CHARLES UNIVERSITY

FACULTY OF SOCIAL SCIENCES

Institute of Economic Studies

Bachelor's Thesis

2022 **Krzysztof Uchman**

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A Panel Data Investigation of the Military Spending – Economic Growth Nexus in the EU

Bachelor's Thesis

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Study programme: Economics and Finance

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Year of the defence: 2022

Declaration

1. I hereby declare that I have compiled this thesis using the listed literature and resources only.
2. I hereby declare that my thesis has not been used to gain any other academic title.
3. I fully agree to my work being used for study and scientific purposes.

In Prague on 01.01.2022 Krzysztof Uchman

References

UCHMAN, Krzysztof. *A Panel Data Investigation of the Military Spending – Economic Growth Nexus in the EU.* Praha, 2022. 45 pages. Bachelor's thesis (Bc). Charles University, Faculty of Social Sciences, Institute of Economic Studies. Supervisor Shahriyar Aliyev, MSc.

Length of the Thesis: 57,969 characters (with spaces)

Abstract

The thesis examines the relationship between economic growth, investment, and military expenditure, utilizing a balanced data panel for 14 European countries over three periods: 1970 – 1991, 1992 – 2020, and 1970 – 2020. A vector autoregression model was applied to estimate the relationship for the European population. Regression of the 14 European countries over the entire period of 1970 – 2020 has yielded neither statistically significant autocorrelation nor cross-correlation between the studied variables. The same is true when regressing the 14 countries in the period 1992 – 2020. For the same group of European countries in the period 1970 – 1991 some statistical significance has been found in the autocorrelation between investment as a share of GDP and its lags. It appears that the introduction of a time break between year 1991 and 1992 (the fall of the Iron Curtain) has no impact on the studied relationship for the selected group of countries and the time period. The results of the thesis suggest no identifiable relationship between the variables for the chosen European sample of 14 countries.

Abstrakt

Práce zkoumá vztah mezi hospodářským růstem, investicemi a armádními výdaji, přičemž využívá vyvážený panel dat pro 14 zemí EU za tři období: 1970-1991, 1992-2020 a 1970-2020. K odhadu vztahu pro obyvatelstvo EU byl použit vektorový autoregresní model. Regrese 14 zemí EU za celé období 1970-2020 nepřinesla mezi zkoumanými proměnnými statisticky významnou autokorelaci ani křížovou korelaci. Totéž platí při regresi 14 členských zemí EU v období 1992-2020. U stejné skupiny zemí EU v období 1970-1991 byla zjištěna určitá statistická významnost autokorelace mezi investicemi jako podílem na HDP a jejich zaostáváním. Ukazuje se, že zavedení časové přetržky mezi rokem 1991 a 1992 (pád železné opony) nemá na zkoumaný vztah pro vybranou skupinu zemí a časové období žádný vliv. Výsledky práce naznačují, že pro vybraný vzorek 14 zemí EU není mezi proměnnými identifikovatelný žádný vztah.

Keywords

Military expenditure, GDP growth, economic growth, investment, panel data, panel VAR model

Klíčová slova

Armádní výdaj, růst HDP, ekonomicky růst, investice, panelový data, panelový VAR model

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A Panel Data Investigation of the Military Spending – Economic Growth Nexus in the EU

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Introduction

Close to the end of the Cold War EU15 countries started decreasing their military expenditure burden as the world was expecting more peace and stability. The falling trend of the share of defense spending in GDP persisted for over two decades with the recent years seemingly reversing this trend. While maintaining a national military is just as necessary today, as it was before the fall of the Iron Curtain, the required magnitude of defense spending is debatable. Given the controversial status of military expenditure and the fact that it essentially competes for funding with many other worthwhile public pursuits, like healthcare or investment (d'Agostino, Dunne, Pieroni, 2019; Dudzeviciute, Peleckis, Peleckiene, 2016; Kollias and Paleologou, 2019), it is beneficial to know what effect, if any, military expenditure has on economic performance. The issue becomes even more relevant and pressing, given the current Covid-19 pandemic, and the associated economic hardship felt not only among the European countries, but around the globe. Increasing the share of military spending in GDP in face of economic downturn, hurdles in global supply chains, and additional burden from necessary healthcare services would be an unfortunate trend to continue, if indeed, defense spending has a negative relationship with GDP growth. On the other hand, if military spending has the capacity to stimulate the economy, then perhaps the upward trend in defense burden is desirable and justified as a step towards economic recovery. Military expenditure may possibly be acting via the demand channel as an aggregate demand stimulator, though the benefits would largely stem from higher utilization of the capital stock. The demand stimulation would translate into a greater multiplier effect when the considered economy already has military industrial capacity, which most developed European countries do, and produces inputs to the military industrial sector domestically (Kollias and Paleologou, 2016 and 2019). Military expenditure can also have a positive economic impact via the supply channel. Commercial applications of military R&D and technological spin-offs are both acknowledged sources of economic performance improvement (Dunne, Smith, Willenbockel, 2005). Irrespectively of both the economic impact and the theoretical explanation of associated economic mechanisms, national defense is a necessity. Each country must at the very least maintain a certain minimum level of the military in order to deter or defend against external aggression. Furthermore, it is important to realize that national security is fundamental to providing an environment where trade and foreign investment are possible, especially long-term (Ahmed and Ismail, 2015).

Research activity around the economic growth – military expenditure is ongoing and no consensus has been reached over the past decades. The methodology has changed over the years of continued research, a wide spectrum of countries and periods has been investigated, which makes robust comparisons between various studies difficult (Desli and Gkoulgkoutsika, 2020; Dunne and Tian, 2013). Nonetheless, a number of surveys and meta-analyses have been conducted over the past years. For instance, Dunne and Tian (2013) which treats almost 170 individual studies indicates that studies from the first decade of the 2000s are more frequently pointing towards a negative effect of military expenditure on growth. Contrary to Dunne and Tian (2013), Yesilyurt and Yesilyurt (2019) find in their meta-analysis of 91 studies that the average effect of military spending on economic growth is approximately zero. A devoted literature review will follow the introduction, but for the purposes of the introduction it must be said that despite a rich history of research in the field, there is no consensus about the relationship between military expenditure and economic growth.

The thesis aims to empirically investigate the relationship between military expenditure and economic growth for selected 13 EU countries, including the UK, and Norway during the period 1970 – 2020. Norway has been included into the sample of "EU" countries due to a combination of 1) its reliance on and cooperation with the rest of the EU (and in particular with Germany) in defense and security matters (Knutsen, 2021), 2) being part of the European Economic Area, and 3) in the interest of expanding the sample of countries examined within this thesis. Throughout the thesis "military expenditure", "military spending", "defense spending", and "defense expenditure" will be used interchangeably and all effectively refer to the spending pertaining to current personnel (both military and civil), retirement pensions of military personnel, social services for personnel and their families, operations and maintenance, procurement, military R&D, military construction work, and military aid (to another country) as defined in the Stockholm International Peace Research Institute (SIPRI) Military Expenditure Database utilized for the purposes of military spending data collection. A few years prior SPIRI extended the Military Expenditure Database, allowing for procurement of data from as early as 1949 up to the year 2020. Kollias and Paleologou (2016) remark that the availability of consistent time series of defense spending allows for estimations over larger time horizons, which produces statistically more robust results and grants the opportunity to draw more reliable inferences. More specifically for the studied topic, the inclusion of both Cold War and post-Cold War data is important for gaining the understanding of the relationship in varying political conditions. Simultaneously, the period studied in this thesis contributes by extending the studied time period into 2020, which 1) provides more insight into the military expenditure – economic growth nexus in the context of the contemporary world, and 2) makes it possible to compare the estimated relationship for the Cold War and post-Cold War. Furthermore, as explained further in the data and summary statistics section, the thesis investigates the potential structural break associated with the end of the Cold War by applying the PVAR model to the entire period 1970 – 2020 and subsequently running separate regressions for periods 1970 – 1991 and for 1992 – 2020.

In the interest of obtaining a balanced data panel for the purposes of running PVAR, while also attempting to maximize the product of country × time dimension from the data available between the datasets used, some countries had to be omitted. Notably, some of the data for Ireland and Germany was missing, and therefore the two countries were not included in the studied sample. The data for remaining EU15 countries and Norway were available. Appendix 1 presents a full list of countries for which data were available, as well as a list of European countries under consideration. More details regarding the data and operations on the data after collection is presented in the data and summary statistics section. The author of the thesis hypothesizes that under the scope of a PVAR model described in the methodology section, there will be no statistically significant relationship between military expenditure and economic growth for the European countries. The hypothesis of no statistically significant relationship is based on the following:

1) as presented in the data and summary statistics section, the share of military expenditure in GDP is small relative to other components, like health and education. Due to this, military spending may not be exerting statistically significant "pressure" on the trajectory of GDP in order for the panel vector autoregression to indicate a statistically significant relationship (Dunne and Tian, 2013).

