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MINISTRY OF DEFENCE EXPENDITURES IMPACT ON ECONOMIC GROWTH OF UKRAINE

Background. ***With the start of the second stage of the Russian-Ukrainian war, the Government of Ukraine and its military command faced an objective examination of the results of years of efforts to develop Ukraine's national security and defence sector. At the same time as defence capability was being enhanced, economic performance was on the rise. This led us to test the hypothesis of whether the increased defence capability caused this growth. This study aims to clarify the relationship between military expenditures and economic growth in Ukraine. The object of the study is a consistent and long-term process of economic growth of the state along with an increase in the level of defence capability as a result of military expenditures in the context of financial support from the Ministry of Defence of Ukraine.***

Methods. ***Theoretical methods: analysis, synthesis, abstraction, generalisation, induction, deduction, explanation, classification. Empirical methods: hypothesis, observation, experiment, description.***

Results. ***This paper defines "military capabilities" and their relationship with military potential. It has been established that the ability to use military potential (military power/strength) is a military capability. Military expenditures are used to develop capabilities in the Ministry of Defence of Ukraine's system. Thus, allocating and redistributing expenditures for the army's needs is financial support. The armed forces' financial support drives the country's economic growth. To establish this fact, the leading indicators of military expenditures in the Ministry of Defence of Ukraine (from now on – MoD) were analysed and the indicator of economic growth – gross domestic product (from now – GDP) from 2012 to 2021. This period is crucial for Ukraine's national security, defence, and economic growth, as the basic principles of state defence policy were established during this time. This motivated us to analyse financial and defence indicators to determine their interrelationship.***

Conclusions. ***Two variables were defined as military expenditures and the GDP, where the first variable is independent and the second is dependent. A high correlation between military spending and economic growth in Ukraine was found by constructing a scatter plot, performing the relevant calculations, obtaining the data in an ANOVA table, setting up a regression line, and conducting null hypothesis tests.***

Keywords: ***military capabilities, military potential, military expenditures, GDP, economic growth, linear regression, correlation.***

Background

The ability of a state to use military strength is the key to success in any military operation. With the Russian-Ukrainian war beginning, the need to study human potential, military strength and capability is urgent. According to the Law of Ukraine "On Defence of Ukraine", the state's defence capability is the nation's ability to use economic, social and military potentials for defence in case of armed aggression or armed conflict (Verkhovna Rada of Ukraine, 1991). The military potential quantitative and qualitatively represents the state's accumulated weapons, equipment, and trained military personnel. However, military potential does not indicate a state's ability to use power to achieve desired effects.

According to the Order of the Ministry of Defence of Ukraine of 22 December 2020 No. 484, "On Approval of the Organisation and Implementation of Defence Planning in the Ministry of Defence of Ukraine, the Armed Forces of Ukraine and other Components of the Defence Forces", the ability of the defence forces to perform specific tasks should be understood as the capability (Ministry of Defence of Ukraine, 2020). In turn, capability development means forming, implementing and supporting army programmes financed from the state budget.

According to the Decree of the President of Ukraine No. 473/2021, "On the Decision of the National Security and Defence Council of Ukraine of 20 August 2021 "On the Strategic Defence Bulletin of Ukraine", with the beginning of the armed aggression of the Russian Federation against Ukraine, the priorities in the implementation of the state's military policy were aimed at strengthening the capabilities of the defence forces (National Security…, 2021). These and other fundamental principles of the state defence policy lead us to the idea of highlighting the capabilities of the Ministry of Defence of Ukraine as the primary determinant of success in countering Russian armed aggression and PSYOP.

The ability of the state to use the accumulated military potential to achieve its military goals is the first task to study. It needs to be clarified what this ability is. The second task is to explain whether this [ability] (through the process of finance providing by completing the military expenditures allocation and redistributing) positively impacts the state's economy. Defining the term "military capabilities" and establishing the relationship (correlation) between the development of military capabilities and economic growth is necessary. Thus, many studies show a positive impact of military expenditures on a state's economy (Koval, 2022). In this study, it is necessary to determine whether such a positive impact exists for Ukraine.

This can be found using the linear regression method. The question is what the variables should be. A previous study found that economic growth can be interpreted as an increase in GDP (Koval, 2022). Military expenditures should be considered state expenses for Ukraine's national security and defence. In the context of this research, it is suggested to identify and analyse statistical data on the Ministry of Defence of Ukraine's expenditures in the national security and defence system. It is proposed that the GDP be used as a primary indicator of the economic growth.

Literature review. The study by A. Alptekin, P. Levine, J. Dunne, N. Tian, and L. Pieroni have led us to the idea that the current level of military capabilities is a product of military expenditures of previous periods (primarily medium- and

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long-term planning) and they do have an impact on the economic growth of the state (Alptekin, & Levine, 2012; Dunne, & Tian, 2015; Pieroni, 2009). Thus, a state that needs to transform its national security and defence sector has enough time to implement the necessary reforms.

Leonard suggests that military capabilities are determined not only by abilities and forces but also by international treaties and domestic obligations, including the country's legislation (Leonard, 2005). J. Kugler, A.F.K. Organski, D. Fox, P. Paret describe military capabilities in the context of the security environment of the countries under study (Kugler, Organski, & Fox, 2011; Lambelet, 1973; Paret, 1989). The authors of the collective monograph of the Ivan Chernyakhovsky National Defence University of Ukraine, "Methodological Aspects of Defence Management in the Armed Forces of Ukraine", claim the importance of optimal use of the military budget and maintaining high quality of products and services, in particular, at the cost of the defence complex of Ukraine (Tkach, 2023).

