USING THE REGRESSION MODEL IN THE ANALYSIS OF THE CORRELATION BETWEEN THE GROSS DOMESTIC PRODUCT AND DEFENCE EXPENDITURES, IN NATO MEMBER STATES

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Abstract

In this paper we propose to highlight correlation between the variables GDP and defence spending, using the linear regression model. It was observed, through the analysis of the literature, that one of the most important factors, influencing defense spending, is the GDP of the states. Thus, the objective of the study, is to try to get information about the ability of the economy (represented by GDP) to influence defense spending, in NATO member states. In the econometric model, the value of the dependency coefficient is expected to be very high and positive. The data from the Database were collected from the official sites.

Keywords: *GDP, NATO, PLS regression method, the Pearson and Spearman coefficient*

JEL classification: *H56, H61, P43*

1. Introduction

In NATO, members' defence and security spending must be very well determined. NATO's operation at immediate response capacity can only be achieved and maintained by ensuring sufficient human, material, and logistical resources. All these resources in turn depend on existing financial resources. As the field of defence is part of the public sector, it is limited both by the existence of public resources and by other influencing factors (Trueba, et al., 2020); (Galvin, 2003). Thus, in this context, the following question can be

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asked: What are the determinants of defence spending? (Fonfría & Marín, 2012) In studies such as (Chowdhury, 1991), (Heo, 2009), (Heo & Robert, 2005) but also in other studies of the literature, it has been observed that several determinants of defence, but one of these factors is predominant. Thus, the most used, significant and important factor influencing defence spending, is considered to be the GDP of states (Huang & Mintz, 1991), (David, 1990).

Starting from this aspect, the objective of the study, is to try to get information about the ability of the economy (represented by GDP) to influence defense spending in NATO member states. In the econometric model, the value of the dependency coefficient is expected to be very high and positive. Also, in conducting this study, several aspects regarding the financing of defence were analysed. But, the most representative indicator, with an influence on defence spending, was observed to be the value of the GDP.

2. Sections

2.1. Methodology

In the research methodology of the article were used, the case study method, the longitudinal study method, and the panel data method. To meet the objective of this paper, data from recent publications and reports on the military expenditures of NATO member states were used, as well as data on the armies of states found in freely accessible international databases.

The database developed for this study is a panel-type database, which included 28 NATO states out of the 30 existing states. Several states were excluded from the analysis of the study, due to the statistical significance of the data series. These states are:

- Iceland - because it does not have its own army, and military spending is very low and not statistically significant;
- Northern Macedonia, - does not present data for the entire period (the period 2010-2012 is missing), this state being established in 2013, which could lead to distortion of the results of the panel type model.

For processing the data and to obtain the empirical results, the statistical-mathematical software Excel and EViews was used.

The literature shows that the level of domestic product (GDP) of states is one of the most significant and most often used influencing factors to determine defence spending. The results of studies such as (Solomon, 2005) in the case of Canada, or the study (Dolores Gadea, et al., 2004), show the importance of the relationship between economic income (GDP) and defence spending. The study (Sandler & Murdoch, 2000) considers that defence spending is influenced by both the GDP of states and the NATO doctrine (strategy). Thus, as mentioned above, several studies state that national GDP is a benchmark that influences the military power of states.

Moreover, some studies highlight the results of the regression parameters of the variables defence spending and GDP as having a two-way relationship: positive between the two variables identified in OECD countries; and a negative one-way relationship between defence spending and GDP, in non-OECD countries. This indicates that an increase in military spending is beneficial, as it leads to an increase in GDP, which then has a positive effect by stimulating the growth of military spending of OECD countries. The results showed a reverse effect in non-OECD countries, of the relationship from the variable defence spending to the variable GDP (Lee & Chen, n.d.).

The results discussed in the study (Atesoglu & Mueller, 1990) show a positive and significant relationship between defence spending and economic growth (GDP) in the United States. Higher defence spending would lead to higher economic growth and vice versa. This finding considers defence spending to be an engine of economic growth rather than a brake on the economy. However, the study's findings show that economic growth resulting from changes in defence spending is low. Thus, even if there were significant reductions in defence spending, the effects on the growth of the United States economy would not be significant.

Based on these aspects, in this study, the GDP was selected as an independent econometric variable. GDP is expected to provide information on the economy's ability to influence defence spending, and the dependency ratio will be high, meaningful, and positive.

