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Modeling the Defense-Growth Nexus in a Post-Conflict Country – A Piecewise Linear Approach

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Modeling the Defense-Growth Nexus in a Post-Conflict Country - A Piecewise Linear Approach*

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Abstract

The defense-growth nexus is investigated empirically using longitudinal data for Guatemala and allowing the effect of defense spending on growth to be nonlinear. Using recently developed econometric methods involving threshold regressions, evidence of a level-dependent effect of military expenditure on GDP growth is found: a positive and significant externality effect of defense spending prevails for relatively low levels of defense spending and becomes negative, albeit insignificant, for higher levels.

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Keywords: Guatemala, defense expenditures, nonlinearity, economic growth, externality effect.

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1 Introduction

The relation between economic well-being and resources absorbed in the military[1] has been widely debated among economists during the last decades. On the one hand, analysts concluded that massive infusion of resources into the military sector had crowded out resources for (supposedly more productive) civilian sectors. On the other hand, it was concluded that the military sector, notably in developing countries, could provide externalities for the civilian sector through various channnels such as, for instance, provision of infrastructure, human capital formation or technological progress.

As Deger and Sen (1995) note, from a purely economic point of view, the military burden is widely regarded as the quintessential unproductive expenditure category (except as an insurance against war). Hence, economists deemed its impact on output growth to be negative for a very long time, even though, with respect to this preposition, no empirical evidence was presented until the seminal contribution by Benoit (1973, 1978). This first extensive empirical investigation of the defense-growth nexus became known mainly for the finding of a (at first sight counter-intuitive) growth-inducing effect of defense since, as mentioned before, economists had hypothesized the opposite. Benoit's results caused considerable controversy and broke up the empirical black spot in this field. As a consequence, a large number of studies were carried out, seeking to assess the growth effect of the military. Since Benoit the research focus and the methodologies employed have changed significantly. In the beginning of the 1980s, cross-sectional studies made up most of the contributions to the defense growth debate.More recently, however, single-country case studies became more popular since they overcome the heterogeneity problem and take into account the historical and institutional information unique for each country (Dunne and Nikolaidou 1999).[2]

This paper provides a contribution to the corpus of case studies in the form of a time-series analysis for Guatemala. The country is particularly interesting because of its strong

[1] The terms *defense* and *military* will be used synonymously throughout the paper.

[2] Panel regressions are another interesting method since within this framework it is possible to gain information on the cross-section as well as the time-series dimension.

military tutelage, the characteristics of a small open economy, the fact that it has undergone considerable change after the end of a long-lasting internal conflict, and the limited empirical evidence on this subject within the Central American region. Due to the fact that military expenditures rose steeply during the civil war, an obvious question to ask how defense contributed to Guatemala's growth performance. In contrast to previous studies analyzing the defense-growth nexus, we use recently developed econometric methods involving threshold regressions. Thus, depending on the respective defense burden, different effects of military spending on growth could prevail. For the case of Guatemala, we find that there is indeed a level-dependent effect of defense spending on growth indicating that defense spending is only conducive to growth at very modest levels, which supports the recent finding by Stroup and Heckelman (2001). The estimated threshold is lower than the obligation set out in the United Nations-sponsored Peace Accords, which limits military expenditure at 0.66 percent of GDP. In addition, we believe that the methodology exposed in this paper could be a useful tool to study a wider set of questions related to economic growth.

The remainder of the paper is organized as follows: Section 2 introduces general aspects of the relationship between defense and growth. Section 3 outlines some developments regarding economic growth, the civil war, and defense spending in Guatemala. Section 4 deals with data recompilation in a post-conflict country. Section 5 investigates the defense-growth nexus in Guatemala within the framework of a factor productivity approach, both based on a linear as well as a nonlinear methodology. Section 6 concludes.

