MILITARY SPENDING, ECONOMIC GROWTH & ENDOGENEITY: A PANEL ANALYSIS 1988-2010

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Abstract

This paper examines the impact of military expenditure on economic growth on a large balanced panel, using an exogenous growth model and dynamic panel data methods for 104 countries over the period 1988-2010. The prime objective of the paper is to consider the possibility of non-linearity, group heterogeneity and endogeneity within the sample. Having estimated and appraised a full sample, it is stratified based upon a range of potentially relevant factors; different levels of income, conflict experience, natural resource abundance, openness and aid. Following the stratification process, a set of instrumental variables are taken for military spending. Using 2SLS and a dynamic Generalized Method of Moments (GMM) method, the sample is regressed to identify for military expenditure. Having considered endogeneity, heterogeneity and non-linearity, the results provided show that there is often more complexity to simply stating that military spending has a negative effect on growth. Certain country characteristics such as abundance in non-fuel natural resources could lead to military burden having no impact on economic growth. While the results range from military spending having a negative effect on countries - the majority - to the less common result of no effect, the startling insight is the absence of evidence suggesting a postive effect.

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Keywords: Military Expenditure; Economic Growth; Conflict; Development

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1 INTRODUCTION

There is a large and growing literature documenting the effects of military spending on economic growth that reflects a continued lack of consensus. This has allowed researchers to revisit the earlier analyses and identify definitive effects of military spending which continues to be the subject of considerable debate. Accompanying the end of the Cold War were considerable reductions in military expenditure. In recent years the declining trend has bottomed out and military spending is once again on the increase across medium and high income countries. However, the lowest income countries continue to experience declines in military spending, and military spending as a share of GDP remains lowest for the low income countries relative to the other income groups (SIPRI and Own Calculations, 2012). While the end of the Cold War led to fewer major international conflicts, there was an increase in internal conflicts and although the number of internal conflicts have declined recently, they remain a predominant source of concern for the developing world. Yet, the major pressure to maintain or increase the level of military spending have not been the result of these strategic needs, but rather from internal pressures by vested interests. These vested interests, commonly known as military industrial complexes, may be individuals, institutions or organisations that benefit from defence spending.

SIPRI (2011) reported that world military expenditure in 2010 reached $1.6 trillion, representing 2.6 percent of global gross domestic product (GDP) or equivalent to $236 per person. These figures highlight the economic significance of military spending and raise questions about the likely impacts of military expenditure. At some level it is obvious that military spending matters. Witness, for example, the divergent paths of Sub-Saharan Africa compared to Western Europe, where those in Sub-Saharan Africa stagnated under high shares of military spending to GDP and conflict experience, while the other prospered with lower shares and no conflict. Nevertheless, there is a lack of reliable estimates on the effect of military spending on economic performance. Thus military spending continues to be an important focus for research since it is an expenditure by government exerting influence beyond the resources it consumes, especially when it leads to or facilitates conflict. It has been commonly identified that most countries need some level of security to deal with possible internal and external threats. However, military expenditure does come with opportunity costs since the resources diverted to military expenditure could be used for developmental purposes which might improve welfare. Such issues are particularly relevant in developing countries since they are often the ones that experience internal conflict and poor economic growth.

While military expenditure and economic growth is viewed by many as one of the most relevant and researched issues today, the empirical estimates of their effects are often contradictory or inconclusive. Some of the confusion and mixed results are due to non-linear relationships between military spending and growth; group heterogeneity within the overall sample; endogeneity between military expenditure and per capita GDP; or incorrectly specified models. Dunne et al (2005) state that it is the identification (reverse causality) issues in the defense-growth literature which often lead to critiques of the estimated results. Aizenman and Glick (2006) and Dunne (2012) argue that linear models lead to inconsistent estimates when the relationship between economic growth and military spending is actually non-linear; they indeed find this to be the case after taking threats and different income groups into consideration respectively. Smaldone (2006) notes that the relationship between military spending and economic growth is indeed heterogeneous the effect differences of military spending on growth was due to variations in the country characteristics.

Taking all these arguments into consideration, the objective of robustness check of this paper is three-fold. First, the paper explores possible non-linearities between military spending and economic growth. Second, the paper examines group heterogeneity within the sample of countries and considers the effect of military burden on growth. Finally, the paper aims to account for the endogeneity problem, one which has plagued the existing literature. The general estimation method used within this paper follows a dynamic first order model with fixed effects. The data is based on a post-Cold War balanced panel of 104 countries from 1988-2010 and to the author's knowledge the data set used is the most complete and reliable available within the literature. The next section reviews the existing literature on the military spending growth relation; it includes an exposition of the growth model based on Dunne et al (2005), which overcomes some of the limitations of earlier models, and previous and current estimation methods. Section 3 offers a discussion of the dataset and introduces the variables used in sub-sample stratification. Section 4 presents the estimation results of the overall sample and considers robustness checks on issues of non-linearity, group heterogeneity and endogeneity. The final section presents some conclusions.

2 LITERATURE REVIEW

2.1 MILITARY SPENDING AND GROWTH NEXUS

2.1.1 Theoretical Considerations

Perhaps the first thing to understand in the literature is the relationship between military spending and development. In applied work this relation has been restricted to the use of economic growth rather than development because of the problems in defining and measuring development. While a theoretical model is often quintessential for any empirical work, most economic theories lack an explicit role for military spending as an economic activity (Dunne and Uye, 2010). The result is the development of various schools of thought in an effort to properly incorporate military spending to economic growth, (Dunne and Coulomb, 2009). Four theoretical approaches have thus been developed. These theoretical approaches have allowed the identification of a number of channels, first identified by Dunne (1996), through which military spending impacts economic growth. These channels may be grouped into three major categories as done by Dunne et al (2005): demand, supply and security.

The first theoretical approach is from the dominant neoclassical perspective and is linked to the supply channel. This perspective considers the state as a rational actor that balances opportunity costs and security benefits of military spending in order to maximize national interest within a well-defined social welfare function. Here military spending is seen as a public good and its economic effects is determined by opportunity costs: the trade off between it and other government spending, more commonly know as "guns versus butter". The competition with the civilian sector for resources, namely, physical capital, human capital, labour technology and natural resources results in these resources being unavailable for civilian use; hence, the opportunity cost of military spending. The resultant effect of military expenditure on the economy through the lens of this approach is still a lively debate. Authors such as Mylonidis (2006) describe crowding out of public and private investment, adverse balance of payment within arms importing countries, inefficient bureaucracies, fewer civilian services, fewer R&D activities, and a dwindling skilled workforce within the civilian sector as just some of the possible opportunity costs associated with higher levels of military expenditure. However, others argue military R&D may result in development of improved technologies with beneficial spillovers into the civilian sector (Dunne and Uye, 2010).

The second and third theoretical approaches are the Keynesian and Institutional approaches and are associated with both demand and supply channel. These two approaches see the state as a proactive entity utilising state funds on military spending as a means of increasing output through the Keynesian multiplier effect (Dunne and Uye, 2010). In the presence of ineffective aggregate demand, increases in military spending can lead to increased capacity utilization, growing profits and subsequently rising investment and growth. The Institutionalist approach combines the Keynesian perspective with a further focus on the fact that high military spending leads to industrial inefficiencies and the development of powerful interest groups, commonly classified as military industrial complexes (MICs), which benefit from said spending. From the demand channel, military spending is often seen as having a growth enhancing effect, with some arguing that in many developing countries, military spending could be viewed as capable of enhancing social infrastructure, human capital and technologies which are likely to bolster future economic development. On the contrary, military spending through the supply side channel is viewed as an opportunity cost which may crowd out physical and human capital investment. Clearly the extent of the effects pointed out will differ depending on country characteristics and is often not possible to deduce through theory whether the net effect of military spending on output is positive or negative.

The final theoretical approach is the Marxist perspective which views military spending in capitalist development as important though contradictory. There are numerous strands to the approach which differ in their treatment of crisis, the extent to which military spending is seen as necessary to capitalist development, and the role of the MIC in class struggle (Dunne and Tian, 2013). An offshoot of this approach provides researchers with the only theory in which military spending is both important in itself and an integral part of theoretical analysis; the under consumption approach. According to the Marxists, military spending has an overall negative impact on growth. Military spending is considered necessary to maintain capitalism and prevent stagnation. In the case where monopolistic firms produce goods and control labour costs, leading to inadequate consumption, military spending is a way - albeit wasteful (not creating further output) - of creating demand to allow firms to sell their goods and realize their profits (Dunne and Uye, 2010).

Having discussed the demand and supply channels the focus now turns to the security channel. As mentioned earlier there is consensus that all nations require some form of security, thus, defence spending is viewed as a means of protecting a country's population and property rights from both internal and external threats. It is often argued that security from such threats is essential to the operation of markets, and hence innovation and profits. However, as always, there is a counter-argument whereby military expenditures that are not driven by basic security needs are the result of rent-seeking activities, provoking damaging conflicts (Collier and Hoeffler, 2004).

2.1.2 Related Literature

The end of the Cold War heralded a significant change in the international security environment. The culmination of these changes was the end of proxy-wars (wars sponsored by Cold War protagonists) and superpower involvement (USSR & USA) in local conflicts, resulting in a dramatic decline in the intensity of conflicts (Dunne and Coulomb, 2009). Despite the drop in intensity, the number of conflicts did not decline. Instead the post-Cold War era led to changes in the type of wars being fought, conflicts changed from interstate to intrastate while a resurgence of interest in the role of economic forces in civil wars was observed. The cumulative effect of these changes is the possible alteration to both the economic impact of conflict and military spending.

In empirical work the presence of no agreed theory of growth among researchers dictates that there is no standard framework to fit military spending into (Dunne, 2012). In developing and developed countries military spending, conflict and economic capacity (institutions, natural resources, education, and investment) all interact to influence growth, as proven through the development of the theoretical approaches and the identification of the different channels. However, the relative importance and sign of these effects cannot be determined through theory but only by empirical analysis.

Research within the military spending and growth literature include Chan (1986), who uncovered inconsistency in the results; Ram (1995), who reviewed 29 studies and concluded there to be little evidence of a positive effect of military spending on growth, but also finding it difficult to state the evidence supported a negative effect. Dunne (1996) surveyed 54 studies and found military spending had, at best, no effect on growth and was more likely to have a negative effect. Further empirical irregularity was found by Smith (2000) showing that the literature to date did not point towards any robust relationship, positive or negative; though Smith did indicate the possibility of a small negative effect in the long-run, however, more sophisticated techniques would be required to uncover such a relationship. Dunne and Uye (2010) in a survey of 102 countries show that negative effects of military spending on growth were reported in 39 and 35 percent of cross-country and case studies respectively. Only 20 percent of studies found positive effects for both types, while over 40 percent found unclear results. Part of the reason for the variation in results is due to different empirical approaches. Research suggests that demand side models are likely to find negative results (crowding out of investment), while supply side models tend to find positive or positive and insignificant results (Brauer, 2002).