To determine the correlation between GDP and defence spending, in addition to the specific stages of regression analysis (PLS - used in this study), importance was given to determining the intensity of the link between the two variables. The determination of the connection intensity was performed by correlation analysis. The most used indicator of correlation analysis is covariance (Pearson coefficient), which shows the simultaneous variation of the variables X and Y, in relation to $\bar{X}$ (the average of X) and with $\bar{Y}$ (the average of Y), according to the relationship:

$$cov(X,Y)=\frac{1}{n}\sum_{i=1}^{n}(xi-\bar{X})(yi-\bar{Y})$$

The simple linear correlation coefficient proposed by Karl Pearson is calculated as:

$$\rho=\frac{cov(XY)}{\sigma(X)\sigma(Y)}$$

The correlation coefficient is calculated only for simple linear regressions and shows the intensity of the connection between X and Y. It takes values in the range $[-1, 1]$, thus:

- if ρ is close to -1, then the connection between X and Y is strong and opposite;
- if ρ is close to 0, then there is no linear connection between X and Y;
- if ρ is close to 1, then the connection between X and Y is strong and of the same meaning;

Also in the correlation analysis, Spearman ρ rank correlation coefficients were used. This nonparametric coefficient measures the degree of ordinal association between two variables and has the following formula:

$$\rho=1-\frac{6\sum_{i=1}^{n}d_i^2}{n(n^2-1)}$$

where d_i - the difference between two ranks located on the same level, in absolute value;
n – the number of pairs.

The significance level test was performed as follows:

$$t=\rho\sqrt{\frac{n-2}{1-\rho^2}}$$

Based on the data series defence expenditures (Ch.Ap.) and GDP, the parameters of the regression model in EViews were estimated, according to the equation:

$$Ch.Ap._{it}=\alpha+\beta_1 GDP_{it}+\varepsilon_{it}$$

- the index i = 1, 2, ... N, where N = 28, represents the unit of analysis; in this case it is NATO member states, from which Iceland and northern Macedonia have been excluded;
- the index t = 1, 2, ... T, where T = 11, represents a given moment in time (the frequency is annual, and the analysed period is between the years 2010-2020);

Independent variable:

$\beta_1 GDP_{it}$ - represents the GDP of country *i*, at time *t*;

Taking into account the results of the studies of the specialized literature, and correlating these results with the objectives of the present subject, in the following part are presented the steps taken and own results obtained, in order to achieve the established objective.

2.2. Results

Using the theoretical part of the previous chapter, the correlation between GDP and defense spending and the intensity of the link between the two variables was determined. The determination of the bond intensity was performed by correlation or covariance analysis (Pearson coefficient). Also in the correlation analysis, Spearman rank correlation coefficients were used ρ.

Determine the p-value (probability associated with the value of t) and compare with the expected level (eg p-value = 0.05, or in other words, the probability of the model is 95%):

- p-value <0.05, there is a dependence between the analysed variables;
- p-value> 0.05, there is no dependence between the analysed variables.

The result of the correlation of the Sperman and Pearson indicators, for the variables defence and GDP expenditures (Ch.Ap) as data series registered in 2020, are presented in table 1.

Table 1: Spearman rank correlation, and Pearson correlation coefficient, for the variables defence and GDP expenditure, in NATO member states, for 2020

State / region	Ch. Ap. 2020 mil. $	GDP 2020 mil. $	Rank Ch. Ap.	Rank PIB	d	d^2
Albania	210	12,110	27	27	0	0
Belgium	5,173	456,074	13	11	2	4

Bulgaria	1,195	55,203	20	21	1	1
Canada	22,150	1,591,313	6	6	0	0
Croatia	986	50,698	22	22	0	0
Czech Republic	3,038	199,678	17	16	1	1
Denmark	4,718	324,576	15	13	2	4
Estonia	669	26,081	24	26	2	4
France	50,247	2,370,079	4	4	0	0
Germany	56,074	3,393,396	3	2	1	1
Greece	4,785	183,130	14	17	3	9
Hungary	1,829	138,714	18	18	0	0
Italy	24,853	1,742,027	5	5	0	0
Latvia	722	29,250	23	25	2	4
Lithuania	1,118	47,102	21	23	2	4
Luxembourg	422	61,971	26	20	6	36
Montenegro	97	4,095	28	28	0	0
Netherlands	12,067	799,607	9	9	0	0
Norway	6,671	402,102	11	12	1	1
Poland	12,043	549,006	10	10	0	0
Portugal	3,472	202,740	16	15	1	1
Romania	5,498	206,003	12	14	2	4
Slovakia	1,753	92,838	19	19	0	0
Slovenia	584	46,438	25	24	1	1
Spain	14,069	1,170,569	7	7	0	0
Turkey	13,303	984,534	8	8	0	0
UK	59,634	2,761,985	2	3	1	1
United States	784,952	19,234,527	1	1	0	0