2 Growth and Defense Spending

Since the seminal contribution by Benoit (1973, 1978), many studies have tried to assess the impact of defense expenditures on growth, yielding a wide array of results. Most analysts attribute this diversity to the lack of consensus among authors as to the proper theoretical avenue of how defense expenditures influences growth (see, e.g., Deger and Sen, 1995). Theoretically, a number of channels by which military spending can influence the economy have been identified in the literature with both positive and negative effects on growth. The defense sector can take skilled labor away from civilian production, but it can also train workers, particularly in developing economies. It could crowd out resources for consumption and investment (demand-side argument), but also provide positive externalities for the civilian sector, such as infrastructure development or technology spillover (supply-side argument). It can lead to destructive wars and stipulate civil strife, but may also maintain peace and provide a secure investment climate.

Clearly, the direction of the overall effect is an empirical question and can differ to a reasonable extent. Deger and Sen (1995), Ram (1995) and Dunne (1996) provide extensive reviews of the literature where the diversity of results is illustrated. Empirical evidence usually tends to vary across countries and over time and is sensitive to the theoretical framework. At first sight, the results tend to show no positive impact of military spending on economic growth, even if a supply-side framework is used, where the positive externality effects of defense should be more obvious. As Ram (1995) notes, it is nevertheless also hard to claim that the evidence supports the view that defense outlays have an overall negative effect on growth: Those demand-side studies that indicate an adverse effect of defense on investment or savings display only a partial view, as potential (positive) externality effects of the military are not explicitly modelled.

Our aim is to contribute to the existing studies by addressing some of the critical issues mentioned in the literature, such as avoiding ad-hoc specifications or cross-sectional panels and taking account of potential nonlinearities, notably in the context of the Feder-Ram model, which is applied in this study.[3] We try to account for these concerns by using a consistent theoretical framework to assess the defense-growth nexus. In addition, we estimate the model for a single country with comparatively long time-series and explicitly model a non-linear defense-growth relationship. And finally, our methodology allows to

[3] Deger and Sen (1995), for instance, note that cross-sectional analysis of the Feder-Ram model could lead to biased results due to nonlinearities in the relationship between economic growth and the relevant military variable specific to the model.

establish a certain threshold level which could be a useful quantitative instrument to set up political targets for defense spending in a post-conflict environment.

3 Economic Growth, the Civil War, and Defense Spending in Guatemala

Historically, Guatemala's modest growth performance was accompanied by a dualistic economic structure, social exclusion and conflict. Paradoxical, the country has experienced relative macro-economic stability during the past decades. Guatemala has a rather low level of external indebtedness, inflation has been held back, and the economy is fairly open and with low levels of protection. Average annual growth rates were about 3.9 percent between 1950 and 2001. Due to rapid population growth, however, per capita growth has averaged only about 1.2 percent per year and had a low impact on poverty. According to the World Bank (2003), poverty rates and inequality are among the highest in the Latin American region. Guatemala performs poorly for indicators of education and health, and ranks highest among states for child malnutrition.

Ever since, the military was repeatedly in power, sometimes through fraudulent elections, sometimes by *coup d'états*. In 1944, the right-wing dictator then in power was overthrown, Guatemala held its first true elections in history and a new constitution was drawn up. However, with an U.S. Central Intelligence Agency-backed coup, the freely elected government of Guatemala was replaced with another right-wing dictatorship. Beginning in 1986, democracy was restored, albeit with civilian governments patronized by the generals. The signing of the Agreement of a Firm and Lasting Peace in 1996 brought a formal end to one of the longest and bloodiest civil wars in Latin America. According to the final report of the Commission for Historical Clarification (1999), the internal conflict left an estimated 200.000 civilians dead and another million were displaced, for a total population of 10 million.

In addition to human sorrow, these events caused the loss of human capital and imposed significant costs for short and long-run development. Despite the civil strife starting around

1960, Guatemala managed to maintain reasonable growth rates until the 1970s. Growth declined dramatically in the 1980s, when tensions exploded into a full-scale civil war. After transition to democratic rule in 1986, growth has recovered but seems to follow a more or less stagnant pattern. In a growth-accounting exercise, Loening (2002) reveals that total factor productivity is low. Among others, prominent reasons behind this performance are low human capital endowment, institutional weakness, and underlying social conflict. Since the signing of the Peace Accords, Guatemala has made progress by increasing investments in infrastructure and human capital. Additionally, it has made efforts in improving public financial management and in the area of tax revenues. However, the implementation of the Peace Accords, which represents a cornerstone for economic and social development, has been uneven.

