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Defence partnerships, military expenditure, investment, and economic growth: an analysis in PESCO countries

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ABSTRACT

This paper employs a panel vector autoregressive (PVAR) approach to investigate the relationship among military expenditure, investment, and economic growth, over the period after the enforcement of the Maastricht treaty (1994–2018) in 25 European countries that participate in the Permanent Structured Cooperation (PESCO). By using the Louvain community detection algorithm on the network links that have been established through defence partnerships in PESCO projects, two different country clusters emerge. Findings suggest that military expenditures can stimulate economic growth but the effects may not be common for all Member States, which might benefit from the involvement in joint defence projects to maximize the effectiveness of their defence spending.

Keywords: Defence partnerships; military expenditures; investments; economic growth; PVAR; PESCO

JEL classifications: H56, C33, C38, O47

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1. Introduction

Targeting the deepening of defence cooperation between the Member States, and in light of an unstable security environment, the EU's Council of Ministers launched the Permanent Structured Cooperation (PESCO) in December 2017, the most recent initiative in the European defence structure after the establishment of the Common Foreign and Security Policy (CFSP) under the Treaty of Maastricht in November 1993. PESCO is a legal framework for enhanced strategic coordination, joint development, and use of military capabilities, whereas it operates on a collaborative project and binding commitments basis (Latici & Lazarou, 2020). Within this initiative, a list of Member States proposes defence projects, with a dual focus on capability and operational aspects, which are functionally and financially supported by the European Defence Fund (EDF) and European Defence Agency (EDA). PESCO members are committed, among others, to increasing national defence budgets and defence investment expenditures, and therefore promoting the European defence technological and industrial base. Given the legally binding nature of the Council decisions, questions arise about the potential impact of increased military spending and investments on European economies.

Military expenditures and their effect on economic growth have long been a matter of investigation among scholars. Since the seminal work of Benoit (1973), an extensive amount of studies has been conducted with a lack of consensus concerning the association between military spending and growth. More specifically, the association between military expenditures and economic growth has been found controversial regarding the sign, and mainly nonlinear. Among other studies, the positive stimulative effect of military expenditures on growth is pointed out in Atesoglu (2002) for USA, in Stewart (1991) for Africa and Latin America, in Lee & Chen (2007) for OECD countries, and in recent meta-analyses (Alptekin & Levine, 2012; Churchill & Yew, 2018) for developed countries. Another strand of literature, that mostly focuses on the "guns vs butter" (allocation effect) and "guns vs growth" (growth effect) trade offs (Heo & Ye, 2016), argues a negative relationship between the two macroeconomic variables. Dunne & Tian (2013) provide strong evidence of an overall negative effect of military expenditure on economic growth, d'Agostino et al. (2017) and d'Agostino et al. (2019) verify the relationship for OECD and non high-income countries, respectively, and Abu-Bader & Abu-Qarn (2003) confirm the reverse relationship for several individual countries. The last strand of literature finds no strong relations between defence expenditures and growth (Huang & Mintz, 1991; Heo, 2010; Dunne & Smith, 2020), while a non-linear relationship has been identified. Stroup & Heckelman (2001) and Kalaitzidakis & Tzouvelekas (2011) find an inverse U-shaped relationship, with low levels of military spending increasing economic growth but higher levels of military spending decreasing it. Alptekin & Levine (2012) and Churchill & Yew (2018) verify this non-linearity.

It is clear that the relationship between defence spending and economic growth cannot be generalized across countries (Chowdhury, 1991; Dunne et al., 2002), and further to the already complicated situation, geo-strategic, social, cultural, and political considerations add extra dimensions (Deger & Sen, 1995). Besides, Dunne & Tian (2020) raise several issues involved in the analyses of this complex relationship. The most major ones are the historical context and the different time periods used, the econometric and estimating techniques applied, as well as the various channels through which military expenditures could affect growth.

Empirical evidence has identified a threefold mechanism through which military expenditures are associated with economic growth (Dunne et al., 2005). First, there is a demand-side channel with two conflict effects, a multiplier one that stimulates economic growth and a crowding-out one reflecting the opportunity costs that the defence financing may have. Second, the supply-side channel with competition effects (Malizard, 2015) between production resources pertains to both the positive technological and productivity diffusion of military spending and the negative wastage of inputs. Finally, scholars have shown the significance of military expenditures to security and political stability, which in turn is pivotal for higher growth rates (Alesina et al., 1996; Blomberg 1996; Erdogdu, 2008). The sense of lack of instability and threats for people and property in a country constitutes a crucial factor for markets' operation, innovation, and investment incentives (Alesina & Perotti, 1996; Dunne et al., 2005; Allard et al., 2012).

In studies concerning specifically the European region, the relationship of military expenditures and economic growth is not clear and is not uniformed across all members (Topcu & Aras, 2015). Dunne & Nikolaidou (2012) and Kollias & Paleologou (2016) point out that military burden[2] does not promote economic growth, while Kollias et al (2007) find evidence on behalf of short run positive effects and Mylonidis (2008) on strong negative ones. The latter emphasizes that given the Common European Security and Defence Policy (CESDP), increased military spending may hamper economic growth.

The purpose of the present paper is to study the collaborations through joint defence projects among European countries and within the PESCO framework, and the effect of military expenditures on economic growth. Differentiating from common literature that explores the association of the variables of interest classifying the countries using mostly economical or geographical criteria (Wijeweera & Webb, 2011; Chang et al., 2014; Pan et al., 2015; Kollias & Paleologou, 2019), an alternative more endogenous way of clustering is adopted in the present analysis. Specifically, the context of the collaborations (links) among countries in projects within the PESCO framework, gives the opportunity to construct a network of defence cooperations and explore possible emerging defence clusters of member states. The modeling approach is applied to 25 countries/Member States that cover the period after the establishment of the CFSP under the Maastricht Treaty, that is years 1994-2018, with two key questions in mind: (i) Can the defence sector stimulate the European economies? (ii) Are the effects homogenous for all member states?

The evidence shows that the defence sector can boost economic growth in PESCO countries. The effect may not be homogenous for all member states, differentiating depending on the defence collaboration cluster that a country belongs to. Nevertheless, emerging defence clusters are far from being tight or exclusive and should be considered mostly as indicative. Military expenditures seem to be economic growth-enhancing presumably for defence-producing countries like France, Germany,

[2] As military burden is referred the share of military expenditure in GDP and indicates the priority that a country attaches to the military, in other words, how much of available output is devoted to defence (Smith, 2017)

Italy, or Spain, and Member States with strong defence ties with them, while for others the effects may be negligible. The results highlight the importance of policies and factors conducive to attracting defence investments and collaborations among Member States.

The remainder of the paper proceeds as follows. Section 2 epigrammatically presents the progress of cooperation on security and defence in EU from the treaty of Maastricht till the establishment of PESCO. Section 3 introduces the framework of analysis and Section 4 presents the descriptive statistics and the empirical results. Finally, Section 5 presents the case of Greece and Section 6 concludes.

2. EU security and defence cooperation - the establishment of PESCO

The foundations for a CFSP, as the second pillar of European Union, were laid with the treaty of Maastricht which was signed in February 1992 and came into force on November 1993[3]. The CFSP was reinforced by the European Council in 1999 to a European Security and Defence Policy (ESDP) and further strengthened with the adoption of a European Security Strategy in 2003. With the treaty of Lisbon[4], which was signed in 2007 and entered into force on December 2009, the Common Security and Defence Policy (CSDP) was introduced and the basis for establishing the PESCO mechanism was set[5]. From 2013 the European Council and officials discussed and highlighted the need to enhance the development of capabilities, adopted a global strategy on foreign and security issues, planed and proposed actions on strengthening Europe's security and defence. Finally, in mid 2017 the European Council calls for the launch of PESCO and establishes it on 11th December of the same year with the

[3] For further information on timeline of the EU cooperation on security and defence visit: https://www.consilium.europa.eu/en/policies/defence-security/defence-security-timeline/

[4] Consolidated versions of the treaties currently in force can be found here: https://eur-lex.europa.eu/collection/eu-law/treaties/treaties-force.html

[5] PESCO's provisions are enshrined in Article 46 of the Treaty on the European Union (TEU) and Protocol 10 on permanent structured cooperation, established by Article 42(6) TEU.