n=28 t=24.6088 ∑ d^2=76
Sperman =0.9792 p value =0.0000
Pearson =0.9897

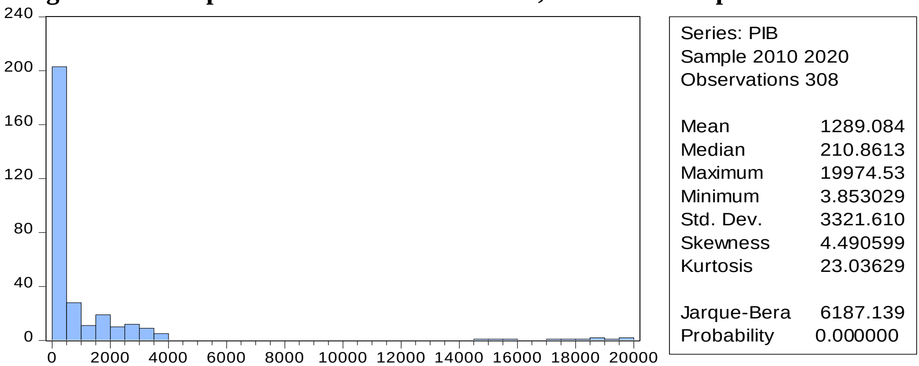
Source: authors' processing

Therefore, for n = 28 (the 28 states included in the analysis) results a ρ (Sperman) of 0.9792. The Pearson coefficient obtained has the value 0.9897. This indicates a positive and very strong relationship between the variable GDP and the variable defence expenditure. In other words, the higher the GDP or the higher the growth, the higher the state's defence expenditures will be.

The regression analysis took into account the two series of data defense expenditures (Ch.Ap.) and GDP, the model was run in Eviews.

Figure 1 shows the descriptive statistics of the variable "GDP". It can be observed that the average of this series is 1,289.08 billion, being an estimator of the central trend of the data series. The median value of the series is $ 210.86 billion. The serial data is scattered around this value. The volatility estimator or Standard Deviation (Std. Dev.), reflects the deviations that occur from the central trend of the data. The standard deviation of this series is $ 3,321.6 billion. The "elongation" to the left or right of the average, or the data distribution parameter, is reflected by Skewness. The Kurtosis parameter captures the data vault, that is, it reflects the existence of possible extreme values in the data. The value of the Kurtosis vaulting coefficient, in the case of the analysed series, being 23.03, which shows a leptokurtic distribution of the data, meaning that the extreme values that appear in the data are distant from the average, and the series does not necessarily follow a normal distribution. The value of the vaulting coefficient Kurtosis, in the case of the analysed series, being 23.03, which shows a leptokurtic distribution of the data. This means that the series does not necessarily follow a normal distribution, and the extreme values that appear in the data are spaced from the average.

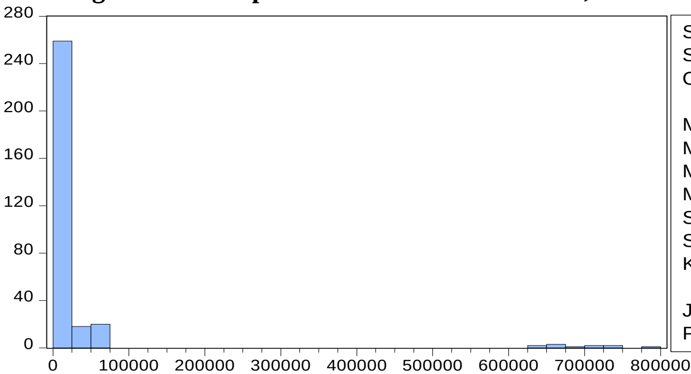
Figure 1: Descriptive statistics of the variable, "GDP" in the period 2010-2020