What is clear regarding past research is the inconclusiveness of the economic effects of military spending, although more recent studies have begun to show more consistent support for a negative impact of military spending on economic growth (Dunne and Tian, 2013). Accompanying the recent research is the increased concern over three problems, namely, group heterogeneity, non-linearity and endogeneity.

In trying to account for group heterogeneity Smaldone (2006), in his review of Africa, argued that the relationship between military spending and growth is heterogeneous, elusive and complex; and that the differences in results for countries within Africa were due to the experience of conflict. Smaldone believed that once the variations (i.e. conflict experience) have been accounted for the effects of military spending on growth could be either positive or negative; although the effects would usually not be pronounced, with the negative effects tending to be widespread and more pervasive in African countries. Other recent studies that have tried to incorporate additional variables in an effort to better comprehend the military spending and growth relationship include Dunne, Nikolaidou and Smith (2002) who include investment in their analysis. By focusing on a small sample of industrialised economies, using panel data techniques, they found evidence of a negative impact of military spending on growth and investment, while finding no evidence of any positive impact.

Although group heterogeneity is an important aspect to consider, other researchers such as Aizenman and Glick (2006) have chosen to investigate the non-linear relationship between military spending and economic growth. They incorporated the variable threat in their empirical analysis and found that military expenditure induced by external threats increased growth, while military expenditure induced by rent-seeking and corruption reduced growth; concluding that the effects of military expenditure on economic growth is non-linear. Yakovlev (2007) like Aizenman and Glick (2006) also explore the non-linear growth effects of military expenditure by including the variable arms trade. The empirical results from Yakovlev (2007) show that although separately, higher military spending and net arms exports are negatively related to growth, higher military spending for a net arms exporter (the interaction term) is less damaging to growth, thus confirming the non-linear relationship between military spending and growth.

Following Smaldone (2006) and Aizenman and Glick (2006), researchers such as Dunne (2012) have attempted to consider both non-linearity and group heterogeneity. By controlling for income groups and conflict experience Dunne was able to find an unequivocal negative effect of military spending on growth within the full panel and income divisions. However, consistent with Smaldone's suggestions, once the Sub-Saharan Africa (SSA) sample was divided into conflict experience, differences emerged. In the short-run, military spending had a negative and significant effect on growth for SSA countries in conflict, but, this wasn't evident in the long-run and the opposite was true for countries not in conflict. Yet, despite the recent increase in investigating and addressing group heterogeneity and non-linearity not much work has gone into the endogeneity concern.

Endogeneity or the identification problem has been argued by many, most notably Dunne and Smith (2010) as the most severe issue afflicting the military spending and growth literature. The identification problem, as stated by Dunne and Smith (2010) is apparent in the contrast between the two literatures of military spending, namely, the economic effects of military spending and the determinants of military spending. The problem arises when the prior literature treats military spending as exogenous and GDP as endogenous, while the latter treats military spending as endogenous and GDP as exogenous. In an ideal world, the identification of both variables requires having certain exogenous strategic or threat variables that explain military expenditure and not GDP, as well as a set of exogenous variables that shifts GDP but not military expenditure. However, as Dunne and Smith point out and many researchers have learnt, it is often very difficult to find such variables. Accompanying the identification problem is the measure problem of the endogenous variable GDP. The GDP data of any country includes military expenditure as a component and ideally one would want to use the non-military component of GDP as the endogenous variable instead of GDP. However, finding reliable data at a cross-country level proves to be yet another challenge that researchers face, with the majority of research conducted with the unsatisfactory, but reliable and available GDP data.

The difficulty encountered in solving the problem of endogeneity has led many researchers away from the reduced form structural models (where the problem originated) to explore other techniques. The most common techniques used to bypass the identification or endogeneity problem are Granger causality, vector auto-regression (VAR) and vector error correction models (VECM). As explained by Dunne and Smith (2010), the attraction of the Granger causality approach is that it treats all variables (i.e. military spending and GDP) as endogenous and identification is no-longer required.

While the popularity of the Granger causality technique – via a VAR framework –has recently produced a substantial number of studies, the results are still mixed, with the limitations of the test often not emphasised. Recent papers using Granger causality, VAR and VECM include Habibullah, Law and Dayang-Affizzah (2008), Smith and Tuttle (2008), Parlow (2009) and Abu-Qarn (2010), who find a non-existent causal relationship between military spending and economic growth. Other authors, such as Ozsoy (2008), Keller, Poutvaara and Wagener (2009), Farzanegan (2012) and Yilgor, Karagol and Saygili (2012) find a uni-directional relationship running from military expenditure to economic growth, while Hirnissa and Baharom (2009) and Malizard (2012) noted bi-lateral relationships between military spending and economic growth and unidirectional relationship moving from growth to military spending.

In the attempt to find a causal relationship between military spending and economic growth, one entity that all the papers have in common is the limited discussion on the shortcomings of the Granger causality test within the context of a VAR and VECM. It would seem that Dunne and Smith (2010) is the singular recent paper to provide an in-depth analysis of the limitations in using Granger causality, VAR and VECM to assess the interaction between military expenditure and growth. There are essentially three main issues in using these techniques. Firstly, the Granger causality test is not very informative since it does not measure economic causality in the commonly understood sense; causality is inferred from a temporal sequence known as *post hoc, ergo propter hoc, "after it therefore because of it"* which in effect explains the problem of using timing to explain causality. Secondly, since Granger causality tests are most commonly used in the context of a VAR, the test is known to be very sensitive to different specifications (i.e. variables included in VAR, lag length, sample, treatment if integration and co-integration, etc.). Finally, since the parameters used within the VAR are not structural, the results could often be unstable over different time periods or dissimilar countries. Although the purpose of this paper is not to critically review the limitations of alternative techniques, it is vital for future researchers to realise and understand the limitations of said techniques. The argument provided against the use of Granger causality, VAR and VECM help justify towards the development of structural models that could solve the identification problem; an approach that this paper will adopt in an attempt to account for endogeneity.

Having examined the existing literature this paper aims to continue the investigation of group heterogeneity, non-linearity and endogeneity. With a balanced panel of 104 countries, the full sample is stratified into sub-samples in order to consider heterogeneity and non-linearity. The estimation results are compared across income groups, developed and developing countries, conflict experience, civil and interstate wars, natural resource abundance, net recipients of aid and trade openness[1]. Endogeneity is accounted for through the use of a structural model, using 2SLS and GMM estimation techniques. Through the use of the above mentioned steps and techniques, this paper provides an in-depth assessment on the robustness of the results considering all the issues within the literature.

2.2 MODELLING MILITARY SPENDING AND ECONOMIC GROWTH

When undertaking econometric analysis in the military spending and growth nexus researchers must first consider the type of study one intends on implementing followed by the type of economic model one intends to use. Whether the research is in the form of a case study or cross country study, all the above mentioned channels and theoretical approaches will need to be incorporated within the context of that particular study. Throughout the related literature, the choice of study has been either a country specific model, conducted by the likes of Gleditsch et al (1996) or cross country models orchestrated by the likes of Knight el al (1996) and Dunne et al (2005). The choice for researchers is simple, by choosing country specific models, one need to carefully incorporate all the channel linkages through which military expenditure will impact growth. While this is an extremely difficult procedure, if done correctly, the benefit is an in-depth understanding of the military spending and growth dynamic. On the other hand, by focusing on cross-country growth models, as is the case with this paper, one may navigate the troublesome channel linkages attached to country specific models in favour of a reduced form relationship between military spending and growth. The use of cross-country studies sacrifices specifics in favour of identifying overall relationships.

Research into the relationship between military spending and economic growth has generally been focused on two types of cross-country growth models. The first type is the exogenous growth model, which comprises of the Feder-Ram and Solow growth models; while the second type are the endogenous growth models, such as the Barro growth model. Since this paper makes use of the

[1] The discussion of the stratification variables can be found under section 4, data description.

exogenous growth model developed by Dunne et al (2005), the modeling section will continue with a background on the Feder-Ram model, followed by its theoretical and econometric inconsistencies. The paper will then provide an exposition of the augmented Solow growth model based on Dunne et al (2005), ending with a brief account of its strengths and weaknesses.

2.2.1 Feder-Ram Model

Early econometric studies run by defense economists on the military spending and growth nexus revolve around the Feder-Ram model. The simple Feder-Ram model gained popularity due to its unique ability to explicitly treat the externality effect of the military sector on the civilian sector, a feature not present in other exogenous growth models.

The foundation of the model first came from Feder's (1983, 1986) paper, where he modeled the effects of exports on growth in developing countries. Biswas & Ram (1986) was then able to adapt Feder's original model for a cross-country study of the effect of military spending on economic growth. Interestingly, although the Feder-Ram model originated from the growth literature it has become most common within the defense and growth literature while being neglected by the growth literature. Owing to the model's introduction of separate production functions for each sector (military and civilian), the growth rates are usually a function of the labour force growth rate, the share of investment and the product of the growth rate and the share of military spending; a concoction of barely identifiable results within the cauldron to interacting variables. Moreover, the Feder-Ram model has been identified as a supply-side model and by construction they generally find either a small positive effect of military spending on growth or no effect (Hartley and Sandler, 1995).

Construction of the Feder-Ram model is through a basic two sector economy which distinguishes between military output (M) and civilian output (C). The model assumes that both sectors employ homogenous labour (L) and capital (K), while the set-up also allows for external effects of military production on the civilian production activity.

$$M = M(L_m, K_m),\ C = C(L_c, K_c) = M^{\theta} c(L_c, K_c) \quad (1)$$

The factor endowment constraints are given by the equations:

$$L = \sum\nolimits_{i \in S} L_i, \quad K = \sum\nolimits_{i \in S} K_i, \quad S = \{m, c\} \quad (2)$$

and domestic income is:

$$Y = C + M \tag{3}$$

The summation of military and civilian goods or "guns" and "butter" in equation (3) is only admissible if C and M represent monetary output values rather than output quantities. Thus, following from Dunne et al (2005) equation (3) is re-written to take price normalisation into account.

$$Y = P_c Cr(L_c, K_c) + P_m Mr(L_m, K_m) \tag{4}$$

Where P_m and P_c denote the (constant unitary) money prices associated with the real output quantities of Mr and Cr respectively. The model also allows the values of the marginal products of both labour (M_L, C_L) and capital (M_K, C_K) to differ across sectors by a constant uniform proportion,

$$\frac{M_L}{C_L} = \frac{M_K}{C_k} = 1 + \mu \tag{5}$$

or equivalently

$$\frac{P_m Mr_L}{P_c Cr_L} = \frac{P_m Mr_K}{P_c Cr_k} = 1 + \mu \tag{6}$$

Equation (5) can be interpreted as a form of intratemporal substitution from military to civilian sector, pinpointing the fact that comparisons of marginal factor productivities across different production sectors depend on the price relation used in the evaluation of sectoral outputs. (Dunne et al, 2004)

By proportionally differentiating equation (3) with (1) and (2), the growth equation is in the form,

$$\widehat{Y} = \frac{C_L L}{Y}\widehat{L} + C_k \frac{I}{Y} + \left(\frac{\mu}{1+\mu} + C_m\right)\frac{M}{Y}\widehat{M} \tag{7}$$

where the hat notation indicates proportional rates of change and I = dK denotes net investment. Using the fact that the last term on the RHS of equation (1) imposes a constant elasticity of C with respect to M, equation (7) can now be rewritten in the form of,

$$\widehat{Y} = \frac{C_L L}{Y}\widehat{L} + C_k \frac{I}{Y} + (\frac{\mu}{1+\mu} - \theta)\frac{M}{Y}\widehat{M} + \theta\widehat{M} \tag{8}$$

permitting the separate identification of the externality effect and the "*marginal factor productivity differential effect*".