While the ratio of military expenditure to GDP says little about the real size of military expenditure, it is a rough indicator of the military's political power as a lobby and the priority given to other fiscal functions by the government. Defense spending reached its height during the peak of the civil war and declined in the advent of the peace process. At first sight, it would appear that defense expenditure as a share of GDP is not excessively high, ranging from 0.7 up to 2% in GDP. In the light of Guatemala's low tax burden and small public sector, however, defense spending becomes quite significant. According to Scheetz (2000), it varies from approximately 14% up to a high of 31% in 1984 in terms of total Treasury-controlled resources. Thus, while defense spending as a percentage of GDP in Guatemala is relatively low, its share of current government expenditures is quite high. The following section provides the details for the construction of our data set.

4 Data Recompilation in a Post-Conflict Country

Since Guatemala is deficient in data, the identification of the macroeconomic impact of defense expenditures on economic growth indicates the need to overcome some data constraints. However, coherent results can still be obtained. It is important to note that a significant fraction of economic activity in Guatemala can be found in the informal sectors, which is not accounted for in the subsequent regressions.

Information about gross fixed capital formation and GDP has been obtained from the Economic Research Department of the Central Bank of Guatemala. Using 1958 as the base year, the data are compiled using the outdated 1953 United Nations System of National Accounts, which is currently under revision within the Central Bank. In absence of reliable long-term information about the economically active population, labor is proxied by the number of private contributors to the Guatemalan social security system. This is done by assuming a constant share of 25% in the total labor force for the time period under consideration. Obviously, this approach is fairly crude and may limit the precision of the econometric estimates. However, Loening (2002) found that the estimated values seemed to give a more reasonable picture than that of the data from official sources, which completely ignore migration and are remarkably free of fluctuations. The calculation for the economically active population derived from the social security statistics comes close to estimates provided by the United Nations Development Program (UNDP) for recent years.

The data used on military spending come from two different sources: First, for the period 1968-1999, they were obtained from the Stockholm International Peace Research Institute (SIPRI).[4] The SIPRI definition of military spending includes military pensions, military interest payments, and paramilitary expenditures, but excludes policy expenditures. We found that the data provided by SIPRI are roughly consistent with the defense ministry expenditures. Considering the extraordinary budget transfers to the defense ministry in 2000 and 2001, we preferred to rely on data obtained from the ministry of finance rather

[4] As for the period of 1968-1999, we had the choice between two data sources, that is, information provided by SIPRI and the official defense ministry expenditures. SIPRI data are identical with defense expenditures until the mid 1970s and again in the 1990s, suggesting that SIPRI relies on official data during these periods. However, we believe that during the internal military conflict in the 1980s, SIPRI estimates could provide a more reliable picture than the official data. Therefore, in our view, the recompiled information from local sources together with the SIPRI data provides a reasonable approximation of defense spending for the country.

than on the SIPRI data for these years. Second, for the period 1950-1967, we recompiled a time series of defense expenditure with official data from the ministry of finance, as reported in the *Memorias de Labores del Banco Central* together with an anonymous specialist from the Central Bank of Guatemala.

A potential third source on military spending comes from Scheetz (2000). Together with a Guatemalan team, he gathered data on military spending from various local sources for 1968-1994, claiming that international data would not reveal adequately the true spending of the defense sector. Compared to the information provided by SIPRI, his data are somewhat higher in levels. After adjusting for prices, however, our findings suggest that the time-series properties of these two sources are almost identical. Consequently, employing the data set from Scheetz does not change much the latter empirical results.[5]

In what follows, it should be kept in mind that any measurement of military expenditures suffers from shortcomings, such as the lack of a broadly accepted definition of military expenditure, the confidential nature of military activities and the strong political influence of military officers in Guatemala's past and present history. Even though the subsequent model may seem mathematically precise, the empirical results should be interpreted as trend indicators for a relatively short time period.