2) Based on the initial inspection of the input data for economic growth and military expenditure it appears as though the two series have years where their behavior diverges significantly. For instance, economic downturn due the Covid-19 pandemic is not reflected in the form of a decrease in military burden.

3) The latest meta-analysis, to the best of the author's knowledge, on the researched topic has found no effect of military spending on economic performance (Yesilyurt and Yesilyurt, 2019).

This concludes the introduction. The following section shall review and discuss the data utilized in the thesis, the operations performed on the data before PVAR is applied and relevant summary statistics shall be presented. Then, the methodology section shall introduce and explain the regression model used to proceed with the estimation for the balanced panel of data obtained. Next the results shall be presented and discussed, after which a robustness check is performed. Lastly, the conclusions section shall summarize the findings, indicate policy recommendations, and point out limitations and possible improvements to be applied in future studies on the topic.

1. Literature Review

The perennial study to open the Pandora’s box and the first to approach the issue of military spending’s effects on economic development is that of Benoit (1973, 1978). Benoit initiated the debate arguing for the positive effect of military spending on economic growth and describing the substantial role of military expenditure on sustained development of the economy. Most of the research that followed utilizes econometric analysis and has disputed Benoit’s results and conclusions. The almost universal application of econometrics in research methodology is one of the few unifying characteristics among the various studies concerning the topic that have amassed over the decades since Benoit’s pioneering work. Desli and Gkoulgkoutsika (2020) comment on the difficulty of direct comparison between the diverse body of work on the topic that is currently in existence, as well as on the inconclusiveness of the evidence stemming from the research. The main culprits causing the lack of scientific consensus and the impossibility of making robust comparisons are the use of different groups of countries, varying time periods, and diverse methodologies.

Kollias and Paleologou (2019) additionally point to the multitude of channels through which defense spending has an effect on economic performance as a reason for a lack of consensus on the mechanism through which defense spending is related to economic growth. Considering the demand-side effects, one can follow Keynesian theory and assert that higher defense spending stimulates aggregate demand, resulting in greater utilization of idle or underemployed capital stock, increased investment, and consequently through the multiplier effect boosts the rate of economic growth (Kollias and Paleologou, 2019). The positive effect is expected to be far greater when the country in question already has sufficient defense industrial capacity and produces the inputs to the military sector domestically. Conversely, in case of a country reliant on importing weaponry and military hardware the potential increase in utilization of the capital stock is considerably smaller, which further translates to less induced investment, a lesser multiplier effect, and less improvement to the economy overall (Kollias and Paleologou, 2019). Nevertheless, such a demand-side channel is thought to be particularly potent in a downturn or in a stagnating economic environment, when a governmental injection can have a revitalizing effect. From the supply perspective R&D in the military sector has the potential to create commercial applications and technological spin-offs which in turn may bolster aggregate demand (Dunne, Smith, Willenbockel; 2005). On the other hand, the defense sector frequently lacks the competitive market pressures of the civilian sector, which may result in inefficient use of resources in comparison with the civilian sector. If the military personnel receives training or education then defense expenditure may lead to the formation of human capital, in turn improving economic performance (Dudzeviciute, Peleckis, Peleckiene; 2016). This, however, is not inevitable as skills gained in the armed forces may not increase the workers' productivity in the civilian sector and their productivity may even be hindered. Some government projects related to national defense result in the creation of infrastructure which can have a positive socio-economic impact. Kollias and Paleologou (2019) note that non-military infrastructure expenditure may be comparatively superior at improving economic performance.

Evidently, military spending has opportunity costs and is frequently state-financed, therefore it is merely a single constituent of a government's budget. The more resources that a government allocates to defense spending, the less is left for other, potentially more socially beneficial, forms of government spending. It also follows that military expenditure has the potential of crowding out other forms of spending, e.g. investment or health systems (d'Agostino, Dunne, Pieroni, 2019; Dudzeviciute, Peleckis, Peleckiene, 2016; Kollias and Paleologou, 2019). While spending on national security may foster savings, investment, and production due to the enhancement of perceived safety (Waszkiewicz, 2020), there exists the danger of creating inefficiencies. Dunne and Tian (2013) explain an institutionalist approach which suggests how military expenditures may cause industrial inefficiencies by facilitating the creation of a powerful interest group benefiting from such spending. The authors refer to the collection of firms, organizations, and individuals with vested interest in maintaining or expanding defense spending as the military industrial complex (MIC). In the presence of a MIC there would be a pressure on increasing the share of GDP spent on defense, which as previously mentioned, carries opportunity costs and may have a crowding out effect on other expenditures. Kollias and Paleologou (2019) explain that while the extent and the precise form of crowding out is dependent on the initial utilization of capital, the government budget constraint necessitates one or more of the following in order to finance larger military expenditures: increased taxes, reductions in other public spending, increased national debt, or expansion of the money supply.

Study surveys performed by Dunne (1996), Smith (2000), Dunne and Uye (2010), Dunne and Tian (2013, 2016) found no empirical regularity, positive, or negative impact of defense spending on growth. Neither was a definitive direction of causality established. From these sources, only the survey by Dunne and Tian (2016) points to a more consistent trend emerging in more recent studies. Once more data covering the period after the Cold War became available and simultaneously constituted a larger portion of the sample, a statistically significant negative effect was identified more frequently by researchers. Dunne and Tian (2016) argue that the post-Cold War period experienced a drastic shift away from military spending coupled with a more stable geopolitical environment. These two factors contributed to increased economic performance, which was interpreted as a peace dividend in exchange for lower defense spending. d'Agostino, Dunne, and Pieroni (2019) further comment that current studies' estimation periods are no longer dominated by data from the Cold War period and it appears to translate into more econometric analyses resulting in a negative relationship between economic growth and military expenditure. The above is not to suggest that any consensus has been reached as the most recent studies seem to unanimously quote the mixed results in the field (d'Agostino, Dunne, Pieroni, 2019; Desli and Gkoulgkoutsika, 2020; Dudzeviciute, Peleckis, Peleckiene, 2016; Kollias and Paleologou, 2019; Saba and Nhepah, 2020; Waszkiewicz, 2020). A meta-analysis by Yesilyurt and Yesilyurt (2019) found based on 91 studies an average effect of military expenditure on economic growth to be approximately zero, which seems to contradict the earlier indications of Dunne and Tian (2016). In fact, Dunne and Tian (2013) determined that close to 53% of post-Cold cross-country research papers suggest a net negative effect of military expenditure on economic growth as opposed to 38% of papers for the Cold War period. In total, however, the authors quote that almost 40% of studies yielded inconclusive results, i.e. no statistical significance in the modeled relationship. Evidently, a consensus in the topic is yet to be reached.

Research has not only focused on all countries in the world with consistently available data, but, as is the aim of this thesis, attempts have been made to gain insight into the relationship between economic growth and military expenditure among European countries. The spectrum of methodological approaches to studying the nexus economic growth – military expenditure is as broad for the literature concerning the EU as is the case for research studying more of the world's regions. Topcu and Aras (2017) investigated the cointegration and the direction of causality in CEE countries over the period 1993 to 2013. Their tests seem to reveal no long-term cointegration between economic growth (GDP per capita in US$) and military expenditure (per capita in US$), while panel Granger causality indicates unidirectional causality from economic growth to military expenditures at 10% significance level. Chang, Lee, and Chu (2015) find the same prevalent direction of causality in their study concerning EU 15 for the years 1988 – 2010 in both short- and long-run. Somewhat contrary to these results, Kollias et al. (2007) find cointegration between the variables for all EU15 countries over the period 1960 – 2000 except for the Netherlands, Sweden, and Spain. Furthermore, the authors report that a positive feedback between GDP growth and military expenditure exists in the long-run, i.e. the causality between economic performance and defense spending is bidirectional. Yet another set of conclusions has been reached by Dudzeviciute et al. (2016), who have divided EU member states into 5 discrete levels of economic development and carried out correlation analysis and Granger causality testing for a relatively short period of 2004 – 2013. All groups of economic development except for the "lower middle economic level" reportedly showed a negative relationship between economic growth (in terms of real GDP per capita) and defense spending (percentage of GDP). The authors further investigated Granger causality and found that for most groups neither defense spending Granger causes real GDP per capita, nor does real GDP per capita Granger cause defense expenditure. Two notable exceptions are included in the study. In case of the "very high economic level" group the null of no Granger causation from defense expenditure to real GDP per capita cannot be rejected at 10% significance level. Furthermore, in case of the "lower middle economic level" group the null of no Granger causation from real GDP per capita to defense spending cannot be rejected at 10% significance level. An estimation of regressions based on Barro's (1991) growth model by Mylonidis (2008) also finds a net negative effect of military expenditure (percentage of GDP) on economic growth (real GDP per capita) for a sample of 14 EU countries over the period 1960 – 2000. Mylonidis (2008) has used both cross-section as well as panel data estimation techniques over eight discrete five-year intervals, the results of which were compared. The panel coefficients estimated are found to confirm the coefficients estimated in the cross-section case, and military spending (percentage of GDP) has a significant and negative impact on economic growth (real GDP per capita). The author refers to Kollias et al. (2007) who found a positive bidirectional effect between economic performance and military expenditure, noting that military expenditures may adversely affect economic growth through crowding-out of investment. Mylonidis (2008) argues that investment, growth, and defense spending are likely to be jointly determined, the hint of which the author finds in the reduction of the absolute size of the estimated coefficient of investment after accounting for military expenditures in the regression. Similarly to the previously discussed studies concerned with a larger scope of countries, the literature which investigates the nexus within the EU also lacks consensus. Moreover, the methodologies, time periods, and therefore the results and conclusions vary greatly among the research papers.