Council Decision (CFSP) 2017/2315[6] including 25 participating Member States [7] that meet specific criteria[8].

According to the principles of the aforementioned decision, PESCO is a "*legal framework for investments in the security and defence*" and "*provides a crucial political framework for all Member States to improve their respective military assets and defence capabilities through well-coordinated initiatives and concrete projects*". Among others, participating Member States subscribe to commitments[9] to increase defence budgets, joint and 'collaborative' strategic defence capabilities, investment expenditure to 20 % of total defence spending (collective benchmark), and expenses for research and technology with a view to nearing the 2 % of total defence spending (collective benchmark). The Council adopted an initial batch of 17 defence projects to be undertaken under PESCO framework on 6 March 2018, a second set of 17 projects on 20 November 2018, a third round of 13 projects on 12 November 2019, and a fourth round of 14 projects on 16 November 2021[10]. A varying group of PESCO Member States carry forward each of the projects, which should support the competiveness of the European defence industry and avoid unneeded overlap (Biscop, 2018), and it is possible for a Member State to participate in an already established project[11].

[6] Council Decision (CFSP) 2017/2315 can be found here: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32017D2315&rid=6#d1e32-70-1

[7] Austria, Belgium, Bulgaria, Czech Republic, Germany, Estonia, Ireland, Greece, Hungary, Spain, France, Croatia, Italy, Cyprus, Latvia, Lithuania, Netherlands, Luxembourg, Poland, Portugal, Romania, Slovenia, Slovakia, Finland and Sweden. Two countries do not participate: Denmark and Malta. United Kingdom, before Brexit, didn't participate as well.

[8] According to the article 1 of the Council Decision (CFSP) 2017/2315: *"PESCO within the Union framework is hereby established between those Member States whose military capabilities fulfill higher criteria as referred to in Article 1 of Protocol No 10, and which have made commitments to one another in this area as referred to in Article 2 of that Protocol, with a view to the most demanding missions, and contributing to the fulfillment of the Union level of ambition".*

[9] ANNEX II of the Council Decision (CFSP) 2017/2315.

[10] One PESCO project was officially closed on 2020 and can be found here: https://pesco.europa.eu/project/european-union-training-mission-competence-centre/

[11] According to the article 5 of the Council Decision (CFSP) 2017/2315*: "participating Member States taking part in a project may agree among themselves to admit other participating Member States which subsequently wish to take part in the project"*.

3. Framework of Analysis

3.1 Network Definition and Community Identification

The first step is to construct a network of collaborations within the PESCO framework. As noted before, the Member States work on joint projects along with other Member States and till now there are 60 different defence projects adopted in four rounds. Following Graph Theory[12], a structure of a network *G* of PESCO inter-relations can be represented as *G = (N,E),* where *N* is the set of countries (nodes) and *E* represent the joint project's collaborations (edges) among the Member States within the PESCO framework for each project. In the present analysis the *G* is characterized as an undirected and weighted network, supposing symmetric and bidirectional collaborations between the Member States and attaching weights to each individual link between a pair of countries depending on the number of different projects they jointly participate to.

The next step is to separate the network's set of nodes into subsets (or clusters or communities). In order to discover clusters of nodes that have a relatively large number of edges among them (dense connection within the cluster) and small connectivity with other clusters (sparse connections between clusters) (Girvan & Newman, 2002; Radicchi et al., 2004), a community detection algorithm is used. In other words, the goal is to discover clusters of Member States that have developed strong defence bonds and ties in the context of PESCO projects participation within the clusters, and loose connections with other clusters. Community detection algorithms use several different structural metrics that capture the quality notion of the clusters (Leskovec et al., 2010). In the present analysis the Louvain clustering method is applied, proposed by Blondel et al. (2008). Louvain is an iterative, heuristic[13] and greedy algorithm based on the optimization of a single metric called modularity[14], which measures the density of links within a community compared to links between communities. In short, the algorithmic procedure starts with each node in a separate

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[12] For more information on Graph Theory see Easley & Kleinberg (2010).

[13] For more information on heuristic procedures see Pearl (1984).

[14] For more information see Newman & Girvan (2004) and Newman (2006). Modularity takes values between -1 and 1. Deviation from randomness is indicated for values different than 0, while values greater than 0.3 indicate a significant community structure.

community and progresses to next iterations until the gain in modularity becomes negligible. As the final output of the algorithm depends on the ordering of the nodes, following Blondel et al. (2008), 100 iterations are applied after each adopted PESCO round. Each node (Member State) is classified in its major community/cluster.

3.2 PVAR Specification

Next, a panel vector autoregression (PVAR) methodology is adopted. A PVAR model consists of a system of equations, where each variable of the system is treated as endogenous and explained by its own lags and the lagged values of the others, while the panel data approach allows for unobserved individual heterogeneity. The optimal lag order for the model was selected by using the method described in Abrigo & Love (2016)[15] and is based on the first-order PVAR which is specified as below:

$$Y_{it} = \Gamma_0 + \Gamma(L)Y_{it-1} + u_t + e_{it}, \qquad i = 1,\dots, N \qquad t = 1,\dots,T \qquad (1)$$

where Y_{it} is a vector of three endogenous variables: Military Expenditures as % of GDP (MIL), Investments (gross fixed capital formation) as % of GDP (INV) and annual GDP growth rates (GDP); Γ_0 is a vector of constants; $\Gamma(L)$ is a matrix polynomial in the lag operator, and u_t and e_{it} are vectors of dependent variable-specific panel fixed-effects and idiosyncratic error, respectively. Following Arellano & Bover (1995), the data were transformed using the Helmert transformation, which ensures the orthogonality between the variables and their lagged values. The model is then estimated using GMM-style instruments, as proposed by Holtz-Eakin et al. (1988). The main characteristic of the PVAR modeling is that it does not impose any strong assumption and treats all the variables in an unrestricted way.

Then, using the Love & Zicchino (2006) approach, the forecast error variance decompositions (FEVDs) for a ten year period are estimated, while the impulse response functions (IRFs) are analyzed. More specifically, the FEVDs give information

[15] Authors describe optimal moment and model selection criteria following Andrews and Lu (2001) and the widely used likelihood-based selection criteria BIC, HQIC, and AIC, while the GMM selection criteria are based on the J statistic for testing over-identifying restrictions. Results are not reported for brevity and are available upon request.

about the variation in one variable due to shock to the others, while the IRFs, without any causal interpretation, show the reaction of one variable of interest to a one-time shock in another variable within the PVAR framework, holding all other shocks equal to zero. The standard errors of the IRFs are also calculated and Monte Carlo simulations (1000 iterations) are used to generate the 95% confidence intervals. In the model, it is assumed that the panel error-term is identical and normally distributed, an assumption that is practically not verified as the actual variance–covariance matrix of the errors is unlikely to be diagonal. Therefore, it becomes necessary to decompose the residuals in a way that they turn out orthogonal, in order to isolate shock to one of the variables in the framework. So, the Cholesky decomposition of the matrix variance-covariance residuals is used, and as proposed by Sims (1980) the variables that appear earlier in the ordering are more exogenous and affect the following variables simultaneously and with lags, whilst the variables appearing later in the system are more endogenous and only affect the previous variables with a lag.

In the present analysis the main interest is the impact of shocks to the MIL and the response of the other two macroeconomic factors. That is in line both with the supply side effects where the military expenditure affect the output growth (Dunne & Smith, 2020) and the commitment within the PESCO framework, where the Member States should increase defence budgets as well investments to a collective benchmark of 20 % of total defence spending. So the MIL is treated as the most exogenous variable with a contemporaneous effect on GDP growth, while GDP growth and INV have effect on MIL only with their lags (so the context is: MIL→INV→GDP). However, in a different context (GDP→INV→MIL) following Kollias & Paleologou (2019), literature on demand for military expenditures, and for robustness reasons, extra results are presented treating MIL as the most endogenous variable, GDP growth as the most exogenous and INV as a buffer one.

