Defense expenditure and economic growth in Visegrad group countries: a panel data analysis

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Abstract. The defense economics literature reveals the complexity and inconsistency of examining the relationship between military spending and economic development. The current scientific research has not established a clear approach to handling this large problem. The defense expenditure has been described and investigated by political, strategic and economic factors. This paper aims to analyze the relationship between military expenditure and economic growth in Visegrad group countries (V4) Czech Republic, Slovak Republic, Hungary and Poland. In this study, we focus on trends of military expenditure and some macroeconomic factors which are influencing military expenditure such as the growth rate of GDP, balance of payments, inflation, foreign direct investment, government debt or net lending/borrowing. The effects of determinants of military expenditure are examined with time series data of the period 1995–2015. The empirical model is based on the statistical method of regression and panel regression.

Keywords: military expenditure, economic growth, V4 countries, panel data analysis.

JEL classification: C33, E69
AMS classification: 62J05

1 Introduction

A closer examination of the relationship between military spending and economic growth has allowed the development of economic mathematical methods in the second half of the twentieth century. The era of mathematical and statistical analysis in the field of defense economics has started with Benoits paper [2] investigating the impact of military expenditure on economic growth in 1973. Since then, various approaches have been applied examining this relationship. With the beginning of the Cold War and changes of the power distribution military spending was favored at the expense of non-defense spending [6]. The disintegration of the bipolarity after 1990 has caused the reduction of military budgets and the effort to replace the shortage of funds by more efficient use of resources. Coulomb and Fontanel [3] investigated the possibility of strengthening the military strategic position on France's case despite the reduction in military spending after 1990. Thus, military expenditure has become a variable adjusting to the current economic situation. In the post-cold period, the cuts in military spending were expected and seemed to be inevitable. Odehnal and Neubauer [16] confirmed this tendency in the study of Germany, Great Britain and France. Still, there were some countries excluded from this trend [5], different determinants of military spending were detected even in NATO countries [17]. In this article, we focus our attention on possible determinants of military expenditure in V4 countries of the period 1995–2015 to examine their effects after the end of Cold War.

2 Data and models

2.1 Data

Analysis of determinants of military expenditure in the Czech Republic (CZE), Slovakia (SVK), Poland (POL) and Hungary (HUN) are based on time series of predominantly macroeconomic variables in time period 1995–2015 (the database SIPRI, The World Bank). To describe military expenditure – MILEX [% of a gross domestic product (GDP)], we use following variables: economic growth – EG [%] , foreign direct investment – FDI [% of GDP], inflation – INFL [%], balance of payments – BOP [billions of dollars], population – POP [in millions], net lending/borrowing – NLB [% of GDP], government debt – DEBT [% of GDP].

2.2 Panel data models

The panel data approach belongs to several statistical methods frequently used to describe relationship among macroeconomics variables in last decades, for example, a question of main inflationary factors in V4 countries is

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discussed in the paper [19], issues connected with military expenditure modeling are examined in the papers [1], [7], [11] or [21].

The general panel model used in econometrics is

$$y_{it} = \alpha_{it} + \beta'_{it} X_{it} + u_{it},$$

where $i = 1, 2, \ldots, n$ is the individual index (group, country), $t = 1, 2, \ldots, T$ is the time index and u_{it} is a random zero mean disturbance term, X_{it} is a $k \times 1$ vector of independent variables, β_{it} is a $k \times 1$ vector of parameters. The parameters β_{it} are not estimable with $N = n \times T$ data points, therefore a number of assumptions are usually made about the parameters, the errors and the exogeneity of regressors. Let us assume that $\alpha_{it} = \alpha$ and $\beta_{it} = \beta$ for all i, t. We get the model

$$y_{it} = \alpha + \beta' X_{it} + u_{it},$$

which is a standard linear model *pooling* all data across i and t, it can be estimated by ordinary least squares (OLS).

To model individual heterogeneity, let us assume that the error term has two separate components $u_{it} = \mu_i + \epsilon_{it}$, where μ_i is specific to the individual and does not change over time.

$$y_{it} = \alpha + \beta' X_{it} + \mu_i + \epsilon_{it}$$

The error term ϵ_{it} is usually assumed independent of both the regressors X_{it} and the individual component μ_i. If the individual component is correlated with the regressors, it it customary to treat the μ_i as next n parameters to be estimated. This is called the *fixed effect* model [9]. If we denote $\alpha_i = \alpha + \mu_i$ we obtain the model

$$y_{it} = \alpha_i + \beta' X_{it} + \epsilon_{it}.$$

This model is sometimes called the *least squares dummy variable* model, it is usually estimated by OLS.