Variants of equation (7) or (8) have been used in cross-sectional analysis by Biswas & Ram (1986), time-series analysis by the likes of Huang & Mintz (1991) and pooled cross-section time series data by Alexander (1990) and Murdoch et al (1997). Model extensions to more than two sectors have also been analysed by the likes of Antonakis (1999) and Nikolaidou (1999).

Although the Feder-Ram model was used extensively in the 1980's and 1990's there are a number of theoretical and econometric problems associated with the model. An interpretation of the empirical literature reveals that any non-zero μ is associated with a situation where one sector is less productive - in its factors of production - than the other, a result made possible by the presence of some organizational slack or X-inefficiency (Dunne et al, 2005). With this in mind, the pooled cross-section time series analysis used by Alexander (1990) estimates μ = -0.88, concluding that the military sector is 88 percent less productive than the rest of the economy. Similarly, Ward, Davis and Chan (1993) found a negative sign for μ and conclude that in Taiwan the military sector is considerably less productive in comparison to the civilian sector.

However, such interpretations are highly incongruent with the underlying theoretical model. Up until Dunne et al (2005), such inconsistencies have remained unnoticed within the literature. The condition of technical efficiency in production holds in the model by assumption. By imposing the condition of uniformity of the factor productivity differential for both factors (labour and capital) through equation (4), studies based on a two sector Feder-Ram model unsuspectingly assume that the economy produces on the efficiency frontier of the production possibility curve[2]. In the context of this two sector model, technical efficiency in production is reached when the marginal product of C is equal to the marginal product of M, or in other words, one cannot increase the production of C without sacrificing some production of M or vice versa. Such a condition is only realised

[2] Point X in figure A1 under Appendix

when the marginal rates of technical substitution (MRTS) between labour and capital are equal across sectors. Since the MRTS is defined as $MRTS_M = Mr_k/Mr_L$ and $MRTS_c = Cr_K/Cr_L$, the efficiency condition can be redefined to the form $Mr_K/Mr_L = Cr_K/Cr_L$, equivalent to equation (5).

As noted by Dunne et al (2005) the suggestion that a non-zero μ, which measures the presence of some sort of sector specific inefficiency, in the use of resources is flawed. A non-zero μ arises when implicit price ratios $P = P_m/P_c$ used to calculate real GDP, does not equal the marginal rate of transformation (MRT) between Mr and Cr (which measures the amount of military good one must forego in order to attain one more civilian good). In the case where $\mu < 0$, the implicit price ratio is now less than the MRT (P<MRT), as shown in figure (A1), the slope of the line is now less than one and hence is not tangent to the production possibility frontier. The calculation of real GDP using $\mu < 0$, done through equation (4), would undeniably rise if resources are transferred from military to civilian production, or vice versa if P>MRT and $\mu > 0$. However, as Dunne et al (2005) correctly points, the rise in real GDP or output is not the result of factor reallocation from a sector with inefficient "intrasectoral" resource management (X-Inefficiency) to a sector with less slack. Figure A1 shows that a GDP increase by moving from X to Z (shifting resources from M to C) is due to the value of a unit of Cr in terms of Mr (Price ratio), used in calculating GDP, being higher than the cost of producing another unit of Cr in terms of Mr (MRT).

Further theoretical criticism emerges in the form of socially desirable outcomes. The question of whether factor reallocation - resulting in an increase in measured real GDP - is a socially desirable or optimal outcome cannot be answered without prior knowledge to whether the relative price (P) used in calculating output (Y) sufficiently replicates the social marginal rate of substitution (Dunne et al, 2005). If the relative price (arising from non-zero μ) does reflect the society's marginal rate of substitution, then the μ reflects a situation where the economy-wide product mix (intersectoral factor allocation) is as a whole inefficient. Yet, the interpretation of this result excludes X-Inefficiency or the ability for one sector to transform inputs to outputs better than another sector (Dunne et al, 2005).

Having provided theoretical criticisms of the Feder-Ram model, there remains a number of econometric problems in early cross-sectional studies that needs to be discussed. Closer inspection of equation (6) reveal that nothing in its derivation reflects what is to be regarded as a variable and what is to be regarded as parameters. Furthermore, it is unclear where the errors emerge and why they are regarded as white noise. Unlike other models growth models, the Feder-Ram model does not incorporate any other source of technological progress except through the military externality. There is also multicollinearity between the final two terms in the estimation of equation (6), which will result in larger standard errors and thus imprecise estimates of the military externality parameter.

Moreover, there is a simultaneity problem when one includes the growth of military spending on the right hand side of equation (6). In the case where military spending is constant, the variations in output growth will determine the growth in military expenditure and not vice versa. Finally, by containing no lagged regressors or dependent variables, the Feder-Ram model is essentially static. This equates to the exclusion of the initial income variable, which is seen as an integral variable in determining growth.

"All these problems go some way to explain the variation in the results encountered in the empirical analyses and when combined with problems of interpretation led to a sense of dissatisfaction in a number of studies." (Dunne et al, 2004:9) As a result of these inconsistencies, analysis into the relationship between military spending and economic growth has since been focused on the other exogenous growth model, the Solow growth model.

2.2.2 Solow Growth Model

> *"All theory depends on assumptions which are not quite true. This is what makes it theory." (Solow, 1956:65)*

The theoretical and empirical deficiencies of the Feder-Ram model have led this paper to explore an alternative model. Specifically, the model developed by Dunne et al (2005), whereby the effect of military spending on economic growth is based on the augmented Solow growth model with Harrod-neutral technical progress.

Introduced in 1956, Solow proposed the study of long-run economic growth by assuming a standard neoclassical production function with decreasing capital. The standard Solow model assumes the rate of saving, population growth and technological progress as exogenous, while the steady-state level of income per capita is determined by either capital or labour. Solow (1956) argues that because savings and population growth rates vary across countries, different countries will reach different steady states. Thus by keeping the growth rates of the two variables separate, the model is able to give testable predictions about how the two variables influence the steady-state level of income. As it turns out, savings rate is positively related to growth, while population growth is inversely related.

The augmented Solow growth model was first introduced by Mankiw et al (1992), while a variant of the model was used by Knight et al (1993, 1996) and Dunne et al (2005) to measure the effect of defence spending on growth. The effect of military spending on economic growth can be modelled in a number of ways. One way is to assume that the military spending share $m = M/Y$ affects factor productivity via a level effect on the efficiency parameter that controls Harrod-neutral technical change. In other words, a permanent change in m does not affect the long-run steady-state growth rate, but has the potential to have a permanent effect on per capita income along the steady-state growth path. The share of military spending can also affect the transitory growth rates along the path to the new steady-state equilibrium. To see this, consider the augmented Solow growth model with the aggregate neoclassical Cobb-Douglas production function featuring Harrod-neutral technological progress as in Dunne et al (2005):

$$Y(t) = K(t)^{\alpha}[A(t)L(t)]^{1-\alpha} \tag{9}$$

where $\alpha \in [0, 1]$, and t denotes time. Y denotes aggregate real income, K is the real capital stock, L is labour and A is the technology parameter evolving according to:

$$A(t) = A_0 e^{gt} m(t)^{\theta} \tag{10}$$

where g is the exogenous rate of Harrod-neutral technical progress and m is the share of military expenditure in total output (GDP).

Continuing with the exposition of the model, the production function can be seen as exhibiting constant returns to scale in its two factors: physical capital (K) and productivity augmented labour (AL). Both inputs and outputs are assumed to be perfectly competitive, all firms are identical and the economy can be described by a representative agent. Together with the standard Solow model assumptions of an exogenous savings rate s, constant labour force growth rate n and constant rate of depreciation δ; the dynamics of physical capital accumulation can be displayed in the following way:

$$\dot{k}_e(t) = s_k k_e^{\alpha}(t) - [n + g + \delta]\dot{k}_e \Leftrightarrow \frac{\partial \ln k_e}{\partial t} = s e^{(\alpha-1)\ln k_e} - (g + n + \delta) \tag{11}$$

where $k_e = K/AL$ denotes the effective capital-labour ratio and α is the constant capital-output elasticity. The steady-state level of k_e is derived to be:

$$k_e^* = \left[\frac{s}{n + g + \delta}\right]^{1/(1-\alpha)} \tag{12}$$

where the asterisk denotes the steady-state value of the variable. Having solved for the steady-state level of k_e, it is now possible to solve for the steady-state value of output. By linearising equation (11) via a truncated Taylor series expansion around the steady-state[3] and substituting equation (12), the result is:

$$\frac{\partial \ln k_e}{\partial t} = (\alpha - 1)(n + g + \delta)[\ln k_e(t) - \ln k_e^*] \tag{13}$$

since $\ln y_e = \ln[Y/AL] = \alpha \ln k_e$, then the transitory dynamics of income per effective worker around the steady-state can be approximated by:

$$\frac{\partial \ln y_e}{\partial t} = (\alpha - 1)(n + g + \delta)[\ln y_e(t) - \ln y_e^*] \tag{14}$$

where the steady-state level of output per effective worker is:

$$y_e^* = \left[\frac{s}{n + g + \delta}\right]^{\alpha/(1-\alpha)} \tag{15}$$

Equation (14) estimates the transitory dynamics of output per effective worker in a neighbourhood of the steady-state. In order to operationalise equation (14) for empirical work this paper follows from Dunne et al (2005) and integrates it forward from t-1 to t and get:

$$\ln y_e(t) = e^z \ln y(t-1) + (1 - e^z) \ln y_e^* \ , \ \ z \equiv (\alpha - 1)(n + g + \delta) \tag{16}$$

Now, using equations (10), (15) and (16) per capita income can be written in the form of:

$$\ln y(t) = e^z \ln y(t-1) + (1 - e^z) * \left\{ \ln A_0 + \frac{\alpha}{1-\alpha}[\ln s - \ln(n + g + \delta)\right\}$$

$$+\theta \ln m(t) - e^z \theta \ln m(t-1) + (t - (t-1)e^z)g \tag{17}$$

where z is still equivalent to $(\alpha - 1)(n + g + \delta)$, while θ is the elasticity of steady-state income with respect to the long-run military expenditure share. The conceptual equation - shown above - can

[3]Re-writing (3) in the form $du/dt = f(u), u = lnk_e$, the linearised form is $f(u^*) + f'(u^*)[u(t) - u^*]$

be adapted to provide the basis for empirical analysis. Using a dynamic panel model specification, equation (17) can now be written in the form:

$$\ln y_{i.t} = \gamma \ln y_{i,t-1} + \sum_{j=1}^{3} \beta_j \ln x_{j,i,t} + \eta_t + \mu_i + \nu_{i,t} \ ; i = 1, 2, , ..., N \ ; t = 1, 2, ..., T \qquad (18)$$

where $x_1 = s_K =$ the gross investment as a share of GDP; $x_2 = (n_{i,t} + g + \delta) =$ labour force growth rate plus $(g + \delta)$ which is a constant, assumed to be equal to 0.05[4]; and $x_3 = m_{i,t}$ which is equal to military spending as a share of GDP. The variable η_t reflects the time specific effects, μ_i represents group specific effects and $\nu_{i,t}$ is the error term. Following from Knight et al (1996), Islam (1995) and Dunne et al (2005) this paper treats s and n as variant across countries and time, while taking g and δ to be uniform time-invariant constants and A_0 as country specific and time-invariant.