Methods

The empirical method was chosen as the primary method in this study, which involved using statistical models to identify the degree of correlation between the growth of military spending and economic growth. For this purpose, the method of regression and regression analysis was used. The models were built, and the data was analysed in Excel spreadsheets. A scatter plot was built, adjusted with a regression line, examined the variance, and tested the null hypothesis.

Results

Before modelling the relationship between military expenditures and economic growth, it is necessary to perform a semantic analysis of the existing definitions of the term "military capabilities". For this aim, it is helpful to present the genesis of scientific views on the nature of the "military capabilities" category as the primary determinant of the state's achievement of military goals (effects). It can be assumed, and also it should be verified, that achieving the desired effects (in any defence or budget operations) requires the relevant capabilities owned by decision-makers. It is suggested that the term "potential" should be viewed as an *undeveloped* ability. Instead, an ability is the possibility and capability to use the potential. The ability should be understood as the capability of the government, military command and leaders to make effective decisions on the rational use of the accumulated military potential to achieve the defined military goals in the short, medium and long-term activity. Capability development should be understood as cultivating a person's profession, speciality or advanced training. An ability is a capability acquired through one of the areas of its development, for example, leadership, education and science.

Military capabilities are a function of past military expenditures (under long-term planning strategic planning) (Alptekin, & Levine, 2012). However, current actual military expenditures (under short-term planning and operational planning) also describe their natural state (real values). The concept of "military capability development" came out of the Cold War literature from the observation that current levels of military spending were not equivalent to the existing stock of weapons or quantity of military personnel that could be used as a force to attack other states or to defend against possible enemies. In the context of the importance of long-term planning (fundamental principles and doctrines) and concrete efforts, a viewpoint on the process of military capability development was formed:

$$military\ capabilities = f(1 \times past\ military\ expenditures + 0{,}1 \times current\ military\ expenditures).$$

In the context of real values (including inflation):

$$military\ capabilities = f(0{,}1 \times past\ military\ expenditures + 1 \times current\ military\ expenditures).$$

Note: all values used in the formula above are approximate and relative to the context.

It is essential to add that achieving the set tasks for developing military capabilities by long-term (strategic) planning has a much more significant impact on the overall level of the state's defence capability, which is enough to counter external aggression successfully.

A. Tellis indicates that military capabilities allow states to defend their population and territory from internal and external threats and state leaders to defend their domestic and foreign interests (if necessary, against the advantages of other competing actors) (Tellis, 2000). P. Paret notes that military capabilities have a causal relationship with state power, as they express and implement the state's military power in various ways within and beyond state borders (Paret, 1989). It is essential to add that the causal relationship between military capabilities and military potential can also be observed.

M. Leonard claims that military strength cannot be measured by military budgets or intelligent missile technology; it is based on treaties, constitutions and legislation (Leonard, 2005). In this case, "military strength" means the "military potential" and "military power" of the state, as it was established in previous studies. Some researchers consider military capabilities as the ability to achieve the desired effects to perform the tasks (Anteroinen, 2012).

Fig. 1 shows three branches of the process of developing military capabilities.

Fig. 1. The process of military capabilities developing

The armed forces have to face new security challenges, so they need to be reorganised, re-equipped and rearmed in a *relevant* timeframe to perform multi-purpose missions, which may include non-military tasks. The development of military capabilities should be understood as necessary to achieve fundamental positive changes in protecting national security. Changes should be significant and not just planned to improve existing capabilities; modernised aircraft, tanks or ships should be updated for the *next generations* (Peternelj, & Kurecic, 2019). This confirms that military capability development planning should be conducted with a long-term perspective.

The author of this research also believes that it is essential to conduct strategic (long-term planning) for capability development to obtain positive effects in the future for the next generations.

Military capability development is an advanced military project to transform the army. This is a state programme to develop and protect national security in the modern age. For example, the current challenge for NATO member states is how quickly they can supply weapons and military equipment to partner countries where active warfare is taking place, as well as the importance of reaching standard agreement on integrated combat command and joint operations and, as a result, unified air and missile defence, as well as shared logistics (Case Study…, 2008). The availability of such military capabilities in the North Atlantic Treaty Organisation results from long-term planning, which, in particular, included providing military assistance to partners in an armed conflict. However, delays in the supply of such equipment are due to the requirement for military personnel to have the *ability* to use the provided weapons and military equipment, which in turn requires a long-term training process.

This and other statements lead us to conclude that the armed forces should be well-equipped and ready to undertake combat operations to protect national security, sovereignty and territorial integrity. This requires providing the armed forces with qualitative and quantitative military capabilities and their regular upgrading to achieve the desired effects in the short, medium and long term perspective. At the same time, the transformation of strategic planning based on the areas of military capability development is necessary to ensure the systematic achievement of the main goals and objectives of the state in the context of national security and defence as defined by the state's military doctrine.

The next category that should be highlighted in the study context is financial support. Developing military capabilities is assumed to be impossible without funding the national security and defence sector, particularly the Ministry of Defence of Ukraine. This sector is financed through the military budget accepted by the government, which is measured by the amount of military expenditures. Allocation and redistribution of military expenditures to the needs of the units under the Ministry of Defence control are defined as financial support of these forces, among which it is reasonable to single out military commands, departments, and military academies since these expenditures are the main contributors to the development of military capabilities.

In the context of this research, it is essential to analyse military expenditures for the Ministry of Defence of Ukraine. These expenditures will be compared to Ukraine's GDP to see if there is a correlation between them. For this purpose, the regression models should be used. Regression is one of the most widely used statistical methods in all fields of science. It is proposed to consider a particular regression analysis case in which a linear relationship can describe the relationship between variables. This will allow to observe the trends in the growth and decrease of specific indicators over time and, based on their analysis, to predict further behaviour. Linear regression allows us to identify correlations using only one explanatory variable. That is why, before starting a study, it is necessary to follow the principles of logic to determine the sequences (observations) required for use. Identifying correlations between non-categorical variables such as military expenditures of the Ministry of Defence of Ukraine and the GDP is essential.