If the individual component μ_i is uncorrelated with the regressors, the model is termed *random effect*, μ_i are not treated as fixed parameters, but as random drawings from a given probability distribution [9]. To get greater efficiency, generalizes least squares (GLS), taking into account the covariance structure of error term, may be used.

3 Empirical results

As a first step, we estimate a linear regression model for each country. The results are summarized in table 1. The table contains estimates for full models (all variables are taken in account), and the reduced models only with statistically significant parameters. It should be noted that economic growth and foreign direct investment are not significant in any country. Inflation is significant only for the Czech Republic (with a negative sign), balance of payments is significant (with a positive sign) in all countries except for Hungary. There is a significant negative effect of population in the Czech Republic and Slovakia, whereas the effect is positive in Poland and Hungary. Net lending/borrowing plays a significant negative role in the Czech Republic, Slovakia and Poland like government debt in all countries except for Poland. The question of spurious regression is closely connected with linear regression models applied to time series when some of them are non-stationary. Unit root tests, such as augmented Dickey-Fuller (ADF) or Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test, are usually used to detect non-stationary behavior of analyzed time series. In case that some of them are non-stationary, it is necessary to test whether examined time series are cointegrated. It should be emphasized that times series are rather short (21 observations). The power of unit root tests and tests of cointegration for such a short time series is small. Time series of military expenditure, population and payments balance can be considered non-stationary, variables net lending/borrowing and government dept seem to be stationary (except for government debt in Hungary). We use the significance level 0.05 in all testing procedures. Normality of residuals of estimated model was not rejected (Shapiro-Wilk test, Lilliefors test), residuals were found uncorrelated (Ljung-Box test). There are several approaches to cointegration testing. One is based on a single equation method (Engle-Granger test), another employs a vector error correction model (Johansen tests). According the results of Johansen tests, the systems of analyzed time series in each country are cointegrated. However, Engle-Granger tests do not reject the null hypothesis of no cointegration. This test is based on ADF test applied on residuals from linear regression models. The power of the test for short time series (and this is our case) is very small. As a result, the tests do not reject the existence of a unit root in residuals. On the other hand, the autocorrelation functions of residuals do not contain significant values, especially for lag 1, when for non-stationary (integrated) time series the value close to one is expected. We came to conclusion that the regressions are not spurious.

The aim of this contribution is to describe military expenditure of V4 countries by selected variables using panel data models. We estimated pooling, fixed and random effect model. Estimation results are summarized in table 2. Statistical software R (the package *plm* [4]) and Gretl was used for necessary calculation. The table contains, as with the individual regression models, estimates for full and reduced (final) models. Economic growth was found

	Dependent variable: MILEX							
	CZE (full)	CZE	SVK (full)	SVK	POL (full)	POL	HUN (full)	HUN
EG	−0.008		0.029		0.044		−0.012	
	(0.007)		(0.020)		(0.042)		(0.013)	
FDI	0.007		−0.035		−0.045		−0.003	
	(0.008)		(0.025)		(0.045)		(0.003)	
INFL	−0.019*	−0.020**	0.026		0.002		0.006	
	(0.009)	(0.009)	(0.024)		(0.010)		(0.012)	
BOP	0.014*	0.015*	0.108***	0.148***	0.010**	0.009**	−0.016	
	(0.008)	(0.008)	(0.035)	(0.026)	(0.004)	(0.003)	(0.014)	
POP	−1.692***	−1.672***	−15.412**	−15.957***	0.560*	0.988***	0.248	0.746***
	(0.254)	(0.226)	(7.052)	(5.177)	(0.305)	(0.135)	(0.678)	(0.178)
NLB	−0.023***	−0.025***	−0.060**	−0.051**	−0.057**	−0.044**	−0.012	
	(0.007)	(0.007)	(0.021)	(0.019)	(0.023)	(0.020)	(0.016)	
DEBT	−0.017***	−0.017***	−0.029**	−0.040***	−0.016		−0.015***	−0.014***
	(0.004)	(0.003)	(0.012)	(0.009)	(0.010)		(0.005)	(0.003)
Const.	19.497***	19.307***	85.703**	89.298***	−19.083	−36.089***	−0.329	−5.294**
	(2.613)	(2.270)	(37.740)	(27.652)	(11.987)	(5.169)	(6.930)	(1.883)
Observations	21	21	21	21	21	21	21	21
R^2	0.972	0.967	0.905	0.870	0.886	0.861	0.875	0.832
Adjusted R^2	0.957	0.956	0.853	0.838	0.825	0.837	0.808	0.813
Note:								*p<0.1; **p<0.05; ***p<0.01