4. Data and Empirical Results

4.1 Network and descriptive statistics

The empirical analysis is based on 25 PESCO Member States for the period 1994-2018. The initial year of the dataset constitutes the first fiscal year after the enforcement of the Maastricht Treaty (November 1993), which established the foundation for the CFSP in the EU[16]. Data on defence projects' collaborations/partnerships come from the official EU site[17], while military expenditures as % of GDP, gross fixed capital formation as % of GDP and economic growth rates are obtained from the World Bank, Worldwide Development Indicators.

Defence collaborations through PESCO projects pertain to a dynamic procedure as new projects can be adopted, completed ones can be closed, new Member States can take part in a project, or a country can decide to leave a project. That means that the network of collaborations within the PESCO framework is periodically updating. Table 1 presents the changing network characteristics exactly after the adoption of each one of the first four rounds of projects. The total project partnerships increased from 617 in the first to 1027 in the fourth round. The average number of partnerships for each Member State raised from 49.36 to 82.16, while the modularity index marginally increased from 0.039 in the first round to 0.052 in the third round and decreased to 0.019 (mean values after 100 iterations) in the fourth round. In order to better represent the changing dynamics of defence collaborations during time, a country is classified in its major cluster after 100 iterations of the Louvain algorithm on the defence partnerships' network after each PESCO round (a total of 400 iterations) resulting in 2 clusters of countries (see Table 2) that have a slightly higher density of

[16] For robustness reasons, results with a different time horizon are also presented.

[17] Data for each round of PESCO projects are taken from here:
First: https://www.consilium.europa.eu/media/33065/st06393-en18-council-decision-pesco_press.pdf
Second: https://pesco.europa.eu/wp-content/uploads/2019/05/CELEX_32018D1797_EN_TXT.pdf
Third: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019D1909&from=EN
Fourth: https://www.consilium.europa.eu/media/53013/20211115-pesco-projects-with-description.pdf

collaborations within the defence clusters as compared to links between the clusters. Hence, in the first three PESCO rounds, there was a trend for an increase in the intensity of the defence collaborations with greater interactions among specific countries (increasing modularity), however, this relationship is rather loose (modularity value is near zero) and weakened even further in the fourth round (modularity further decreased to near zero). In other words, the emerging clustering is far from being tight, exclusive or stable; instead, it should be considered as indicative or almost random (modularity near zero). Blockmans & Crosson (2019) and Nádudvari et al. (2020) provide further analytical information on emerging patterns and capability development priorities.

The average variable values per Member State are shown in Table 2. Figure 1 presents the military burden and the growth rates of all PESCO countries through time. The formed network with the country clusters after the fourth round of adopted PESCO projects is also presented. The mean defence expenditure is 1.62%, while the mean growth performance is 2.75%. Luxembourg is the country with the lowest military burden at 0.57% and Ireland the one with the highest growth rate at 5.89%. The average defence spending is declining in time, while the economic crisis of 2008 had a significant negative impact on growth of about -5%. The countries with the highest number of partnerships after the fourth round of adopted PESCO projects are France, Spain, Germany and Italy, while Ireland is the less active country in the context of defence collaborations with only 7 partnerships. On average, countries of Cluster 1 have lower mean variable values than countries of Cluster 2, but higher weighted node degrees. Specifically, after the fourth PESCO round, Cluster 1 has an average number of partnerships of 100.91, while the corresponding value for Cluster 2 is 64.38.

The study proceeds with the statistical tests and PVAR analysis for three different panels of data. More specifically, all PESCO countries, Cluster 1 countries, and Cluster 2 countries constitute Panel A, Panel B, and Panel C, respectively.

4.2 Cross-sectional Dependence, Panel Unit Root and Cointegration Tests

First, the cross-sectional dependence (CD) tests of Pesaran (2004) and Friedman (1937) are applied and the results suggest the presence of CD (Part A of Table 3). Next step is to test whether the main variables of interest are stationary. The tests applied are those of Breitung (2001), Im et al. (2003), and Pesaran (2007), and results suggest that the variables are stationary for all panels in first differences (Part B of Table 3). The first two tests, however, concern first-generation tests, which assume no CD and results could be biased depending on the degree of CD. Pesaran's (2007), on the other side, is a second-generation panel unit root test that accounts for CD of the series. Since all panels under study are integrated in first order and cross-sectionally dependent, then the existence of a long-run relationship between all variables is examined. The cointegration technique proposed by Westerlund (2007) is employed, which deals with CD using robust critical values through bootstrapping. More specifically, the G_τ and G_α tests are employed to verify the alternative hypothesis that the panel is cointegrated as a whole ("Group" - between dimension), while the other two (P_τ and P_α) test the alternative that at least one unit is cointegrated ("Panel" - within dimension) [18]. As Table 3 (Part C) shows the null hypotheses of no cointegration could not be rejected. Therefore, I proceed with the estimation of a PVAR model with all variables in first differences.

4.3 PVAR results, Granger Causality and Variance decomposition

First, the stability of the PVAR models is verified by checking whether all eigenvalues lie within the unit circle[19]. Table 4 (Part A) presents the causal relationship between military burden, investments and economic growth. Results for the entire sample (Panel A) and Cluster 1 (Panel B) indicate that MIL has a positive effect on GDP at 1%

[18] For more information see Persyn & Westerlund (2008). For the implementation of the cointegration tests, a bootstrap approach with 400 iterations is applied, a constant is included, and the Akaike information criterion (AIC) is used to determine the optimal lag and lead length for each separate time series. Results are similar when a trend is included.

[19] Graphs of eigenvalue stability conditions are not reported for brevity and are available upon request.

significance, while for Cluster 2 (Panel C) the effect is insignificant. So, within the PESCO framework there is evidence of Keynesian-type demand effects that can boost economic growth (*inter alia:* Dunne et al., 2005; Kollias et al., 2007; Kollias & Paleologou 2016, 2017) however the effects are not significant for both communities of countries. Member States more densely connected in the defence partnership context with countries like France, Germany, Italy, Spain, and Sweden, with a significant defence industrial base (Kollias & Paleologou, 2016) could enjoy growth benefits. Concerning the effects of MIL on INV, results are mixed with both demand stimulation (Panels A and C) and crowding-out effects (Panel B). For INV, there is evidence for weak positive effects on MIL (Panels A and C), possibly through the dynamic development of civilian technologies which could be used in the defence sector (Suttmeier & Cong, 2005). On the other hand, it has mainly negative (Panels A and C) or insignificant (Panel B) effects on GDP. This negative association is well documented in the literature and could be attributed to the anticipating future growth that decreases saving, constituting a limiting factor for investment or with the fact that investment is less costly (or more productive) when growth is high, driving firms to anticipate investment projects when expecting a decline in growth (Attanasio et al., 2000). Further, it could be related to the negative or zero returns of the ascending capital flows (Cheung et al., 2012). Blomström et al. (1996) also find no evidence that fixed investment plays a key role in economic growth, which relates more closely to subsequently rather than to current or past capital formation. The last is also verified by the present results as GDP is found to have positive effects on INV in all three Panels. Contrarily the effects are slightly negative on MIL for Panels A and B, an indication that more money is not allocated to defence, in line with previous research (Kollias & Paleologou, 2016).

The above results and the established causality between the variables are verified from the panel Granger causality test (Granger, 1969). Based on accumulated impacts between the covariates, it provides a general view of the causality between variables. As presented in Part B of Table 4, MIL and GDP are bi-directionally connected for Panels A and B, while the causal relationship is totally absent in Panel C. The Granger causalities from the INV to MIL and GDP could also be characterized as bidirectional, however, in Panel B the causation is found to be unidirectional. In that case, it could be argued that the causality runs one way only from MIL and GDP to INV.