Analysing the scientific literature, it was possible to identify one of the few reasons for conducting this kind of research (Koval, 2022). As for the conclusions, it is rational to refer to the "Guns vs. Butter" model, which demonstrates the relationship (and also – causation) between investment in the defence sector and the production of consumption goods. At the same time, current research aimed at determining whether a correlation between military spending and social welfare may yield meaningful results.

The correlation between variables can be deterministic (functional), probabilistic or stochastic. To measure the degree of linearity between two variables, the sample correlation coefficient was used:

$$r = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2}\sqrt{\sum(y_i - \bar{y})^2}} = \frac{\sum x_i y_i - n\bar{x}\bar{y}}{\sqrt{\sum x_i^2 - n\bar{x}^2}\sqrt{\sum y_i^2 - n\bar{y}^2}}.$$

The correlation coefficient has the same slope as the slope of the regression line, so using the signal of the correlation coefficient, it is known as the slope of the regression line and vice versa. The correlation coefficient is a single number that measures the strength and direction of a linear relationship between two variables. The sign of the correlation coefficient shows the direction of the relationship. Positive coefficients indicate that when one variable's value increases, the other variable's value also tends to increase. Negative coefficients indicate that when one variable's value rises, the other variable's value tends to decrease.

The higher the absolute value of the correlation coefficient, the stronger the relationship is. When $|r|$ is between:

- 0 і 0,25 – correlation is very weak;
- 0,25 і 0,5 – correlation is weak;
- 0,5 і 0,75 – there is a moderate correlation;
- 0,75 і 1 – correlation is strong.

When interpreting correlation coefficients, predictions can be made about one variable based on another, but only if there is a relationship or statistical association between them. However, the existence of a correlation between *X* and *Y* does not necessarily mean that one variable causes the other.

Correlation does not mean causation. If the correlation coefficient is close to 1, it does not mean that *X* causes *Y* or *Y* causes *X*, as there may be a third variable that causes both X and *Y* to be affected simultaneously. A false correlation is a mathematical relationship in which two or more events or variables are related but not causally related due to coincidence or the presence of some third, unknown variable. When variables are related such that when one changes, the other changes, it *may* be assumed that there

is a causal relationship between them; however, in cases where this is not obvious, there is no reason to conclude only based on a high correlation that changes in one variable cause changes in the other.

***Note**: it is necessary to justify the need to increase military expenditures and maintain them at the appropriate level to protect the population of Ukraine, its infrastructure, national wealth and reserves, etc., from existing or possible enemies.*

At the same time, we are faced with a dilemma: what is the priority for the government – the development of the defence sector or social welfare development programmes? Is it reasonable to increase military expenditures if the national wealth remains unchanged? Is it appropriate to increase the percentage of national security and defence spending that exceeds the actual growth of GDP?

It is worth noting that the percentage is the right choice to indicate. Still, the percentage should only be considered for an increase if the available funding is insufficient to develop and maintain military capabilities per NATO standards. Any new project requires a significant investment at the formation stage, even if this investment is to be provided on a loan basis. The previous study mentioned the concept of military credit and debt, where the state has a higher chance of winning a war (Koval, & Lopes, 2023).

At the same time, the army project exists and has been functioning for over thirty years. During this period, there were many questions about the wisdom of maintaining and developing the armed forces, and with the beginning of the war, the rhetoric was changed, pointing out the need to improve the quality and quantity of military capabilities. The lack of capability to defend against direct armed Russian intervention resulted in numerous losses in critical infrastructure, the economically active population, and investment in industry.

Despite these facts, investment in the Ukrainian economy grew, at least until February 2022. However, numerous cases of state officials breaking the principles of public administration and corruption have led to enormous losses in human resources, equipment and infrastructure. Protecting the accumulated industrial and human potential from external and internal influences is essential. The loss of strategically important territories, which served as a centre for developing and increasing the state's capital, has caused enormous economic damage.

Today, Ukrainians are facing the biggest crisis. The previous crisis was caused by the *destruction* of the Ukrainian People's Republic by the Bolsheviks and the subsequent *genocide* of the Ukrainian people. The cause of the current crisis is probably the careless approach of officials to state service, as well as the high level of corruption at all levels and branches of state administration (World Corruption…, 2022). It is worth noting that officials who are empowered to make critical decisions for the economic growth of the state, as well as the development of its national security and defence sectors, are not always able to be guided by the principles of transparency, consistency and integrity (honesty), which, in turn, leads to numerous gaps in both public administration and providing a proper and accurate standard of the social and economic well-being of the nation.

It is not possible to identify gaps within the framework of this study. Still, the need for a profound transformation of the Armed Forces of Ukraine can be justified with the implementation of advanced standards, in particular, through the practice of NATO countries, as well as some of their partners, namely South Korea, Israel, Japan and Sweden (until April 2023). Decision-makers should set clear priorities in developing and maintaining high military capabilities.

It should be proposed to consider a particular vision of Ukraine's security, according to which an increase in national wealth, and thus social welfare, is impossible without a high level of national security and defence. Hence, a high-income level is not always a determinant of social welfare and life satisfaction. At the same time, a high level of income indicates the ability of the state not only to generate GDP but also to distribute it wisely, as well as to control the adequacy of funding various state programmes, including the defence sector.

A highly economically developed country has a significant prospect of close integration with the world's most powerful economies, which, in turn, provides for the ability to receive and manage foreign investment in the economy. At the same time, the state must ensure high security and capital protection from external and internal destructive influences.