Unlike the Feder-Ram model, the Solow model is a one-sector model with military expenditure influencing growth in an ad hoc manner. The assumptions of exogenous savings and technological progress can be seen as reasonable since, firstly; there is little reason to expect the share of military expenditure to change technology, while secondly; the model makes no explicit recognition that – through the budget constraint – changing military expenditure will change the savings rate. The advantages of the model include an ad hoc error term which navigates econometric problems previously complicating the Feder-Ram model. Compared to the Feder-Ram model the Solow model forms a much tighter theoretical model with testable restrictions on the estimated coefficients. Additionally, the distinction between variables and parameters is more distinct as compared to the Feder-Ram model. Moreover, the Solow model provides a definitive link between theory and econometrics, a link often missing in modern macroeconomics regressions.

However, because the Solow model offers such a tight theory, some of the assumptions are seen as problematic. Chief amongst them is the exclusion of a range of exogenous variables (i.e. institutions, aid, and natural resources) which many growth economists believe are necessary in explaining economic growth. Furthermore, the assumption that the share of capital across countries is equal, a common Solow assumption, is clearly invalid in reality. As a result of such difficulties, recent empirical analysis have used a more ad hoc approach to find variables that are statistically significant and robust in explaining growth (Yakovlev, 2007). Yet, by using this ad hoc approach

[4] The assumption that $(g + \delta) = 0.05$ follows from Mankiw et al (1992); whereby they chose values to match available data. By using U.S data on capital consumption allowance and captial-output ratio a value of 0.03 was obtained for δ, this number was supported by Romer (1989) where he used a broader sample of countries and found δ to be between 0.03 and 0.04. Mankiw et al (1992) also found that growth in per capita income averaged 1.7 percent per year for the U.S and 2.2 percent per year for their intermediate group of countries, suggesting that a g of 0.02 is a reasonable assumption.

researchers have removed the biggest advantage of using the Solow model, the ability to link theory to econometrics. With this in mind, this paper proceeds to turn back the years and estimate the effect of military spending on growth using a non-ad-hoc approach.

2.3 ESTIMATION METHODS

In undertaking the empirical analysis of military spending and economic growth a problem worth noting is that in developing countries, military burden as a share of GDP is relatively small compared to other components of GDP (i.e. healthcare or education). This greatly diminishes the ability to find a statistically significant effect of military spending on growth when there are other, more significant, influences. In such scenarios, apart from when countries are engaged in conflict, one might not expect to find significant impacts of military spending on growth. Another major obstacle has been poor data quality and the lack of exogenous variation. However, since the end of the Cold War, data quality has vastly improved, and developments into novel techniques have helped overcome the lack of exogenous variation in the data ((Dunne et al, 2002); (Dunne et al, 2004)). One technique is to pool cross-section and time series data, this was especially true for a homogenous group of countries (Murdoch et al, 1997).

Although pooling data solves the lack of exogenous variation problem, there are issues with the pooled estimates. The parameters estimated using cross-section and time-series tend to measure different things; the former measuring long-run effects, while the latter short-run effects (Dunne and Smith, 2001). Furthermore, the pooled estimates can be considered simply as a weighted average of the two, a problem in itself. Due to the difficulties in distinguishing the cyclical demand side effects from medium-term supply side growth effects, growth equations have been most successful in cross-section analysis.

However, as noted earlier, there are possible solutions to the problems plaguing growth equation estimations. Panel data methods such as pooling are the simplest solution, while fixed effects and random coefficient estimators provide more dynamic approaches. As panel data methods become increasingly popular, one of the most common panel estimators is the fixed effects estimator (one-way fixed effect). This type of estimation method allows the intercept to differ across countries while ignoring all information in a cross-sectional relation. The fixed effects estimator can be written in the form:

$$y_{it} = \alpha_i + \beta x_{it} + u_{it} \quad ; \; i = 1, 2, ..., N \quad ; \; t = 1, 2, ..., T \tag{19}$$

Apart from the one-way fixed effects estimator, there is also the two-way fixed effects estimator which allows for both country and time-fixed effects. The two-way fixed effects estimator can be displayed as:

$$y_{it} = \alpha_i + \theta_t + \beta x_{it} + \mu_{it} \;\; ; \; i = 1, 2, ..., N \;\; ; \; t = 1, 2, ..., T \tag{20}$$

The two way-fixed effects estimator is adopted for empirical analysis; the time effect will be captured through the trend variable (*year*), between the period 1988 to 2010[5]. Coinciding with the increased popularity of panel data methods has been the availability of longer time-series data leading to the introduction of dynamic specifications into panel data methods (Dunne and Smith, 2002). However, this raises a number of new issues as seen in the equation:

$$y_{it} = \alpha_i + \theta_t + \beta x_{it} + \lambda y_{i,t-1} + \mu_{it} \;\; ; \; i = 1, 2, ..., N \;\; ; \; t = 1, 2, ..., T \tag{21}$$

In dynamic form, the fixed effect estimator is inefficient due to lagged dependent variable ($y_{i,t-1}$) bias, which biases the OLS estimator β ($x_{i,t-1}$) downwards. Moreover, the fixed effect estimator is also inconsistent as N (number of groups) tends towards infinity for fixed T (years). It is however, consistent as T tends towards infinity and where T is large the bias is relatively small. There is further heterogeneity bias when the parameters differ over groups, this bias arises when the error term in the fixed effects equation is:

$$\mu_{i,t} = \epsilon_{i,t} + (\beta_i - \beta)x_{i,t} + (\lambda_i - \lambda)y_{i,t-1} \tag{22}$$

In this case, where there is positive serial correlation in the independent variables, the resultant heterogeneity bias will bias the estimates of λ upwards. But this bias can potentially be dealt with by estimating each equation individually and taking an average of the individual estimates (Pesaran and Smith, 1995).

Since the data available in the analysis is not long enough[6] to employ methods of large-N and large-T, this paper follows from Dunne (2012) and uses a fixed effects model while introducing dynamics. For long-run estimates, the overall bias is trivial since the estimate of β is biased

[5] There is also the random effects estimator, but since this is not used in the investigation, it will not be discussed.
[6] T=23 years (1988-2010)

downwards and that of λ is biased upwards, thus making each other obsolete[7] (Dunne and Smith, 2002)

Having provided a detailed review of existing theoretical approaches, related literature, models and estimation methods, this paper will now move onto the assessment of the data, followed by estimations of the overall model. As discussed above, the issue of non-linearity, heterogeneity and endogeneity is of great concern to researchers and this paper will attempt to consider each of these three aspects in a robustness check.

3 DATA DESCRIPTION

All the Solow-style regressions estimated within this paper are based on the same balanced panel data set. Starting with the military expenditure dataset of 170 countries - provided by the Stockholm International Peace Research Institute (SPIRI) - countries were excluded on the basis that a maximum of three missing observations are allowed for the military expenditure variable. The final balanced panel comprises 104 countries with annual data spanning the period 1988 to 2010. All the regressions include lagged log values for military expenditure, capital stock, and real per capita GDP, while all the variables except for the trend term are in natural log form. In order to incorporate dynamics into the analysis, the lagged variables are seen as essential towards the estimation process.

The two main variables of concern, real per capita GDP (growth) and military expenditure as a share of GDP are obtained from World Bank and SIPRI respectively. Unlike Islam (1995) or Yakovlev (2007) this paper does not use five-year averages of per capita GDP; the motivation being that business cycle effects are important and form part of the long-run determinants of growth. The variable gross-fixed capital formation as a share of GDP is obtained from the World Bank's World Development Indicators (WDI) database and will be used as a measurement of capital stock. Due to difficulties obtaining reliable data for the average growth rate of the working-age population this paper uses the common alternative of population growth instead, this data is also taken from the World Bank's WDI.

For the purposes of empirical analysis, indicator variables relating to the specific sub-samples (income groups, developed and developing countries, conflict experience, civil and interstate wars, natural resource abundance, net recipients of aid and trade openness) are used for sample stratifications. The rationale behind using the sample stratification method and indicator variables relate

[7] We are essentially estimating $\beta/(1-\lambda)$

to the nature of the study as well as the type of sub-samples considered. Many of the sub-samples considered (i.e. conflict experience, developed and developing and natural resource abundance) are invariable across time and country and thus cannot be included in the growth regression as dummy or categorical variables. Subsequently, the approach is to disaggregate the overall sample into smaller sub-samples, which takes into consideration group heterogeneity and non-linearity, and thus enabling the investigation of the robustness of the results.

Following from the above argument, non-linearity within the full panel is considered through the stratification of countries according to levels of development and income. The classifications of countries that are either developed or developing are excerpted from the World Bank's WDI database; developed countries are quoted a numerical value of one while all the remaining countries within the sample receive a zero value. Income groupings are derived from the definitions provided by the International Monetary Fund (IMF). In order to homogenise the sample size of the different income groups this paper combines the IMF's definition of low and low-middle income countries to form low-income countries. High-middle income countries are now defined as middle-income countries, while the definition of high-income countries has been left unchanged.

Conflict experience would seem to be an important potential source of heterogeneity. As mentioned, Smaldone (2006) argued that military burden within Africa generally corresponds to the security realities they face[8], and often affects the relationship between military spending and economic growth. Dunne (2012) provide support to this claim, showing that differing national attributes in SSA - presence or absence of conflict - systematically affect socioeconomic development. The conflict indicator variable is extracted from the Uppsala Conflict Data Program and International Peace Research Institute Oslo (UCDP/PRIO) database. As is common within the literature. conflict is defined as having at least 25 combat-related deaths per year, but a cumulative battle death of over 1,000 throughout the duration of the conflict is also considered. A country is given a numerical value of one if it has experienced a conflict between the period 1988 to 2010 or a zero otherwise. In addition, variables for civil and interstate war are created; the construction of the two variables follows identically from the conflict variable.