Table 1 Linear regression models for individual countries, standard errors are in parenthesis; MILEX – military expenditure, EG – economic growth, FDI – foreign direct investment, INFL – inflation, BOP – balance of payments, POP – population, NLB – net lending/borrowing, DEBT – government debt

significant only for the pooling model. In this model, almost all variables are statistically significant, only variable FDI is not significant. The estimated parameters in the final fixed and random models are nearly the same. We conducted several statistical tests to decide which model is better for the description of military expenditure. The first – the test of poolability – tests the hypothesis that the same coefficients apply to each individual (country). The p-value of this test is 0.00029 which means, that the fixed or random effect model should be preferred to the pooling model. Hausman test [8] offers the way how to compare fixed and random effect models. The p-value of this test for final models is 0.49251. According to this result we favor the random effect model

$$\mathit{MILEX} = 2.458 + 0.017 \cdot \mathit{INFL} + 0.011 \cdot \mathit{BOP} - 0.037 \cdot \mathit{NLB} - 0.024 \cdot \mathit{DEBT}.$$

From the perspective of the V4 countries, military expenditure is mainly influenced by inflation, balance of payments, net lending/borrowing and government debt. The effect of inflation and balance of payments is positive meaning that of inflation or balance of payments is increasing, military expenditure is increasing as well and vice versa. The opposite effect can be detected for the variables net lending/borrowing and government debt.

Analysis of residuals reveals that estimated model is not able to describe behavior of military expenditure in Slovakia for the years 1995 and 1996 satisfactorily. These values are considerably higher than other values, and corresponding residuals are big which causes rejection of normality. If one trims these values, normality of residuals is not rejected by common normality tests (Shapiro-Wilk, Lilliefors, Jarque-Bera test). The question of spurious regression is relevant in context of panel data modeling too. Firstly, we conducted unit root tests for panel data (Levin-Lin-Chu [13] and Im, Pesaran and Shin test [10]) with the result that time series of military expenditure, payments balance a government debt are non-stationary, inflation and net lending/borrowing are stationary. Cointegration relationship can be tested by the panel cointegration tests proposed by Pedronni [18], package *pco* in R software [15]. All tests reject the null hypothesis of no cointegration, which means that the system of analyzed panel data is cointegrated.

	Dependent variable: MILEX					
	pooling (full)	pooling	FE (full)	FE	RE (full)	RE
EG	0.034***	0.033***	0.014		0.014	
	(0.012)	(0.011)	(0.011)		(0.011)	
FDI	0.002		0.002		0.001	
	(0.004)		(0.004)		(0.004)	
INFL	0.017***	0.018***	0.019***	0.016***	0.016***	0.017***
	(0.006)	(0.006)	(0.007)	(0.006)	(0.006)	(0.005)
BOP	0.012**	0.011**	0.014**	0.012**	0.013**	0.011**
	(0.006)	(0.006)	(0.005)	(0.005)	(0.005)	(0.005)
POP	0.012***	0.012***	−0.234		−0.047	
	(0.003)	(0.003)	(0.229)		(0.111)	
NLB	−0.055***	−0.055***	−0.039***	−0.037***	−0.040***	−0.037***
	(0.013)	(0.013)	(0.013)	(0.012)	(0.012)	(0.012)
DEBT	−0.014***	−0.014***	−0.024***	−0.026***	−0.024***	−0.024***
	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)
Const.	1.597***	1.602***			3.152	2.458***
	(0.123)	(0.122)			(2.437)	(0.221)
Observations	84	84	84	84	84	84
R^2	0.620	0.619	0.639	0.626	0.635	0.612
Adjusted R^2	0.585	0.590	0.590	0.592	0.601	0.592
Note:						*p<0.1; **p<0.05; ***p<0.01

Table 2 Panel data models – pooling, fixed effect (FE) and random effect (RE) models, standard errors are in parenthesis; MILEX – military expenditure, EG – economic growth, FDI – foreign direct investment, INFL – inflation, BOP – balance of payments, POP – population, NLB – net lending/borrowing, DEBT – government debt

4 Discussion

The aim of this study has been to examine the relationship between military expenditure and economic growth in Visegrad group countries (V4) Czech Republic, Slovak Republic, Hungary and Poland. In this complex problem we decided to focus mainly on the following variables which could determine military expenditure such as the growth rate of GDP, population, balance of payments, inflation, foreign direct investment, government debt or net lending/borrowing. The results of the estimated panel model show that balance of payments and inflation have a positive impact on military expenditure, and that net lending/borrowing and government debt have a negative impact on military expenditure. For the whole group, we find no impact of economic growth and FDI on military expenditure.