5 A Production-Function Based Model

This section tries to empirically establish the relationship between defense expenditures and growth based on the widely used Feder-Ram model (Feder, 1982; Biswas and Ram, 1986). Its popularity in defense economics may be explained because of its ability to explicitly treat

[5] His information was requested for use in the peace negotiations and was later used in a Harrod-Domar-type growth model by Marwah et al. (2002). They find that military expenditure tend to have a negative effect on GDP growth and other macroeconomic variables, regardless of the presence or absence of military rule.

externality effects of the defense on the civil sector.[6] The model is a two-sector neoclassical growth model with an economy composed of a civilian and a defense sector, and it allows the defense sector to be treated as one sector in the economy and the size effect of the sector and its differential productivity effect to be distinguished. After presenting the theoretical model, the relationship between GDP growth and defense spending will then be estimated, allowing for level dependence in the effects of military spending on growth.

5.1 Growth and Defense Spending: A Factor Productivity Approach

Assume that the economy is composed of two sectors, the defense and the civilian sector. Let real output in the defense sector at time t be $D(t)$, and that in the civilian sector be $C(t)$. Furthermore, let us assume that labor ($L(t)$) and capital ($K(t)$) are the only inputs in each sector, that the relative marginal products of labor and capital may differ across the two sectors and that the size of the defense sector output ($D(t)$) may act as an externality factor for the civilian sector.

Consider the production functions of the two sectors,

$$C(t) = C(L_c(t), K_c(t), D(t))$$

and

$$D(t) = D(L_d(t), K_d(t))$$

where the lower case subscripts c and d denote sectoral inputs ($L(t) = L_c(t) + L_d(t)$ and $K(t) = K_c(t) + K_d(t)$), and total output in the economy ($Y(t)$) is the sum of output in both sectors. The marginal productivities of the factors of production – labor and capital – in the defense sector may not be the same as in the civilian sector. Allowance is made for this by assuming that the marginal productivity of factors used in the defense sector is equal to

[6] For a critique of the Feder-Ram model, see Dunne, Smith and Willenboeckel (2001).

$(1+\delta)$ times the corresponding marginal factor productivity in the civilian sector, i.e.,

$$\frac{D_l}{C_l} = \frac{D_k}{C_k} = (1+\delta)$$

where the subscripted letters refer to marginal products (assumed constant). If δ is positive, factors of production have a larger marginal productivity in the defense sector and vice versa if δ is negative. If δ is zero, marginal productivities are equal across the two sectors.

Differentiating total output with respect to time and substituting $dK(t)/dt$ by investment, $I(t)$, yields

$$\frac{dY(t)/dt}{Y(t)} = \alpha\frac{I(t)}{Y(t)} + \beta\frac{dL(t)/dt}{L(t)} + \varphi\frac{dD(t)/dt}{D(t)}\frac{D(t)}{Y(t)} \tag{1}$$

where $\alpha = C_K, \beta = C_L$ and $\varphi = (\delta/(1+\delta) + C_d)$. However, this specification only allows to test empirically whether both C_d and δ are zero at the same time. In order to be able to test independently the significance of each parameter, it must also be assumed that the effect of defense expenditure on the civil sector has constant elasticity. This implies a production function in the civil sector such as

$$C(t) = D(t)^{\theta}\Psi(L_c(t), K_c(t)),$$

for $\theta \in \mathbb{R}$. The resulting econometric specification under this assumption is

$$\frac{dY(t)/dt}{Y(t)} = \alpha\frac{I(t)}{Y(t)} + \beta\frac{dL(t)/dt}{L(t)} + \phi\frac{dD(t)/dt}{D(t)}\frac{D(t)}{Y(t)} + \theta\frac{dD(t)/dt}{D(t)} \tag{2}$$

where $\phi = \delta / (1 + \delta) - \theta$, that is the productivity differential across sectors (also referred to as the size effect of military spending) and θ is the intersectoral externality parameter. Specification (2) allows the identification of the purely externality-driven effect of defense spending. Table 1 presents the estimation of the parameters of (2).