A second potential source of heterogeneity is natural resource endowment. Similar to the greed and grievance argument put forward by Collier and Hoeffler (2004), in the case where rebellions or civil wars are motivated by greed primary commodity exports substantially increase conflict risk. They also argue that in the presence of natural resource abundance, opportunities arise through extortion and looting of profits from those in control of the resource, thus making conflict or rebellion

[8] Aizenman & Glick (2006) provided an empirical evaluation of non-linear interactions between military expenditure, security and corruption and its effects on growth. Military spending alone decreases growth but in the presence of threats raises growth.

feasible or perhaps even attractive. Research from the natural resource and growth literature provide a similar hypothesis; Sarr et al (2011) explains that in a resource rich country, an unchecked ruler can use natural resources as collateral and facilitate acquisition of loans and subsequently loot the economy. The act of looting then leads to political instability and hence diminished growth. It certainly seems reasonable to suggest that countries that are natural resource abundant may differ in their relation between military spending and economic growth.

With this in mind, this paper investigates the possibility that natural resource abundant countries have additional incentives to acquire rents and loot the economy. In this case, military spending by the ruler or ruling party either increases the probability of staying in power or increases risk of civil war or rebellion (Collier & Hoeffler, 2004). Irrespective of whether a civil war erupts, the military spending and looting process is likely to continue, and with it, probable impacts on economic growth. Consistent with accepted norms within the literature, natural resource dependence is used as a proxy for natural resource abundance. Natural resource dependence is measured as the ratio of mineral exports to total exports. If mineral exports constitute more than 25 percent of a country's total exports, the country is then classified as mineral dependent. This is consistent with the IMF's definition of export dependence.

Data on natural resource dependence is obtained from the Haglund (2011) and the UNCTAD-stat database. Here, the focus is on the six types of fuels and non-fuel minerals defined by the Standard International Trade Classification (SITC) codes, (See Table 1, below). The natural resource indicator is divided into three variables, each variable is allocated a value of one or zero. The first variable (*avenat*) characterises whether a country is natural resource dependent via a combination of fuel and non-fuel minerals. The second variable (*fuel*) indicates whether a country is fuel dependent; while the third variable (*non-fuel*) records countries that are non-fuel mineral dependent. The construction of the mineral dependence variable (mineral exports constitute at least 25 percent of total exports) is calculated on 2010 data, while there exists data for the years 1996 and 2005 this paper believes that since natural resources are considered invariable over time, taking 2010 as the "snap shot" year is reasonable[9].

[9] Using data from 1996 and 2005 changes the long-run estimate of military expenditure from significant at the 6 percent level to insignificant. For the year 1996, the countries Australia, Belize, Bolivia, Burkina Faso, Indonesia, Mozambique, Mali and South Africa are dropped from the sample. For the year 2005, the countries Belize, Bolivia, Burkina Faso and Ghana are dropped from the sample.

Table 1: Six types of minerals as classified by SITC codes

SITC code and description	
SITC 27: Crude fertilizers, other than those of division 56, and crude minerals (excluding coal, petroleum and precious metals.)	
SITC 28: Metalliferous ores and metal scrap	
SITC 68: Non-ferrous metals	Non-fuel minerals
SITC 667: Pearls and semi-precious stones	
SITC 971: Gold, non-monetary	
SITC 3: Mineral fuels (including natural gas), lubricants and related materials.	Fuel

Another potentially important variable to consider is foreign aid. The foreign aid variable can be incorporated into the estimation via either the conflict of growth literature. Aid through the conflict literature relate to Collier and Hoeffler's (2004) identification of diaspora and its impact on conflict through the flow of funds that can support a rebellion or war. Aid through the growth literature is the resultant of the formulation of the Washington Consensus and recent developments within the literature have considered the impact of aid on developing economic growth. However, there remains no consensus. Burnside & Dollar (2000) concluded that aid has a beneficial impact on growth in developing countries with sound policies (fiscal, monetary and trade) and no impact in the presence of poor policies. On the other hand, Easterly, Levine & Roodman (2004) and Hansen & Tarp (2000) rebut Burnside & Dollar (2000)'s claim and find that aid works for countries with poor policies. While there is no consensus regarding the impact of aid on growth, the commonly agreed upon challenge is aid fungibility. Aid recipients, mainly developing countries such as in SSA, receive high amounts of aid and this often leads to in-discretionary spending in the form of military expenditure. The unchecked spending of development aid on military leads to opportunity costs since the resources being allocated to defence could be otherwise spent on furthering the pace of development. Thus it is reasonable to believe that the impact of military spending may differ between countries which are net aid recipients and those that are non-recipients.

The data on net aid recipient (*Aid*) is taken from the World Bank's WDI. The sample is first divided into countries which are net recipients of aid and those which aren't. Since there is no commonly accepted categorisation of net aid recipients a definition needed to be created. The data on net recipients of aid is measured as a share of GDP, thus this paper proceeds to define any country which, on average, received less than 0.01 percent of aid as a share of GDP as non-aid recipients. Having separated the sample of countries into aid recipients and non-aid recipients, it is further divided into countries that receive low, medium and high levels of aid. Countries which receive between 0.01 and one percent of aid as a share of GDP are categorised as low recipients of aid; those that receive between one and three percent as medium aid recipients; and greater than three percent as high aid recipients.

Following trade liberalisation and globalisation, the issue of trade openness and its impact on growth has become a significant topic of research within the growth literature. Similar to the literature on foreign aid, there is no consensus as to whether trade openness is positively or negatively related to economic growth. Proponents of trade openness having a progressive effect on development include Edwards (1997), Frankel and Romer (1999) and Dollar and Kraay (2004). Those that find trade openness to have a discouraging effect on growth include Yanikkaya (2002), with Rodriguez and Rodrik (2000) finding little evidence that open trade policies are associated with economic growth period.

While trade has become an important topic within the growth literature, the issue of military spending, trade and economic growth has also been explored. Yakovlev (2007) found that countries involved in arms trade can impact upon economic growth for a given level of military expenditure. Although it is unclear how trade openness may affect growth; the results from Yakovlev (2007) provide reason to suppose that military spending in open economies have an altered impact on growth than more closed economies. In 2011, according to SIPRI, the top 7 suppliers of arms in the world are also within the top 10 of the world's top military spenders[10]. Since the majority of the world's economies are arms importers, a more open economy could represent greater net arms imports than the equivalent closed economy, thus representing an opportunity cost to development. The variable openness is calculated by taking the sum of a country's imports and exports and dividing that by its GDP[11]. A country is defined as open if its share of imports and exports to GDP is higher than the similarly calculated world average, and vice versa for a closed economy.

Consistent with the other indicator variables the trade openness variable (*trade*) takes on the value of either one for open or zero for closed. The imports, export and GDP figures are recorded in constant US dollars; the GDP figures have also been deflated using Purchasing Power Parity (PPP). Due to missing observations this paper was unable to take the sample average of a 23 year period or the initial period (1988). As a result, two arbitrary years within the time-series data is chosen, namely years 2000 and 2009, and used to identify changes in openness[12].

Having described the data on potential factors of non-linearity and group heterogeneity this paper moves to consider the data used to account for endogeneity. The endogeneity between the

[10] The world's top 7 arms exporters in descending order; USA, Russia, Germany, France, China, UK, Italy

[11] Written as $(X_{i,j} + M_{i,j})/Y_{i,j}$ where i and j refer to country and year respectively.

[12] The full sample is divided into 79 open and 25 closed countries for the year 2000 and 78 open and 26 closed countries for the year 2009. During the 10 year period countries such as Uganda and China moved from closed to open while others such as France and Greece moved the opposite direction

variables per capita GDP growth (*cly*) and military expenditure (*clm*) has resulted in a need to find reasonable instruments. Using variables from the literature on the determinants of military spending, three variables, two political and one economic, were chosen as instruments for military expenditure. The economic variable, log trade ($lTrade$), is calculated by taking the log of the sum of imports and exports between the period 1988 to 2010 from the trade database within the WTO. The first political variable, democracy ($Democracy$), is taken from the Polity IV database and measures the difference between the democracy and autocracy. This data ranges from -10 (autocracy) to +10 (democracy) and is between the period 1988 to 2010. The second political variable, log of threat, is taken from the Miller (2012) whereby he calculates threat via a multi-step procedure. The threat variable ranges from 0 (no threat) to 1 (maximum threat). The creation of the variable is done by merging the first and second contiguous countries with the National Material Capabilities section found in the Correlates of War (COW) database. This variable is then merged with a list of war fighting countries from COW. Finally, by taking into account the capabilities of the first and second order contiguous states, the threat variable ($lThreat$) is created. Due to data restrictions from COW's contiguity database, the threat variable was only created for the period 1988-2006. As a result all regressions ran with ($lThreat$) will only be up to 2006.

Table 2 below provides a summary of the final data set containing 104 countries over a twenty-three year period. The sample includes 28 developed countries, 76 developing countries, 28 African countries, 20 Asian and Oceania countries, 26 European countries, 20 North and South American and 10 Middle Eastern countries[13].

[13] A list of countries featured in the full sample can be found in Table A1 in the appendix.

Table 2: Variable Description and Summary Statistics

Variable	Variable Description	Mean	Std.Dev
y	Real per capita GDP	12157	12718
m	Military expenditure as share of GDP	2.74	3.73
k	Gross fixed capital formation as share of GDP	21.28	6.57
ly	Natural log of real per capita GDP	8.73	1.29
lm	Natural log of military expenditure as share of GDP	0.71	0.75
lk	Natural log of gross fixed capital formation as share of GDP	3.02	0.30
ly1	Lagged natural log of real per capita GDP	8.73	1.30
lm1	Lagged natural log of military expenditure as share of GDP	0.72	0.75
lk1	Lagged natural log of gross fixed capital formation as share of GDP	3.02	0.30
cly	Growth rate of real per capital GDP (log)	0.02	0.05
clm	Growth rate of military expenditure as share of GDP (log)	-0.02	0.20
clk	Growth rate of fixed capital formation as share of GDP (log)	0.00	0.15
lngdpop	Population growth rate (clpop)+0.05	-2.74	0.18
dev	Development indicator	0.27	0.44
inc	Income indicator (1=Low income, 2=Middle income, 3=High income)	1.93	0.84
conflict	Conflict indicator	0.37	0.48
civilwar	Civil war indicator	0.32	0.47
intwar	Interstate war indicator	0.11	0.31
aid	Aid Indicator (1=Net recipient of aid, 0=Non-net recipient of aid)	0.63	0.48
aid2	Aid Indicator (0=Non-net recipient of aid, 1=Low aid, 2=Medium aid, 3=High aid)	1.39	1.28
fuel	Fuel dependent countries	0.15	0.36
nonfuel	Non-fuel mineral dependent countries	0.17	0.38
nat	Aggregate natural resource dependence	0.34	0.47
comnat	Combined fuel and non-fuel natural resource dependence.	0.41	0.49
open00	Openness indicator (1=open, 0=not open) in 2000	0.76	0.43
open09	Openness indicator (1=open, 0=not open) in 2009	0.75	0.43
ltrade	Sum of imports and exports between 1988-2010 (log)	23.60	2.18
Democracy	Polity IV: -10 (autocracy) to +10 (democracy)	4.05	6.44
lThreat	Ranges from 0 (no threat) to 1 (maximum threat)	0.30	0.18

4 EMPIRICAL ANALYSIS

Following from equation (18), the general first-order dynamic model used for empirical analysis takes the the form of:

$$\ln y_{i.t} = \gamma \ln y_{i,t-1} + \sum_{j=1}^{3} \beta_j \ln x_{j,i,t} + \eta_t + \mu_i + \nu_{i,t} \ ; i = 1, 2, , ..., N \ ; t = 1, 2, ..., T$$

where y is GDP per capita; $x_1 = k$ is gross investment as share of GDP; $x_2 = n + g + \delta$ is the labour force growth rate + 0.05; and $x_3 = m$ is the military expenditure as a share of GDP. The re-parameterised general first-order dynamic model has all variables in log form; with c representing the change in the independent and dependent variables (i.e. $cly =$ change in per capita GDP) and $ly1, lk1$ and $lm1$ representing the lagged level of per capita GDP, gross investment as share of GDP and share of military spending to GDP respectively. The results of the full sample are reported in Table 3, Column 1.