It is necessary to express the opinion that the national wealth of Ukraine can be preserved and increased by establishing effective state management and control over the allocation and redistribution of such resources. Without proper organisation and control, the growth of military strength and capabilities is difficult, as funds allocated for transforming the armed forces can be used non-targeted and inefficiently.

Thus, the necessity to protect human resources, capital, infrastructure and the country's position in the international arena is the reason for developing the capability to use military power.

Note: when it comes to protecting the interests of the state at the international level, it is difficult not to quote James Sherr: "*Influence is the ability to persuade others to consider our wishes without using force or direct threats. In the case of Western countries, this means adhering to international norms and rules, which, in particular, have many limitations*" (Sherr, 2013). It is worth noting that the Western decision-making model is directly opposed to the "Russian despotic hierarchy". Ukraine needs to be guided by the Western model of state-building, which primarily involves "disabling" the system's shortcomings – a corruption, namely, corrupt "connections", patronage, protectionism, and "notions". Instead, market relations, competitiveness, openness, transparency and regulations should be established.

The development of military capabilities must go hand in hand with the decision-maker's ability to take responsibility. Otherwise, it will turn into tyranny. Effective state management and control are possible only if officials have sufficient competencies and a high level of responsibility. Examples of such regulations include those of the EU and NATO, which, unlike the standards of the Eurasian alliances created by the Russian Federation, have higher standards and better performance and, therefore, assume that the candidate state has the relevant capabilities. Following the example of Western countries, Ukraine can effectively transform its armed forces and increase economic growth.

The first step towards developing an effective model for transforming the country's defence sector is to analyse military expenditures and their impact on economic growth. The defence sector and the economy are considered to be

two separate variables. By studying both variables, the relationship between them can be established. It is important to note that this study does not establish a causal relationship between the variables considered. GDP growth is influenced by many other factors besides the increase in military expenditures. However, numerous facts over a long period of state formation show that poor defence expenditure leads to a decrease in defence capability and, thus, to a lower level of protection of human capital and public resources, which are crucial factors in the growth of national wealth.

It is also assumed that the GDP growth may be nominal, with consumption prices increasing over a long period. On the other hand, GDP growth is influenced by an increase in the quantity of goods and services produced, an increase in their quality, or more goods and services of higher value. And this increase in GDP is no longer nominal but *real*. Inflation should be considered while analysing real GDP statistics and summing up all economic goods and services at constant prices over a given period.

It would be pretty logical to assume that since the GDP of a country is influenced by the production of goods and services, it is advisable to compare GDP growth with different categories of production: military and social goods. This is the main idea of the "Guns or Butter" method. However, in the course of this study, it is assumed that a higher level of defence capability of a state can lead to its economic growth, mainly due to its ability to provide for the safety of life and health of its population, as well as production facilities.

The country's industry can meet both domestic and foreign demand. External demand means foreign consumers of Ukrainian products and potential investors. This also gives rise to the idea that arms and military equipment exports are essential to increase economic growth.

Table 1 presents Ukraine's GDP (current, UAH) and the budget of the Ministry of Defence of Ukraine. The period until 2021, before a full-scale Russian invasion, is analysed, as it is of relevance to the development of Ukraine's capabilities before the Russian Federation declares a special military operation on the territory of Ukraine. *Just before an "examination"*. In the following studies, it is necessary to analyse the GDP for the following years. It is worth noting that there is a measure of real GDP per capita and real GDP. This indicator is more realistic as the population increased and decreased during the review period. GDP per capita is a good, imperfect indicator of a country's living standard.

Considering the importance of demographics in calculating economic growth, estimating real GDP per capita from 2022 onwards is difficult, as about six million Ukrainians have migrated abroad (of which approximately 2 million are economically active citizens). Analysing the data from the Ministry of Finance of Ukraine, the difference in the population of Ukraine between 2021 and 2022 is not entirely clear, but it is assumed that the lack of a meaningful difference is due to the temporary factor of population movement abroad, in which migrants remain Ukrainian citizens (Minfin, 2023).

It should be added that another reason for GDP growth/fall is a period of economic depression. A decrease in GDP per capita is one of the criteria for determining a recession. A decline in real GDP also tends to go hand in hand with an increase in unemployment. Unemployment, in turn, is a consequence of job losses (employment), a decrease in the number of economically active people, in particular, due to the damage of infrastructure, and a loss of human capital. This is caused, among other things, by the country being at war. Increasing military capability to counter existing and potential threats to national security enhances the chances of saving the country's economic resources.

Table 1

Statistical data of the GDP and the Ministry of Defence of Ukraine expenditures

(UAH, trill.)

Year	GDP (current) **(x)**	The Ministry of Defence of Ukraine expenditures **(y)**	**% (y/x*100)**
2021	4,363582	0,133488	3,06
2020	3,818456	0,120034	3,14
2019	3,675728	0,105543	2,87
2018	3,083409	0,094958	3,08
2017	2,445587	0,068537	2,80
2016	2,034430	0,058099	2,86
2015	1,430290	0,027346	1,91
2014	1,365123	0,027346	2,00
2013	1,410609	0,015281	1,08
2012	1,304064	0,016388	1,26

Source: formed based on the source (Minfin, 2023; Ministry of Defence of Ukraine, 2023).

The table shows that since 2012, Ukraine's real GDP has grown by 3.35 times, while the MoD budget has increased by eight times. The difference in the growth of the two variables can be explained, among other things, by the fact that the MoD budget grew by 2.43 times in percentage value. This is not surprising, as Russia has annexed parts of Ukrainian territory, sponsored separatist movements in eastern Ukraine, and subsequently sent its forces, assets and military personnel to engage in direct combat with the Armed Forces of Ukraine. Such changes in the state's budget allocations were necessary due to the start of the anti-terrorist operation as the first stage of the Russian-Ukrainian war and the countering of the full-scale Russian invasion of Ukraine as the second stage.