Insert Table 1 around here

Equation (2) is estimated using annual data in constant 1958 Guatemalan Quetzals ranging from 1950 to 2001. The first column in table 1 presents the estimated parameters in (2) using OLS. The investment and the labor variable enter with the expected (significant) positive sign. Both the size as well the externality effect are indifferent from zero, indicating that there is no significant effect of defense on growth. Although this result may give a first indication of the direction of nexus between economic growth and defense spending in Guatemala, the potential endogeneity of the explanatory variables in (2) would render the OLS estimates inconsistent. The second column in table 1 shows the estimated parameters if instrumental variable estimation is applied. Lags of the explanatory variables and GDP growth are used as instruments. The quality of the results does not vary with the instrumental variables estimation and the estimated parameters corresponding to both defense variables in (2) are in both cases insignificantly different from zero. The endogeneity problem, thus, does not seem to distort the estimate. However, the nonsignificant results could also be the result of omitted nonlinearities, which we are going to model explicitly in the next section.

5.2 The Nonlinear Generalization

The notion that government expenditures in general could affect growth in a nonlinear way has already been formalized in papers by, e.g. Barro (1990) or Kormendi (1983). Here theoretical results predict a negative growth effect in countries where government expenditures (and thereby also defense expenditure as a crucial component of government expenditure) exceed a certain threshold, resulting in an inverse U-shaped relationship between these two variables. In defense economics, the defense-growth nexus was assumed to be linear for a very long time until recently the notion that defense expenditures (as a form of public expenditures) could have a nonlinear growth effect has become more popular. This nonlinearity issue was first mentioned in papers by Kinsella (1990) and Hooker and Knetter (1997), empirical applications are papers by Heo (1998) and Stroup and Heckelman (2001).

A basic illustration of how defense could influence growth nonlinearily (under the assumption of diminishing returns to all sectors of the economy) is given by Stroup and Heckelman (2001). Their line of reasoning is as follows: As the proportion of a country's productive resources diverted to the military sector increases, the total direct and indirect opportunity costs (lost economic growth) in the civilian sector will increase at an increasing rate. However, the total indirect benefits (additional economic growth) arising from military use of those resources will simultaneously increase at a decreasing rate. Summing these two functions to find the net influence of military resource use on economic growth reveals a non-linear, concave defense burden function describing the relationship between the size of the military sector and economic growth in the national economy.

Insert Figure 1 around here

An initial indication of the presence of nonlinearities can be demonstrated by looking at the scatterplot of the residuals of equation (2) against the fitted values of defense expenditures and applying the Nearest Neighbor Fit method to these two series (see, e.g., Cleveland, 1993 and 1994). This non-parametric approach fits for each data point in the sample a local linear regression line, weighting the other observations: Data points that are relatively far from the point being evaluated get small weights in the sum of squared residuals, while closer data points get higher weights. The resulting nonlinear curve is presented in Figure 1. The inverse U-shaped curve suggests a leveling out of the growth-inducing effect of defense expenditures with the possibility of a reversed effect beyond a certain threshold such as suggested by Stroup and Heckelman (2001).

As mentioned before, the relationship defined by (2) does not allow for a nonlinear effect of defense spending on growth rate in the form of, for instance, a level-dependent parameter for the defense expenditure variable. Thus, the results could not display the true relationship between defense and growth such as, for example a nonlinear generalization of equation (2). A straightforward generalization that easily allows for a nonlinear growth-defense expenditure link and provides a convenient framework for testing for linearity is given by

$$\frac{dY(t)/dt}{Y(t)} = \alpha\frac{I(t)}{Y(t)} + \beta\frac{dL(t)/dt}{L(t)} + \phi^i\frac{dD(t)/dt}{D(t)}\frac{D(t)}{Y(t)} + +\theta^i\frac{dD(t)/dt}{D(t)}, \tag{3}$$

where

$$i = \begin{cases} 1 \; if \; D_t \leq \gamma \\ 2 \; if \; D_t > \gamma \end{cases} \tag{4}$$

The specification is, thus, piecewise-linear, and the level of total defense spending, D_t, is the variable responsible for the regime which is active. The threshold parameter, γ, needs to be estimated as well. If γ were known, the estimation of ϕ_t^i and θ_t^i, $i = 1, 2$ would be straightforward: the sample is divided into two subsamples, which are assigned label 0 and 1 according to (4), and the ϕ and θ-parameters are estimated for each subsample.