The empirical results from the full sample show a very well-defined empirical model. All the traditional growth variables, consistent with Solow (1956) and Mankiw et al (1992)'s predictions, are statistically significant with signs as expected. The change in log of capital or gross investment (*clk)* is positive and significant; indicating that for the full sample of countries, the higher the investment (or savings as explained by Solow (1956)), the richer the country. The variable log of population growth rate + 0.05 (*lngdpop*) is negative and significant, pointing towards the fact that the higher the rate of population growth, the poorer the country. The lagged level value of per capita GDP (*ly1*) is negative and significant, this, as expected, is the standard result in the empirical growth literature known as conditional convergence.

The most important variables within the overall regression are the two military expenditure variables. The change in log of military expenditure (*clm*) measures the short-run relationship between military spending and growth, while the lagged level term (*lm1*) measures the long-run effect. The estimation results from Table 3 clearly show a negative relationship (short and long-run) between military expenditure and economic growth. This result is highly consistent with the more recent cross-country studies, (Dunne and Tian, 2013).

Table 3: The Growth Effects of Military Expenditure

	1
Sample	All Countries
Variables	cly
clk	0.0554***
	(8.53)
clm	-0.028***
	(-5.69)
lngdpop	-0.0542***
	(-6.09)
ly1	-0.0917***
	(-12.61)
lk1	0.0273***
	(5.63)
lm1	-0.0170***
	(-4.81)
year	0.00199***
	(9.01)
Constant	-3.369***
	(-8.5)
Observations	2,148
Number of id	104
R-squared	0.127

Dependent variable: Growth rate of real per capita GDP (cly)

t-ratios in parentheses

*Significant levels: ***p<0.01, ** p<0.05, *p<0.1*

4.1 ROBUSTNESS CHECKS

While the estimation results from the full sample suggest that military spending has a negative and significant impact on economic growth, the concerns of non-linearity, heterogeneity and endogeneity within the literature must be considered. It is reasonable to argue that due to the large number of countries used in the empirical analysis, country characteristics - particularly one that is invariable across time - can play a vital role in explaining the military spending and growth relationship. The effect of military expenditure may well be very different for countries differing in income, development, conflict experience, natural resources, aid and openness. Although the majority of these country characteristics described have been well researched within the growth literature, hardly any have been considered within the military spending and growth relation. Through the use of the above mentioned country classifications the remainder of the empirical analysis section will attempt to fully investigate the robustness of the impact of military expenditure on economic growth.

4.1.1 Non-Linearity

As Dunne (2012) and Pieroni (2006) argue, the effect of military expenditure could be very different for countries with different development and income levels, suggesting a non-linear relation. Consequently, the first split is into developed and developing countries. Analysing the developed (Column 1, Table 4) and developing countries (Column 2, Table 4) reduces the sample size to 28 and 76 countries respectively, however, the results remain remarkably similar to that of the full sample (Table 3). The estimation results from the sample of developing countries is consistent with the full sample, all the growth variables are significant and of the expected sign, while the two military variables are negative and significant at the one percent significance level. The results for the sample of developed countries show there to be a negative and significant short run effect of military spending on growth but no long-run effect. The initial stratification process has already revealed some interesting results, the insignificant coefficient of military spending for the developed sample suggests that - ceteris parabis - developed countries tend to experience the negative effects of military spending for a shorter time horizon than developing countries. While this is indeed an interesting result, further stratifications are required before any meaningful analysis can be done regarding why long-run military burden has no effect on growth for developed countries.

Although the results from Table 3 and Column 1 and 2 of Table 4 are extremely useful and generally consistent, it is possible that these aggregate groups still hide certain non-linearities. To consider such differences, the full sample is stratified into three different income groups. Columns 3, 4 and 5 in Table 4 show the results of income group stratifications. As with earlier estimations, the empirical growth model is generally well specified. In terms of sign, the results for the low, medium and high-income countries (Column, 3, 4 and 5 respectively) are consistent, with the majority being statistically significant. For all three income groups the effect of military burden on growth is negative and significant in the short-run. However, in the long-run this negative and significant effect is only evident in the low and high-income countries[14]. Similar to the sample of developed

[14] The difference in sample size of 5 countries between the high income and developed countries are due to countries classified as high income in terms of per capita GDP (oil economies) but not developed. The 5 countries are, Bahrain, Hungary, Kuwait, Oman and Saudi Arabia.

countries, by disaggregating the full sample into different income groups, there seems to exist certain characteristics within medium income countries that lead to no significant long-run effect of military spending on growth. These results support Dunne (2012), where he also found insignificant long-run effects for his two middle income groupings. While the results from the medium income countries suggest further investigation is needed, the difference in the impact of long-run military spending on growth between high income and developed countries is also an important finding. Of the five countries that are high-income but not developed, four are oil rich, Middle East and North Africa (MENA) countries. Oil seems to be an important characteristic in influencing the effects of military spending, a phenomenon that will be assess when considering group heterogeneity.

Table 4: The Growth Effects of Military Expenditure, Stratifying for Income & Development

	1	2	3	4	5
Sample	Developed	Developing	Low	Medium	High
Variables	cly	cly	cly	cly	cly
clk	0.213***	0.0431***	0.00124	0.137***	0.120***
	(15.03)	(5.75)	(0.13)	(11.76)	(9.24)
clm	-0.0181***	-0.0283***	-0.0326***	-0.0214**	-0.0247***
	(-3.22)	(-4.54)	(-3.76)	(-2.51)	(-3.77)
lngdpop	-0.0925***	-0.0451***	-0.0257*	-0.0199	-0.0831***
	(-7.13)	(-4.17)	(-1.67)	(-0.92)	(-8.09)
ly1	-0.0443***	-0.0940***	-0.0935***	-0.0953***	-0.0820***
	(-3.6)	(-10.52)	(-7.39)	(-7.26)	(-6.36)
lk1	0.0233**	0.0230***	0.0140*	0.0384***	0.0210**
	(2.53)	(4.02)	(1.81)	(4.42)	(2.19)
lm1	-0.00933	-0.0179***	-0.0265***	-0.00421	-0.0200***
	(-1.59)	(-4.29)	(-4.56)	(-0.72)	(-3.03)
year	0.0001	0.00252***	0.00256***	0.00304***	0.000588
	(0.28)	(9.28)	(6.94)	(6.82)	(1.64)
Constant	-0.0441	-4.430***	-4.500***	-5.366***	-0.609
	(-0.08)	(-8.97)	(-6.6)	(-6.83)	(-0.96)
Observations	607	1,541	821	623	695
Number of id	28	76	40	31	33
R-squared	0.375	0.113	0.127	0.271	0.257

Dependent variable: Growth rate of real per capita GDP (cly)

t-ratios in parentheses

*Significant levels: ***p<0.01, ** p<0.05, *p<0.1*

Furthermore, analysis into the coefficients of the military spending show that low income countries tend to experience a larger negative impact on growth (short and long-run) than the corresponding medium and high income countries. The result is consistent with the military spending coefficients in Table 4, Column 1 and 2, where the military burden in developing countries has a larger negative coefficient than developed countries. This result is in-line with other recent studies that have looked at the relationship between military expenditure and economic growth. Authors such as Yang et al (2011) and Hou and Chen (2012) have found military spending to be negative and significant in low income and developing countries while the same result could not be concluded about the remaining countries.

One possible explanation to support this result is to combine the literature of conditional convergence with opportunity costs. Using this approach, a description can be made according to the theory of conditional convergence[15] where poorer, developing countries should grow at a faster rate than the richer developed countries[16]. However, as discussed in the literature review, military spending always leads to opportunity costs, and as a result, poorer countries have had to pay a "*heavier price*"[17] on growth compared to richer countries (Yang et al, 2011). Thus potentially explaining the larger negative coefficients on military expenditure observed for the low income and developing countries.

Having stratified for non-linearity, the results - with the exception of long-term military burden on medium income and developed countries - are extremely robust. Even after dividing the sample into smaller and more homogenous sub-samples, defence spending shows a consistently negative and significant effect on growth.

4.1.2 Heterogeneity

With estimation results being robust from different income and development stratifications the next step is to consider possible heterogeneity in the sample. An ideal starting point is to consider conflict experience since previous studies, particularly in Africa, have found differences in the military spending growth relation for countries who have experienced conflict and those who have not (Dunne, 2012). However in a larger, more general study, the results contradict that of Dunne (2012). Breaking the full sample into groups of countries that have experienced conflict and those who have not experienced conflict leaves 38 countries for the prior and 66 countries for the latter.

[15] The model predicts this to be to true throughout the different stratifications implement within the paper.

[16] Developed, developing and income groups have been classified in such a way that all low income countries will fall under the developing category.

[17] Instead of using its limited resources for developmental purposes, resources are instead diverted to the arms industry or arms imports. An opportunity cost on economic growth.

The results in Table 5 show significant negative effects of military spending on growth both in the short and long-run, irrespective of whether a country has experienced conflict.

An interesting comparison can be made between the coefficients of *clm* and *lm1* for the conflict and no-conflict group. Here the comparison is between the short-run and long-run effects of military burden for cases of conflict. The coefficients of *clm* and *lm1* in Table 5, Column 1 and 2 strongly substantiate the notion of economic costs of military spending and conflict, providing additional insight for analysis.