Part C of Table 4 reports the FEVD of the PVAR model 10 periods ahead. It is shown that MIL explains approximately 5.5% and 19.7% of the total variance of the GDP for Panels A and B, respectively, while the percentage is limited to 0.9% for Panel C. MIL also explains only 1% of the variation of INV in Panel A, 10.1% in Panel B and 2.7% in Panel C. INV explains about 27.9%, 9.3% and 40.9% of the variation of GDP in Panels A, B, and C, respectively, while its explanatory power is negligible for MIL (below 1% in every Panel). Finally, GDP has the largest explanatory power in the variation of INV in Panels B (8.2%) and C (9.5%), whilst it explains between 0.1 and 1.1% of the fluctuations of MIL.

4.4 Impulse response analysis

Next, in Figure 2, the IRFs and the 95% confidence intervals for the variable order MIL→INV→GDP are presented. An initial observation in the IRFs plots is that in all cases any deviations from the equilibrium position fade in a maximum time span of 3-4 periods. A positive shock in MIL statistically significantly affects GDP only for Panels A and B, whereas the effect is insignificant in Panel C. INV is significantly affected by MIL only for Panels B and C, negatively and positively, respectively. INV shocks have a non linear impact on GDP: initially, it is positive, while later it turns significantly negative in all cases. Concerning INV's effects on MIL, in Panel B affects it negatively, and in Panel C affects it positively. GDP shocks positively affect INV in all Panels, while for MIL the effects are insignificant in Panels A and C, and negative in Panel B. Note that as a result of the ordering, the response of MIL to GDP and INV to MIL and GDP is constrained to zero in the first period.

4.5 Robustness

To sharpen the robustness of the results, several additional analyses are performed. First, an extended time span is used and specifically for the period 1970-2018. MIL still has a positive significant effect on GDP only for Panels A and B, while the effect is insignificant in Panel C. A main difference in the estimations compared to the initial model is the fact that all effects on INV are insignificant for Panels A and C. Results remain similar if we account for years after the activation of the Lisbon Treaty (2010-2018). However when we account only for years 1970-1993[20], that is the period before the establishment of the CFSP under the Treaty of Maastricht, results indicate that MIL has an insignificant effect on GDP for Panels B and C, and a negative one for Panel A. It appears that the strong positive association of MIL and GDP after the establishment of the CFSP (sample period 1994-2018) drives the relationship for the extended time span for the period backwards to 1970s (sample period 1970-2018). That is perhaps an indication that after the beginnings of a common defence policy, the structural and political changes that took place towards strengthening the security and promoting international cooperation, promoted the positive relationship of military expenditures and economic growth as well.

Second, following similar literature (Konstantakis et al., 2017), I also control for global factors in order to weaken the possible cross-sectional dependence. Specifically, an exogenous key dummy variable that captures the global financial crisis of 2007–2009 is added in the equation (1)[21]. The estimation results are presented in Part B of Table A1. Coefficients and significances are quite similar to those presented in the initial model. The crisis had a significant negative effect on INV and GDP, while it had an insignificant association with MIL. Results are similar if the world GDP growth is used as a proxy (Comunale, 2017).

Third, following a demand-side effect framework, the military expenditures are treated as the most endogenous and the GDP growth as the most exogenous variable in the Cholesky ordering decomposition (GDP→INV→MIL). The IRFs are presented in Figure A1 and the results do not vary significantly from the ones presented in Section 4.4/Figure 2. A MIL shock positively affects GDP in Panels A and B, while there is evidence of a potentially negative effect on GDP on period 2 in Panel C. Results do not

[20] Results are not reported for brevity and are available upon request

[21] The equation becomes: $Y_{it} = \Gamma_0 + \Gamma_1(L)Y_{it-1} + \Gamma_2 X_{it} + u_t + e_{it}$, where X_{it} is a dummy variable that takes the value of 1 for years 2007 to 2009, and 0 otherwise.

vary significantly even if the ordering becomes MIL→GDP→INV, as in Kollias & Paleologou (2016), treating the share of investment in GDP as the most endogenous variable and GDP growth as a buffer variable.

5. The case of Greece

Small states like Greece find themselves in similar dilemmas with those that they confronted when the ESDP was established. Their engagement with PESCO is encouraged by the fear of entrapment or abandonment, the sense of suitability, and their temptation to take advantage of further integration (Pedi, 2021). From the Greek perspective, PESCO is perceived as a significant step towards achieving European strategic autonomy, and meaningful defence integration with a positive impact on the continent's security. The initiative could offer expand opportunities for the domestic defence industry and economies of scale in the military procurements, while SMEs could also benefit from available funding (Efstathiou, 2018).

Greece is one of the countries with the highest defence spending (Figure A2) and the country with the highest military expenditures as % of GDP (Table 2, Figure A3) within the PESCO framework. This demonstrates the increased significance of the defence sector for its limited budget and economy, with considerable trade-offs with social and welfare expenditures (Kollias & Paleologou, 2011). Moreover, the average GDP growth for the period 1994-2018 was the second lowest at 0.981% (Table 2). In the first four PESCO rounds, Greece increased the number of its defence partnerships from 62 to 92 (Table 2) and currently participates in 18 out of 60 active joint projects[22], rendering the country among the most active Member States.

The analysis provides evidence that, within the PESCO framework, Greece's military expenditures could have a positive impact on GDP growth. By examining the dynamic context of shaped defence clusters, resulting from the application of the community

[22] https://www.consilium.europa.eu/media/53013/20211115-pesco-projects-with-description.pdf

detection algorithm to the partnerships (network links) that emerged after four rounds of adopted PESCO projects, it appears that Greece might benefit from denser defence collaborations with countries such as France, Germany, Italy, and Spain in terms of higher levels of economic growth. Otherwise, a significant link between defence spending and growth may not be evident.

Though the commitments undertaken by the Member States may mainly have a political nature, if adhered to, they might trigger economic growth. Except from the increased defence budgets and the expansion of investments, which might be related to beneficial spillovers and domestic growth in Greece (Dimelis, 2005), other binding common commitments could also be favorable for the country. For example, increasing the share of expenditure allocated to defence R&D may further contribute to the country's economic performance. Moretti et al. (2019) point out the global benefits of national R&D that constitutes the main input of innovation (Peri, 2005), which in turn is one of the main drivers of economic growth (Romer, 1990). Moreover, the EDF, as another collective benchmark and commitment referred to in the PESCO establishment decision, also aims to incentivize and support collaborative defence research and capability development projects, and constitutes the European Commission's most serious and ambitious statement of intent to drive forward European defence cooperation (Muravska, 2020).

It remains to be seen if a small state like Greece could overcome its defence bureaucracies and if the private sector will manage to follow the developments and take full advantage of economies of scale, new technology and innovation spillovers, and EU funding opportunities (Pedi, 2021). The defence sector might thus act as a key pillar for boosting the economy's growth potential.

6. Conclusion

The assessment of the economic effects of defence spending constitutes a long-lasting multidimensional debate. Literature evidence varies on several issues like the different contexts, time spans, geographical regions, or estimation techniques applied.

This article has studied the association of military expenditures with economic growth within the PESCO framework, where the target is the increase in defence spending and binding commitments to investments. Based on a data sample of 25 European Member States for the period after the enforcement of the Maastricht Treaty (1994–2018), which laid the foundations for a CFSP, results indicate that military expenditures could have a positive effect on economic growth. Nevertheless, the effects may differ depending on the defence partnerships each Member State has developed. Specifically, a community detection algorithm was applied on the network links that have been established through the context of country partnerships in PESCO defence projects and two different country clusters have emerged. In each one, the Member States have developed greater defence bonds within the cluster, and loose connections with the other cluster. Despite the fact that the aforementioned emerging clustering is rather loose, and should merely be taken as indicative and not exclusive, it does offer evidence that Member States with strong defence ties in the cluster with countries like France, Germany, Italy, and Spain could have significant positive economic effects, whereas for the others the effects may be insignificant.