However, in our case the estimation of γ is done as follows (see e.g. Hansen 2000): a grid search is conducted on D_t, and (3) is estimated for every realized value of D_t after trimming some percentage on the tails of the distribution of D_t for obvious identification reasons.[7] Finding a least squares estimator of γ implies to evaluate the sum of squared errors of model (3) for all possible values of γ and choose the estimator $\widehat{\gamma}$ fullfilling

$$\widehat{\gamma} = argmin_{\{D_t\}} \sum_t \widehat{\epsilon}_t(D_t)^2 \tag{5}$$

that is the value of D_t that minimizes the sum of squared residuals in the nonlinear regression (3)-(4).[8]

[7] The grid search for the estimate of the threshold parameter was done after trimming 25% from the extremes of the empirical distribution of D_t.

[8] See Hansen (1996, 2000) for the properties of this estimator.

The threshold model provides an intuitive and simple setting for testing for linearity. In principle, the idea would be to test $\phi_1 = \phi_2$ and $\theta_1 = \theta_2$ under H_0. However, this simple testing problem presents an extra difficulty given the fact that the threshold parameter, γ, is only identified under the alternative hypothesis of nonlinearity, so classical tests such as the F-test, have nonstandard distributions. In the spirit of Andrews and Ploberger (1994), Hansen (1996, 2000) overcomes the problem by a bootstrap procedure where – using the linear relationship – artificial data on the dependent variable is simulated and both a linear and a piecewise linear model with the estimated threshold are calculated resulting in an asymptotic distribution of the following likelihood ratio test of H_0:

$$LR_0 = (S_0 - S_1)/\widehat{\sigma}^2 \tag{6}$$

where S_0 and S_1 are the residual sum of squares under $H_0 : \gamma_1 = \gamma_2$, and $H_1 : \gamma_1 \neq \gamma_2$, respectively, and $\widehat{\sigma}^2$ the residual variance under H_1. In other words, S_0 and $S_1$are the residual sum of squares for equation (3) with and without threshold effects. The corresponding test statistic is computed and the procedure is repeated a large number of times, leading to an approximate distribution of the test statistic under the null of linearity. The percentage of replicated test statistics that exceed the original value of the test statistic computed with real data is thus the p-value of the linearity test. The asymptotic distribution of LR_0 is nonstandard and strictly dominates the χ^2 distribution.[9]

Insert Table 2 around here

Table 2 presents the estimated parameters from equation (3)–(4), together with the test statistic for linearity and the p-value resulting from the bootstrap method described above.[10] While based on the results of the estimation of the linear model given by (2) one could conclude that military expenditure seems to have no significant effect on economic growth, the

[9] The distribution of LR_0 depends in general on the moments of the sample; thus critical values cannot be tabulated.

[10] We have also included an autoregressive term (not reported here). The results without including the autoregressive term, however, do not differ much from those presented here and are available from the authors upon request.

conclusion changes if we allow for a nonlinear, level-dependent effect of defense spending on GDP growth. The results indicate evidence of nonlinearity at the 0% significance level, and the estimated threshold is at $\hat{\gamma}$= 16218.3 thousand constant 1958 Guatemalan Quetzals. As a percentage of GDP for the year 2001, that would amount to as much as 0.33. Taking the average GDP from 1950 to 2001 gives a percentage of 0.66: Interestingly, this is equivalent to the amount set out in the Peace Accord. The nonsignificant partial correlation found between GDP growth and defense spending when estimating the linear model appears positive and significant for levels of defense expenditure below the estimated threshold in the case of the nonlinear specification. For values of defense spending above the threshold, the relationship appears negative but not significant. The size effect is negative and significant in the "low spending regime" but not significant in the "high spending regime".