The study of the economic growth – military expenditure nexus is characterized by numerous challenges preventing a unanimous verdict on the topic. Apart from the issues covered thus far in this literature review, it is critical to mention the endogeneity inherent to the topic. One cannot be sure whether it is the defense spending having an effect, e.g. via mobilizing idle capital stock, on economic growth, whether it is economic growth which allows for more military expenditures, or whether the relationship is bidirectional. d'Agostino et al. (2019) suggest that the endogeneity problem is twofold. On one hand, the literature on the demand for military expenditure suggests that the variable is affected by growth. On the other hand, the estimates may reflect unmeasured shifts in military spending correlated with a high risk of lower growth or omitted variables. A variety of tools has been applied to consider endogeneity. To name a few, d'Agostino et al. (2019) have developed an endogenous growth model based on Barro's (1990) contributions, Desli and Gkoulgkoutsika (2020) have used the dynamic common correlated effects estimator by Chudik and Pesaran (2015), and Saba and Ngepah (2020) have employed a mixture of approaches with the panel unit root test and the panel cointegration test being two of them. This thesis shall utilize the panel vector autoregression model inspired by the study in the field by Kollias and Paleologou (2019). More details regarding the applied methodology and the approach to endogeneity shall be included in the methodology section of the thesis.

2. Data and summary statistics

Following the large number of papers written on the relationship between the military expenditures and GDP growth (see for example, Dunne and Nikolaidou, 2012; Topcu and Aras, 2014; Kollias and Paleologou, 2019; Desli and Gkoulgkoutsika, 2020), the percentage share of military expenditures in GDP serves as the measure of military expenditures. The percentage share of military expenditures in GDP was collected from the Stockholm International Peace Research Institute (SIPRI) Military Expenditure Database. The SIPRI Database is treated as a reliable independent source of data on defense spending worldwide and much of literature concerned with the economic growth – military spending nexus utilizes the Database as a source of data (Kollias and Paleologou, 2019). The full SIPRI database contains time series for 173 countries for the period 1949-2020, however observations for certain countries in particular years are missing. Observations may be unavailable due to unreliability, or inaccessibility of data, the dissolution or (re)formation of a country, and other possible occurrences affecting the data collection process and its reliability. A dedicated discussion of the achievements and pitfalls of the SIPRI Military Expenditure Database as well as a critical discussion related to the creation of the fairly recent dataset is available in Perlo-Freeman and Skons (2016) and in Perlo-Freeman (2017). An investigation of methodological perils associated with the construction of the new consistent dataset is beyond the scope of this thesis.

Utilizing the percentage share of the military expenditures in GDP has obvious advantages over applying the absolute value. Firstly, it allows to draw immediate comparisons between the countries. Secondly, it clearly represents the military burden on the economy with reference to the economy's overall performance (assuming GDP as the performance measure). Thirdly, using the percentage share of GDP intuitively implies that the series must satisfy the stationarity condition, i.e. due to stabilizing the mean and variance of the series, compared to the absolute or per capita measures. In series where monetary values are considered, the variance may be expanding (trending series).

In order to measure the economic growth, the real GDP growth is used as per the literature in the field (see for example, Dunne and Nikolaidou, 2012; Topcu and Aras, 2014; Kollias and Paleologou, 2019; Desli and Gkoulgkoutsika, 2020). The real GDP growth does not depend on the inflation rate, therefore, it is closer to being an objective measure of the economic performance. Using the growth rates instead of GDP per capita has similar advantages to those mentioned above regarding the military expenditures share in GDP. Namely, it allows for easy comparison between the countries and implies stationarity of the series.

As mentioned in the literature review, some of the previous research investigating the relationship between military expenditure and economic performance suggests the existence of a crowding-out effect of military expenditures, which is reflected in the decrease in investment in the economy. In addition, investment has an empirically well-established positive relationship with the long-run economic growth (Bond et al., 2010). Thus, the data on the investment for the sample economies is needed in order to introduce investment as a variable in the PVAR estimation process. Following the reasons mentioned for percentage share of military expenditure in GDP above, the percentage share of investment expenditures in GDP is used.

The series of real GDP growth and the share of investment expenditures in GDP are collected from the World Development Indicators database over the corresponding period (GDP growth (annual %) ID: NY.GDP.MKTP.KD.ZG and Gross capital formation (% of GDP) ID: NE.GDI.TOTL.ZS, respectively). WDI offers a wide assortment of comparable statistics concerning global development, time series indicators for 217 economies with an appreciably large time period available.

For the sake of brevity, henceforth the following acronyms will be used for the variables: *milex* for the fraction of military expenditures in GDP (in %), *gdp* for real GDP growth (in %) and *inv* for the fraction of investment in GDP (in %).

Due to the differing number of countries between the two databases used, and because of the missing data on the economic indicators for the earlier years, after merging two datasets, an unbalanced panel with 165 countries over the period of 1960-2020 is obtained.

In order to produce reliable estimation results, the data panel must be balanced. Moreover, the estimation of a panel vector autoregression model is possible only for a balanced panel. Therefore, the next step must solve the issue of the tradeoff between cross-sectional and time dimensions. The thesis follows Kollias and Paleologou (2019) by maximizing the product of country × time dimension in order to resolve the tradeoff between these two dimensions for the sake of obtaining a balance data panel. For the data considered, the maximum number of country × time observations, 2376, is available starting from the year 1977, but by sacrificing just 132 observations it is possible to expand the time dimension by 7 additional years starting from 1970. Therefore, for the purposes of this thesis, the balanced panel of 44 countries over the period of 1970-2020 is selected. The list of the 44 countries is given in the appendix 1 and the summary statistics for the data are presented in table 1.

Table 1. Summary statistics for the time series

	milex	*gdp*	*inv*
Average	2.469	3.466	23.908
Min	0	-27.33	5.965
1st quartile	1.354	1.652	19.816
Median	2.075	3.533	22.937
3rd quartile	3.157	5.506	26.789
Max	17.274	27.424	52.219
Standard deviation	1.730	3.909	6.314

Source: Author's calculations

The military burden on average constitutes around 2.5% for the full dataset of 44 countries over the analyzed period with 50% of countries having military expenditures between 1.35% and 3.16% of GDP. The maximum value of 17.27% is noted for Egypt in the year 1974.

The average GDP growth over the period is 3.47%. Half of the country-time observations have GDP growth of less than 3.5%. The minimum growth of -27.33% occurred in Iran in 1980 and the maximum growth of 27.42% was observed in Algeria in 1972.

The investment share in GDP constitutes on average 23.9% of GDP with the minimum of almost 6% (Nepal, 1970) and maximum of 52% (Algeria, 1978). The summary statistics presented in table 1 reveal that there is enough variability in all variables in the dataset in order to be used in the estimation.

To achieve a better insight into particular periods captured in the data considered, the period of 1970-2020 is divided into 5 decades (the last one includes the year 2020) and the summary statistics are recalculated for each decade. The full results are available in appendix 2. Table 2 only reports the means and standard deviations for the three variables.

Table 2. The means and standard deviations for the series by decades

	1970-79	1980-89	1990-99	2000-09	2010-20
			gdp		
Mean	5.10	3.25	3.48	3.21	2.23
St dev	4.35	4.43	3.36	2.98	3.53
			inv		
Mean	24.99	24.44	23.50	23.11	23.22
St dev	7.36	6.14	6.02	5.47	6.64
			milex		
Mean	3.19	3.08	2.28	1.90	1.76
St dev	2.48	1.80	1.22	1.03	1.05

Source: Author's calculations

From table 2 above it can be observed that the average fraction of military expenditures in GDP is decreasing over the reported decades. An especially notable decrease happened between the 1980s and the 1990s, potentially due to the collapse of the Soviet Union and the end of the Cold War.

GDP growth slows down over time. While in the 1970s the average growth was around 5.1%, by 2010s it has fallen to 2.23% on average with lower standard deviation.

