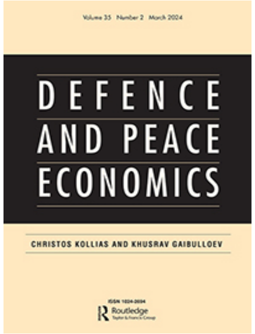

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Military Spending and Economic Output: A Decomposition Analysis of the US Military Budget

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ABSTRACT
Although the economic effects of defense expenditures have become an issue of intense interest over the recent decades, little is known about how the individual components of military spending affect the economy. Nevertheless, military spending is highly heterogeneous in its nature consisting of assorted categories that broadly encompass salaries' payment, operations, training, research and development, and maintenance of equipment, arms and facilities. Naturally, this implies that military spending can affect the economy in various and probably contradictory ways. Hence, by considering this distinctive element of military spending, the present paper aims to uncover the economic effects of the most important components of the US defense budget focusing on a period from 1949 to 2021. Applying linear and non–linear methods on a Barro–style regression, the statistical evidence reported herein suggests that heavy reliance on the military sector entails potentially high opportunity costs.

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Introduction

One of the most intriguing research questions in the field of Defense Economics relates to the type of underlying relationship between defense spending and economic activity. Since Benoit's (1973, 1978) pioneering works, a vast and growing literature has centered on the economic effects of military spending (*inter alia*: Dunne and Smith 2020; Dunne and Tian 2015; Emmanouilidis and Karpetis 2021a, 2021b; Kollias et al. 2021; Kollias and Paleologou 2016, 2019; Kollias and Tzeremes 2022; Phiri 2019; Saba 2022; Yakovlev 2007; Yolcu Karadam, Yildirim, and Öcal 2017; Yolcu Karadam, Öcal, and Yildirim 2021). Within this strand of the literature, appreciably fewer studies have considered the issue of military spending heterogeneity by disaggregating the economic effects of defense outlays (Becker and Dunne 2021; Chletsos and Kollias 1995; Malizard 2013; Mohanty, Panda, and Bhuyan 2020; Sezgin 2003).

Although the literature has recognized a broad spectrum of channels through which defense outlays affect the economy, a comprehensive and meticulous review of which is provided, among others, by Dunne, Smith, and Willenbockel (2005) and Sandler and Hartley (1995, p.203), an empirical examination at a disaggregated level could offer valuable insights into the underlying defense–growth relationships since the individual components of defense spending are likely to be associated with different economic effects. As highlighted by Ram (1995, p.269), it would be still useful to

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examine the growth effects of the individual components even if total defense spending neither promotes nor hurts growth.

In this spirit, the present paper aims to contribute to the existing pool of literature by investigating the compositional effects of the US military budget on domestic income. Given the sheer size of its military sector and its hegemonic role in the global arena, the US paradigm has attracted the attention of many researchers (*inter alia*: Atesoglu 2009; Heo 2010; Smith and Tuttle 2008; Ward and Davis 1992). However, only a fraction of these have analyzed the compositional effects of the US military spending but mostly at the state level and/or on economic outcomes other than national income, such as poverty, inequality, unemployment, and inflation (Borch and Wallace 2010; Henderson 1998; Mehay and Solnick 1990; Mintz, Huang, and Heo 1992).

Another additive element encapsulated in the present analysis is the use of the NARDL method of Shin, Yu, and Greenwood-Nimmo (2014) to uncover the short – and long–run asymmetric effects of military spending on GDP since the analysis of this type has gained growing interest over the recent few years by the relevant literature (Ahad and Dar 2017; Lanrui et al. 2022; Syed 2021; Ullah et al. 2021). Of course, the present analysis deviates from the aforementioned studies as it also deals with the asymmetries that can arise from the individual components of defense spending. Indeed, the examination of asymmetries in that context can be particularly salient. For example, countries may shift resources within defense budgets according to their strategic and economic needs. As highlighted by Becker (2021), NATO members facing high unemployment reduce defense burdens, but at the same time tend to reorient funds towards military personnel, as this type of spending is believed to have a more direct link to employment than other components of defense spending. Inevitably, this behavior can lead to a differential impact on GDP where positive changes in military spending and its components may have a different effect from the one generated due to negative changes in terms of sign, size, and statistical significance.

To achieve its primary objective, the paper utilizes the National Defense Budget Estimates for FY2022 (Green Book) released by the US Department of Defense (DoD). The components that occupy the largest share of DoD spending and are the subject of the current analysis are Military Personnel (*mper*), Operation and Maintenance (*O&M*), Procurement (*proc*), and Research, Development, Test and Evaluation (*RDT&E*). Appropriations for *mper* reflect the costs of salaries and other compensations for military personnel, active and retired, and reserve forces. Moreover, *proc* expenditures fund acquisition programs intended to produce military equipment and include all related costs that are an integral part of the preparation of an end item. *O&M* refers to expenses associated with fuel, supply, routine maintenance and major overhaul of plant and equipment. In addition, *O&M* accounts for salaries of DoD civilian employees, operating forces, education, recruiting and training activities, and supply operations. Finally, *RDT&E* expenditures finance the efforts made by contractors and the government for basic and applied research, advanced technology development, system development and demonstration, operational systems development and management support (Towell 2021).

The rest of the paper is organized as follows. Section 2 provides a brief overview of the US military spending profile and its economic performance. In addition, Sections 3 and 4 are respectively concerned with the data sources and model specification as well as the econometric methods employed, whereas Section 5 is devoted to the presentation and discussion of the empirical estimates. Finally, the last Section provides some useful policy recommendations.

The US Economy and Its Defense Budgets: A Brief Description of the Series

After the end of World War II and until the first round of the oil crisis, the US economy performed remarkably well, as the average annual growth rate of real GDP during this period exceeded 3%.[1] Such growth had several sources. The use of military spending as a tool to stimulate demand undoubtedly played an important role in that development as well (Nincic and T. R. Cusack 1979; Reich 1972). Throughout that period, the level of defense burden was quite impressive as it averaged over 9% of GDP.[2] An early surge in defense spending, as clearly shown in Figure 1, occurred at the

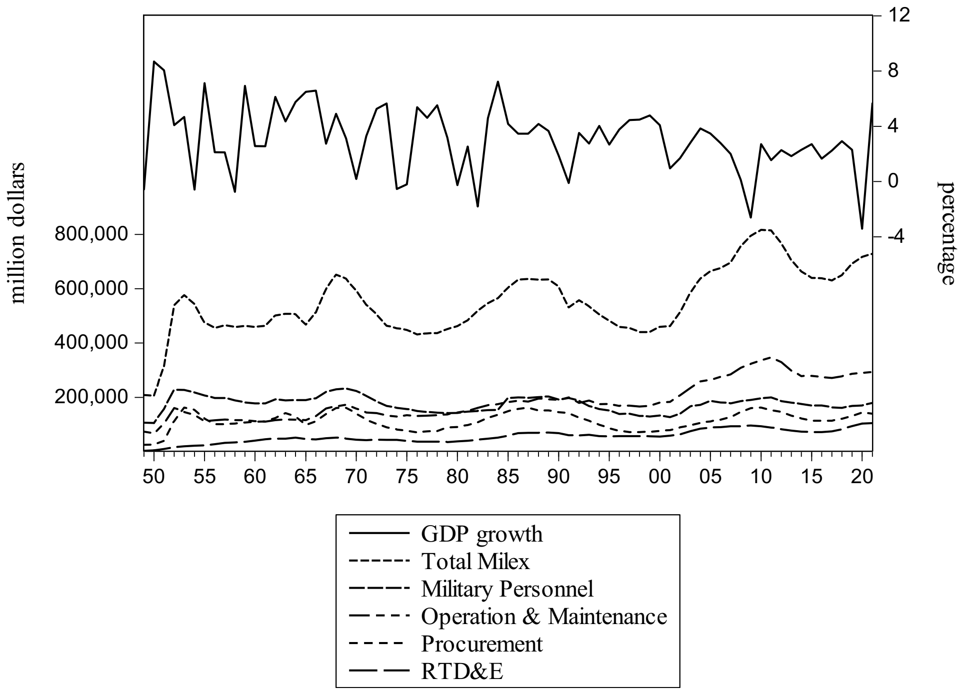

Figure 1. GDP growth, Total Military Spending, and its Components (in constant dollars 2022) 1949-2021.

outset of the Korean War in 1950, whereas the US involvement in the Vietnam War in the mid–1960s was another incident that propelled defense spending upwards (Cusack 1992, p.104). A look at the disaggregated data (see Figure 2) reveals that the US involvement in the Vietnam incurred high operational and procurement costs, however, the share of military spending devoted to military personnel was even larger at that time, representing approximately 40% of total spending. Besides, due to intensifying arms race with the Soviet Union, there was a significant increment in military *R&D* activities. In this direction was the establishment of the Defense Advanced Research Projects Agency (DARPA) by Department of Defense in 1958, which aimed to promote technology for military use (Gallo 2021).