Table 5: The Growth Effects of Military Expenditure, Stratifying for Experiences in Conflict

	1	2	3	4
Sample	Conflict	No Conflict	Civil	Interstate
Variables	cly	cly	cly	cly
clk	0.0414***	0.0646***	0.0421***	0.123***
	(4.28)	(7.41)	(4.13)	(5.37)
clm	-0.0331***	-0.0234***	-0.0320***	-0.0180*
	(-4.61)	(-3.5)	(-4.23)	(-1.74)
lngdpop	-0.0354***	-0.0715***	-0.0281**	-0.144***
	(-2.7)	(-5.86)	(-2.02)	(-3.71)
ly1	-0.118***	-0.0710***	-0.106***	-0.126***
	(-9.37)	(-7.5)	(-7.85)	(-5.27)
lk1	0.0314***	0.0227***	0.0299***	0.0765***
	(3.84)	(3.69)	(3.5)	(3.99)
lm1	-0.0208***	-0.0180***	-0.0193***	-0.0138**
	(-4.37)	(-3.33)	(-3.81)	(-2.12)
year	0.00320***	0.00104***	0.00318***	0.00264***
	(9.58)	(3.43)	(8.52)	(4.28)
Constant	-5.607***	-1.677***	-5.644***	-4.758***
	(-9.29)	(-3.06)	(-8.34)	(-4.51)
Observations	773	1375	674	227
Number of id	38	66	33	11
R-squared	0.195	.110	0.184	0.327

Dependent variable: Growth rate of real per capita GDP (cly)

t-ratios in parentheses

*Significant levels: ***p<0.01, ** p<0.05, *p<0.1*

In a study conducted in 2010, Brauer and Dunne show the effects of conflict on per capita GDP in seven war-afflicted countries; whereby fifteen years after the end of their respective conflicts many of the countries remain unable to reach their pre-war per capita GDP levels[18]. In conjuncture to the military spending literature, the opportunity cost of short-run military burden in countries experiencing conflict is much greater than an equivalent no conflict country. The rationale behind this draws strongly from neoclassical theory, where instead of using the limited resources for development purposes and boosting welfare it is used for either arms production or arms imports. Combine this with conflict[19], the measurable cost of military spending could be much higher for the conflict stricken country. The coefficient *clm* (Table 5, Column 1 and 2) shows a larger negative effect of military spending on the economy for the conflict sample (-0.033) as compared to the no conflict sample (-0.0234), supporting the hypothesis.

In terms of econometric results the "most cited" number for the cost of conflict is from Collier (1999, p. 176) where he states that on average it costs a country 2.2 percent of GDP for every year of conflict. This results leads to a second interesting comparison. Simple logic would deduce that a long-term conflict for a country would result in higher cumulative costs and a lower GDP base[20]. Violence diverts resources, disrupts economic activity, destroys physical and human capital and thus its effects cannot be counted as contributing to the well-being of a country Anderson and Carter (2009).

In line with the cost of conflict literature, suppose a country experiences a prolonged conflict, the resultant outcome is potentially an extremely low per capita GDP level (i.e. DR Congo or see figure A2), and instead of using the remaining resources (extremely scarce) for more productive ends, it is instead used for military purposes. The resultant opportunity costs of military spending and conflict, both in the short and long-run, will be higher for a country in conflict compared to one that isn't. One could further argue that production of arms or arms imports prolongs the already drawn-out conflict and thus amassing further costs on economic growth. Returning to the estimates provided in Table 5, the average short (-0.0331) and long-run (-0.0208) coefficient of military spending for countries in conflict is indeed larger than the equivalent no conflict sample of (-0.0234) and (-0.018) respectively. By providing a brief analysis this paper is able to lay the foundation for future avenues of research in costs to conflict.

Although disaggregating the full sample into conflict and no conflict is useful; it is possible that the type of conflict may be more relevant, thus Table 5 also reports results for countries that

[18] See figure A2 provided by UNDAP (2008, p.111, Figure 4.2) under appendix

[19] In the presence of conflict, the majority of the means of production ceases, with some switching its production to arms in order to support the "war effort".

[20] See figure A2 in appendix

experienced civil conflicts and those that experienced interstate conflicts. Stratifying the conflict group into civil and interstate conflict reduces the sample size to 33 countries for the prior, 11 countries for the latter and 6 countries experiencing both[21]. The estimation results for countries with civil war experiences (Table 5, Column 3) are consistent with the overall sample, conflict and no-conflict groups, with significant negative short and long-run effects of military burden on the economy.

Moreover, the empirical results from Table 5 reveal an intriguing result. Previous assertions by the likes of Collier (1999) and Herbst (1991) have argued that civil conflicts are liable to be more damaging than interstate conflicts, a result that is not supported within this paper. Consistent with earlier estimates, all the variables in Table 5, Column 4 are of the expected sign, while both the change in military expenditure as share of GDP (*clm*) and the level lagged value of military expenditure (*lm1*) are negative and significant. This suggests that irrespective of whether a country experiences a civil or interstate conflict, the effect of military spending on growth is negative.

Additionally, conflict could have a different effect on countries at different income levels. To investigate this, the 38 countries that have experienced conflict are divided into low-income (24), medium-income (9) and high-income (4) countries. Due to the lack of observations for the medium and high-income groups the results should be analysed with caution[22]. While the results in Table 6, Column 1 shows a negative and significant short and long-run effect of military expenditure on growth in low-income countries, this is not supported in Column 2, where military expenditure for medium-income countries is only significant at the 10 percent level for the short-run and insignificant in the long-run. The estimation results for high-income conflict experienced countries (Table 6, Column 3) are consistent with that of Column 1; military burden appears to have a negative and significant short and long-run effect on growth.

Interestingly, the coefficient of *clm* for the conflict affected high-income countries is more than three times larger than the conflict affected low-income countries and larger than the overall conflict, civil and interstate war sample. Similarly, the long-run coefficient *lm1* is twice as large as the low-income conflict affected countries and three times greater than the overall conflict, civil and interstate conflict group. Contrary to the results from Table 4, where military spending was more harmful to lower income countries than higher income countries, once conflict is introduced, military spending is seen to be more damaging on growth for the higher income groups.

[21] Ethiopia, India, Iran, Pakistan, Peru and United Kingdom

[22] The consistency in the sign and statistical significance of the Solow growth variables even when the sample is limited to 98 observations or 5 countries (confict and high income) provides further evidence to well defined nature of our empirical model.

Table 6: The Growth Effects of Military Expenditure, Stratifying for Conflict & Income

	1	2	3
Sample	Low & Conflict	Medium & Conflict	High & Conflict
Variables	cly	cly	cly
clk	0.0210*	0.181***	0.0875***
	(1.93)	(6.73)	(3.11)
clm	-0.0343***	-0.0226*	-0.113***
	(-3.78)	(-1.84)	(-3.63)
lngdpop	-0.0302**	-0.00729	-0.0705**
	(-2.06)	(-0.12)	(-2.45)
ly1	-0.106***	-0.146***	-0.450***
	(-7.37)	(-4.61)	(-9.41)
lk1	0.0251***	0.0343*	0.0923***
	(2.68)	(1.7)	(3.37)
lm1	-0.0282***	0.00281	-0.0575***
	(-4.47)	(0.35)	(-3.84)
year	0.00323***	0.00366***	0.00775***
	(7.67)	(4.11)	(6.69)
Constant	-5.793***	-6.120***	-11.23***
	(-7.4)	(-4.09)	(-5.83)
Observations	486	189	98
Number of id	24	9	5
R-squared	0.214	0.356	0.574

Dependent variable: Growth rate of real per capita GDP (cly)

t-ratios in parentheses

*Significant levels: ***p<0.01, ** p<0.05, *p<0.1*

Also, what is striking about Table 6's results are the coefficients of *clm* and *lm1* for the medium-income conflict experienced countries (Column 2). As identified earlier, there seems to be a group of countries whereby military expenditure has no effect on economic development; thus the insignificance of the short and long-run military spending variables in Column 2 provides further insight on the characteristics of that particular group of countries. While military expenditure was only insignificant for medium-income groups in the long-run (Table 4, Column 2), combining the sample with conflict experience provides insignificant results for both the military expenditure variables. It would seem that within the sample of 104 countries the medium income group[23] offers the most

[23] The 9 medium income countries that provided the intriguing results in Table 6, Column 2 are Algeria, Colom-

fascinating and intriguing estimates. In order to fully understand the characteristics of those countries - where military spending has no effect on economic development - further research should be done into the medium income sample.

Having estimated the full sample, income groups and conflict experience this paper now attempts to identify other possible heterogeneous effects of military expenditure on growth. To consider the possible impact of natural resource differences the UNCTADstat database was used to divide the full sample into 43 countries that are resource dependent and 61 countries that are not resource dependent. The classical Solow variables shown in Table 7 are once again of the expected sign; increases in capital accumulation or savings increase economic growth, increases in population decrease growth and the lagged level of per capita GDP proves the presence of condition convergence These results further cement the empirical model used as the preferred model in estimating growth and its relationship with military spending. Military burden, in Column 1 and 2 of Table 7, has negative and significant short and long-run effects of similar size for both countries with or without an abundance in natural resources[24]. In the rationale of stratifying for natural resource abundance an indirect hypothesis was that resource rich countries spend on average more on military than non-resource rich countries[25].

Estimates of the mean shows that resource rich countries allocate on average 3.6 percent of their GDP to military expenditure, while non-resource rich countries spend only 2.24 percent of their GDP. This difference of 1.16 percentage points is statistically significant. Interestingly, while countries with different natural resource levels spend different amounts on military, Table 7's results suggest that regardless of whether a country is natural resource dependent, military spending is bad for the economy. Moreover, the coefficients of the two military spending variables in Table 7 Column 1 and 2 show that although on average natural resource abundant countries spend more on military then non-natural resource abundant countries, the negative effect is less for the resource abundant countries. Initially this may seem counter-intuitive since the argument of higher military spending leads to higher opportunity costs, yet what the stratification may be picking up is the damping effect that natural resources have on the negative impact of defence burden on the economy. It could simply be the case that while military expenditure is bad for the economy, the income that comes from natural resource exports provides a buffer on the negative effects (making military burden more affordable), one that doesn't exist for non-natural resource abundant countries.

bia, Ecuador, Iran, Lebanon, Peru, Russia, South Africa and Turkey. It would seem that the countries are very heterogenous, with no clear trend of common characteristics apart from income groupings.

[24]It should be noted that within some natural resource abundant countries (Table 7, Column 1) one type of mineral export (fuel or non-fuel) does not constitute more than 25% of total exports, but, the combination of all mineral exports exceeds the 25% threshold amount.

[25]See page 23, under natural resources.