Contrary to the previously discussed two variables, the fraction of investment in GDP appears to be almost stable over the whole period, starting from 25% in 1970s and slightly decreasing to 23.22% in 2010s. The variation in the investment is also relatively stable which is captured by the standard deviation.

After the summary statistics for the sample of 44 countries the European sample will be considered next. There are only 13 EU countries in the full sample, including the UK, for which complete data over the period 1970-2020 is available. In addition, Norway was included in the restricted sample as described in the introduction. The list of countries is provided in appendix 1.

The development of military expenditures in these countries is shown in figure 1. The graph (figure 1) reveals that the military expenditures in the European countries included tend to decrease over the period from 1970 to approximately the second half of the last decade included, with the most salient decrease occurring in the 1990s. In the second half of the last decade the military expenditures visibly start increasing.

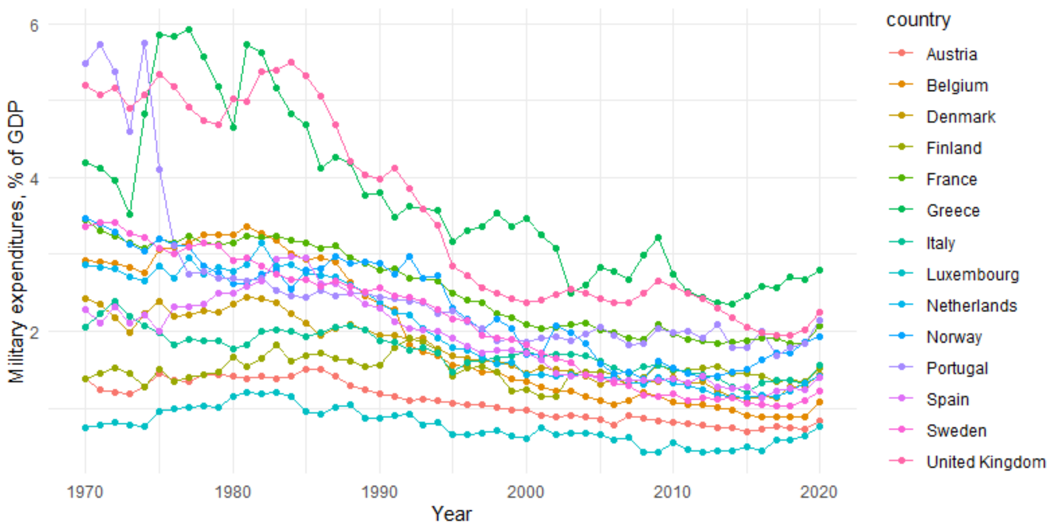

Figure 1. Military expenditures in the European countries (Source: Author's calculations)

Appendix 3 shows the averages of GDP growth and the share of military expenditures in GDP calculated by the decades for the European countries. Greece emerges as the leading country in terms of the military spending to GDP indicator over the whole sample period, followed by the UK, Portugal and France. Averages for the 14 European countries reveal a number of important facts. Firstly, one may note the heterogeneity in the average military expenditure levels and their dynamics among the European countries. Figure 1 graphically represents the different shares of defense spending in GDP per each country and how that share has been developing over the studied period. The same heterogeneity within the sample of 14 European countries is notable on the averages table in appendix 3. Secondly, based on the observable decrease in the average share of military spending from 1980s to 1990s visible among the countries in the table included in appendix 3, and considering the end of the Cold War, a structural break is suggested. The structural break in the series is set to the year 1991 with the fall of the Iron Curtain. Thirdly, the European countries appear to converge over the reported period with regards to the military spending to GDP indicator.

Interestingly, among the leaders according to the military spending to GDP indicator both countries with relatively weaker economies (Greece, Portugal) and relatively stronger economies (the UK, France) are present. This may indicate a possibility that the military burden does not necessarily depend on the level of economic development of a given economy, but rather on other factors; perhaps, political and socio-economic factors.

With the data properly selected and summary statistics briefly analyzed, the following steps shall ensure that the selected data can be used for the purposes of the panel variable autoregression model. When working with the time series, one must first verify their stationarity. A time series is called stationary if its probability distribution does not change over time (Stock and Watson, 2015). A more formal definition of stationarity (or strict stationarity) is given by Hamilton (1994): „A process is said to be strictly stationary if, for any values of $j_1, j_2, \dots, j_n$ the joint distribution of $(Y_t, Y_{t+j1}, Y_{t+j_2}, \dots, Y_{t+j_n})$ depends only on the intervals separating the dates $(j_1, j_2, \dots, j_n)$ and not on the date itself ".

Intuitively, a stationarity assumes that we can use historical data to predict the future values of a time-series because its distributional properties do not change over time. If the distributional properties were not constant, i.e. the non-stationary case, then the effects of a shock will not gradually disappear, but instead the effects would remain permanently. Therefore, stationarity is needed for the purposes of forecasting.

For the univariate time series, the conventional test for the stationarity is the augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1981). Another name of the stationarity test is the "unit root test". In the case of a panel data, ADF would be problematic as the addition of a time dimensions simultaneously means that the data gains a cross-sectional dimension. The stationarity test for the panel data utilized in this thesis is the one proposed by Levin et al. (2002). The choice of this test is based on the suggestion of the authors (Levin, Lin and Chu, 2002) that their test is appropriate for the panels of moderate size (between 10 and 250 cross-sectional units with 25-250 time periods) and this test has better performance over other testing procedures. Furthermore, in choosing the Levine et al. (2002) stationarity test the thesis follows existing literature dedicated to researching the military spending – economic growth relationship (Ahmed and Ismail, 2015; Kollias and Paleologou, 2019; Saba and Ngepah, 2020; Saba and Shahid, 2015).

To present a brief description, the Levin, Lin and Chu test assumes the null hypothesis that $\delta = 0$ against the alternative that $\delta < 0$ in the model:

$$\Delta y_{it} = \delta y_{it-1} + \sum_{L=1}^{P_i} \theta_{iL} \Delta y_{it-L} + \alpha_{0i} + \varepsilon_{it}$$

The time trend is not included in the model as the descriptive analysis above clearly suggests that the series under consideration are not trending.

Under the null hypothesis the series would have a unit root (hence, it would be non-stationary). On the other hand, if the null hypothesis is rejected, then the existence of the unit root is also rejected and the series is assumed to be stationary.

The number of lags, P_i, included into the model is not preemptively known and, thus, the authors (Levin, Lin and Chu, 2002) propose to start with the predetermined maximum lag order and then reduce it if the t-statistic on $\hat{\theta}_{iL}$ suggests so. The results of the Levin test are shown in table 3.

Table 3. The results of a Levin unit root test for the series

	gdp	*inv*	*milex*
Test statistic	-19.51	-7.8664	-8.0564
p-value	< 0.001	< 0.001	< 0.001
Decision	No unit root	No unit root	No unit root

Source: Author's calculations

Based on the test results above, the null hypotheses are rejected for all three series. Thus, henceforth stationarity will be assumed, and the panel VAR model can be estimated. Moreover, as the series are stationary, the possibility of a spurious correlation between the series is excluded (Granger and Newbold, 1974).

In order to investigate the correlation between the series for the European countries individually, the Spearman rank correlation is calculated. While the Pearson correlation coefficient captures the linear relationship between the variables, the Spearman rank correlation coefficient is able to measure if two variables have a monotonic, though not necessarily linear, relationship. This is a nonparametric test and, hence, is more flexible and does not need any additional assumptions in the form of a structural relationship between the variables. The results are presented in table 4.

Table 4. Spearman rank correlation coefficients between the series

	gdp and inv	*gdp and milex*	*inv and milex*
Austria	0.51	0.24	0.48
Belgium	0.36	0.18	-0.01
Denmark	0.21	0.06	0.12
Finland	0.23	-0.1	0.01
France	0.4	0.41	0.28
Greece	0.56	0.24	0.77
Italy	0.6	0.58	0.8
Luxembourg	0.5	0.09	0.39

Netherlands	0.65	0.21	0.51
Norway	0.14	0.46	0.5
Portugal	0.55	0.36	0.58
Spain	0.51	0.16	0.2
Sweden	-0.06	-0.04	0.48
United Kingdom	0.35	0.22	0.75

Source: Author's calculations

The results of the Spearman rank correlation presented in table 4 suggest that the strongest correlation between the GDP growth and military expenditures is in Italy (0.58), Norway (0.46) and France (0.41), while for the rest of the sample the correlation appears to be moderate or relatively weak. According to the Spearman rank correlation, investment is strongly related to the military expenditures in case of Italy (0.8), Greece (0.77), the UK (0.75), and is moderately related in case of Portugal (0.58).

It can be noted that the correlation between military expenditures and GDP growth, military expenditures and investment, as well as between GDP growth and investment is positive for almost all countries. The positive relationship between GDP growth and investment is expected as there exists solid empirical evidence for such a relationship (Bond et al., 2010). A positive relationship, in particular, between GDP growth and military spending, however, appears to be both contrary to the research hypothesis and to recent findings in the field outlined in the literature review.