One should also take into account that PESCO was established in recent years and at the moment it constitutes the latest step towards a gradual integration in the European defence sector. After the adoption of the CFSP[23], which is the point after which a positive relationship between MIL and GDP appears[24], various collaborations

[23] Menon (1996) points out that "post-Maastricht scholarly evaluations have tended to be positive about its implications for enhanced European defence co-operation and have stressed the fact that Europe seemed to be moving towards a European defence structure"

[24] This comes out from the robustness analysis that shows an insignificant association of the variables of interest for the period before the establishment of the CFSP (1970-1993) for both clusters of countries (Panels B and C).

between several countries were active[25]. It may be possible to argue that this portion of countries is actually the ones that developed dense collaborations within the framework of the PESCO defence initiative, seizing the opportunity for further flourishing their defence industry and consequently their economies. In this sense, the emerging clustering appears to be endogenous to the type of the recent historical relationship, which is defined by factors primarily structural or political in nature like industrial cooperation, integrated supply chains, foreign policy orientation, or level of ambition in international security policy (Blockmans & Crosson, 2019). In economic terms, there is evidence of differentiated integration, benefiting presumably the growth of advanced defence-producing economies.

The implication of the results is straightforward. The EU initiative for the defence integration among Member States, except the economic scales in the defence sector and positive effects on defence capabilities, might also have a significant economic impact and boost investments and growth in the Union. Member States seeking more involvement in joint defence projects, especially with countries with advanced defence industrial base, could maximize the effectiveness of their defence spending with positive spillovers and growth potentials for their economies.

A limitation of the present study is the fact that for the construction of the defense collaboration network, to which the community detection algorithm was applied, all PESCO defence projects are treated with the assumption that are equally valued. However, the adopted projects concern several operational areas, from developing joint training and facilities to maritime, air, cyber, and space capabilities. Thus, future research could capture the defense collaboration network dynamics more effectively by assigning different weights to projects involving heavier industries or more advanced technologies and requiring more sources. The varying levels of countries' absorptive capacities could also be considered, as well as the fact that some countries act as leaders or observers in several defence projects.

[25] Examples of collaboration for countries like Belgium, France, Germany, Luxemburg, Spain, and Italy, include the three-nation Tornado, the four-nation Eurofighter Typhoon, and the seven-nation Airbus A400M airlifter (Hartley, 2008). Further co-operative ventures are described in Menon (1996).

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Tables

Table 1: Network and PESCO characteristics

Network Attributes	PESCO Characteristics	State of Network / PESCO			
		Round 1 (17 projects)	Round 2 (34 projects)	Round 3 (47 projects)	Round 4 (60 projects)
Nodes	Member States	25	25	25	25
Edges	Unique partnerships	291	292	290	283
Weighted edges	Total partnerships	617	783	878	1027
Density	Proportion of total possible unique partnerships	0.970	0.973	0.967	0.943
Average degree	Average number of partner countries	23.28	23.36	23.20	22.64
Average weighted degree	Average number of partnerships	49.36	62.64	70.24	82.16
Modularity - mean (sd)	Density of collaborations inside defence clusters compared to links between defence clusters	0.039 (0.009)	0.048 (0.007)	0.052 (0.005)	0.019 (0.015)

Notes: Modularity values calculated after 100 iterations of Louvain Algorithm.

Table 2: List of countries, mean variable values (1994-2018) and defence partnerships

Country	Macroeconomic Variables			Defence Partnerships after each PESCO round			
	Military Expenditures % GDP	Investments % GDP	Growth % GDP	1st	2nd	3rd	4th
PESCO countries	1.623	23.207	2.751	49.36	62.64	70.24	82.16
Cluster 1	1.457	22.807	2.459	58.67	76.17	86.58	100.91
Belgium	1.190	23.038	1.851	62	85	90	104
Czechia Republic	1.481	29.115	2.745	43	63	67	61
France	2.469	22.050	1.681	75	123	148	210
Germany	1.358	20.901	1.502	69	91	113	145
Ireland	0.618	24.196	5.891	18	18	16	7
Italy	1.532	19.648	0.764	95	111	130	143
Luxembourg	0.579	20.065	3.330	35	35	38	61
Netherlands	1.407	21.177	2.124	73	92	100	107
Portugal	1.936	22.066	1.430	47	62	63	79
Romania	1.959	24.363	3.342	54	62	76	96
Spain	1.479	24.345	2.247	90	126	143	149
Sweden	1.480	22.726	2.613	43	46	55	51
Cluster 2	1.775	23.581	3.025	40.77	50.15	55.15	64.38
Austria	0.876	24.667	1.933	45	49	52	60
Bulgaria	2.107	21.184	2.879	41	44	47	55
Croatia	3.355	23.142	2.227	51	58	58	59
Cyprus	2.416	20.724	2.953	63	56	57	60
Estonia	1.665	29.625	4.236	23	40	40	63
Finland	1.430	22.490	2.358	36	48	52	52
Greece	2.877	20.134	0.981	62	73	76	92
Hungary	1.264	24.122	2.458	41	55	73	84
Latvia	1.195	26.207	3.926	28	38	39	49
Lithuania	1.063	21.337	4.286	29	31	44	49
Poland	1.920	21.461	4.246	30	70	81	105
Slovakia	1.606	26.850	4.119	46	50	53	56
Slovenia	1.313	24.764	2.906	35	40	45	57

Notes: Its country is classified in its major cluster after 100 iterations of Louvain algorithm on defence partnerships’ network after each PESCO round (total 400 iterations)

Table 3: Cross-sectional Dependence, Panel Unit Root and Cointegration tests

	MIL	INV	GDP
Part A: Cross-sectional Dependence (CD) tests			
	MIL	INV	GDP
Panel A: PESCO Countries			
Pesaran	6.751 (0.000)	23.985 (0.000)	40.867 (0.000)
Friedman	206.878 (0.000)	142.365 (0.000)	197.426 (0.000)
Panel B: Cluster 1			
Pesaran	5.352 (0.000)	12.829 (0.000)	23.350 (0.000)
Friedman	233.126 (0.000)	59.683 (0.000)	128.428 (0.000)
Panel C: Cluster 2			
Pesaran	2.174 (0.029)	11.592 (0.000)	18.704 (0.000)
Friedman	50.94 (0.000)	101.99 (0.000)	109.542 (0.000)
Part B: Panel Unit Root tests			
		Levels	
Panel A: PESCO Countries			
Breitung	3.566 (1.000)	-4.025 (0.000)	-10.659 (0.000)
Im–Pesaran–Shin	-3.287 (0.001)	-1.643 (0.050)	-7.814 (0.000)
Pesaran's CADF	-4.141 (0.000)	-1.789 (0.037)	-6.130 (0.000)
Panel B: Cluster 1			
Breitung	3.486 (1.000)	-2.530 (0.006)	-8.204 (0.000)
Im–Pesaran–Shin	-3.501 (0.000)	-0.710 (0.239)	-5.848 (0.000)
Pesaran's CADF	-1.082 (0.140)	1.093 (0.863)	-3.391 (0.000)
Panel C: Cluster 2			
Breitung	1.150 (0.875)	-3.156 (0.001)	-7.083 (0.000)
Im–Pesaran–Shin	-1.195 (0.116)	-1.597 (0.055)	-5.218 (0.000)
Pesaran's CADF	-2.275 (0.011)	-2.165 (0.015)	-4.177 (0.000)
		First Differences	
Panel A: PESCO Countries			
Breitung	-5.936 (0.000)	-11.920 (0.000)	-15.704 (0.000)
Im–Pesaran–Shin	-12.455 (0.000)	-11.228 (0.000)	-14.247 (0.000)
Pesaran's CADF	-7.998 (0.000)	-9.868 (0.000)	-10.310 (0.000)
Panel B: Cluster 1			
Breitung	-4.299 (0.000)	-7.504 (0.000)	-10.519 (0.000)
Im–Pesaran–Shin	-8.786 (0.000)	-7.719 (0.000)	-10.113 (0.000)
Pesaran's CADF	-4.433 (0.000)	-5.368 (0.000)	-7.719 (0.000)
Panel C: Cluster 2			
Breitung	-4.136 (0.000)	-9.516 (0.000)	-11.700 (0.000)
Im–Pesaran–Shin	-8.831 (0.000)	-8.154 (0.000)	-10.040 (0.000)
Pesaran's CADF	-6.05 (0.000)	-8.074 (0.000)	-7.075 (0.000)
Part C: Cointegration tests			
Panel A: PESCO Countries			
G_τ	-2.055 (0.828)	-1.446 (0.915)	-2.189 (0.417)
G_α	-2.517 (0.980)	-1.516 (0.922)	-1.830 (0.777)
P_τ	-16.652 (0.273)	-5.62 (0.487)	-11.566 (0.520)
P_α	-4.348 (0.843)	-2.748 (0.988)	-4.857 (0.632)
Panel B: Cluster 1			
G_τ	-2.271 (0.590)	-1.46 (0.875)	-2.802 (0.235)
G_α	-3.110 (0.895)	-1.898 (0.905)	-2.501 (0.410)
P_τ	-6.249 (0.680)	-2.811 (0.720)	-4.565 (0.775)
P_α	-3.085 (0.912)	-1.908 (0.965)	-2.675 (0.782)
Panel C: Cluster 2			
G_τ	-1.856 (0.865)	-1.433 (0.828)	-1.623 (0.730)
G_α	-1.955 (0.973)	-1.153 (0.960)	-1.194 (0.912)
P_τ	-12.585 (0.247)	-4.341 (0.880)	-9.224 (0.385)
P_α	-4.355 (0.805)	-2.951 (0.745)	-4.509 (0.367)