Source: author processing

The descriptive statistics of the dependent variable (defence expenditures) are presented in (Figure 2). It can be observed that the average of this series is 35028.12 million dollars, being an estimator of the central trend of the data series. The median value of the series is 3918.6 million dollars. The serial data is scattered around this value. The volatility estimator or Standard Deviation (Std. Dev.), Reflects the deviations that occur from the central trend of the data. The standard deviation of this series is 128 million dollars. The "elongation" to the left or right of the average, or the data distribution parameter, is reflected by Skewness. The Kurtosis parameter captures the data vault, it reflects the existence of possible extreme values in the data. The value of the Kurtosis vaulting coefficient, in the case of the analysed series, being 23.03, which shows a leptokurtic distribution of the data, meaning that the extreme values that appear in the data are distant from the average, and the series does not necessarily follow a normal distribution. The value of the vaulting coefficient Kurtosis, in the case of the analysed series, being 23.03, which shows a leptokurtic distribution of the data. This means that the series does not necessarily follow a normal distribution, and the extreme values that appear in the data are spaced from the average.

Figure 2: Descriptive statistics of the variable, "defence expenditures"



Series: CH_AP_	
Sample 2010 2020	
Observations 308	
Mean	35028.17
Median	3918.601
Maximum	784952.0
Minimum	56.93507
Std. Dev.	128336.7
Skewness	4.919609
Kurtosis	25.73061
Jarque-Bera	7873.134
Probability	0.000000

Source: authors' processing

The empirical results obtained are presented in Table 2:

Table 2: Results of estimating the regression model in EViews, for the variables defence and GDP expenditures

Dependent Variable: CH_AP_
Method: Panel Least Squares
Sample: 2010 2020
Periods included: 11
Cross-sections included: 28
Total panel (balanced) observations: 308

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PIB	37.76776	0.465849	81.07291	0.0000
C	-13657.66	1657.469	-8.240070	0.0000

R-squared	0.955516	Mean dependent var	35028.17
Adjusted R-squared	0.955370	S.D. dependent var	128336.7
S.E. of regression	27112.11	Akaike info criterion	23.25982
Sum squared resid	2.25E+11	Schwarz criterion	23.28404
Log likelihood	-3580.012	Hannan-Quinn criter.	23.26951
F-statistic	6572.816	Durbin-Watson stat	0.123774
Prob(F-statistic)	0.000000		

Source: own processing

The above results highlight the following:

- the model is correctly specified, because the value of the F statistic is 6572.81 (Prob. for F is 0.00); the values of t-student statistics for the variable GDP, show that it differs significantly from 0 (and Prob. for t-Student is 0.00;
- the value of the DW statistic equal to 0.12 highlights a positive autocorrelation at the level of the error series;

Starting from the premise of a strong correlation between GDP variables and defense spending, an econometric study was used. The PLS method was used to observe the influence of the independent variable GDP on the dependent variable defense expenditure. Thus, the results obtained by econometric analysis show that there is a strong positive linear dependence between the two variables. It can be stated that 95.55% of the variance of the dependent variable can be explained by the chosen model.

3. Conclusions

By estimating the correlation between the GDP variable and the defence expenditure variable, a significant dependency relationship was expected. This estimate sought to obtain information on the economy's ability to influence defence spending. Often the national GDP is associated as a reference indicator that decisively influences the military power of states.

From the econometric analysis it was found that in the period included in the research, between the two variables there is a strong, linear, and positive dependence. The increase of the Gross Domestic Product influences in proportion of 95.55% the increase of the defence expenses.

For the two variables, the method of determining the intensity of the correlation link by covariance parameters was also used. For the 28 states included in the analysis, a ρ (Sperman) of 0.9792 resulted. The Pearson coefficient obtained in the model has the value 0.9897. This indicates a very strong positive relationship between the GDP variable and the defence expenditure variable during the analysis period. Basically, the higher the GDP or the higher the growth, the higher the state's defence spending.

The results obtained in this study are satisfactory and lead to the achievement of the goal initially set.

But, the dynamics of defense spending deserve to be studied in the light of as many indicators as possible that may affect or influence the growth and dynamics of this type of spending in modern states. The more comprehensive a range of indicators and influencers can be included in the analysis, the more accurate the results will be. This topic remains open to the attention and study of other researchers.

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