In this study, it is possible to observe a linear relationship between the two variables, but further research should use many other factors that affect the state's economic growth in one way or another.

First, a scatter plot should be drawn. Mark the independent variable on the horizontal axis and the dependent variable on the vertical axis. Thus, it was determined that the independent variable is the budget of the Ministry of Defence of Ukraine, and the dependent variable is the GDP. Hence, it is necessary to observe if

there is a correlation between these two variables, namely the level of dependence of the GDP on military expenditures. Fig. 2 presents the scatter plot. The first step is to conclude the level of correlation. The scatter plot below highlights some of the properties between the data, namely the type of relationship between the GDP and the MoD expenditures.

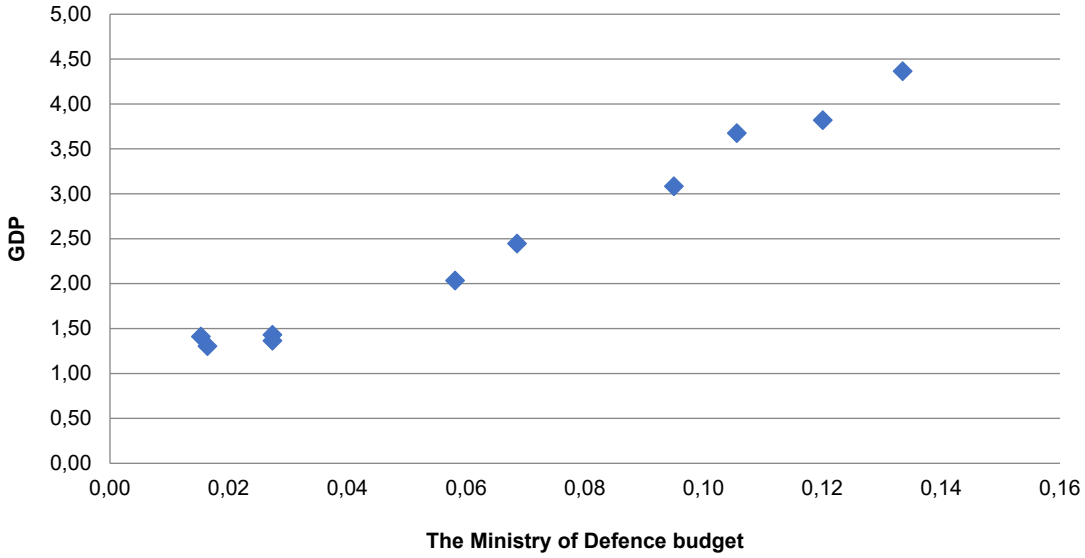

Fig. 2. Points represent the statistical data of two variables

Source: created by the author.

As the military budget increases, the GDP tends to increase, indicating a positive correlation between the two variables. Any outliers should be identified in the plot. They may look like points isolated from the primary data set. Random outliers should be investigated because sometimes there are errors in recording or plotting the data. However, no such outliers were identified, meaning there is a higher chance of a high level of correlation between the two variables.

A sample linear correlation coefficient was used to measure the intensity of the relationship between these two variables. In this case, *r* = 0.9906 means a high positive linear correlation: the higher the Ministry of Defence expenditures, the higher the GDP is. It should be noted that all calculations were made using Excel spreadsheets. With the help of spreadsheets, the needed values can be calculated.

The least-squares regression line of GDP according to MoD expenditures is expressed by the equation of the simple linear regression model:

$$Y = a + bX + \varepsilon,$$

where Y – dependent variable; X – independent or explained variable; ε – errors, deviations or balances, where $\varepsilon \sim N(0, \sigma_\varepsilon^2)$. Under ideal conditions, the error should be zero, but this is only the case in differential relationships. In stochastic relationships, it is expected that $E[\varepsilon] = 0$.

Frequently, when estimating correlations and predictions, there needs to be more information about the entire population, only about individual observations in the sample. To estimate the parameters a and b based on the information contained in the sample, the "Least Squares Method" is usually used.

The residual is the value of $y - \hat{y}$, where y is the observed value and $\hat{y}$ is on a possible live above or below y. So, there are positive and negative residuals. Least squares regression line for the dependent variable on the independent variable:

$$r_1^2 = (y_1 - \hat{y}_1)^2,\ r_2^2 = (y_1 - \hat{y}_1)^2,$$
$$r_3^2 = (y_1 - \hat{y}_1)^2.$$

Need to minimise:

$$S = r_1^2 + r_2^2 + r_3^2.$$

To summarise, the following:

$$SE = \sum_{i=1}^{n} (y_i - \hat{y}_i)^2 = \sum_{i=1}^{n} \left[y_i - \left(\hat{a} + \hat{b}x_i\right)\right]^2 = 0{,}2275.$$

To minimise the sum of the squares of the residuals, solve the following problem:

$$\begin{cases} \dfrac{\partial SE}{\partial a} \\ \dfrac{\partial SE}{\partial b} \end{cases} = 0.$$

Solving this system in *a* and *b*:

$$b = \frac{\sum x_i y_i - n\bar{x}\bar{y}}{\sum x_i^2 - n\bar{x}^2} =$$
$$= \text{number, very closed to zero (but not a zero)},$$
$$a = \bar{y} - b\bar{x} = 0{,}77$$

where $\bar{x}$ and $\bar{y}$ are the means of x and y, respectively. If,

$$S_{xx} = \sum x_i^2 - n\bar{x}^2 = 0{,}017962345,$$
$$S_{yy} = \sum y_i^2 - n\bar{y}^2 = 12{,}20247137,$$
$$S_{xy} = \sum x_i y_i - n\bar{x}\bar{y} = 0{,}463785566.$$