The oil crisis of 1973 exacerbated inflationary pressures (DeLong 1997) and caused an economic recession between 1973 and 1974. At the same time, there was a remarkable de–escalation of the defense budgets, given that their annual contraction averaged close to 5% between 1968 and 1976. Not only the economic climate was unfavorable for maintaining high defense outlays, but also the end of the direct American military involvement in the Vietnam War together with the anti-military sentiment that brought skepticism towards any military buildup, was pivotal to the cuts in the US military budget at that time (Gaddis 1983). Such reductions though were uneven across the different components of the military budget, as they primarily concerned expenditures on personnel and defense procurement.[3]

Nevertheless, the Soviet invasion of Afghanistan in 1979, which terminated the détente era, was undeniably a blow to the US interests in the Middle East (Gray and Barlow 1985). The defense doctrine adopted under Carter's presidency, which became more explicit during the Reagan Administration, was to signal a restoration of American power (Salmon 1997). This development contributed to a considerable military buildup since military expenditure as a share of GDP increased from 4.9% in 1978 to 6.5% in 1987.[4] Of course, to implement this strategic plan not only the expansion of forces was necessary but also their modernization (Looney and Mehay 1990). This is

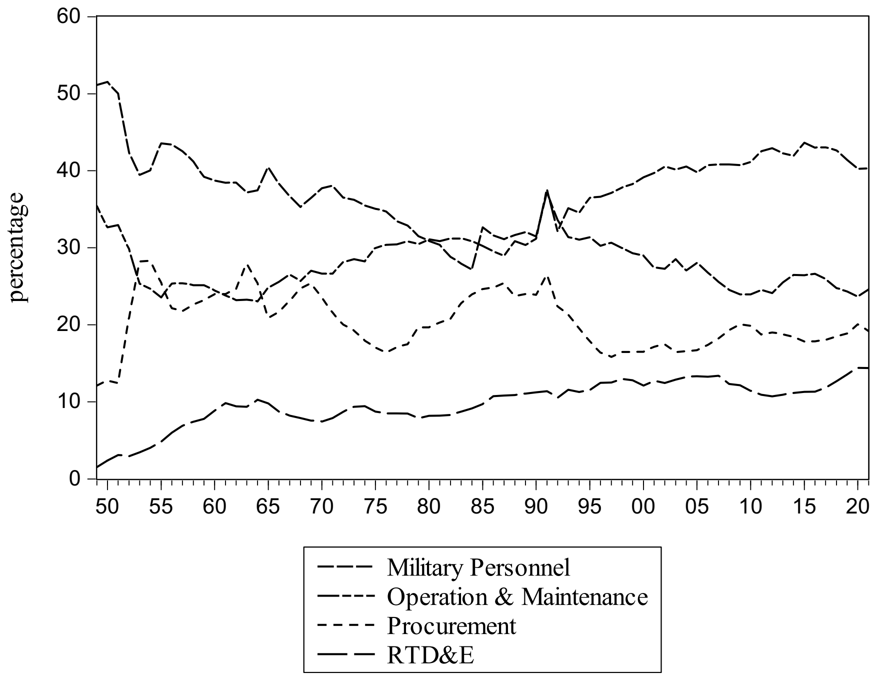

Figure 2. Military Spending Components as a share of Total Defense Outlays 1949-2021.

presumably the reason why there was a remarkable increase in defense procurement and *R&D* during the 1980s.

Despite its good performance in the late 1980s, the economy was experiencing a considerable imbalance between domestic savings and investment triggered primarily by the sustained large Federal deficit and a fall in household savings (Organisation for Economic Co-operation and Development. (OECD) 1988). Meanwhile, the official ending of the Cold War brought a gradual decline in the country's defense spending (Sandler and George 2016). Such a pattern though lasted only about a decade. The wars on terror were the landmarks of a new era with sustained high defense budgets, as clearly depicted in Figure 1. The US military involvement overseas, kept the *O&M* costs at high levels, which now accounted for the largest share of total defense spending (see Figure 2).

Contrary to the 1990s, which was a period of strong economic expansion with surging stock markets and rising productivity due to technical progress in the computer and communication industry (Organisation for Economic Co-operation and Development. (OECD) 2000), the economy slowed abruptly between 2000 and 2001. The terrorists' attacks on 11 September 2001 were also added to that economic situation, prolonging, at least temporarily, the slowdown (Rose and Blomberg 2010). Over the next six years following the recession of 2001, the economic expansion continued at a steady pace. Real GDP was growing on average by an annual rate of 2.7% (Organisation for Economic Co-operation and Development. (OECD) 2007).

After a long period of robust economic growth, real GDP declined by 2.6%. Inevitably, the adverse economic conditions, which resulted in the 2011 Budget Control Act, along with the withdrawal of a significant portion of US troops from Afghanistan and Iraq, led to a 21% drop in US military spending between 2010 and 2015 (Perlo-Freeman et al. 2016). These reductions appear to have affected, albeit not equally, all components of defense spending. From 2017 onwards, however, defense outlays exhibited an upward trend. The increases were mainly due to the promotion of *RDT&E* and modernization activities, while the escalating strategic competition with China and Russia also contributed to this military build–up (da Silva, Tian, and Marksteiner 2021).

Model Specification and Data Sources

To empirically investigate the growth effects of military spending, the paper proceeds to the estimation of a Barro–style growth model since the benefits of estimating a growth equation of this type are well–documented in the literature.[5] Although several variations of the endogenous growth model encountered in the defense–growth literature (d'Agostino, Dunne, and Pieroni 2017, 2019; d'Agostino et al. 2020; Compton and Paterson 2016; Mylonidis 2008; Utrero-González, Hromcová, and Callado-Muñoz 2019), the present paper adopts a quite similar specification to the one employed in Dimitraki and Menla Ali (2015), and Dimitraki and Win (2021). Particularly, the utilized empirical model is defined as follows:

$$Y_t = b_0 + b_1 inv_t + b_2 civ_t + b_3 milex_{jt} + b_4 pop_t + e_t \quad (1)$$

where Y_t, inv_t and civ_t denote the natural logs of GDP (in levels), government investment and non–defense government consumption expenditures respectively, pop_t stands for the population growth, $milex_{jt}$ for $j = 1, \ldots, 5$ corresponds to the natural log of the various components of military spending, i.e. $j = 1$ total outlays (*tmilex*), $j = 2$ *mper*, $j = 3$ *O&M*, $j = 4$ *proc*, and $j = 5$ *RDT&E*, and e_t is an error term.

To estimate the above–presented specification the study utilizes annual data covering the period from 1949 to 2021. Regarding the variables' sources, it is worth noting that all variables, except for the defense outlays, were derived from the Federal Reserve Bank of St. Louis. Moreover, as mentioned above, the data related to military spending (in constant dollars) correspond to those provided in the National Defense Budget Estimates for FY2022 (Table 6.11).

Econometric Techniques

Before implementing the lineal and the non–linear ARDL methods, it is initially necessary to ensure that all series are either stationary, I(0), or integrated of order one, I(1), since the applicability of the bounds testing procedure is dependent upon this condition. To this end, two alternative unit root tests are utilized. The first unit root test adopted is the one proposed by Elliott, Rothenberg, and Stock (1996), known as DF–GLS test. This test is substantially a modification of the DF test in the sense that instead of the initial series, it uses the locally detrended series. Despite the advantages of the DF–GLS method over the traditional DF test, its implementation can be rendered problematic since conventional unit root tests are prone to biases when exogenous shocks affect the series' data–generating process (Perron 1989). As such, the Zivot and Andrews (1992) (ZA) test, which accounts for any potential shift in levels (Model A) or in trend (Model B) of the series or in both (Model C), is additionally employed.