The growth rate of GDP was chosen as an indicator of the economic growth. According to Tambudzai [20] increasing levels of GDP causes rising of the demand of defence to protect natural and national resources. Kollias et al. [12] used the FDI inflows to Cyprus as approximation of the safeness of national economy. Even though the foreign direct investment was important for this study of Cyprus, in our results we did not observe any significant influence across the whole sample. This may indicate that the use of the FDI variable is appropriate for developing economies, see [12], [20]. The impact of military expenditures on external debt and external borrowing was investigated by Dunne, Perlo-Freeman and Soydan [7]. The results indicate that military expenditures have positive impact on debt for developing countries. For group of V4 we discovered reversed effects of the government debt or net lending/borrowing on military expenditures. Net lending/borrowing had a significant negative effect on military expenditures in the Czech Republic, Slovakia and Poland. Government debt had a significant negative effect in the Czech Republic, Slovakia and Hungary.

The change of population can possibly affect military expenditure as a part of government expenditure. Tambudzai and Harris [20] saw ambiguous effects in the influence of population on military expenditure. Increasing population is causing an added need of protection against an external threat. On the other hand, rising size of population might have a crowding out effect on military spending because of demanding social and health services.

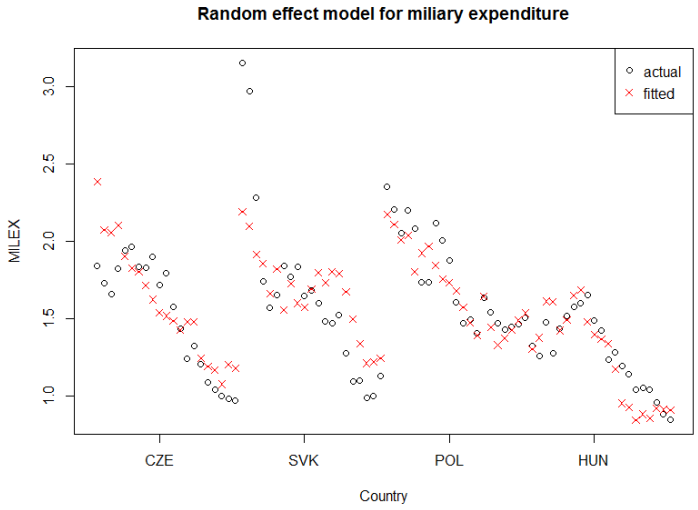

Figure 1 Random effect model for military expenditure

The negative effect of population of the Czech Republic and Slovakia on military expenditures suggests that social government expenditures are declining the military expenditures. An exactly opposite effect of population was discovered in Hungary and Poland. The inflation is negatively significant only for the Czech Republic according to our findings. For the rest of the countries we did not find any relevant effects.

The balance of payments was used here as an indicator of the economy's transactions with the rest of the world. Dunne and Nikolaidou [5] used the trade balance as one of the economic variables in their study of Greece. The trade balance as a part of the balance of payments can be also used as an external factor of military expenditures expressing the openness of the national economy and showing the trend of the balance of payments. Due to no evidence of any impact of economic variables on military expenditure in Greece, Dunne and Nikolaidou did not find any impact of trade balance on military expenditure. The balance of payments was used here as an indicator of the economys transactions with the rest of the world. Dunne and Nikolaidou [5] used the trade balance as one of the economic variables in their study of Greece. The trade balance as a part of the balance of payments can be also used as an external factor of military expenditures expressing the openness of the national economy and showing the trend of the balance of payments. Due to no evidence of any impact of economic variables on military expenditure in Greece, Dunne and Nikolaidou did not find any impact of trade balance on military expenditure. Our finding is that the balance of payments is having a significant and positive impact on military expenditure on the Czech Republic, Slovak and Poland.

5 Conclusion

The contribution deals with panel data models for V4 countries with the aim to describe behavior and possible determinants of military expenditure in these countries. Several mainly macroeconomic indicators were employed and the model was estimated. The random effect model with four regressors (inflation, balance of payments, net borrowing/lending and government debt) was finally used. First, the empirical results do not prove, for the observed four countries as a whole, any impact on economic growth, FDI and the size of population on military expenditure. Second, the panel data model indicates that, an increase of the balance of payments and inflation has positive effects on military expenditures. Third, there is a negative impact of government debt and net lending/borrowing on military expenditures for V4 countries. The balance of payments was found to have a positive effect on military expenditures for all examined countries expect Hungary. Military expenditures of each V4 country are positively influencing the balance of payments. The empirical results suggested that military expenditures are mainly influenced also by inflation, government debt and net lending/borrowing for V4 countries. We have identified various effects of other indicators on military expenditures. Inflation is significantly negative only for the Czech Republic (no significance shown for the rest of the countries). There is a significant negative effect of the population in the Czech Republic and Slovakia, while the effect is positive in Poland and Hungary. Government debt is significantly negative for the Czech Republic, Slovakia and Hungary. Net lending/borrowing is significantly negative for the Czech Republic, Slovakia and Poland.

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