Therefore,

$$b = \frac{S_{xy}}{S_{xx}} = 25{,}8198786,$$

$$a = \bar{y} - b\bar{x} = 0{,}770886944,$$

$$r = \frac{S_{xy}}{\sqrt{S_{xx}S_{yy}}} = 0{,}99063077.$$

The equation of the regression line is:

$$\hat{Y} = 25{,}82x + 0{,}7709.$$

Error variance is an unknown parameter, so estimate it with help:

$$\sigma_\varepsilon^2 = \frac{1}{n-2}\sum_{i=1}^{n}[Y_1 - \hat{Y}_i]^2 = 0{,}028448044.$$

The ANOVA analysis is a method of analysing the quality of the regression model that relies on splitting the total variation of the variable *Y* into components. If the value of a variable is to be predicted, the best estimate is based on an average. However, if the regression model is adjusted, the best estimate is now based on the regression line, which leads to an error. Total deviations explained by the regression:

$$Y_i - \bar{Y} = (\hat{Y}_i - \bar{Y}) + (Y_i - \hat{Y}_i),$$

$$d_t = d_r + d_e,$$

where d_t – total deviation; d_r – explanatory deviation; d_e – unexplained deviation. Initial or total variation:

$$ST = \sum_{i=1}^{n}(Y_i - \bar{Y})^2 = 12{,}20.$$

Variation explained by regression:

$$SR = \sum_{i=1}^{n}(\hat{Y}_i - \bar{Y})^2 = 11{,}97.$$

Unexplained variation:

$$SE = \sum_{i=1}^{n}(Y_i - \hat{Y}_i)^2 = 0{,}227584355.$$

The determination coefficient evaluates the quality of the adjustment of the linear regression line:

$$r^2 = \frac{SR}{ST} = \frac{ST - SE}{ST} = 1 - \frac{SE}{ST} = 0{,}981349.$$

The determination coefficient that can explain these relations is the fraction of total variation, ST, defined by regression. The analysis of variance is usually summarised in the ANOVA table, the following Tab. 2.

Table 2

Analysis of Variance (ANOVA)

Variation sources	variations	dg	Variance	F-test
Regression	*SR* = 11,97	1		SR/σ_ε^2 = 420,93
Error	*SE* = 0,227	*n* – 2 = 10 – 2	σ_ε^2 = 0,285	
Total	*ST* = 12,20	*n* – 1 = 10 – 1		

Source: created by author.

$$\sigma_\varepsilon^2 = \frac{SE}{n-2} = 0{,}285.$$

This table is usually designated by the ANOVA table. Next, it is necessary to check calculations using the Data Analysis module in Excel.

The adjusted regression line can be seen in Fig. 3. 98.13 % of the variation in the GDP is explained by military expenditures through the adjusted regression line. Only 1.87 % of the variability in GDP is due to factors not included in the model, which remains to be explained.

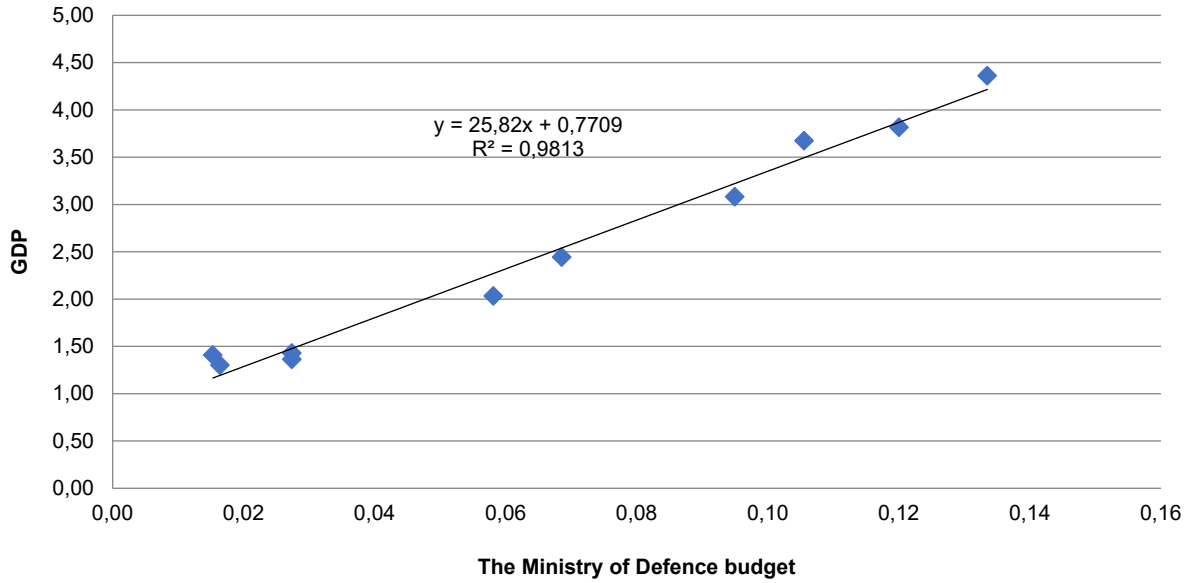

Fig. 3. Adjusted regression line

Source: Created by author.

The adjusted regression line equation can be used to estimate Ukraine's GDP if, for example, the budget of the Ministry of Defence is UAH 0.113578 trillion. Under such circumstances, the GDP is expected to be UAH 3.703457 trillion. This is a forecast which was made using the formula above.