The examination of whether the series under consideration exhibit a stable long–run pattern relies on the approaches of Pesaran, Shin, and Smith (2001) and Shin, Yu, and Greenwood-Nimmo (2014). Given that the latter is an asymmetric extension of the former, it would be more convenient to start with the linear ARDL. Specifically, this test relies on the transformation of an ARDL specification into an Unrestricted Error Correction Model (UECM) through which one can derive information about short – and long–run dynamics. In the context of the present study, the estimated UECM takes the following form:

$$\begin{aligned}\Delta Y_t = a_0 + \sum_{i=1}^{p} a_{1i}\Delta Y_{t-i} + \sum_{j=0}^{q_1} a_{2j}\Delta inv_{t-j} + \sum_{j=0}^{q_2} a_{3j}\Delta civ_{t-j} + \sum_{j=0}^{q_3} a_{4j}\Delta milex_{t-j} + \\ + \sum_{j=0}^{q_4} a_{5j}\Delta pop_{t-j} + \rho_1 Y_{t-1} + \rho_2 inv_{t-1} + \rho_3 civ_{t-1} + \rho_4 milex_{t-1} + \rho_5 pop_{t-1} + e_t\end{aligned} \quad (2)$$

where ρ, for $i = 1, 2, 3, 4,$ and5, represents the long–run multipliers, a_i, for $i = 1, 2, 3, 4,$ and5, correspond to the short–run coefficients of the underlying ARDL model, while p, and q_i, for $i = 1, 2, 3, 4,$ stand for the optimal lag length defined through the Akaike (AIC) criterion.

Based on (2), Pesaran, Shin, and Smith (2001) suggested the application of F or Wald testing to check the hypothesis of no cointegration $H_0 : \rho_i = 0$ against the alternative of cointegration $H_a : \rho_i \neq 0$. The decision regarding the existence of cointegration can be made as follows. When the calculated value of the test exceeds the critical value of the upper limit, i.e. [I (1)], then the null hypothesis is rejected implying the existence of cointegration. Otherwise, it cannot be claimed the existence of cointegration between the dependent variable and the regressors.

Nevertheless, the linear ARDL method is mainly appropriate when the regressors' effects are linear and symmetric. In other words, the linear model may miss some key information pertaining to the underlying relationships when the variables follow a non–linear pattern. On the other hand, the NARDL method of Shin, Yu, and Greenwood-Nimmo (2014) accounts for asymmetric relationships via the decomposition of the variables into partial sum processes of positive and negative changes:

$$x_t^+ = \sum_{j=1}^{t} \Delta x_j^+ = \sum_{j=1}^{t} \max(\Delta x_j, 0) \tag{3.a}$$

$$x_t^- = \sum_{j=1}^{t} \Delta x_j^- = \sum_{j=1}^{t} \min(\Delta x_j, 0) \tag{3.b}$$

where x is a vector consisting of the model variables.

Taking into account equations (3.a) and (3.b), the asymmetric error correction model in the current framework can be expressed as:

$$\begin{aligned}
\Delta Y_t = {} & a_0 + \sum_{i=1}^{p} a_{1i}\Delta Y_{t-i} + \sum_{j=0}^{q_1} a_{2j}^{+}\Delta inv_{t-j}^{+} + \sum_{j=0}^{q_2} a_{2j}^{-}\Delta inv_{t-j}^{-} + \sum_{j=0}^{q_3} a_{3j}^{+}\Delta civ_{t-j}^{+} + \sum_{j=0}^{q_4} a_{4j}^{-}\Delta civ_{t-j}^{-} + \\
& + \sum_{j=0}^{q_5} a_{5j}^{+}\Delta milex_{t-j}^{+} + \sum_{j=0}^{q_6} a_{6j}^{-}\Delta milex_{t-j}^{-} + \sum_{j=0}^{q_7} a_{7j}^{+}\Delta pop_{t-j}^{+} + \sum_{j=0}^{q_8} a_{8j}^{-}\Delta pop_{t-j}^{-} + \rho_1 Y_{t-1} + \\
& + \rho_2^{+} inv_{t-1}^{+} + \rho_2^{-} inv_{t-1}^{-} + \rho_3^{+} civ_{t-1}^{+} + \rho_3^{-} civ_{t-1}^{-} + \rho_4^{+} milex_{t-1}^{+} + \rho_4^{-} milex_{t-1}^{-} + \rho_5^{+} pop_{t-1}^{+} + \\
& + \rho_5^{-} pop_{t-1}^{-} + e_t
\end{aligned} \tag{4}$$

where the subscripts (+) and (–) denote the positive and negative partial sum decompositions respectively, whereas the notation for the rest parameters and variables is identical to the linear case.

Within the above non–linear specification, the existence of cointegration can be tested through two alternative statistics. Following Banerjee, Dolado, and Mestre (1998), the first one is a t–test (t_{BDM}) that checks the hypothesis of no cointegration ($H_0 : \rho_1 = 0$) against the alternative of cointegration ($H_a : \rho_1 < 0$). The second is the bounds testing procedure of Pesaran, Shin, and Smith (2001) based on an F–test (F_{PSS}) under the joint null hypothesis of no cointegration ($H_0 : \rho_1 = \rho_2^+ = \rho_2^- = \rho_3^+ = \rho_3^- = \rho_4^+ = \rho_4^- = \rho_5^+ = \rho_5^- = 0$) against the presence of cointegration ($H_a : \rho_1 \neq \rho_2^+ \neq \rho_2^- \neq \rho_3^+ \neq \rho_3^- \neq \rho_4^+ \neq \rho_4^- \neq \rho_5^+ \neq \rho_5^- \neq 0$).

At the same time, to ensure that the estimated NARDL is correctly specified, it is necessary to investigate the existence of short – and long–run asymmetries for all regressors. The investigation of this issue can be easily achieved through a Wald–type test. Taking military spending as an example, the null hypothesis examined for the presence of short–term asymmetry is $H_0 : \sum_{j=0}^{q_5} a_{5j}^{+} = \sum_{j=0}^{q_6} a_{6j}^{-}$, while for long–term asymmetry the null hypothesis tested[6] is $H_0 : -\rho_4^+/\rho_1 = -\rho_4^-/\rho_1$. Rejection of the null hypothesis in both cases implies the existence of short – and long–run asymmetric effects meaning that the estimated model should be described by relation (4). However, failure to reject the two null hypotheses in all cases suggests that the effect of the variables is symmetric and thus equation (4) falls into the traditional linear model of equation (3).

The final stage of the empirical analysis involves the derivation of the asymmetric cumulative dynamic multipliers, which depict the responses of the dependent variable to a unit positive and negative change in the regressors. The formula utilized to calculate the multipliers is as follows:

$$m_h^+ = \sum_{j=0}^{h} \frac{\partial y_{t+j}}{\partial x_t^+},\ m_h^- = \sum_{j=0}^{h} \frac{\partial y_{t+j}}{\partial x_t^-},\ h = 0, 1, 2, \ldots \tag{5}$$

where x represents again the vector of regressors.

Note that when $h \to \infty$, $m_h^+ \to \theta^+$ and $m_h^- \to \theta^-$, with $\theta^+ = -\rho_i^+/\rho_1$ and $\theta^- = -\rho_i^-/\rho_1$ for $i = 2, 3, 4, 5$, being the asymmetric long–run coefficients. Through this analysis, therefore, it is possible to trace the path from one equilibrium to another, after a positive and negative unit change, as well as to observe the duration of the adjustment process.

Discussion and Interpretation of the Empirical Estimates

As noted above, a necessary preliminary test involves the examination of the series' stochastic properties to ascertain that none of the series is an *I*(2) process. The resulting *t*–statistics of the employed unit root tests are presented in Table 1. More specifically, the *DF–GLS* test results largely indicate the existence of a unit root in variables' levels, except for *tmilex* for which the null hypothesis is rejected at a 5% significance level. This applies though only when including a time trend in the auxiliary regression. A quite similar picture also emerges from the *ZA* test in which the null hypothesis is not rejected in the cases of *GDP, inv, civ, pop, tmilex*, and *RDT&E* regardless of the estimated model. By contrast, the military variables of *mper, O&M*, and *proc* appear to be stationary processes in all three models. In any case, considering the *t*–statistics of both tests it can be concluded that the variables' order of integration lies between *I*(0) and *I*(1).

ARDL Estimates

The existence of structural breaks in the series' generating process is perhaps an early indication of asymmetric relationships between the variables in question (Shahzad et al. 2017).[6] Before entering the discussion concerning the non–linear analysis, Table 2 displays the results of the linear ARDL specification for each one of the estimated models, i.e. for $j = 1, \ldots, 5$, as well as the relevant diagnostic and cointegration tests. Interpreting the short–run results first, it is evident that military spending, despite its positive sign, is not a statistically significant determinant of income. Thus, the short–run empirical findings do not reconcile with the Keynesian views that military spending as part of the total government budget can be used as a tool to stimulate aggregate demand. At a disaggregated level though it seems that *O&M* expenditures are conducive to income, as the variable's coefficient appears positive and statistically significant in the period *t*–1, at the significance level of 5%. Such a result is presumably not surprising since a significant portion of *O&M* spending is devoted to consumables including fuel, supplies, spare parts and other materials used for routine maintenance. In addition, the magnitude of the estimated coefficient implies that an increase of 1% in *O&M* contributes to income by 0.1% after one period.

