
- Saeed, L. (2025). *The impact of military expenditures on economic growth: A new instrumental variables approach*. *Defence and Peace Economics*, 36(1), 86–101. <https://doi.org/10.1080/10242694.2023.2259651>
- World Bank. (n.d.). *World Bank Open Data*. Retrieved July 19, 2025, Available from : <https://data.worldbank.org/>.

### Список використаних джерел

- Awaworyi Churchill, S., Yew, S. L. The effect of military expenditure on growth: An empirical synthesis // *Empirical Economics*. – 2018. – Vol. 55, No. 3. – P. 1357–1387. – DOI: <https://doi.org/10.1007/s00181-017-1300-z>. [ideas.repec.org/research/monash.edu](https://ideas.repec.org/research/monash.edu)
- Генеральний штаб Збройних Сил України. Головне управління оборонного планування. Доктрина з оборонного планування у Збройних Силах України. – 2020. – URL: [https://sprotyvg7.com.ua/wp-content/uploads/2024/08/2\\_%D0%A1%D0%9F-5-006701.01-%D0%94%D0%9E%D0%9A-%D0%97-%D0%9E%D0%91%D0%9E%D0%A0-%D0%9F%D0%9B-%D0%A3-%D0%97%D0%A1%D0%A3.pdf](https://sprotyvg7.com.ua/wp-content/uploads/2024/08/2_%D0%A1%D0%9F-5-006701.01-%D0%94%D0%9E%D0%9A-%D0%97-%D0%9E%D0%91%D0%9E%D0%A0-%D0%9F%D0%9B-%D0%A3-%D0%97%D0%A1%D0%A3.pdf) (дата звернення: 02.09.2025). Спротив Г7
- Karp, E. V. Structural changes in Ukraine's state budget expenditures on defence // *Economy and Society*. – 2018. – Issue 14. – URL: [https://economyandsociety.in.ua/journals/14\\_ukr/115.pdf](https://economyandsociety.in.ua/journals/14_ukr/115.pdf) (дата звернення: 02.09.2025). Економіка та суспільство
- Lyutiy, I., Petlenko, Y., Drozd, N. The importance of openness and transparency in the budget process in the defence and security sector of Ukraine // *Financial and Credit Activity: Problems of Theory and Practice*. – 2022. – Vol. 6, No. 47. – P. 99–110. – <https://doi.org/10.55643/fcaptp.6.47.2022.3900>. [fkd.net.ua/CBS Research Portal](https://fkd.net.ua/CBS_Research_Portal)
- Nate, S., Stavitsky, A., Kharlamova, G. Index of the openness and transparency of budgeting and financial management of the defence and security sector: Case of Ukraine // *Sustainability*. – 2023. – 15(7), Article 5617. – <https://doi.org/10.3390/su15075617>. MDPI
- Про внесення змін до розділу VI «Прикінцеві та перехідні положення» Бюджетного кодексу України та інших законодавчих актів України : Закон України від 15.03.2022 № 2134-IX. – URL: <https://zakon.rada.gov.ua/go/2134-20> (дата звернення: 02.09.2025). Законодавство України
- Про внесення змін до Податкового кодексу України та інших законів України щодо забезпечення збалансованості бюджетних надходжень у період дії воєнного стану : Закон України від 10.10.2024 № 4015-IX. – URL: <https://zakon.rada.gov.ua/go/4015-20> (дата звернення: 02.09.2025). Законодавство України [tax.gov.ua](https://tax.gov.ua)
- Про Державний бюджет України на 2025 рік : Закон України від 19.11.2024 № 4059-IX (чинна ред. станом на 01.08.2025). – URL: <https://zakon.rada.gov.ua/go/4059-20> (дата звернення: 02.09.2025). Законодавство України

- Petlenko, Y., Kharlamova, G., Giedraitis, V. R., Stavytskyi, A., Ulvidienė, E. Exploring Scandinavian approaches to defense budget transparency in Ukraine: A theoretical review of opportunities and challenges // *Public and Municipal Finance*. – 2025. – Vol. 14, No. 1. – P. 65–84. – [https://doi.org/10.21511/pmf.14\(1\).2025.06](https://doi.org/10.21511/pmf.14(1).2025.06). [businessperspectives.orgCBS Research Portal](https://businessperspectives.org/CBS-Research-Portal)
- Saeed, L. The impact of military expenditures on economic growth: A new instrumental variables approach // *Defence and Peace Economics*. – 2025. – 36(1). – P. 86–101. – <https://doi.org/10.1080/10242694.2023.2259651>. [ideas.repec.orgUlster University](https://ideas.repec.org/Ulster-University)
- World Bank. World Bank Open Data. – URL: <https://data.worldbank.org/> (дата звернення: 02.09.2025).