Being the adjusted model based on information from a sample, it is natural to raise questions about the adequacy of the model to the population from which the sample was extracted. It is, therefore, usual to develop statistics tests on the parameters and explanatory capability of the model. When the slope of the regression line is null there is not a linear regression between the two variables. Therefore the independent variable has no explanatory capability regarding to Y.

In addition, several bilateral and unilateral tests can be made on the parameters $a\ b$. Hypothesis testing – model suitability. The hypothesis that the slope of the regression line is positive will be tested at the 5 % significance level. The most common test is the two-sided test (test bilaterally if the slope of the regression line is null, indicating if one regression model is suitable to the study set of observations). However, other tests may be conducted.

Null hypotheses: $H_0: b = 0$. Bilateral test: $H_0: b \neq 0$. Statistic Test:

$$T_b = \frac{\hat{b} - b}{\hat{\sigma}_\varepsilon \div \sqrt{\sum(x_i - \bar{x})^2}} \sim t(n-2) = 20{,}5167942605.$$

Calculate the value t_b based on the sample (admitting H_0 is true). Critical or rejection Region:

$$CR = \left[-\infty; -t_{\frac{\alpha}{2}}(n-2)\right] \cup \left[t_{\frac{\alpha}{2}}(n-2); +\infty\right] = \\ = [2{,}306;\ +\infty].$$

Decision/conclusion: thus, like $t_b \in CR, H_0$ is rejected at a 5 % significance level; that is, the information collected indicates that the slope of the regression line may be positive, an indication given by the alternative hypothesis. Whenever population characteristics have been estimated from a sample, these estimates may be subject to errors due to the natural variability of the sample results. It is, therefore, natural to quantify this error margin, which can be done by establishing confidence intervals.

Suppose confidence intervals need to be established for the parameters a, and b these can be obtained from the following statistics:

$$T_a = \frac{\hat{a} - a}{\hat{\sigma}_\varepsilon \sqrt{\frac{1}{n} + \frac{\bar{x}^2}{\sum(x_i - \bar{x})^2}}} \sim t_{n-2} = 7{,}7511399069,$$

$$T_b = \frac{\hat{b} - b}{\hat{\sigma}_\varepsilon \div \sqrt{\sum(x_i - \bar{x})^2}} \sim t_{n-2} = 20{,}5167942605.$$

Confidence interval for the parameter a:

$$\left[\hat{a} - t_{\frac{\alpha}{2}}(n-2)\hat{\sigma}_\varepsilon \sqrt{\frac{1}{n} + \frac{\bar{x}^2}{S_{xx}}}; \hat{a} + t_{\frac{\alpha}{2}}(n-2)\hat{\sigma}_\varepsilon \sqrt{\frac{1}{n} + \frac{\bar{x}^2}{S_{xx}}}\right] = \\ = [0{,}54154451; 1{,}00022938].$$

Confidence interval for the parameter b:

$$\left[\hat{b} - t_{\frac{\alpha}{2}}(n-2)\frac{\hat{\sigma}_\varepsilon}{\sqrt{S_{xx}}}, \hat{b} + t_{\alpha/2}(n-2)\frac{\hat{\sigma}_\varepsilon}{\sqrt{S_{xx}}}\right] = \\ = [22{,}91783458;\ 28{,}72192262].$$

To estimate the mean Y for a given value x_0, use $\hat{Y}_0 = \hat{a} + \hat{b}x_0$:

$$\hat{Y}_0 \sim N\left(\hat{a} + \hat{b}x_0; \sigma_\varepsilon^2\left[\frac{1}{n} + \frac{(x_0 - \bar{x})^2}{\sum(x_i - \bar{x})^2}\right]\right),$$

$$\hat{Y}_0 = 3{,}703457116,$$

$$x_0 = 0{,}113578.$$

It is a centred estimator from $E(Y_0)$.

T Statistic:

$$T_c = \frac{\hat{Y}_0 - E(Y_0)}{\hat{\sigma}_\varepsilon \sqrt{\frac{1}{n} + \frac{(x_0 - \bar{x})^2}{\sum(x_i - \bar{x})^2}}} \sim t_{n-2}.$$

The confidence interval for Y mean is given by:

$$\left[\hat{y}_0 - t_{\frac{\alpha}{2}}(n-2)\hat{\sigma}_\varepsilon \sqrt{\frac{1}{n} + \frac{(x_0 - \bar{x})^2}{S_{xx}}}; \hat{y}_0 \right. \\ \left. + t_{\alpha/2}(n-2)\hat{\sigma}_\varepsilon \sqrt{\frac{1}{n} + \frac{(x_0 - \bar{x})^2}{S_{xx}}}\right] = \\ = [3{,}5200630455; 3{,}8868511866].$$

Similarly, to estimate the actual value of Y for any given value x_0, use the following:

T Statistic:

$$T_P = \frac{Y_0 - \hat{Y}_0}{\hat{\sigma}_\varepsilon \sqrt{1 + \frac{1}{n} + \frac{(x_0 - \bar{x})^2}{\sum(x_i - \bar{x})^2}}}.$$

The prediction interval Y is given by:

$$\left[\hat{y}_0 - t_{\frac{\alpha}{2}}(n-2)\hat{\sigma}_\varepsilon \sqrt{1 + \frac{1}{n} + \frac{(x_0 - \bar{x})^2}{S_{xx}}}; \hat{y}_0 \right. \\ \left. + t_{\alpha/2}(n-2)\hat{\sigma}_\varepsilon \sqrt{1 + \frac{1}{n} + \frac{(x_0 - \bar{x})^2}{S_{xx}}}\right] = \\ = [3{,}2734458019; 4{,}1334684302].$$

The estimated regression line equation should only be used to obtain estimates for the variable *Y* for values of *x* between the minimum and maximum values used to estimate the model parameters. The relevance of regression methods for forecasting continues after the development of regression models. In other contexts, regression methods are used to model intermediate procedures of more complex forecasting methods, for example, identifying a model with trends or seasonality series in so-called decomposition models. Finally, regression analysis is suggested to verify calculations using the Data Analysis module in Excel spreadsheets. The results are shown in Tab. 3.