With respect to the long–run coefficients, there is an indication that military spending has been detrimental to income given that the coefficient of the former is negative and statistically significant, but only at a 10% significance level. This result contradicts a part of the literature that was led to a positive relationship between the US defense spending and income (or growth) (Atesoglu 2002, 2009; Atesoglu and Mueller 1990; Emmanouilidis and Karpetis 2020; Pieroni, d'Agostino, and Lorusso

Table 1. Unit root test results.

	GDP	*inv*	*civ*	*pop*	*tmilex*	*mper*	*O&M*	*proc*	*RDT&E*
					DF-GLS (t-statistics)				
					Levels				
Intercept	−0.4125	0.5491	0.6634	1.0329	−1.1585	−1.8170	−0.5213	−0.7410	−0.1734
Trend & Intercept	−0.6437	−1.0713	−1.1934	−1.8836	−3.1347**	−2.3179	−2.9146*	−3.0018*	−1.6858
					First Differences				
Intercept	−0.4145	−5.2900***	−0.6190	−6.3504***	−4.5057***	−3.8141***	−5.3595***	−4.0795***	−0.9659
Trend & Intercept	−6.3567***	−9.6340***	−1.7330	−6.8635***	-	−3.7696***	−6.9033***	−4.1378***	−1.9344
					ZA (t-statistics)				
					Levels				
Intercept	−3.6860	−2.6110	−4.2800	−3.5900	−4.1540	−6.5590***	−6.9850***	−5.376***	−3.6190
Trend	−3.8510	−3.1630	−5.1470***	−2.1000	−3.4740	−6.1220***	−5.8290***	−5.0950***	−3.1810
Trend & Intercept	−3.8600	−3.7490	−4.8610*	−3.1820	−3.9270	−6.5280***	−6.9280***	−5.4910**	−3.5520
					First Differences				
Intercept	−8.1430***	−7.6130***	−9.0280***	−7.6090***	−7.6050***	-	-	-	−5.547 ***
Trend	−7.8290***	−6.8820***	-	−7.5050***	−7.2990***	-	-	-	−5.286***
Trend & Intercept	−8.0830***	−7.5410***	−8.9820***	−7.8210***	−7.6310***	-	-	-	−5.542**

The optimal lag selection was determined using the Akaike information criterion. The ZA critical values at the usual levels of significance for the Models A, B and C are respectively: 1%: 5.34, 5%: 4.80, 10%: 4.58, & 1%: 4.93, 5%: 4.42, 10%: 4.11 & 1%: 5.57, 5%: 5.08, 10%: 4.82.

*,**,*** denote significance at 10%, 5% and 1%, respectively.

Table 2. ARDL estimates of the defense-GDP relationship.

Variables	Model 1	Variables	Model 2	Variables	Model 3	Variables	Model 4	Variables	Model 5
C	1.4256*** (0.4514)	C	2.5089*** (0.5703)	C	0.9091*** (0.3392)	C	2.6001*** (0.5742)	C	0.4801 (0.3023)
GDP_{t-1}	−0.0783* (0.0403)	GDP_{t-1}	−0.1433*** (0.0462)	GDP_{t-1}	−0.0543 (0.0407)	GDP_{t-1}	−0.2347*** (0.0575)	GDP_{t-1}	−0.0537 (0.0416)
inv_{t-1}	0.0461* (0.0256)	inv_{t-1}	0.0610** (0.0291)	inv_{t-1}	0.0179 (0.0248)	inv_{t-1}	0.1291*** (0.0324)	inv_{t-1}	0.0397 (0.0306)
civ_{t-1}	−0.0106 (0.0199)	civ_{t-1}	−0.0068 (0.0248)	civ_{t-1}	0.0098 (0.0207)	civ_{t-1}	−0.0231 (0.0213)	civ_{t-1}	−0.0140 (0.0245)
pop_{t-1}	−0.0322** (0.0158)	pop_{t-1}	−0.0382** (0.0173)	pop_{t-1}	−0.0114 (0.0139)	pop_{t-1}	−0.0697*** (0.0183)	pop_{t-1}	−0.0154 (0.0168)
$tmilex_{t-1}$	−0.0634** (0.0243)	$mper_{t-1}$	−0.1168*** (0.0319)	$O\&M_{t-1}$	−0.0418** (0.0197)	$proc_{t-1}$	−0.0792*** (0.0193)	$RDT\&E_{t-1}$	−0.0087 (0.0159)
Δinv_t	−0.0363 (0.0691)	Δinv_t	−0.0287 (0.0856)	Δinv_t	0.0295 (0.0647)	Δinv_t	−0.0045 (0.0839)	Δinv_t	0.0763 (0.0508)
Δinv_{t-1}	−0.1810*** (0.0590)	Δinv_{t-1}	−0.2649 (0.0898)	Δinv_{t-1}	−0.1794*** (0.0593)	Δinv_{t-1}	−0.3505*** (0.0933)	Δinv_{t-1}	−0.0903* (0.0455)
$\Delta tmilex_t$	0.0461 (0.0519)	Δinv_{t-2}	−0.0705 (0.0745)	$\Delta O\&M_t$	0.0158 (0.0465)	Δinv_{t-2}	−0.0797 (0.0795)		
$\Delta tmilex_{t-1}$	0.0514 (0.0418)	Δinv_{t-3}	−0.1541 (0.0593)	$\Delta O\&M_{t-1}$	0.1084** (0.0448)	Δinv_{t-3}	−0.1540** (0.0733)		
		Δciv_t	0.0488 (0.0387)			$\Delta proc_t$	−0.0140 (0.0381)		
		$\Delta mper_t$	−0.0320 (0.0574)			$\Delta proc_{t-1}$	0.0496 (0.0380)		
		$\Delta mper_{t-1}$	0.0703 (0.0536)			$\Delta proc_{t-2}$	0.0556 (0.0380)		
		$\Delta mper_{t-2}$	0.0996 (0.0498)						
		$\Delta mper_{t-3}$	0.0687 (0.0457)						
Long-run effects									
L_{inv}	0.5884* (0.3180)	L_{inv}	−0.4012*** (0.0932)	L_{inv}	0.3296 (0.4189)	L_{inv}	0.5503*** (0.1110)	L_{inv}	0.7391 (0.6579)
L_{civ}	−0.1359 (0.2861)	L_{civ}	−0.2815*** (0.0998)	L_{civ}	0.1815 (0.3513)	L_{civ}	−0.0988 (0.0989)	L_{civ}	−0.2624 (0.5639)
L_{pop}	−0.4110* (0.2458)	L_{pop}	−0.2522*** (0.0798)	L_{pop}	−0.2107 (0.2706)	L_{pop}	−0.2970*** (0.0691)	L_{pop}	−0.2882 (0.3575)
L_{tmilex}	−0.8090* (0.4843)	L_{mper}	−0.0883* (0.0460)	$L_{O\&M}$	−0.7698 (0.7168)	L_{proc}	−0.3374*** (0.0708)	$L_{RDT\&E}$	−0.1626 (0.3369)
Statistics and diagnostics									
$Adj\ R^2$	0.1751	$Adj\ R^2$	0.1985	$Adj\ R^2$	0.1631	$Adj\ R^2$	0.2339	$Adj\ R^2$	0.0918
LM	1.0977 [0.5776]	LM	0.9065 [0.6355]	LM	0.7466 [0.6885]	LM	0.1906 [0.9066]	LM	0.2811 [0.8685]
$ARCH$	0.0263 [0.8710]	$ARCH$	0.0349 [0.8517]	$ARCH$	0.0047 [0.9448]	$ARCH$	0.0005 [0.9943]	$ARCH$	0.0064 [0.9358]
$CUSUM$	Stable	$CUSUM$	Stable	$CUSUM$	Stable	$CUSUM$	Stable	$CUSUM$	Stable
$CUSUMsq$	Stable	$CUSUMsq$	Stable	$CUSUMsq$	Stable	$CUSUMsq$	Stable	$CUSUMsq$	Stable
F_{PSS}	3.8324*	F_{PSS}	4.9708**	F_{PSS}	2.8572	F_{PSS}	5.3088***	F_{PSS}	1.6785

(.) and [.] include standard errors and p-values, respectively. L represents the estimated long-run coefficients.
*,**,*** denote significance at 10%, 5% and 1%, respectively.