Notes: No. countries in panels: (A) 25 (B) 12 (C) 13. Cross-sectional dependence tests: Friedman's (1937) chi-square, and Pesaran's (2004) CD test. Panel Unit Root tests: Lamda statistic for Breitung (2001), Z statistic for Im-Pesaran-Shin (2003), and Pesaran's (2007) CADF. Cointegration tests concern the study of Westerlund (2007). *p*-values in parentheses. Bootstrapped (400 iterations) *p*-values for the cointegration tests

Table 4: GMM estimations, Granger Causality and Variance Decomposition

Part A: Estimated results for the dynamic panel GMM			
	Dependent variable		
Independent variables	MIL	INV	GDP
Panel A: PESCO countries			
MIL_{t-1}	-0.030 (0.096)	1.053 (0.403)***	3.477 (0.415)***
INV_{t-1}	0.007 (0.003)*	-0.027 (0.096)	-0.549 (0.113)***
GDP_{t-1}	-0.004 (0.002)**	0.180 (0.042)***	0.129 (0.068)*
Panel B: Cluster 1			
MIL_{t-1}	-0.032 (0.048)	-3.676 (1.784)**	14.939 (2.017)***
INV_{t-1}	-0.003 (0.002)	0.120 (0.165)	-0.185 (0.174)
GDP_{t-1}	-0.003 (0.001)***	0.166 (0.042)***	-0.154 (0.043)***
Panel C: Cluster 2			
MIL_{t-1}	-0.032 (0.114)	1.792 (0.588)***	0.028 (0.426)
INV_{t-1}	0.011 (0.003)***	-0.091 (0.041)**	-0.735 (0.143)***
GDP_{t-1}	-0.003 (0.002)	0.296 (0.054)***	0.205 (0.117)*
Part B: Granger causality tests			
	Dependent variable		
Independent variables	MIL	INV	GDP
Panel A: PESCO countries			
MIL	-	6.819 (0.009)***	70.181 (0.000)***
INV	4.822 (0.028)**	-	23.411 (0.000)***
GDP	4.187 (0.041)**	18.176 (0.000)***	-
Panel B: Cluster 1			
MIL	-	4.246 (0.039)**	54.830 (0.000)***
INV	2.430 (0.119)	-	1.127 (0.289)
GDP	20.231 (0.000)***	15.334 (0.000)***	-
Panel C: Cluster 2			
MIL	-	9.278 (0.002)***	0.004 (0.947)
INV	8.632 (0.003)***	-	26.514 (0.000)***
GDP	2.006 (0.157)	30.211 (0.000)***	-
Part C: Variance Decomposition			
	Response variable		
Impulse variable	MIL	INV	GDP
Panel A: PESCO countries			
MIL	0.994	0.010	0.055
INV	0.002	0.935	0.279
GDP	0.003	0.054	0.665
Panel B: Cluster 1			
MIL	0.981	0.101	0.197
INV	0.008	0.816	0.093
GDP	0.011	0.082	0.708
Panel C: Cluster 2			
MIL	0.988	0.027	0.009
INV	0.009	0.877	0.409
GDP	0.001	0.095	0.581

Notes: No. countries in panels: (A) 25 (B) 12 (C) 13, No. obs. in panels: (A) 542 (B) 264 (C) 278. **Part A:** Instruments: l(1/4). Country-clustered standard errors in parentheses. **Part B**: The entries in the table are the chi-square statistics for the null hypothesis that the excluded (independent) variable does not Granger cause the equation variable (dependent) vs. the alternative hypothesis that the excluded variable Granger causes the equation variable. *p*-values in parentheses. **Part C:** Cholesky ordering MIL→INV→GDP (treating GDP growth as the most exogenous variable) *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Figure 1: (A) Timelines of GDP growth - Military expenditures for PESCO countries, Cl uster 1, and Cluster 2 (B) Network plot of PESCO defence partnerships. Area of nodes proportional to their weighted degree-partnerships number