The results showing a negative size effect of defense spending on GDP growth in the lower regime, together with a positive externality effect correspond to the findings of e.g. Ward and Davis (1992). Note also that the threshold is at comparatively low levels, indicating that the positive effect of defense prevails only for very modest levels of defense expenditures and that when calculating δ, the factor productivity differential, gives a negative value for the lower regime, indicating that factors of production have a larger marginal productivity in the civil sector.[11]

However, as we estimate equation (3) with yearly data, one could criticize the results since such data could not capture a long-term growth effect. Here, the usual empirical procedure is to use multi-year averages. We have thus reestimated equation (3) using three-year averages.[12] The results of the estimation are displayed in table 3. Overall, the results stay roughly the same, but two differences may be noted: first the adjusted R^2 rises by more than 52 percentage points, second, the threshold is even lower and estimated at 10010.52 thousand Guatemalan Quetzals. The nonlinear effects of defense, thus, seem to be similar

[11] Since the parameters are insignificant in the high spending regime, we could not calculate δ for this case.

[12] As we had data for 50 years only, taking longer, e.g. five-year, averages (such as usually done in the growth literature) seemed to make no sense since that would have given us only 10 datapoints. Thus, three-year averages reflect the trade-off between too few data points and a reasonable longer-term average.

in the short and long term.

Insert Table 3 around here

The question arises why defense spending is empirically found to have a positive growth effect below a certain threshold and a negative (albeit insignificant) impact above that threshold (notwithstanding the negative and significant "size effect" of defense under the threshold in the sectoral model). One possible explanation is that up to a certain amount of defense spending, basic externalities such as infrastructural investment, new technologies or human capital formation overcome the potential crowding-out effect. When these needs are satisfied, the defense sector may carry out investment which is rather unproductive and at best will have no effect on the production of the civilian sector. This may be especially the case in war periods, where defense expenditures hardly have an externality effect. The results also seem to confirm the theoretical arguments as well as their empirical results brought forward by Marwah et al. (2002) and Stroup and Heckelman (2001).

6 Conclusions and Outlook

Using a factor productivity approach within a linear and a nonlinear methodology, this paper has aimed to overcome some of the perceived deficiencies of previous work. Within this framework, we have provided new evidence on the growth-defense nexus for a post-conflict country. For the case of Guatemala, we find that defense spending does not generate positive externalities, the defense sector is less productive than the civilian sector and does not appear to affect growth positively after it has surpassed (a comparatively low) threshold. While for very modest levels these effects are positive and significant, they become negative, albeit nonsignificant, for relatively higher levels. The benefit of the applied methodology is that it allows to set up an explicit threshold level which could be used as a quantitative instrument to establish a political target for defense spending, notably in a post-conflict environment. Our estimates indicate that some sort of optimal defense outlay that could be conducive to growth should lie around 0.33% of GDP.

Periods of civil strife are clearly in the high-spending regime in which defense has no positive effect on growth. While this finding seems to be almost obvious, it should be kept in mind that increases in the level of defense expenditure itself can be an important source of frictions that hamper growth. Given a limited government budget, increases in defense spending will necessarily be met at the expense of other government services. Considering the context of Guatemala's low tax burden and small public sector, the perception of inadequate social spending can create feelings of frustration and may aggravate the micro-insecurity situation. This could lead to further increases in security spending and thus intensify social conflict. In this context, it is worth mentioning that defense spending has climbed since 2000 and is far above our estimated threshold parameter. Above this level, defense is likely to have no positive impact on growth, implying that, at best, it will have no significant effect on the production in the civilian sector.