2008) but is corroborated by another, which has found that the US defense outlays are detrimental to the domestic economy (Heo and Eger 2005; Ward and Davis 1992).

The disaggregated analysis reveals that the resulted negative long–run association is driven principally by expenses on *proc* and to a lesser extent on *mper*. The fact that *mper* expenses are an economic barrier in the long run, a result that is in line with the panel estimates of Becker and Dunne (2021), is rather plausible. This is because the compensation and the salaries of the military personnel may be associated with high opportunity costs given that this type of spending is unproductive in its nature. Additionally, although the economic virtues of procurement spending are often be claimed, for example Ruttan (2006) gives several examples of how defense *R&D* and procurement spending has promoted technology development across miscellaneous US industries, the growth inhibiting effects of this type of military spending can still be reasonably explained. A negative economic impact can arise due to the existence of trade–offs. Mintz (1992) for instance, confirmed this phenomenon for the period under the Reagan administration, when remarkable increases of procurement spending were combined with cuts in welfare programs. Another reason is that the procurement–driven productivity growth concerns only a few industries that are defense–dependent and not the whole manufacturing sector (Saal 2001). Therefore, the impact of these programs on total productivity growth can be infinitesimal and even negative when these programs draw away funds from more productive spending within the industry (Dumas 1986).

Finally, the lower part of Table 2 displays the results of the relevant diagnostic tests together with the F_{PSS} values of the bounds testing procedure. In general, the diagnostics confirm the validity of the derived ARDL models. The residuals are uncorrelated and homoscedastic since the *chi–square* values of the *Breusch–Godfrey* and *ARCH* tests are insignificant in all cases, while the resulting CUSUM statistics imply the dynamic stability of the estimated coefficients. Hence, the estimated ARDL specifications can be further exploited for investigating cointegration relationships. In this context, the F_{PSS} statistics reveal that the null hypothesis of no cointegration can be rejected at the usual significance level of 5% only in the case of Models 2 and 4, whereas for Model 1, a stable long–run relationship between the variables of interest is observed at the 10% level. By contrast, the F_{PSS} statistics reveal the absence of cointegrating relationships when *O&M* and *RDT&E* are included in the estimated ARDL models. This is presumably because the intricate linkages between those specific components of military spending and economic output cannot be sufficiently captured by a linear specification. Inevitably, this necessitates the employment of a model that accounts for non–linear relationships such as the NARDL.

NARDL Estimates

A usual step for the proper specification of the NARDL model involves the examination of the short – and long–run asymmetries. Table 3. presents the Wald statistics for the tests of short – and long–run asymmetry between US GDP and the set of regressors. Overall, the results confirm the presence of short – and long–run asymmetric relationships as the null hypothesis of symmetry is rejected in the majority of the cases. Therefore, it can be claimed that negative and positive changes in the regressors exert differential impact on US GDP. As regards military spending and its components, which are the variables of interest, the derived Wald statistics suggest the presence of long–run asymmetries in all cases, but they reject the existence of short–run asymmetry in the case of total outlays and procurement spending. This implies that some of the operating channels responsible for asymmetric effects may need some time to materialize and hence may not be traceable in the short run.

Having established the existence of asymmetries in most cases, the next step of the analysis involves the estimation of the optimized NARDL models, the results of which are presented in Table 4. To produce the NARDL estimates a quite similar approach to Zheng, Zhou, and Wen (2021) was adopted. First, the lag selection for estimating the NARDL specification, as described by equation 4, was based on the *Akaike* information criterion setting the maximum lag order equal to 4. Next, the

Table 3. Wald tests for short- and long-run asymmetry.

	inv	*civ*	*pop*	*tmilex*	*mper*	*O&M*	*proc*	*RDT&E*
Long-run asymmetry (W_{LR})								
Model 1	36.4882***	28.9105***	16.1931***	142.1416***	-	-	-	-
	[0.0000]	[0.0000]	[0.0000]	[0.0000]				
Model 2	5.8569**	3.0584*	2.7341*	-	85.1817***	-	-	-
	[0.0155]	[0.0803]	[0.0982]		[0.0000]			
Model 3	50.2536***	23.7161***	15.5807***	-	-	122.1195***	-	-
	[0.0000]	[0.0000]	[0.0001]			[0.0000]		
Model 4	0.3996*	0.9147	3.8056*	-	-	-	5.5059***	-
	[0.5272]	[0.3389]	[0.0511]				[0.0190]	
Model 5	20.1143***	0.5674	14.3636***	-	-	-	-	7.2456***
	[0.0000]	[0.4513]	[0.0002]					[0.0071]
Short-run asymmetry (W_{SR})								
Model 1	7.1624***	11.8285***	1.3700	0.4431	-	-	-	-
	[0.0074]	[0.0006]	[0.2418]	[0.5056]				
Model 2	9.8691***	10.0935***	0.9957	-	16.1635***	-	-	-
	[0.0017]	[0.0015]	[0.3184]		[0.0001]			
Model 3	11.2655***	-	1.1722	-	-	5.1416**	-	-
	[0.0008]		[0.2789]			[0.0234]		
Model 4	0.3128	1.5934	2.6533	-	-	-	0.2348	-
	[0.5759]	[0.2068]	[0.1033]				[0.6279]	
Model 5	0.1624	-	27.6235***	-	-	-	-	-
	[0.6869]		[0.0000]					

p-values in [.]. *,**,*** denote significance at 10%, 5% and 1%, respectively.
W_{LR} stands for the Wald statistics used to test the presence of long-run asymmetric effects for each explanatory variable $(H_0 : -\rho^+/\rho_1 = -\rho^-/\rho_1)$, while W_{SR} corresponds to the Wald statistics for testing the short-run asymmetries $\left(H_0 : \sum_{j=0}^{q_1} a_{ij}^+ = \sum_{j=0}^{q_2} a_{ij}^-\right)$.

best fitting NARDL models were specified relying on the previous Wald statistics as well as on stepwise regressions to omit redundant variables.

An initial conclusion that can be drawn from Table 4 is the existence of a strong indication of cointegration since all extracted F_{PSS} values are statistically significant at the usual significance levels, while according to the t_{DBM} statistics the existence of cointegration is supported in most cases. In addition, the adjusted R^2 are clearly higher than those derived from the corresponding linear modes, which is a further indication of the suitability of the NARDL model in our analysis.

Regarding the short–run results, it is obvious that military spending exerts a positive symmetric effect on GDP that becomes statistically significant in periods $t-2$ and $t-3$. This finding is consistent with Gupta, Kabundi, and Ziramba (2010) who showed, in the case of the US, that military expenditures promoted economic activity in the short run. In addition, the cumulative short–run effect implies that an increase of 1% in military spending contributes to income by 0.3%. At a disaggregated level, the empirical output shows that positive changes in *mper* are associated with higher economic performance. A 1% increase in *mper* leads to a 0.38% cumulative GDP increase in the short run. Thus, raising the salaries of military personnel or the employment levels of the military would induce an economic uplift. At the same time, reductions in *mper* are beneficial to economic output since a negative change of 1% causes output to raise by 0.27%. This is presumably an indication that *mper* expenses are responsible for crowding–out effects on investment and/or other forms of social spending. This argument is corroborated by the study of Malizard (2015), whose findings supported the crowding out of investment by non-equipment spending in the case of France. By contrast, Mintz (1992) found no evidence to support direct trade–offs between *mper* expenses and welfare spending in the US postwar period. As the author explains, *mper* costs do not necessarily substitute social spending since the armed forces provide health and education to many people who would otherwise need government support. In any case, the magnitude of the coefficients reveals that cuts in military personnel expenses will promote the economy to a lesser extent than an increase in this specific component of defense spending.

Table 4. NARDL estimates of the defense-GDP relationship.