After the description of the data and preliminary observation of the relationships between the variables used, the following section is devoted to explaining the research methodology of the thesis.

3. Methodology

Given the obtained balanced data panel, panel VAR is proposed as the appropriate model to estimate the relationship between the military expenditures, GDP growth and the level of investment in the economy. The presented approach largely follows Kollias and Paleologou (2019). Panel vector autoregression appears as the superior choice of methodology, in particular, over the usual panel data regression models (random effects, fixed effects), or the usual VAR models for reasons outlined below:

1) The data has two dimensions: countries and time, while conventional VAR models do not include the cross-sectional dimension.

2) Military expenditures, GDP growth and the level of investment are all considered to be endogenous variables. As it has been mentioned in the literature review, there are cross-correlations between these variables and their lags which contradicts the assumptions (1) of the panel data regression model about the conditional independence of the error term and the regressors, and (2) the absence of the autocorrelation between error terms in different time periods.

3) The data are observational and thus one cannot employ any kind of a pseudo-experiment to establish the causal relationship between military expenditures and GDP growth.

The panel vector autoregression model is an extension of a usual VAR model, which controls for the individual heterogeneity of entities (like in case of the fixed effects model).

The general form of a panel VAR model was proposed by Canova and Ciccarelli (2004). The description of the generalized PVAR model is based both on the contribution of Canova and Ciccarelli (2004) and on the relevant section of Kollias and Paleologou (2019):

$$y_{i,t} = A_0 a_{i,t} + L_1 y_{i,t-1} + \cdots + L_p y_{i,t-p} + u_{i,t},$$

Where $y_{i,t}$ is a vector of panel data variables with the dimension $K \times 1$.

$i = 1 \dots N$ represents entities dimension

$t = 1 \ldots T$ represents time dimension

$a_{i,t}$ is a vector of deterministic terms, including a linear trend, dummies or a constant.

A_0 is the parameter matrix

$L_1, \ldots L_p$ are the $K \times K$ matrices attached to the lagged variables $y_{i,t-1}, \ldots y_{i,t-p}$

The error process is decomposed into three parts: entity-specific effects (μ_i), time specific effects (γ_t) and the disturbance term ($\varepsilon_{i,t}$):

$$u_{i,t} = \mu_i + \gamma_t + \varepsilon_{i,t}$$

The estimation process aims to estimate the matrices the matrices $L_1, \ldots, L_p$ as the values provide insights into the studied relationship.

Canova and Ciccarelli (2013) note that panel vector autoregression has two features that distinguish this model from the conventional VAR model and from other panel data regression models:

1) The error terms are correlated across the cross-sectional units. This is called „static interdependence".

2) The error process may be unit-specific. This is called „cross-sectional heterogeneity", which has been explained along with the discussion on the decomposition of the error process into the three parts.

Every variable included in the autoregression is explained by its own lags as well as by lags of other variables included in the model. This thesis utilizes a Panel VAR model with one lag, which can be represented with the following equation:

$$\begin{bmatrix} gdp_{i,t} \\ inv_{i,t} \\ milex_{i,t} \end{bmatrix} = \begin{bmatrix} a_{10} \\ a_{20} \\ a_{30} \end{bmatrix} + \begin{bmatrix} L_{11} & L_{12} & L_{13} \\ L_{21} & L_{22} & L_{23} \\ L_{31} & L_{32} & L_{33} \end{bmatrix} \begin{bmatrix} gdp_{i,t-1} \\ inv_{i,t-1} \\ milex_{i,t-1} \end{bmatrix} + \begin{bmatrix} u_1 \\ u_2 \\ u_3 \end{bmatrix} \quad (1)$$

where *gdp* is the real GDP growth (in %),

inv is the share of investment in GDP (in %),

milex is the share of military expenditures in GDP (in %).

Firstly, the model is estimated for the full sample of countries (44 countries given in the appendix 1) over the period of 1970-2020. Secondly, the panel VAR model is estimated for the sample of 14 European countries over the whole time period, and separately for the periods before and after 1991. The reason for the break set in year 1991 is to take into account a potential structural break due to the end of Cold War and the change in the military policy of the European countries under consideration.

As noted by Kollias and Paleologou (2019), before the estimation of the panel VAR model the data must be transformed to remove trends and to keep only the variations. The underlying structure of the data must be identical for each cross-sectional unit, which is usually violated in practice. But the restriction is necessary in order to ascertain that the matrices L are identical for all cross-sectional units (Kollias and Paleologou, 2019).

The introduction of the country fixed effects helps to overcome this problem, however due to the lags of the dependent variables, the fixed effects are correlated with the regressors. The latter problem can be solved with either first differencing or forward orthogonal deviations.

The logic of the first differencing is as follows: when subtracting the lagged variables from the left and right sides of equation (1) above, the time-invariant component μ_i is removed from the error process, leaving the matrices L unchanged.

Thus, the first differencing helps to overcome the problem of the correlation between the cross-sectional heterogeneity and the variables' lags (Arrelano and Bond, 1991).

The forward orthogonal deviations are proposed by Arrelano and Bover (1995). The error term is transformed in the following way:

$$u_{it}^{*} = c_t \left[u_{it} - \frac{1}{T-t} (u_{it+1} + u_{it+2} + u_{it+T}) \right], t = 1, \dots, T-1$$

where $c_t^2 = \frac{T-t}{T-t+1}$.

The logic of the forward orthogonal deviations is as follows: for every observation u_{it} from $t = 1, \dots, T-1$ the mean of the remaining future observations (the part $\frac{1}{T-t}(u_{it+1} + u_{it+2} + u_{it+T})$) is subtracted and the resulting differences are weighted by c_t in order to equalize the variances.

Following the suggestion of Arrelano and Bover (1995), and Hayakawa (2009) that forward orthogonal deviations lead to the better performance of the GMM estimation, the latter is used in the estimation of panel GMM.

This concludes the methodology section. The thesis continues onto the estimation results and discussion.

4. Estimation results and discussion

The panel VAR model estimation results for the full sample of 44 countries are presented in table 5.

Table 5. The panel VAR estimation results for 44 countries

	$gdp_{i,t}$	$inv_{i,t}$	$milex_{i,t}$
$gdp_{i,t-1}$	0.3279** (0.1013)	0.2048 (0.1112)	-29.9172 (68.7760)
$inv_{i,t-1}$	-0.0311 (0.1284)	0.7144*** (0.1342)	16.6599 (28.9810)
$milex_{i,t-1}$	25.4206 (27.6757)	22.7817 (27.2219)	0.1853 (0.3200)

Source: Author's calculations

The results suggest no significant relationship between lagged military expenditures and GDP growth, or between lagged military expenditures and investment. The lagged GDP growth has a significant effect on the GDP growth in the following period, and similarly the lagged investment significantly influences the future investment level (i.e. there is statistically significant autocorrelation in case of these two variables). No statistically significant cross-correlation has been found between the variables. Overall, for the sample of the 44 countries there merely exists statistically significant autocorrelation for GDP growth and investment for the period 1970 – 2020. The estimation results for the 14 European countries over the whole period (panel A) and separately for 1970-1991 (panel B) and 1992-2020 (panel C) are shown in table 6.

Table 6. The panel VAR estimation results for the European countries

	$gdp_{i,t}$	$inv_{i,t}$	$milex_{i,t}$
Panel A: the EU countries over 1970-2020			
$gdp_{i,t-1}$	0.4851 (0.4764)	0.1875 (0.5445)	-26.1465 (457.0337)
$inv_{i,t-1}$	-0.1934 (0.4164)	0.6864 (0.6143)	40.0407 (211.5902)
$milex_{i,t-1}$	130.6350 (140.7266)	49.3224 (265.2118)	0.0751 (1.0047)
Panel B: the EU countries over 1970-1991			
$gdp_{i,t-1}$	0.8877 (0.7067)	0.0820 (0.6425)	3.7098 (6.0147)
$inv_{i,t-1}$	-0.3492	0.8200*	-0.2934

	(0.3502)	(0.3303)	(1.9940)
$milex_{i,t-1}$	6.1035 (8.0471)	-2.2954 (6.4155)	39.7724 (66.8511)
Panel C: the EU countries over 1992-2020			
$gdp_{i,t-1}$	0.3928 (0.3332)	0.2959 (0.2937)	0.9207 (2.9638)
$inv_{i,t-1}$	-0.2318 (0.4376)	0.6732 (0.4967)	-0.8798 (2.5775)
$milex_{i,t-1}$	3.8984 (5.6678)	-1.4168 (5.4910)	-7.3128 (55.5093)

Source: Author's calculations

For the restricted sample of the EU countries the relationships between GDP growth, investment and their lags disappear (i.e. the autocorrelations). Defense spending does not appear to have a statistically significant relationship with any of the remaining two variables. Furthermore, no autocorrelation can be observed in any of the periods for military expenditure (i.e. the previous year's military expenditure is no basis for forecasts of the current year's expenditures). Overall, in all three periods, 1970 – 2020, 1970 – 1991, 1992 – 2020, none of the relationships are statistically significant with the exception of the autocorrelation of investment in the period 1970 – 1991. These findings support the view that military expenditures do not influence the GDP growth or the level of investment in the economy of the European countries and that defense spending is not determined by either GDP growth or investment.