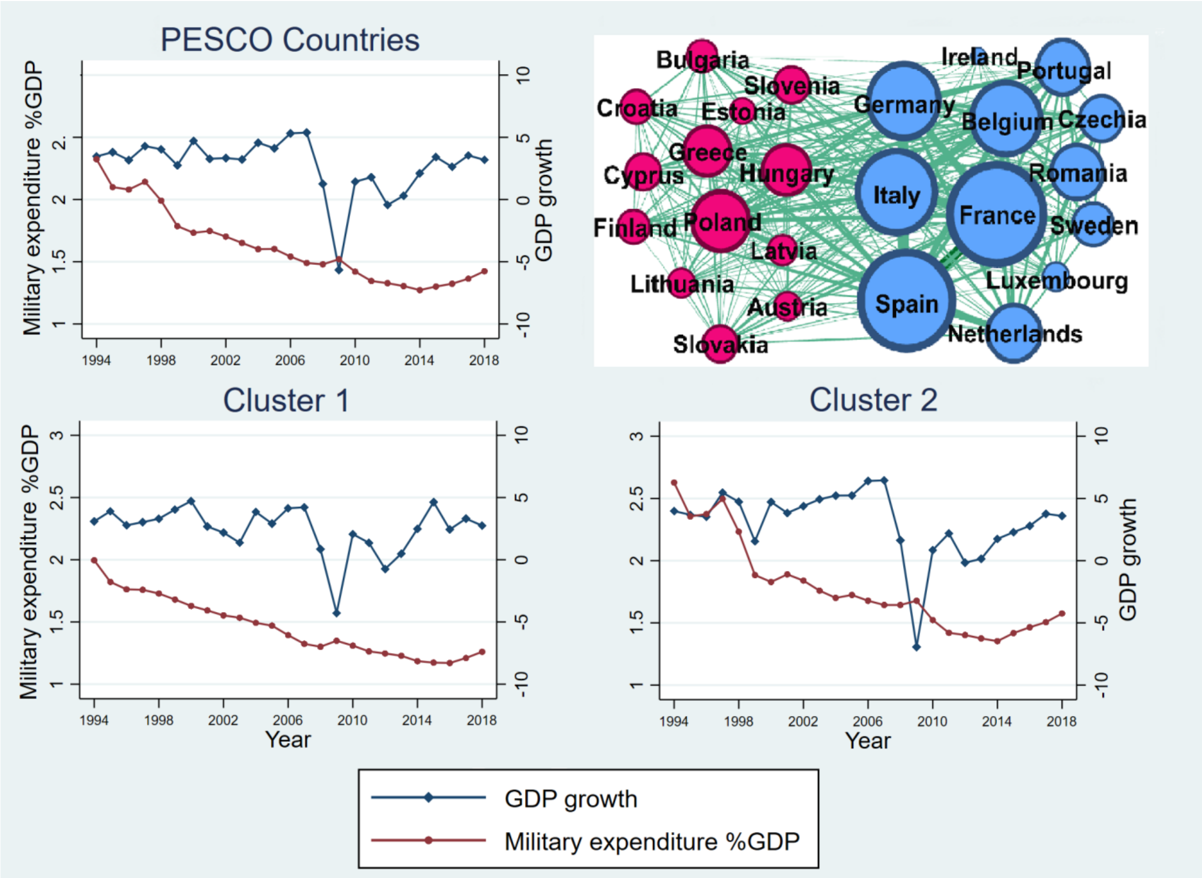
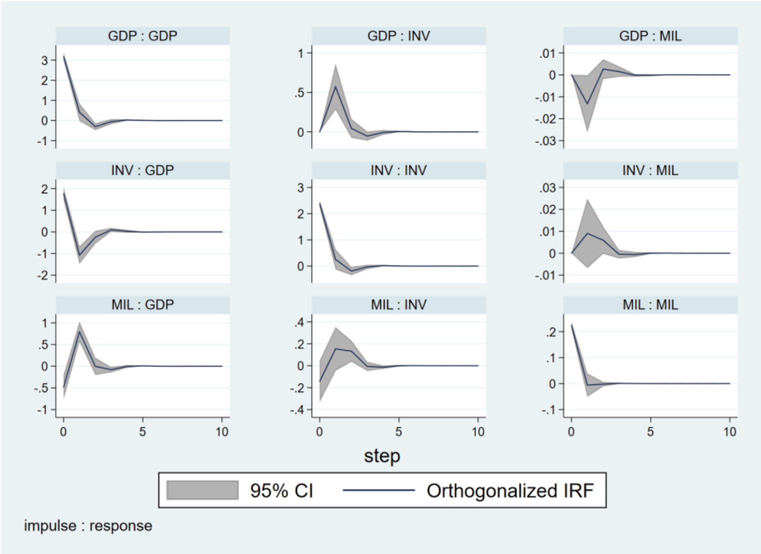
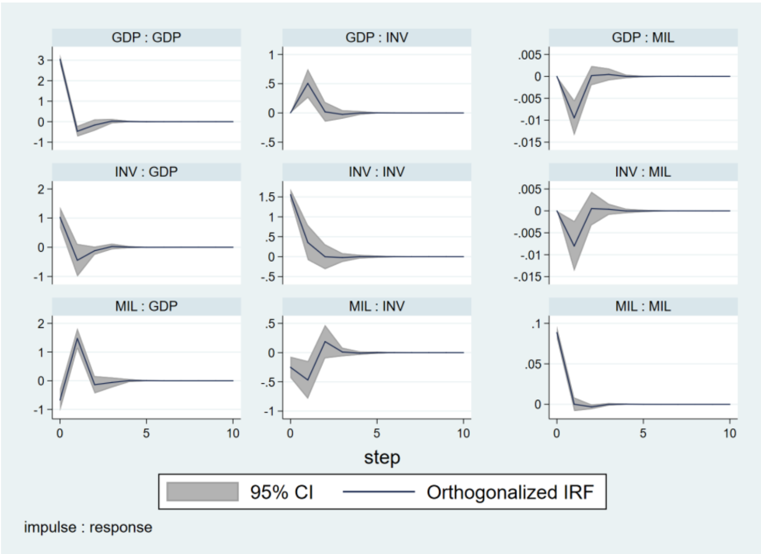


Figure 2: Impulse Responses for panels: (A) Full Sample (B) Cluster 1 (C) Cluster 2. Cholesky ordering: MIL→INV→GDP (treating military expenditures as the most exogenous variable)

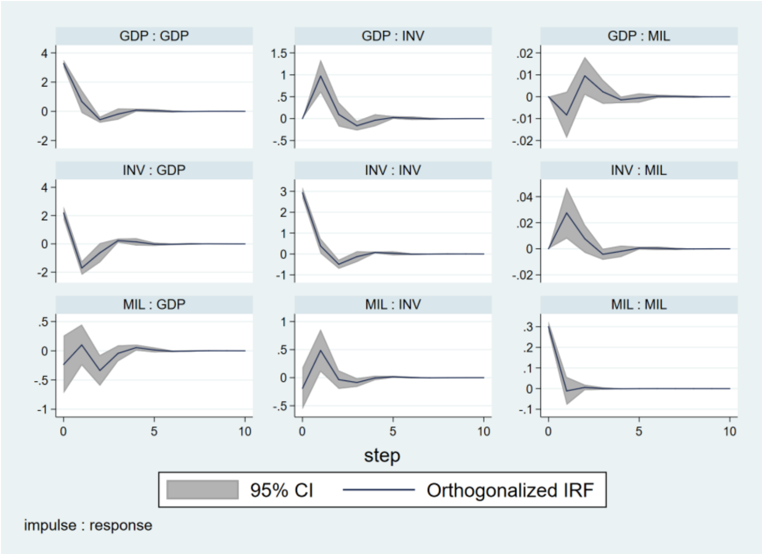
Panel A: PESCO Countries



Panel B: Cluster 1



Panel C: Cluster 2


GDP : GDP
GDP : INV
GDP : MIL
INV : GDP
INV : INV
INV : MIL
MIL : GDP
MIL : INV
MIL : MIL
step
95% CI
Orthogonalized IRF
impulse : response

Appendix

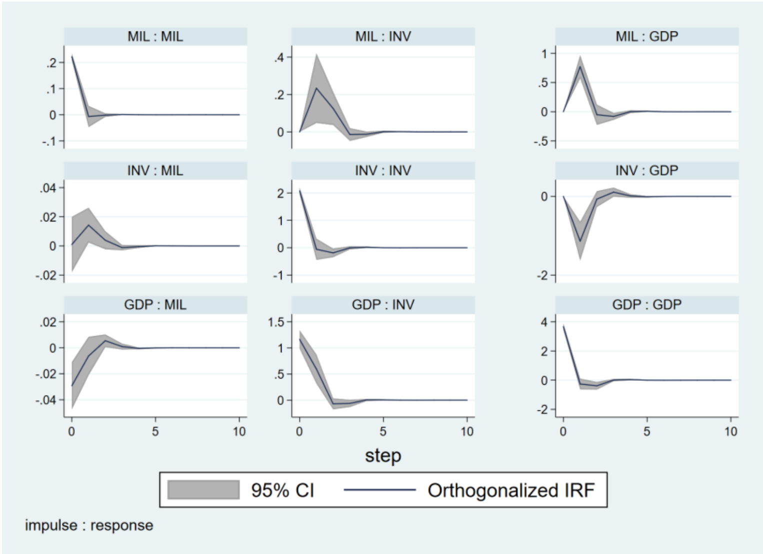
Table A1: Estimated results for the dynamic panel GMM

Part A: Years 1970-2018			
	Dependent variable		
Independent variables	MIL	INV	GDP
Panel A: PESCO countries			
MIL_{t-1}	-0.056 (0.067)	-0.086 (0.375)	2.903 (0.857)***
INV_{t-1}	0.003 (0.007)	0.006 (0.064)	-0.486 (0.076)***
GDP_{t-1}	-0.009 (0.005)*	0.117 (0.042)	0.043 (0.059)
Panel B: Cluster 1			
MIL_{t-1}	-0.003 (0.001)***	-7.838 (1.075)***	17.386 (1.595)***
INV_{t-1}	-0.014 (0.003)***	-0.007 (0.094)	-0.047 (0.118)
GDP_{t-1}	-0.006 (0.002)***	0.069 (0.039)*	-0.031 (0.041)
Panel C: Cluster 2			
MIL_{t-1}	0.003 (0.071)	0.318 (0.490)	0.735 (0.558)
INV_{t-1}	0.010 (0.011)	-0.058 (0.053)	-0.715 (0.094)***
GDP_{t-1}	-0.016 (0.009)*	0.205 (0.051)	0.082 (0.083)
Part B: Including exogenous variable			
	Dependent variable		
Independent variables	MIL	INV	GDP
Panel A: PESCO countries			
MIL_{t-1}	-0.023 (0.089)	1.026 (0.405)**	4.475 (0.563)***
INV_{t-1}	0.008 (0.003)**	-0.003 (0.099)	-0.479 (0.102)***
GDP_{t-1}	-0.004 (0.002)**	0.169 (0.041)***	0.095 (0.064)
Crisis	-0.012 (0.027)	-1.088 (0.382)***	-3.252 (0.436)***
Panel B: Cluster 1			
MIL_{t-1}	-0.015 (0.043)	-3.811 (1.748)**	13.941 (2.274)***
INV_{t-1}	-0.003 (0.002)	0.142 (0.154)	-0.156 (0.166)
GDP_{t-1}	-0.003 (0.001)***	0.153 (0.046)***	-0.177 (0.033)***
Crisis	0.015 (0.015)	-0.684 (0.398)*	-2.829 (0.551)***
Panel C: Cluster 2			
MIL_{t-1}	-0.005 (0.112)	1.682 (1.547)***	0.087 (0.369)
INV_{t-1}	0.013 (0.003)***	-0.046 (0.048)	-0.648 (0.123)***
GDP_{t-1}	-0.005 (0.002)***	0.276 (0.048)***	0.159 (0.103)
Crisis	-0.049 (0.031)	-1.507 (0.414)***	-3.611 (0.494)***