Variables	Model 1	Variables	Model 2	Variables	Model 3	Variables	Model 4	Variables	Model 5
C	4.7097*** (0.7246)	C	5.3745*** (0.6811)	C	3.0901*** (0.5094)	C	1.8251*** (0.5354)	C	1.1657*** (0.4197)
GDP_{t-1}	−0.6750*** (0.1077)	GDP_{t-1}	−0.7003*** (0.0898)	GDP_{t-1}	−0.4733*** (0.0748)	GDP_{t-1}	−0.2629*** (0.0780)	GDP_{t-1}	−0.1233** (0.0599)
inv^{+}_{t-1}	0.3404*** (0.0642)	inv^{+}_{t-1}	0.3049*** (0.0489)	inv^{+}_{t-1}	0.2484*** (0.0396)	inv_{t}	0.1507*** (0.0382)	inv^{+}_{t-1}	0.1272*** (0.0407)
inv^{-}_{t-1}	2.0693*** (0.4314)	inv^{-}_{t-1}	0.7989*** (0.2082)	inv^{-}_{t-1}	2.4736*** (0.4911)	civ_{t-1}	−0.0512** (0.0381)	inv^{-}_{t-1}	−1.0128*** (0.2713)
civ^{+}_{t-1}	−0.1184** (0.0533)	civ^{+}_{t-1}	−0.1836*** (0.0469)	civ^{+}_{t-1}	−0.1405*** (0.0375)	pop^{+}_{t-1}	−0.0650 (0.0431)	civ_{t-1}	−0.1133*** (0.0328)
civ^{-}_{t-1}	−1.0093*** (0.2132)	civ^{-}_{t-1}	−0.2819*** (0.0867)	civ^{-}_{t-1}	−0.6600*** (0.1415)	pop^{-}_{t-1}	−0.0669*** (0.0232)	pop^{+}_{t-1}	0.1709*** (0.0447)
pop^{+}_{t-1}	−0.3986*** (0.0814)	pop^{+}_{t-1}	−0.2020*** (0.0516)	pop^{+}_{t-1}	−0.2375*** (0.0662)	$proc^{+}_{t}$	−0.0576 (0.0418)	pop^{-}_{t-1}	−0.0937*** (0.0236)
pop^{-}_{t-1}	0.0084 (0.0372)	pop^{-}_{t-1}	−0.1910*** (0.0448)	pop^{-}_{t-1}	−0.0049 (0.0279)	$proc^{-}_{t}$	−0.0976** (0.0415)	$RDT\&E^{+}_{t-1}$	−0.0777* (0.0435)
$tmilex^{+}_{t-1}$	0.0509 (0.0504)	$mper^{+}_{t-1}$	−0.0133 (0.0381)	$O\&M^{+}_{t-1}$	0.1109*** (0.0390)	ΔGDP_{t-2}	0.1229 (0.1619)	$RDT\&E^{-}_{t-1}$	0.1585** (0.0713)
$tmilex^{-}_{t-1}$	−0.8571*** (0.1427)	$mper^{-}_{t-1}$	−0.5770*** (0.0755)	$O\&M^{-}_{t-1}$	−0.8869*** (0.1491)	ΔGDP_{t-3}	−0.2044 (0.1423)	ΔGDP_{t-2}	−0.2896* (0.1580)
Δinv^{+}_{t}	0.1512 (0.1270)	Δinv^{+}_{t}	0.0992 (0.0870)	Δinv^{+}_{t}	0.1781* (0.0893)	Δinv_{t-1}	−0.3216*** (0.1002)	ΔGDP_{t-3}	−0.4954*** (0.1505)
Δinv^{+}_{t-1}	−0.1160 (0.1039)	Δinv^{+}_{t-1}	−0.4012*** (0.0932)	Δinv^{+}_{t-2}	−0.2268*** (0.0738)	Δinv_{t-3}	−0.1863** (0.0706)	Δinv_{t-2}	−0.1619** (0.0720)
Δinv^{+}_{t-2}	−0.3683*** (0.1144)	Δinv^{+}_{t-2}	−0.2815*** (0.0998)	Δinv^{-}_{t-1}	−1.2764*** (0.3830)	Δciv_{t-1}	0.0913* (0.0528)	Δciv^{+}_{t-1}	0.2016*** (0.0713)
Δinv^{+}_{t-3}	−0.2052** (0.0969)	Δinv^{+}_{t-3}	−0.2522*** (0.0798)	Δinv^{-}_{t-2}	−0.7908** (0.3838)	Δpop_{t}	−0.0467 (0.0290)	Δpop^{+}_{t}	−0.2226*** (0.0725)
Δinv^{-}_{t}	−0.3226 (0.4169)	Δciv^{+}_{t}	−0.0883* (0.0460)	Δciv^{-}_{t-1}	0.7319*** (0.1488)	Δpop_{t-1}	−0.0302 (0.0294)	Δpop^{+}_{t-2}	−0.1388** (0.0648)
Δinv^{-}_{t-1}	−1.4694*** (0.4951)	Δciv^{+}_{t-1}	0.0766 (0.0550)	Δciv^{-}_{t-2}	0.6949*** (0.1311)	Δpop_{t-2}	0.0572* (0.0297)	Δpop^{+}_{t-3}	−0.1813*** (0.0599)
Δinv^{-}_{t-2}	−0.8856** (0.4208)	Δciv^{+}_{t-2}	−0.0668 (0.0492)	Δpop_{t}	−0.0886*** (0.0324)	Δpop_{t-3}	−0.0312** (0.0282)	Δpop^{-}_{t}	0.0711 (0.0453)
Δciv^{+}_{t}	−0.1056** (0.0487)	Δciv^{-}_{t}	0.2108 (0.1344)	Δpop_{t-2}	0.1366*** (0.0310)	$\Delta proc_{t-2}$	0.0554 (0.0346)	Δpop^{-}_{t-2}	0.1080* (0.0556)
Δciv^{+}_{t-1}	0.0684 (0.0681)	Δciv^{-}_{t-1}	0.5356*** (0.1334)	$\Delta O\&M^{+}_{t-3}$	0.1131** (0.0501)	$\Delta proc_{t-3}$	0.0315 (0.0251)	Δpop^{-}_{t-3}	0.0587 (0.0489)
Δciv^{-}_{t}	0.1614 (0.1642)	Δciv^{-}_{t-2}	0.6194*** (0.1267)	$\Delta O\&M^{-}_{t}$	−0.4041*** (0.1243)			$\Delta RDT\&E^{+}_{t}$	−0.2370*** (0.0834)
Δciv^{-}_{t-1}	0.9036*** (0.2026)	Δciv^{-}_{t-3}	0.1770 (0.1325)	$\Delta O\&M^{-}_{t-1}$	0.3020*** (0.0886)			$\Delta RDT\&E^{+}_{t-1}$	0.1744** (0.0759)
Δciv^{-}_{t-2}	0.6909*** (0.1609)	Δpop_{t}	−0.0486 (0.0294)					$\Delta RDT\&E^{+}_{t-2}$	−0.1118 (0.0686)
Δciv^{-}_{t-3}	0.1619 (0.1725)	Δpop_{t-1}	0.1318*** (0.0377)					$\Delta RDT\&E^{+}_{t-3}$	0.2206*** (0.0546)
Δpop_{t}	−0.1105*** (0.0396)	Δpop_{t-2}	0.1915*** (0.0346)						
Δpop_{t-1}	0.0485 (0.0379)	Δpop_{t-3}	0.0642** (0.0288)						
Δpop_{t-2}	0.1409*** (0.0367)	$\Delta mper^{+}_{t}$	0.0743 (0.0550)						
Δpop_{t-3}	0.0460 (0.0330)	$\Delta mper^{+}_{t-1}$	0.0974* (0.0521)						
$\Delta tmilex_{t}$	−0.0559 (0.0621)	$\Delta mper^{+}_{t-2}$	0.1400** (0.0529)						
$\Delta tmilex_{t-1}$	0.0675 (0.0603)	$\Delta mper^{+}_{t-3}$	0.1405*** (0.0476)						
$\Delta tmilex_{t-2}$	0.1414** (0.0592)	$\Delta mper^{-}_{t}$	−0.2773*** (0.1008)						
$\Delta tmilex_{t-3}$	0.1595*** (0.0473)								
Long-run asymmetric effects									
L^{+}_{inv}	0.5042*** (0.0494)	L^{+}_{inv}	0.4353*** (0.0449)	L^{+}_{inv}	0.5248*** (0.0582)	L_{inv}	0.5733*** (0.1516)	L^{+}_{inv}	1.0312* (0.6080)
L^{-}_{inv}	3.0654*** (0.4591)	L^{-}_{inv}	1.1406*** (0.2715)	L^{-}_{inv}	5.2255*** (0.8298)	L_{civ}	−0.1950 (0.1366)	L^{-}_{inv}	−8.2096* (4.9266)
L^{+}_{civ}	−0.1755** (0.0666)	L^{+}_{civ}	−0.2621*** (0.05354)	L^{+}_{civ}	−0.2968*** (0.0656)	L^{+}_{pop}	−0.2474 (0.1794)	L_{civ}	−0.9186 (0.5706)
L^{-}_{civ}	−1.4952 (0.0679)	L^{-}_{civ}	−0.4025*** (0.1280)	L^{-}_{civ}	−1.3943*** (0.2803)	L^{-}_{pop}	−0.2547** (0.1159)	L^{+}_{pop}	1.3860* (0.7464)
L^{+}_{pop}	−0.5904*** (0.1121)	L^{+}_{pop}	−0.2884*** (0.0761)	L^{+}_{pop}	−0.5018*** (0.1426)	L^{+}_{proc}	−0.2194 (0.1960)	L^{-}_{pop}	−0.7601* (0.4318)

(*Continued*)

Table 4. (Continued).