The estimation results are in line with those obtained by Kollias and Paleologou (2016) for the sample of the EU15 countries (Ireland and Germany were not included in the sample of countries of this thesis due to the incompleteness of data for the investigated period). The authors also found no statistically significant relationship between military expenditures and GDP growth, as well as between military expenditures and investment. Kollias and Paleologou (2019) claim that at least it is possible to trace the direction of the effect considering the sings of the coefficients. For the subsamples before and after 1991 the sign on lagged military expenditures effect on GDP growth is positive, which supports demand stimulation (Keynesian view), while the coefficient of investment is negative, which is evidence of the crowding-out effect. Nevertheless, it must be stated that the coefficients are not statistically significant and therefore little weight can be ascribed to conclusions reached on their basis.

Kollias and Paleologou (2016) used the period 1961-2014 for their estimation, while this thesis investigates a period 1970 – 2020, providing greater insight into the post-bipolar period. In addition, the thesis has accounted for the possible break set to the year of the fall of the Iron Curtain, 1991.

It must be noted that the utilized panel VAR model assumes a uniform structure among all the European countries, that is, the same coefficients on the lagged variables. At the same time, several papers mention the heterogeneous effects of military expenditures on the GDP growth (Kollias, et al., 2004; Kolias et al, 2007; Topcu and Aras, 2015).

Dunne and Nikolaidou (2012) using the random effects and fixed effects estimation techniques came to similar results, concluding that military expenditures do not have an effect on the GDP growth or on investment in the economy. They also stress the potential heterogeneous effects for the different EU countries.

As noted in the exploratory analysis, not all studied countries demonstrate a strong correlation between military expenditures. GDP growth, and investment, therefore, on average this effect can, indeed, be equal to zero.

5. Robustness check

As there is an alternative way of dealing with the correlation between the country fixed-effects and the lags of the variables, first differencing, the same panel VAR model was estimated using first differencing for the same samples in order to verify the robustness of the results. Table 7 displays the estimation results.

One notable difference is the statistically significant coefficient estimate of the lagged military expenditures on the GDP growth for the 1970 – 1991 period. This result, however, is not stable and is dependent upon the method of the data transformation. Therefore, it cannot be treated as a robust piece of evidence for the demand stimulation effect of the military expenditures (the Keynesian view).

Table 7. Robustness checks with the use of the first differencing

	$gdp_{i,t}$	$inv_{i,t}$	$milex_{i,t}$
Panel A: the EU countries over 1970-2020			
$gdp_{i,t-1}$	0.7551 (0.6731)	0.2766 (0.7770)	6.8419 (7.7729)
$inv_{i,t-1}$	-1.0261 (0.9224)	-1.6085*** (0.4208)	-5.5853 (5.9756)
$milex_{i,t-1}$	0.1296 (24.4547)	6.4637 (13.4674)	123.1448 (159.0294)
Panel B: the EU countries over 1970-1991			
$gdp_{i,t-1}$	0.8093 (0.5909)	0.2517 (0.1668)	2.1656 (4.2031)
$inv_{i,t-1}$	-0.6473 (0.8630)	-0.9060 (0.6529)	0.3277 (1.9458)
$milex_{i,t-1}$	19.0762*** (5.2526)	0.0451 (4.7688)	22.9925 (56.7335)
Panel C: the EU countries over 1992-2020			
$gdp_{i,t-1}$	0.2851 (0.4418)	0.2951 (0.2775)	1.0107 (4.6706)
$inv_{i,t-1}$	-0.8033 (1.0388)	0.5985 (0.6911)	1.0423 (8.4878)
$milex_{i,t-1}$	-18.3775 (24.2219)	7.4265 (25.3112)	5.2253 (298.9248)

Source: Author's calculations

With regards to the remaining coefficients' estimates, the signs of the coefficients between the lagged military expenditures and the two other variables in all the periods considered have altered, which confirms the initial conclusion of no definite effect of military expenditures on either GDP growth, or on investment.

The estimation results suggest that for the sample of 14 European countries (including the UK) military expenditures have no statistically significant effect on either GDP growth or on investment. Even though, some countries demonstrate the positive correlation between the military expenditures and the economic growth, under the lens of the PVAR model the relationship disappears.

These findings do not necessarily suggest that the European countries can increase their military expenditures without any effect on the GDP growth or the investment level. Rather, it can be concluded that the previous strategy with regards to defense spending was such, that it did not have a significant impact on the economic conditions within the studied countries. Clearly, a more extreme utilization of the scarce public resources for military purposes might affect the equilibrium and lead to different effects on the economic performance, or investment level.

Conclusion

The thesis has made an attempt to estimate the relationship between military expenditures, GDP growth, and the level of investment for a balanced panel of 14 selected European countries, including the United Kingdom, over the period 1970 – 2020. A panel vector autoregression was also performed on a world sample of 44 countries according to the data availability for an identical period. A possible structural break set to the year 1991, the fall of the Iron Curtain, has been considered due to an observable decrease in the average share of military spending, and a shift in the defense and political realities related with the end of the Cold War. The estimation results for the panel of 44 countries reveal no significant relationship between lagged military expenditures and GDP growth, or between military expenditures and investment. Statistically significant autocorrelation was detected for GDP growth and investment. For the European sample of 14 countries such autocorrelation disappears in all considered periods and variables, except for the case of investment during the period 1970 – 1991 where autocorrelation is statistically significant at the 5% level. Moreover, PVAR results indicate no statistically significant relationships between military expenditure and any of the remaining two variables for any of the investigated periods. A robustness check for the sample of 14 European countries indicates one notable difference in the period 1970 – 1991, namely a statistically significant relationship between lagged military expenditures and GDP growth. The result is not stable and is dependent on the method of data transformation, therefore it cannot be considered as robust evidence for stimulation of economic growth.

Overall, the thesis has not found empirical evidence to support claims of a negative impact of military expenditure on GDP growth, or for a crowding-out effect of defense spending on investment for the studied countries. Equivalently, a positive effect of military spending on economic growth has not been revealed during the econometric investigation. Dunne and Tian (2013) note that the military expenditure has a relatively low percentage share in GDP compared to components, like health and education. For that reason, such components which constitute a higher percentage share in GDP have a more substantial influence on the trajectory of GDP growth than defense spending itself. Effectively, even if an effect exists it may not become apparent under econometric inspection unless, e.g. an armed conflict between countries is ongoing (Dunne and Tian, 2013). Therefore, the findings of this thesis do not necessarily suggest that further increases in military expenditures of the selected European countries will have no effect on their economic performances. Instead, it can simply be stated that the defense spending accounted for in the regression did not have a significant impact on the economic conditions within the studied countries. In addition, Dunne and Tian (2013) highlight that military expenditures entail further expenses, e.g. in case of procuring arms for national armed forces from abroad would drain reserves of foreign exchange. To the best of the author's knowledge and in accordance with Dunne and Tian (2013), little can currently be done to enhance the quality of research in that regard due to a lack of reliable data on the components of military expenditure.

The methodology applied for the purposes of the thesis has certain limitations. The utilized panel vector autoregression model assumes a uniform structure among all the countries included in the regression. Assuming the same coefficients on the lagged variables is both a strong and an unrealistic assumption, which is necessary for the purposes of performing the regression. The 14 European countries considered differ in their military industrial capabilities, military burden throughout the years 1970 – 2020 (though there is apparent convergence in terms of the military spending to GDP indicator), and, crucially, in the effects of military expenditures on the GDP growth (Kollias et al., 2004; Kollias et al., 2007; Topcu and Aras, 2015). A significant number of countries could not have been considered under the utilized method for the chosen period due to data unavailability. Importantly, missing data for Germany and Ireland made it impossible to include the countries in the balanced panel for the studied period. The aforementioned lack of reliable data on the components of military expenditure excludes arms transfers from detailed econometric investigation, which is a significant detriment as arms transfers are an important part of military expenditures (Dunne and Tian, 2013). Moreover, the use of simply military expenditure and investment may be limiting as military expenditure might proxy variables such as government spending, policies, etc. (Desli and Gkoulgkoutsika, 2020). The addition of control and potentially dummy variables in future research could paint a clearer picture of the studied relationship.