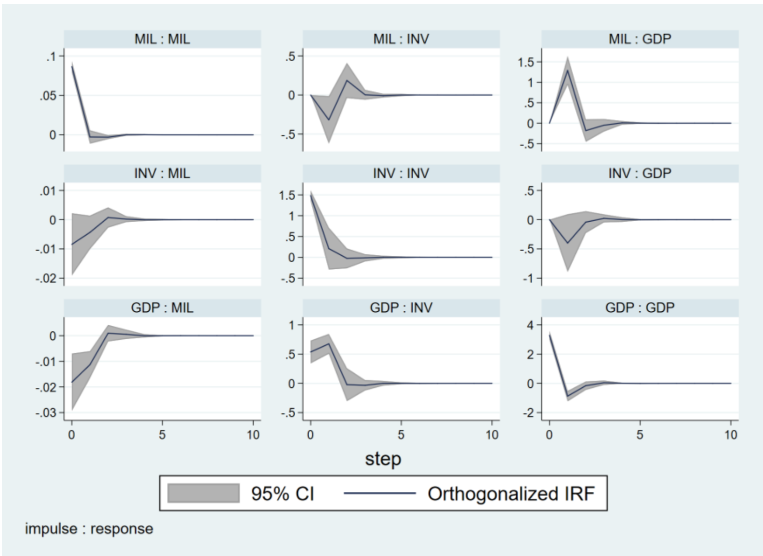
Notes: No. countries in panels: (A) 25 (B) 12 (C) 13, Instruments: l(1/4). Country-clustered standard errors in parentheses. Part A: No. obs. in panels: (A) 875 (B) 506 (C) 369. Part B: No. obs. in panels: (A) 542 (B) 264 (C) 278. *** *p*<0.01, ** *p*<0.05, * *p*<0.1

Figure A1: Impulse Responses for panels: (A) Full Sample (B) Cluster 1 (C) Cluster 2. Cholesky ordering: GDP→INV→MIL (treating GDP growth as the most exogenous variable)

Panel A: PESCO Countries



Panel B: Cluster 1



Panel C: Cluster 2

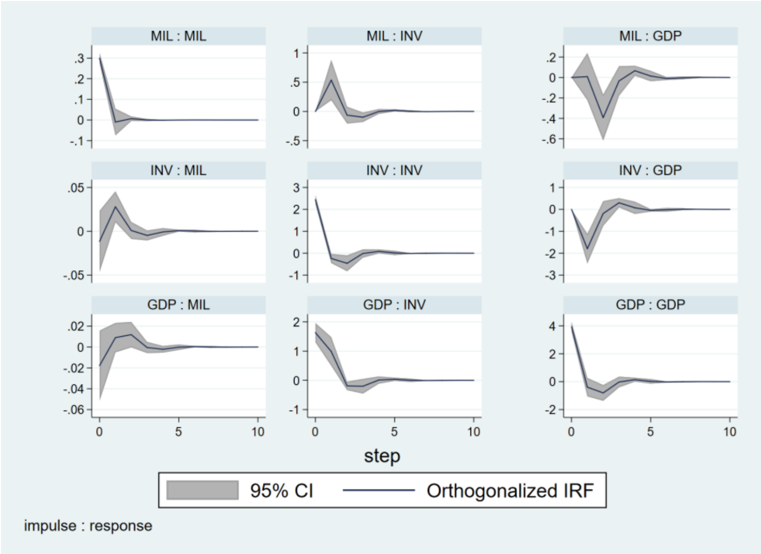


Figure A2: Military Expenditures in PESCO Countries in constant prices (2010)

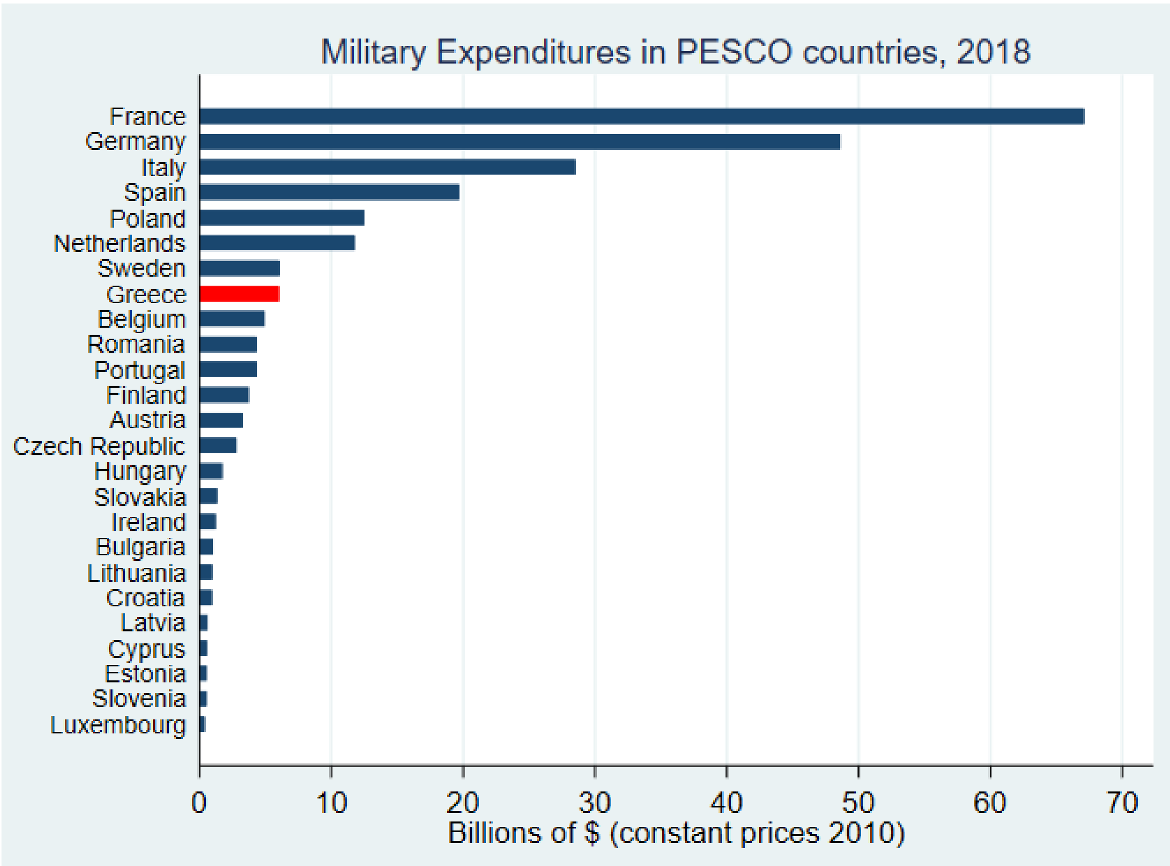


Figure A3: Military Expenditures in PESCO Countries as % of GDP, 2018