Variables	Model 1	Variables	Model 2	Variables	Model 3	Variables	Model 4	Variables	Model 5
L^{-}_{pop}	0.0125 (0.0551)	L^{-}_{pop}	−0.2728*** (0.0498)	L^{-}_{pop}	−0.0105 (0.0588)	L^{-}_{proc}	−0.3714*** (0.0996)	$L^{+}_{RTD\&E}$	−0.6298 (0.5847)
L^{+}_{tmilex}	0.0754 (0.0679)	L^{+}_{mper}	−0.0190 (0.0555)	$L^{+}_{O\&M}$	0.2343*** (0.0606)			$L^{-}_{RTD\&E}$	1.2850** (0.6312)
L^{-}_{tmilex}	−1.2697*** (0.1034)	L^{-}_{mper}	−0.8238*** (0.0648)	$L^{-}_{O\&M}$	−1.8737*** (0.2295)				
Statistics and diagnostics									
$Adj\ R^2$	0.4943	$Adj\ R^2$	0.6155	$Adj\ R^2$	0.5034	$Adj\ R^2$	0.2651	$Adj\ R^2$	0.4146
LM	2.9576 [0.0855]	*LM*	2.2770 [0.1398]	*LM*	2.9087 [0.2335]	*LM*	2.2624 [0.3226]	*LM*	0.6239 [0.4296]
ARCH	0.05398 [0.8163]	*ARCH*	0.0048 [0.9435]	*ARCH*	0.0015 [0.9686]	*ARCH*	0.9173 [0.3382]	*ARCH*	0.5834 [0.4450]
CUSUM	Stable	*CUSUM*	Stable	*CUSUM*	Stable	*CUSUM*	Stable	*CUSUM*	Stable
CUSUMsq	Stable	*CUSUMsq*	Stable	*CUSUMsq*	Stable	*CUSUMsq*	Stable	*CUSUMsq*	Stable
t_{BDM}	−6.2652***	t_{BDM}	−7.7937***	t_{BDM}	−6.3227***	t_{BDM}	−3.3684	t_{BDM}	−2.0574
F_{PSS}	7.4856***	F_{PSS}	11.8194***	F_{PSS}	8.5725***	F_{PSS}	4.5538**	F_{PSS}	5.7619***

(.) and [.] include standard errors and p-values, respectively. L^{+} and L^{-} represent the estimated long-run coefficients associated with positive and negative changes in the variable x.
*,**,*** denote significance at 10%, 5% and 1%, respectively.

Similar to personnel costs, positive and negative changes in *O&M* expenses have the same short–run economic influence with the cumulative effects showing, respectively, that 1% expansion of this budgetary item leads to a 0.11% rise in income and a 1% contraction results in 0.10% increase in the level of output. Thus again, a positive change has a greater economic impact than a negative one, although the difference between them is quite marginal. What is clear from the estimates is that both types of change in *O&M* costs create remarkably smaller economic effects than those generated from personnel spending, despite the equal allocation of resources among the two components over the period examined. It, therefore, seems that the compensation paid to the enlisted members of the armed services and officers is responsible for greater short–run economic effects than funding operating costs of units, base operations, depot maintenance, etc. This probably explains why *mper* spending is commonly seen as an economic stabilizer (Becker 2021). In economic terms, this is perhaps due to the greater effects of the former type of spending on private consumption and employment. As pointed out by Mintz, Huang, and Heo (1992, p.23), military budget allocations to the *mper* component can create remarkably more job positions than allocations to any other military budget item.

With respect to the remaining variables, a short–run asymmetric relationship is also revealed for *RDT&E*. It seems, however, that in the short–run only positive changes in *RTD&E* matter for the economy. The cumulative effect is positive implying that intensified efforts in the research and development of military equipment will be economically beneficial in the short run. Specifically, the magnitude of the coefficients suggests that a rise of 1% in *RTD&E* can promote economic output by 0.15%.

Turning our attention to the long–run estimates, it turns out that military budget expansions do not matter for the US economy. Only negative changes in the aggregate defense outlays are economically important given the existence of statistical significance following a negative change. The estimated coefficient of L^{-}_{tmilex} suggests an inverse relationship with income. Particularly, a 1% decrease in defense outlays leads to 1.2% increase in economic output. This finding, which is in line with the estimates of Ahad and Dar (2017) for the US case, is a rather strong indication that the finance of the military budget is associated with considerable opportunity costs. Thus, the estimates insinuate that some resources sacrificed in the military sector could be better exploited for more productive uses like social welfare programs, private investment, and other civilian activities. Indeed, the ‘guns vs butter’ trade–off has found empirical support in the US case (Russett 1969; Mintz and Huang 1991) and appears to be more intense when leaders want to avoid a rise in taxation, as occurred during the Reagan years (Carter, Ondercin, and Palmer 2021). Furthermore, military spending has been found to compete with private investment (Heo and Eger 2005; Mintz and Huang 1990), while opportunity costs could also arise from the use of valuable scientific personnel and assets in the defense industry that could be used in the civilian sector (Hartley 2006), which exhibits higher factor productivity than the military sector (Ward and Davis 1992).

As regards the individual components, the estimates indicate that from all positive changes only those in $L^{+}_{O\&M}$ are associated with economic output. Particularly, it is shown that a 1% positive shock can improve economic performance by 0.23%. Thus, apart from the obvious economic costs mentioned above, spending on *O&M* might lead to increased economic benefits. Naturally, this finding seems to justify the allocation of resources in large amounts, observed especially in the aftermath of the terrorists’ attacks in 2001, to *O&M* activities. A strong military cannot only guarantee internal security but could foster regional or international leadership and dominance over other countries (Heo 1998), which, in turn, might be conducive to the domestic economy due to access to raw materials, improvement of trade performance or strengthening of the domestic currency. At the same time, some spin–off effects stemming from *O&M* programs may take the form of human capital–enhancing activities that might be useful in the labor market after leaving the military (Hisnanick 2003).

Furthermore, the long–run findings uncover a negative but statistically insignificant relationship between US GDP and positive changes in *mper, proc*, and *RDT&E* expenses. Although for military personnel expenditures the interpretation may seem somewhat obvious, as this type of spending does not contribute to the productivity of the economy, for *proc* and *RTD&E* spending the underlying relationships may be even more complex. This is because the country supports a developed DIB, which implies that it can promote aggregate productivity through the transmission of innovation to the civilian sector and in this way can stimulate growth (Goel, Payne, and Ram 2008). However, as Mowery (2010) eloquently explains, specific requirements of the defense sector may undermine the applicability of new technologies to the civilian sector. In addition, as time goes by and technologies mature, the growing divergence between the needs of the civilian and the military sector may decrease the benefits of spin–offs.

Furthermore, the negative changes in *mper, O&M* and *proc* exert a statistically significant inverse effect on output. Specifically, the coefficient of L^{-}_{mper} suggests that a unit decrease in *mper* can induce an economic upturn of 0.82%. Similarly, a unitary negative change in $L^{-}_{O\&M}$ can spur economic activity by 1.87%. Comparing the coefficient values of L^{-}_{mper} and $L^{-}_{O\&M}$, it appears that the associated opportunity costs are rather greater for the latter than those triggered by the former. Perhaps, some types of expenses in *O&M*, such as the funding of public utilities, local transportation, food services etc., are even less productive than those included in *mper*. Moreover, the empirical evidence shows that a reduction of 1% in procurement programs can increase output by 0.37%. Such finding, however, is rather hard to reconcile with the evidence provided by Hooker and Knetter (1997), who found that the cuts in procurement programs affected adversely the US employment growth rate.

Contrary to the previous components, negative changes in *RDT&E* seem to have a positive association with GDP. Specifically, a 1% decrease in *RDT&E* expenditures leads to an economic decline of 1.28%. Therefore, even though increases in *RDT&E* do not affect economic activity, reductions in it appear to be economically detrimental. This is rather plausible since some valuable knowledge stemming from basic and applied research will be lost along with some novel technologies that would be useful in the civilian sector.