In light of increasing military integration with the advent of the Permanent Structured Cooperation (PESCO) in 2017 as the main initiative under the Common Security and Defence Policy (CSDP) involving even non-EU-member states, like Norway (Gotkowska, 2018), and growing military burden of the GDP among the

European countries it is important for the European governments to have an understanding of the economic implications of increased military spending. The recent upward trend in military expenditure does not seem to have a statistically significant impact on GDP growth. The findings imply that continued military growth and integration are statistically not expected to have a significant economic effect, and by the same token, defense spending does not appear to be a viable tool of aggregate demand stimulation to answer the pandemic-related economic downturn. The thesis takes another step toward appraising the relationship between military expenditure and economic growth. The results presented in the thesis are consistent with the findings of Dunne and Nikolaidou (2012) and of Kollias and Paleologou (2016).

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List of Appendices

Appendix 1. List of countries in the sample

List of countries in the full sample:

Algeria, Argentina, Australia, Austria, Belgium, Brazil, Cameroon, Chile, Colombia, Costa Rica, Denmark, Dominican Republic, Ecuador, Egypt, Arab Rep., El Salvador, Finland, France, Greece, Guatemala, India, Iran, Islamic Rep., Italy, Kenya, Korea, Rep., Luxembourg, Malaysia, Mexico, Morocco, Nepal, Netherlands, Norway, Pakistan, Paraguay, Peru, Portugal, Singapore, South Africa, Spain, Sri Lanka, Sweden, Thailand, Turkey, United Kingdom, United States

List of the European countries in the sample:

Austria, Belgium, Denmark, Finland, France, Greece, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, United Kingdom

Appendix 2. Summary statistics for the full sample by decades

	1970-79	1980-89	1990-99	2000-09	2010-20
			GDP growth		
Min	-13.95	-27.33	-7.93	-10.89	-11.15
Q1	2.97	1.25	1.73	1.67	1.12
Median	5.03	3.46	3.67	3.37	2.55
Mean	5.10	3.25	3.48	3.21	2.23
Q3	5.03	3.46	3.67	3.37	2.55
Max	2.97	1.25	1.73	1.67	1.12
St dev	4.35	4.43	3.36	2.98	3.53
			Investment		
Min	5.96	10.33	12.53	10.85	11.89
Q1	20.02	20.70	19.63	19.44	18.49
Median	24.37	23.60	22.40	22.25	22.42
Mean	24.99	24.44	23.50	23.11	23.22
Q3	24.37	23.60	22.40	22.25	22.42
Max	20.02	20.70	19.63	19.44	18.49
St dev	7.36	6.14	6.02	5.47	6.64
			Military expenditures		
Min	0	0	0	0	0
Q1	1.66	1.78	1.47	1.21	1.08
Median	2.70	2.68	2.12	1.65	1.48
Mean	3.19	3.08	2.28	1.90	1.76
Q3	2.70	2.68	2.12	1.65	1.48
Max	1.66	1.78	1.47	1.21	1.08
St dev	2.48	1.80	1.22	1.03	1.05

Source: Author’s calculations

Appendix 3. Average GDP growth rate and share of military expenditures in GDP in the European countries by decades

	1970-79		1980-89		1990-99		2000-09		2010-2020	
	gdp	milex	gdp	milex	gdp	milex	gdp	milex	gdp	milex
Austria	4.09	1.33	2	1.4	2.71	1.08	1.71	0.88	0.79	0.76
Belgium	3.53	3.01	2.15	3	2.18	1.73	1.81	1.18	0.96	0.97
Denmark	2.39	2.25	1.91	2.2	2.45	1.76	0.98	1.41	1.49	1.26
Finland	3.76	1.42	3.64	1.65	1.88	1.6	2.09	1.36	0.84	1.45
France	4.1	3.21	2.35	3.12	2.02	2.53	1.46	2.03	0.58	1.9
Greece	5.49	4.9	0.78	4.71	2.06	3.48	2.77	2.94	-2.72	2.57
Italy	4.02	2.04	2.55	1.97	1.51	1.7	0.54	1.62	-0.57	1.38
Luxembourg	3.68	0.89	4.56	1.07	4.69	0.76	3.31	0.61	2.21	0.53
Netherlands	3.46	2.8	1.96	2.78	3.32	1.92	1.67	1.4	0.98	1.24
Norway	4.46	3.14	2.86	2.77	3.56	2.47	1.84	1.68	1.27	1.6
Portugal	5.62	4.24	3.35	2.55	2.92	2.2	0.95	1.92	0.02	1.91
Spain	3.87	2.25	2.79	2.67	2.66	1.94	2.65	1.45	-0.02	1.29
Sweden	2.53	3.21	2.3	2.71	1.75	2.22	2.12	1.46	2.05	1.1
United Kingdom	3	5.03	2.67	4.96	2.24	3.2	1.62	2.47	0.96	2.2