One explanation of the non-significant externality effect on growth over a certain threshold is that the military sector can be thought of not having spent much on externalities, such as technology, equipment, infrastructure or human capital formation. If instead, as suggested by some observers, military spending is predominately devoted to salary payments and other monetary benefits, especially to the military hierarchy, the defense sector is rather unproductive to the economy. With improvements in fiscal transparency and access to disaggregated data on the final use of defense expenditure, it will be up to future studies to analyze this relationship more closely.

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Table 1: Production Function Approach: Linear Specification

Parameter	OLS: Estimate (s.e)	IV: Estimate (s.e)
α	0.501*** (0.136)	0.339**(0.166)
β	0.091** (0.043)	0.119**(0.065)
ϕ	0.158 (5.532)	6.370 (8.077)
θ	0.011 (0.068)	-0.060 (0.098)
R^2_{adj}	0.482	0.436
DW	1.861	1.798

***(**)[*] stands for 1% (5%) [10%] significant, DW is the Durbin-Watson test statistic.

Table 2: Production Function Approach: Nonlinear Specification

	Lower regime ($D_t \leq \gamma$)	**Upper regime** ($D_t > \gamma$)
Parameter	Estimate (s.e.)	Estimate (s.e.)
α	0.260 (0.173)	
β	0.113*** (0.051)	
ϕ	-102.908*** (40.701)	7.477 (7.037)
θ	1.083*** (0.410)	-0.089 (0.090)
γ	16218.3	
R^2_{adj}	0.386	
DW	2.035	
Linearity Test	10.268 (p-value 0.008)	

***(**)[*] stands for 1% (5%) [10%] significant, DW is the Durbin-Watson test statistic. 2,000 replications were used in the bootstrap for the linearity test.

Table 3: Production Function Approach: Nonlinear Specification, averages

	Lower regime ($D_t \leq \gamma$)	**Upper regime** ($D_t > \gamma$)
Parameter	Estimate (s.e.)	Estimate (s.e.)
α	2.843*** (0.875)	
β	0.214* (0.124)	
ϕ	-1537.438** (650.374)	-1.617 (17.830)
θ	14.663** (5.970)	-0.109 (0.238)
γ	10010.52	
R^2_{adj}	0.933	
DW	1.465	
Linearity Test	100.824 (p-value 0.000)	

***(**)[*] stands for 1% (5%) [10%] significant, DW is the Durbin-Watson test statistic. 2,000 replications were used in the bootstrap for the linearity test.

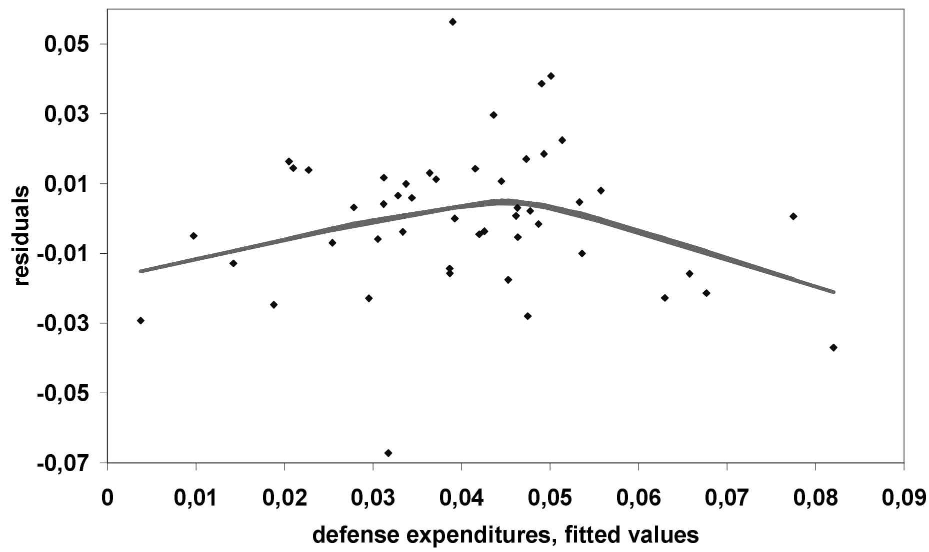

Figure 1: The Nearest Neighbor Fit