Table 3

The results of regression analysis

Regression Statistics						
Multiple R	0,99063077	**Absolute value of the coefficient of correlation**				
R Square	0,981349323	**Coefficient of determination**				
Adjusted R Square	0,979017988					
Standard Error	0,168665481					
Observations	10	**n**				
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	1	11,97488701	11,97488701	420,9388467	3,33352E-08	
Residual	8	0,227584355	0,028448044	**Error variance**		
Total	9	12,20247137				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95 %*	*Upper 95 %*
Intercept	0,770886944	0,099454655	7,751139907	5,47829E-05	0,541544099	1,00022979
X Variable 1	25,8198786	1,25847529	20,51679426	3,33352E-08	22,91782938	28,72192782
	Parameters		**Statistic**			
	values		**Test for the**			
			Parameters			
			Estimation Test			

Source: created by author.

The regression analysis results show no discrepancies between them and the adjusted regression line built based on calculations. This implies that there is a high level of correlation between the GDP and military expenditures. This study cannot claim that economic growth is influenced only by the expenditures of the Ministry of Defence of Ukraine, but such expenditures do have a positive impact.

Discussion and conclusions

It is found that in the context of the development of the state's defence ability, the development of military capabilities plays an important role. An assumption about the importance of military capability development with regression analysis results is confirmed. This study presents the main drivers of real GDP growth. For example, real GDP can be increased by increasing the production of goods and services. Once both economic growth and military capability development need to be observed, an essential next step is to analyse the production and export of Ukrainian defence products. It is necessary to identify the indicators that best describe the performance of Ukraine's military-industrial complex (from now on – MIC) and its impact on economic growth and defence capability. It is assumed that the MIC is the sphere of production that can positively influence two sectors of state-building at once – national security and defence economic growth.

Among other equally essential tasks is the need to use forecasting methods to identify the probable trend of further development or reduction of defence production. It is considered that Ukraine's ability to resist existing and possible armed aggression depends on the volume of military production itself and with foreign partners.

Further research should examine the methods and models of decision-making by officials. Using statistical data from completed conflicts it is also planned to use the probit model to calculate the state's probability of success in a particular military operation. It is necessary to focus on the level of military capabilities of each state involved in the conflict and the availability of international technical assistance.

Finally, having obtained the results of the probability of success in a military operation and constructed a decision matrix (reward matrix) for decision-making, it will be possible to study the processes of optimising the financing of the capability to use military power under uncertainty.

Meanwhile, the term "real" is recognised as crucial. It is the value of something that is currently useful. Considering the real value of GDP, it is concluded that this rule should be applied to military capabilities. This means that it is necessary to find a way to calculate a specific military capability inflation index.

So far, there is an awareness of a study that describes how this rule is applied to the Swedish national security and defence sector (Nordlund, 2016).

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ВПЛИВ ВИДАТКІВ МІНІСТЕРСТВА ОБОРОНИ НА ЕКОНОМІЧНЕ ЗРОСТАННЯ УКРАЇНИ

В с т у п . ***З початком другого етапу російсько-української війни перед урядом України та військовим командуванням постало питання об'єктивного оцінювання результатів багаторічних зусиль з розбудови сектору національної безпеки і оборони України. Одночасно з посиленням обороноздатності зростали й економічні показники. Це спонукало до перевірки гіпотези про те, чи саме посилення обороноздатності спричинило це зростання. Мета дослідження – необхідність з'ясувати зв'язок між військовими витратами та економічним зростанням в Україні. Об'єкт дослідження – послідовний та довготривалий процес економічного зростання держави з одночасним підвищенням рівня обороноздатності як результат військових витрат у контексті фінансового забезпечення Міністерства оборони.***

М е т о д и . ***Застосовано такі методи: теоретичні – аналіз, синтез, абстрагування, узагальнення, індукція, дедукція, пояснення, класифікація; емпіричні – гіпотеза, спостереження, експеримент, опис.***

Р е з у л ь т а т и . ***Визначено поняття "військові спроможності" та їхній зв'язок з військовим потенціалом. Встановлено, що здатність використовувати військовий потенціал (військову міць/силу) є військовою спроможністю. На розвиток спроможностей у системі Міністерства оборони України спрямовуються військові видатки. Таким чином, розподіл і перерозподіл видатків на потреби армії є фінансовим забезпеченням. Фінансове забезпечення збройних сил є рушійною силою економічного зростання країни. Щоб встановити цей факт, було проаналізовано провідні показники військових видатків Міністерства оборони України (далі – МОУ), а також показник економічного зростання – валовий внутрішній продукт з 2012 по 2021 р. Цей період визначальний для національної безпеки, оборони та економічного зростання України, оскільки саме в цей час були сформовані основні засади державної оборонної політики. Це спонукало нас проаналізувати фінансові та оборонні показники для визначення їхнього взаємозв'язку.***

В и с н о в к и . ***Дві змінні були визначені як військові витрати та державний бюджет, де перша змінна незалежна, а друга – залежна. Побудувавши точкову діаграму, виконавши відповідні розрахунки, отримавши дані в таблиці ANOVA, встановивши лінію регресії та провівши перевірку нульової гіпотези, було виявлено високу кореляцію між військовими витратами та економічним зростанням в Україні.***

К л ю ч о в і с л о в а : ***військові спроможності, військовий потенціал, військові витрати, ВВП, економічне зростання, лінійна регресія, кореляція.***

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