Source: Author’s calculations

Appendix 4. R code with the data pre-processing and estimation

```
rm(list = ls())

# Load the libraries
library('WDI')
library('openxlsx')
library('reshape2')
library('tidyr')
library('dplyr')
library('plm')
library('panelvar')
library('stargazer')
library('ggplot2')

# Load military data and pre-process the data
setwd('C:/Thesis /Data')
file_name = 'SIPRI-Milex-data-1949-2020_0.xlsx'
military = read.xlsx(file_name, sheet = 'Share of GDP', colNames = TRUE, rowNames = TRUE, rows = c(6:197), cols = c(1,3:74), skipEmptyRows = TRUE)
military = na.omit(military)
military[] = sapply(military[], as.numeric)
military$country = row.names(military)
a = pivot_longer(military, '1949':'2020', names_to = 'year', values_to = 'militaryExp')
rownames(a) <- NULL

# Rename countries according to WDI names
a$country[a$country=='Bosnia-Herzegovina'] = 'Bosnia and Herzegovina'
a$country[a$country=='Brunei'] = 'Brunei Darussalam'
a$country[a$country=='Cape Verde'] = 'Cabo Verde'
a$country[a$country=='Central African Rep.'] = 'Central African Republic'
a$country[a$country=='Congo, Repubic of'] = 'Congo, Rep.'
a$country[a$country=='Czechia'] = 'Czech Republic'
a$country[a$country=='Dominican Rep.'] = 'Dominican Republic'
a$country[a$country=='Egypt'] = 'Egypt, Arab Rep.'
a$country[a$country=='eSwatini'] = 'Eswatini'
a$country[a$country=='Gambia'] = 'Gambia, The'
a$country[a$country=='Iran'] = 'Iran, Islamic Rep.'
a$country[a$country=='Korea, North'] = 'Korea, Dem. People\'s Rep,'
a$country[a$country=='Korea, South'] = 'Korea, Rep.'
a$country[a$country=='Kyrgyzstan'] = 'Kyrgyz Republic'
```

```
a$country[a$country=='Laos'] = 'Lao PDR'
a$country[a$country=='Korea, South'] = 'Korea, Rep.'
a$country[a$country=='Norh Macedonia'] = 'North Macedonia'
a$country[a$country=='Russia'] = 'Russian Federation'
a$country[a$country=='Slovakia'] = 'Slovak Repblic'
a$country[a$country=='Syria'] = 'Syrian Arab Republic'
a$country[a$country=='Trinidad & Tobago'] = 'Trinidad and Tobago'
a$country[a$country=='UAE'] = 'United Arab Emirates'
a$country[a$country=='UK'] = 'United Kingdom'
a$country[a$country=='USA'] = 'United States'
a$country[a$country=='Venezuela'] = 'Venezuela, RB'
a$country[a$country=='Viet Nam'] = 'Vietnam'
a$country[a$country=='Yemen'] = 'Yemen, Rep.'

# Load GDP and Investment data from WDI
#WDIsearch('capit.*GDP')
gdp = WDI(indicator=c('NY.GDP.MKTP.KD.ZG','NE.GDI.TOTL.ZS'), start=1960, end=2020)
gdp$iso2c = NULL
data = merge(gdp, a, by.x = c('country','year'), by.y =  c('country','year'), sort = TRUE)

# Find for which number of years there are maximum T x N observations for a balanced panel
obs = data.frame(year = numeric(), observations = numeric())

for (i in c(1950:2020)){
  a = subset(data, data$year>= i)
  missing <- unique(a$country[!complete.cases(a)])
  bData = a[!(a$country %in% missing),]
  obs[i-1949,1] = i
  obs[i-1949,2] = nrow(bData)
}
max(obs)

# We take a subset of countries from 1970
data = subset(data, data$year>= 1970)
missing <- unique(data$country[!complete.cases(data)])
data = data[!(data$country %in% missing),]
data$militaryExp <- data$militaryExp * 100
data$year <- as.numeric(data$year)
unique(data$country)
```

```
# Create dummies for the 10 years and produce means for gdp growth and milex for each decade
data$'decade' = ifelse((data$year >=1970)&(data$year) <=1979,'1970-79',
                  ifelse((data$year >=1980)&(data$year) <=1989,'1980-89',
                     ifelse((data$year >=1990)&(data$year) <=1999,'1990-99',
                        ifelse((data$year >=2000)&(data$year) <=2009,'2000-09','2010-20'))))
data$decade <- as.factor(data$decade)

CountryMeans <- data %>% group_by(country, decade) %>% summarize('gdp' =
round(mean(NY.GDP.MKTP.KD.ZG),4), 'milex' = round(mean(militaryExp),4))
ContrySumm <- pivot_wider(CountryMeans, id_cols = country, names_from = decade, values_from =
c('gdp', 'milex'))

# Save the results
file_name = 'Summary.xlsx'
write.xlsx(CountrySumm, file_name, sheetName = "Sheet1",
     col.names = TRUE, row.names = TRUE, append = FALSE)

# Same for the EU only
Europe <- c('Austria', 'Belgium', 'Denmark', 'Finland', 'France', 'Greece', 'Italy', 'Luxembourg',
'Netherlands', 'Norway', 'Portugal', 'Spain', 'Sweden','United Kingdom')
EurData <- data[is.element(data$country, Europe),]
EURMeans <- EurData %>% group_by(country, decade) %>% summarize('gdp' =
round(mean(NY.GDP.MKTP.KD.ZG),2), 'milex' = round(mean(militaryExp),2))
EURSumm <- pivot_wider(EURMeans, id_cols = country, names_from = decade, values_from = c('gdp',
'milex'))

# Save the results
file_name = 'EUSummary.xlsx'
write.xlsx(EURSumm, file_name, sheetName = "Sheet1",
     col.names = TRUE, row.names = TRUE, append = FALSE)

# Plot the military expenditures for the EU countries
ggplot(data=EurData, aes(x=year, y=militaryExp, group=country, color=country)) +
  geom_line() + geom_point() + theme_minimal() + xlab('Year') + ylab('Military expenditures, % of
GDP')


# Spearman correlation for each EU country
EurCorr <- EurData %>% group_by(country) %>% summarize('gdp / inv' =
round(cor(NY.GDP.MKTP.KD.ZG, NE.GDI.TOTL.ZS, method = 'spearman'),2),
```

```
                                'gdp / milex' = round(cor(NY.GDP.MKTP.KD.ZG, militaryExp, method =
'spearman'),2),
                                'inv / milex' = round(cor(NE.GDI.TOTL.ZS, militaryExp, method =
'spearman'),2))

# Save the result
file_name = 'EUCorr.xlsx'
write.xlsx(EurCorr, file_name, sheetName = "Sheet1",
        col.names = TRUE, row.names = TRUE, append = FALSE)

#Make a panel dataset:
pData <- pdata.frame(data, index = c("country", "year"))
pData$year <- as.numeric(pData$year)

#SUMMARY
summary(data)
apply(data, 2, sd)

TotalSummary <- data %>% group_by(decade) %>% summarize('gdp min' =
round(min(NY.GDP.MKTP.KD.ZG),2),
                                        'gdp Q1' = round(quantile(NY.GDP.MKTP.KD.ZG, 0.25),2),
                                        'gdp median' = round(quantile(NY.GDP.MKTP.KD.ZG, 0.5),2),
                                        'gdp mean' = round(mean(NY.GDP.MKTP.KD.ZG),2),
                                        'gdp Q3' = round(quantile(NY.GDP.MKTP.KD.ZG, 0.5),2),
                                        'gdp max' = round(quantile(NY.GDP.MKTP.KD.ZG, 0.25),2),
                                        'gdp sd' = round(sd(NY.GDP.MKTP.KD.ZG),2),
                                        'inv min' = round(min(NE.GDI.TOTL.ZS),2),
                                        'inv Q1' = round(quantile(NE.GDI.TOTL.ZS, 0.25),2),
                                        'inv median' = round(quantile(NE.GDI.TOTL.ZS, 0.5),2),
                                        'inv mean' = round(mean(NE.GDI.TOTL.ZS),2),
                                        'inv Q3' = round(quantile(NE.GDI.TOTL.ZS, 0.5),2),
                                        'inv max' = round(quantile(NE.GDI.TOTL.ZS, 0.25),2),
                                        'inv sd' = round(sd(NE.GDI.TOTL.ZS),2),
                                        'milex min' = round(min(militaryExp),2),
                                        'milex Q1' = round(quantile(militaryExp, 0.25),2),
                                        'milex median' = round(quantile(militaryExp, 0.5),2),
                                        'milex mean' = round(mean(militaryExp),2),
                                        'milex Q3' = round(quantile(militaryExp, 0.5),2),
                                        'milex max' = round(quantile(militaryExp, 0.25),2),
                                        'milex sd' = round(sd(militaryExp),2))
```

```
TotalSummary <- t(TotalSummary)

# Save the results
file_name = 'Summary.xlsx'
write.xlsx(TotalSummary, file_name, sheetName = "Sheet1",
        col.names = TRUE, row.names = TRUE, append = FALSE)


########## PVAR ESTIMATION ###############
# Test for unit roots
# GDP growth
purtest(pData$NY.GDP.MKTP.KD.ZG,pmax = 4, exo = "intercept", test = c("levinlin"))

# Investment
purtest(pData$NE.GDI.TOTL.ZS, pmax = 4, exo = "intercept", test = c("levinlin"))

# Military
purtest(pData$militaryExp, pmax = 4, exo = "intercept", test = c("levinlin"))

# Estimate PVAR model full sample
model1 = pvargmm(dependent_vars = c('NY.GDP.MKTP.KD.ZG', 'NE.GDI.TOTL.ZS', 'militaryExp'),
                 lags = 1, transformation = 'fd',
                 data = pData,
                 panel_identifier=c("country", "year"),
                 steps = c("twostep"),
                 system_instruments = FALSE,
                 max_instr_dependent_vars = 10,
                 max_instr_predet_vars = 10,
                 min_instr_dependent_vars = 2L,
                 min_instr_predet_vars = 1L,
                 collapse = FALSE)
summary(model1)

# Estimate PVAR model for the EU
Europe <- c('Austria', 'Belgium', 'Denmark', 'Finland', 'France', 'Greece', 'Italy', 'Luxembourg',
'Netherlands', 'Norway', 'Portugal', 'Spain', 'Sweden','United Kingdom')
EurData <- pData[is.element(data$country, Europe),]

model2 = pvargmm(dependent_vars = c('NY.GDP.MKTP.KD.ZG', 'NE.GDI.TOTL.ZS', 'militaryExp'),
```

```
            lags = 1, transformation = 'fd',
            data = EurData,
            panel_identifier=c("country", "year"),
            steps = c("twostep"),
            system_instruments = FALSE,
            max_instr_dependent_vars = 10,
            max_instr_predet_vars = 10,
            min_instr_dependent_vars = 2L,
            min_instr_predet_vars = 1L,
            collapse = FALSE)

summary(model2)

# Divide european countries before and after 1991
EurDataPre <- EurData[as.integer(EurData$year) < 1992-1969, ]
EurDataPost <- EurData[as.integer(EurData$year) >= 1992-1969, ]

# Estimate PVAR model for the EU before 1991
model3 = pvargmm(dependent_vars = c('NY.GDP.MKTP.KD.ZG', 'NE.GDI.TOTL.ZS', 'militaryExp'),
            lags = 1, transformation = 'fd',
            data = EurDataPre,
            panel_identifier=c("country", "year"),
            steps = c("twostep"),
            system_instruments = FALSE,
            max_instr_dependent_vars = 10,
            max_instr_predet_vars = 10,
            min_instr_dependent_vars = 2L,
            min_instr_predet_vars = 1L,
            collapse = FALSE)

summary(model3)

# Estimate PVAR model for the EU after 1991
model4 = pvargmm(dependent_vars = c('NY.GDP.MKTP.KD.ZG', 'NE.GDI.TOTL.ZS', 'militaryExp'),
            lags = 1, transformation = 'fd',
            data = EurDataPost,
            panel_identifier=c("country", "year"),
            steps = c("twostep"),
            system_instruments = FALSE,
            max_instr_dependent_vars = 10,
```

```
        max_instr_predet_vars = 10,
        min_instr_dependent_vars = 2L,
        min_instr_predet_vars = 1L,
        collapse = FALSE)

summary(model4)



# OUTPUTS TO PRINT:
# List of countries
paste0(unique(data$country), collapse = " ", sep = ",")

#SUmmary statistics
summary(data)
apply(data, 2, sd)

########################
# Appendix:



# Check the data (SKIP)
cntrs<-rownames(military[is.na(military$`1949`),])
rownames(military[is.na(military$`1992`),])
sum(rownames(military[is.na(military$`1950`),]) == cntrs)

apply(military, 2, function(x) sum(rownames(military[is.na(x),])==cntrs))

# Check when countries are not in the set
gdpconts = unique(gdp$country)
milconts = unique(a$country)

sort(setdiff(milconts, gdpconts))
sort(setdiff(gdpconts, milconts))
```