Asymmetric Adjustment Paths

As mentioned above, the final tool utilized involves the examination of the asymmetric adjustment of the US GDP from its initial equilibrium to the new steady state following a positive and negative shock in military spending. The extracted dynamic multiplier graphs are displayed in Figure 3, in which the *X*–axis represents time and the *Y*–axis depicts the magnitude of responses of GDP due to a positive/negative shock in military spending. The positive and negative responses of GPD are represented by the solid and dashed black lines, respectively. In addition, the red dotted line reflects the asymmetry curve that is derived from the difference $m^{+}_{h} - m^{-}_{h}$. This curve is shown together with the confidence bands (thin red lines) that correspond to the 95% significance level. In this context, statistical significance arises only when the two thin red lines are below or above zero simultaneously.

Overall, the graphs indicate that positive changes in military spending and its components are of little economic importance, regardless of the time horizon. Despite a positive spike in the short run, the magnitude of the effects tends to approach zero in the long run. Exceptions are *mper* and RTD&E expenses, positive shocks of which are clearly associated with negative economic effects in the long run. However, the effects due to positive changes appear to be statistically insignificant in most cases. On the contrary, the results confirm the existence of an inverse and statistically significant relationship between the US GDP and negative shocks of *tmilex, mper, O&M* and *proc* both in the short – and long–run. Therefore, a reduction in military spending would be economically beneficial not only in the long run but even at the initial stages following the policy change. It is also evident that the effects of the negative shocks dominate those of the positives implying the great benefits of reducing military

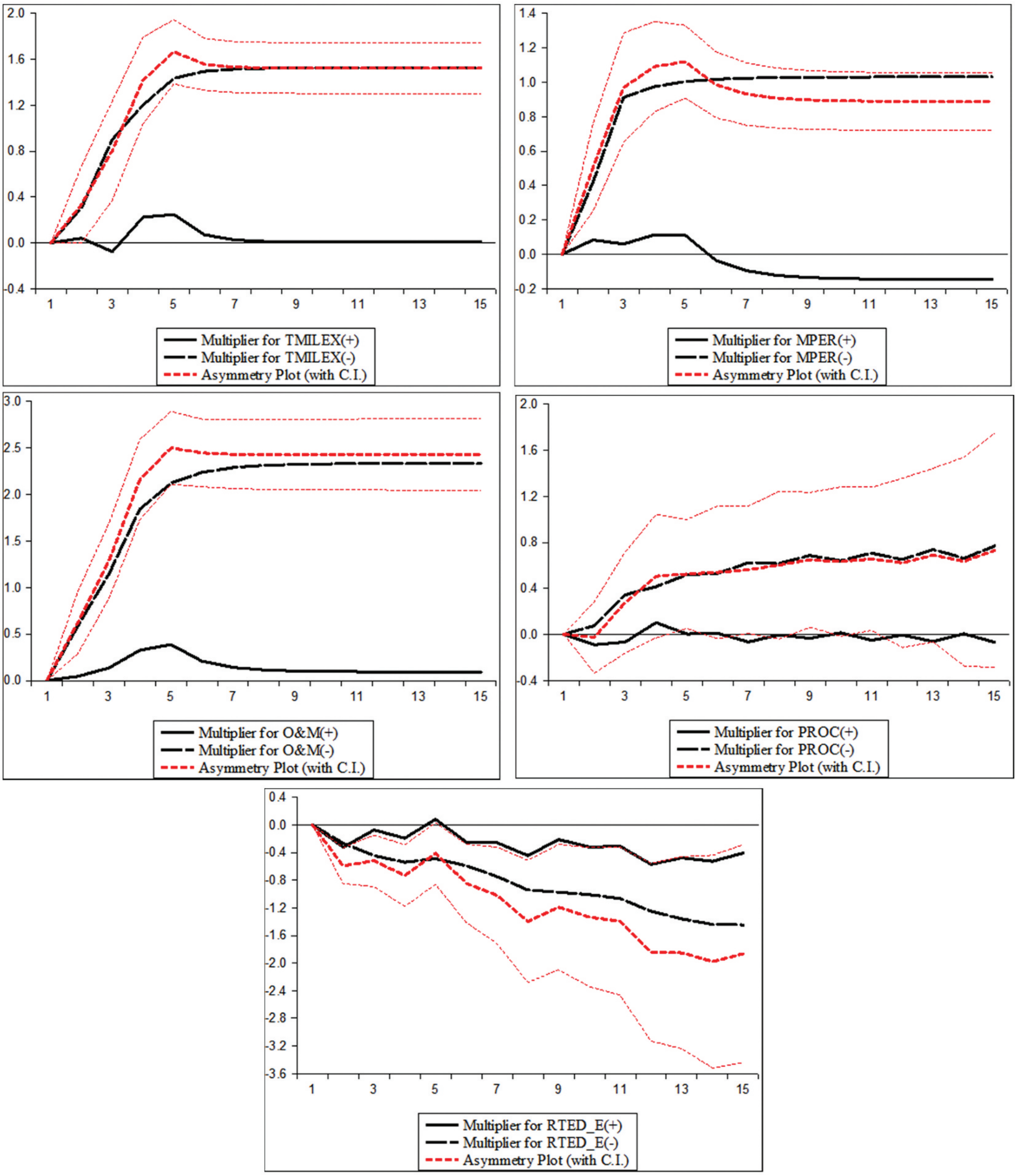

Figure 3. Dynamic adjustment of US GDP to asymmetric unit shocks of military spending and its components.

budgets. Nevertheless, this does not apply to *RTD&E* spending as negative changes are responsible for a gradual decline in GDP.

Conclusions

To preserve the country's hegemonic role in the international political arena, the US administrations have been historically obliged to allocate a huge amount of economic resources to the defense sector. As natural consequence of that, the economic effects of the US defense outlays have attracted a great deal of attention. Despite this, little is known about how the individual components of the US defense budget affect the economy. Therefore, by employing disaggregated data of the US defense outlays that cover the period from 1949 to 2021, the role of the present paper is to shed light on the compositional effects of defense spending on economic output. Particularly, in the context of a Barro–style regression model, the research question is being tested by implementing linear and non–linear techniques that account for short – and long–run effects.

In general, the evidence derived from the empirical analysis indicates that the economic effects of defense spending are rather time dependent and contingent upon the type of change (positive or negative). On the one hand, the linear estimates show that total defense spending exerts a non–significant positive effect in the short run but negative and statistically significant in the long run. On the other hand, the NARDL analysis unveils that some short–run positive effects can be triggered following an increase in military spending. As anticipated, such finding is primarily driven by expenses on military personnel, although *O&M* and *RDT&E* spending seem to play some role as well. In addition, the long–run non–linear estimates show that positive changes in military spending do not matter for the US economy. Only negative changes affect GDP and are economically advantageous. The economic benefits seem to be greater after a negative change in *mper* and *O&M* expenses. This does not apply though to *RDT&E* spending, negative changes of which hinder economic activity.

In the light of the above presented findings, it is an undisputed fact that military budget expansions cannot be deemed as lever of sustained growth. By contrast, the empirical findings comport with the discussions dominated in the early 1990s about the existence of a 'peace dividend' in the US economy (Mintz and Huang 1990; Ward and Davis 1992). Reductions in military spending and especially on the side of labor–intensive programs would probably shape the conditions for a better economic performance. Nevertheless, large cuts in defense spending can be economically damaging to states that are heavily dependent on the defense industry, while reductions in military personnel can increase the poverty of low–skilled workers as Henderson's (1998) study has shown. Besides, the estimates suggest that the reallocation of resources to capital–intensive military programs that could potentially promote factor productivity and technologies of dual use will not be necessarily conducive to the economy. Of course, the economic benefits and/or costs of the ongoing restructuring of the defense budget carried out in recent years, as expressed by increased *RTD&E* spending, will become clearer in the near future when more observations will be available. In any case, as military spending cutbacks are particularly difficult to be achieved due to strategic and political reasons, this study opens the debate on the optimal allocation of defense budgets in order to minimize potential opportunity costs.

Notes

1. U.S. Bureau of Economic Analysis, https://www.bea.gov/data/gdp/gross-domestic-product.
2. Stockholm International Peace Research Institute (SIPRI), https://milex.sipri.org/sipri.
3. Cumulatively, the reduction in total defense outlays reached 39.7% from 1968 to 1976. At a disaggregated level, spending on military personnel and procurement reduced by 41.1% and 77%, respectively, whereas the decrease in *O&M* and *RDT&E* activities was equal to 23% and 32.6% respectively.
4. See Note 2.
5. See Dunne, Smith, and Willenbockel (2005) for an extensive overview of the theoretical models employed in the relevant literature.
6. The nonlinearity assumption is also supported by the DBS test results of Broock et al. (1996). Under the null hypothesis the test assumes that the series are identically and independently distributed (i.i.d.), while rejection of the null hypothesis confirms the series' nonlinear dependencies.

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