Table 7: The Growth Effects of Military Expenditure, Stratifying for Natural Resource

	1	2	3	4
Sample	Natural Resource	No Resource	Fuel	Non-fuel
Variables	cly	cly	cly	cly
clk	0.0416***	0.0767***	0.0202	0.0507***
	(4.49)	(8.12)	(1.46)	(3.65)
clm	-0.0247***	-0.0294***	-0.0398***	-0.00612
	(-3.31)	(-4.48)	(-3.27)	(-0.58)
lngdpop	-0.0472***	-0.0750***	-0.0945***	-0.0240*
	(-4.12)	(-5.06)	(-4.46)	(-1.65)
ly1	-0.126***	-0.0673***	-0.117***	-0.149***
	(-9.66)	(-7.27)	(-5.33)	(-7.49)
lk1	0.0309***	0.0244***	0.0274**	0.0327***
	(3.87)	(3.96)	(2.22)	(2.6)
lm1	-0.0156***	-0.0196***	-0.0254**	-0.00783
	(-2.94)	(-4.07)	(-2.52)	(-1.16)
year	0.00310***	0.00100***	0.00246***	0.00365***
	(9.12)	(3.44)	(4.55)	(7.24)
Constant	-5.323***	-1.657***	-4.156***	-6.260***
	(-8.75)	(-3.15)	(-4.36)	(-6.91)
Observations	864	1284	355	380
Number of id	43	61	18	19
R-squared	0.163	0.122	0.165	0192

Dependent variable: Growth rate of real per capita GDP (cly)

t-ratios in parentheses

*Significant levels: ***p<0.01, ** p<0.05, *p<0.1*

Having seen military spending to have consistently negative and significant results for both the natural resource and non-natural resource abundant countries, the next step is to consider if there are any differences in the type of resource. The resource abundant group is broken down into those that are resource rich in fuel and those rich in non-fuel minerals, giving the results in Column 3 and 4 respectively. These results show clear differences[26], the 18 fuel resource rich countries (Table 7, Column 3) show a significant short and long-run negative impact of military expenditure on

[26] The difference in sample size between the sum of the fuel and nonfuel minerals countries and the natural resource abundant countries are the countries that fit into the profile identified in footnote 22 and 23 above. The 6 countries are namely, Albania, Brazil, Bulgaria, Canada, India and Senegal.

growth, however, for the non-fuel minerals rich countries (Table 7, Column 4) military expenditure has no impact on economic growth. This result confirms the earlier notion that oil economies is seen as driving the results in the developed and middle income countries as well as the natural resource abundant countries.

The insignificant results of military burden on growth for the non-fuel resource rich countries further helps to build the unique sample of countries, whereby, due to their characteristics, they seem to be immune to the generally estimated negative impacts of military expenditure. Analysis into the sample of nineteen countries shows that the majority fall within the low-income grouping (eleven countries), while six fall into the medium-income group, with the remaining two categorised as high income countries. As identified in the results above, medium income countries (Table 4, Column 2) showed insignificant long-run effects of military spending on growth while its interaction with conflict experience provided insignificant results altogether. With this in mind, the same regression as shown in Table 7, Column 4 is run but, excluding all the medium income countries from the sample[27]. Remarkably, once the medium income countries were removed from the sample, the long-run (*lm1*) effect of military spending on economic growth is now negative and significant at the five percent level. Although the short-run (*clm*) effect remains insignificant, these results provides further proof that medium income countries are the unique sample of interest, with non-fuel resource abundance an extra characteristic to consider.

Moving to consider the possible impact of aid, Table 8 shows the estimation results for countries that received aid and those that do not receive aid. The sample of aid recipients are further divided into countries that receive low, medium and high amounts of aid. The division into sub-samples has allowed for the consideration of non-linearity, that has been identified in the growth literature, while simultaneously accounting for possible group heterogeneity within military spending. By considering different levels of aid it is possible to identify whether such differences could affect growth via the indirect relationship with military burden; thus a consideration of the non-fungibility issue. In this scenario aid feeds into military spending more for countries receiving higher levels of aid than the case for countries that received lower levels of aid. Such in-discretionary and unnecessary spending of aid on military, above the optimum, could theoretically result in military spending having a greater opportunity cost and thus hamper development. On the other hand, similar to the argument provided for natural resource abundance, aid could provide a buffer on the potential negative impacts of military spending.

The initial results from Column 1 and 2 of Table 8 reveal that irrespective of whether a country is a recipient of foreign aid military burden has a negative and significant short and long-run effect on growth. The estimation results from Columns 3, 4 and 5 – representing countries that receive

[27] Regression results are shown in table A2 in the appendix.

low, medium and high aid respectively – are striking. Military burden seems to have no effect on growth for countries that receive low levels of aid, while stark contrasts exist when compared to countries that receive medium and high levels of aid. For these two groups, military expenditure has a negative and significant impact on growth.

Table 8: The Growth Effects of Military Expenditure, Stratifying for Net Recipients of Aid

	1	2	3	4	5
Sample	Aid	No Aid	Low Aid	Medium Aid	High Aid
Variables	cly	cly	cly	cly	cly
clk	0.0300***	0.165***	0.151***	0.0384*	0.00607
	(3.82)	(13.45)	(10.23)	(1.88)	(0.59)
clm	-0.0305***	-0.0212***	-0.00839	-0.0377***	-0.0376***
	(-4.75)	(-3.02)	(-0.92)	(-2.67)	(-4.01)
lngdpop	-0.0427***	-0.0868***	-0.0908***	0.00642	-0.0326**
	(-3.87)	(-5.69)	(-5.6)	(0.16)	(-2.16)
ly1	-0.108***	-0.0692***	-0.105***	-0.213***	-0.103***
	(-10.43)	(-6.6)	(-5.2)	(-7.41)	(-7.36)
lk1	0.0171***	0.0468***	0.0260***	0.0358**	0.0102
	(2.85)	(5.35)	(2.77)	(2.22)	(1.24)
lm1	-0.0182***	-0.0171**	0.00617	-0.0251**	-0.0254***
	(-4.27)	(-2.51)	(0.97)	(-2.41)	(-4.07)
year	0.00270***	0.000968***	0.00256***	0.00306***	0.00295***
	(9.22)	(2.76)	(4.32)	(5.09)	(6.87)
Constant	-4.676***	-1.607**	-4.500***	-4.412***	-5.212***
	(-8.86)	(-2.52)	(-4.37)	(-4.32)	(-6.55)
Observations	1325	823	390	239	696
Number of id	65	39	19	12	34
R-squared	0.131	0.245	0.331	0.227	0.142

Dependent variable: Growth rate of real per capita GDP (cly)

t-ratios in parentheses

*Significant levels: ***p<0.01, ** p<0.05, *p<0.1*

Furthermore, the coefficients of military burden, both in the short (*clm*) and long-run (*lm1*), increase in size as the level of aid increases, reaching a threshold level, whereby afterwards the negative effect decreases[28]. The coefficients for the short-run effect of military burden is -0.0305 for

[28] The stratification method results in the inability to explicitly identify the threshold level. But, from the regression results suggest that the turning point is near the upper end of the medium aid recipient countries.

countries that receive aid[29], this increases to -0.0377 for the medium aid recipients, it then decreases marginally to -0.0376 for high aid recipients. The same trend can be observed with the long-run effect. As the above analysis has shown, the estimation results provide significant support for non-linear effects of military expenditure and aid on growth. Countries who receive higher amounts of aid tend to use it in an in-discretionary manner, thus leading to greater negative growth impacts through greater opportunity costs. One could point out that the estimation results hide significant amounts of endogeneity. It would be completely sensible to argue that countries receiving high levels of aid are often low income countries with poor institutions, and experienced conflict; while low aid recipients experience the opposite.

Before moving onto the final sample stratification, it is once again worthwhile to note that of the nineteen countries within the low aid recipient sample fourteen are from the medium income group; thus further reinforcing the earlier findings that this unique group of countries are the main drivers for the insignificant results seen in the coefficients of military spending.

Finally, the final impact of trade openness is considered. The sample stratification involves dividing the original sample into groups that are either classified as open or closed economies based on international trade. Estimation results from Table 9 show that military burden for open economies, in 2000 and 2009, is negative and significant. A similar conclusion can be made for the closed economies; military expenditure has a negative impact on economic growth, albeit only at the 10 percent level in the short-run for closed economies in the year 2000. A comparison of military expenditure coefficients shows that there is a larger negative impact of military expenditure on growth for open economies as opposed to closed economies. Furthermore, the mean estimates for military expenditure for the open economies in the years 2000 (Column 1) and 2009 (Column 3) are 2.79 and 2.8 percent respectively. These estimates are significantly greater than the sample of closed economies for the years 2000 (Column 2) and 2009 (Column 4), calculated to be 2.41 and 2.4 percent respectively. The majority of countries that were open in 2000 remain open in 2009, as is the case for the closed economies. The only shift in the openness position came from the countries China, Egypt and Uganda, which moved from closed in 2000 to open in 2009 and France, Greece, Italy and Sierre Leone; which moved from open in 2000 to closed in 2009.

Combining Table 9's results with the mean estimations provides evidence to support Rosh's (1988) hypothesis. Countries that are highly integrated in the global economy would find it easier to access finance for arms purchases, leading to higher military expenditure (Rosh, 1988). While the results suggest that, undeniably, there is a significant difference in the level military expenditure

[29] The insignificant effects of military spending for the low aid recipients means the inability to compare the coefficients with the medium and high aid recipients. By using the overall aid recipient in replacement of the low-aid recipients, similar conclusions can be drawn since the overall sample is a weighted average of all three aid recipient groups.

between open and closed economies, the most important finding is that regardless of the amount spent on arms or the level of trade liberalisation, military expenditure has a negative impact on economic growth. Moreover, the results even indicate that the greater amount of military expenditure, the higher the economic cost.

Table 9: The Growth Effects of Military Expenditure, Stratifying for Trade Openness

	1	2	3	4
Sample	Open 2000	Closed 2000	Open 2009	Closed 2009
Variables	cly	cly	cly	cly
clk	0.0358***	0.154***	0.0302***	0.162***
	(4.87)	(11.5)	(4.07)	(12.9)
clm	-0.0310***	-0.0146*	-0.0301***	-0.0181**
	(-5.24)	(-1.82)	(-5.15)	(-2.17)
lngdpop	-0.0454***	-0.0632***	-0.0675***	-0.0477***
	(-4.13)	(-4.69)	(-5.84)	(-3.72)
ly1	-0.105***	-0.0653***	-0.0823***	-0.120***
	(-11.26)	(-5.47)	(-9.5)	(-7.3)
lk1	0.0184***	0.0522***	0.0206***	0.0611***
	(3.27)	(5.42)	(3.73)	(5.98)
lm1	-0.0198***	-0.0112**	-0.0189***	-0.0129**
	(-4.48)	(-2.17)	(-4.3)	(-2.33)
year	0.00198***	0.00207***	0.00156***	0.00265***
	(7.19)	(6.23)	(5.56)	(7.74)
Constant	-3.171***	-3.906***	-2.607***	-4.571***
	(-6.44)	(-6.47)	(-5.16)	(-7.57)
Observations	1630	518	1610	538
Number of id	79	25	78	26
R-squared	0.115	0.315	0.103	0.345

Dependent variable: Growth rate of real per capita GDP (cly)

t-ratios in parentheses

*Significant levels: ***p<0.01, ** p<0.05, *p<0.1*

Following from considerations of non-linearity and group heterogeneity, the estimation results shows a surprising amount of consistency. The question of result robustness within the literature seems to have been answered. Apart from certain characteristics (medium-income, non-fuel resource rich and low aid recipients), where military spending has no effect on economic growth, the estimation results from Table's 3 to 9 point overwhelmingly in favour of military spending having a negative impact on growth for both the short and long-run. In the process of considering robustness, this paper has stumbled upon an interesting set of country characteristics which seems to have a profound impact on the relationship between military spending and economic growth.

4.1.3 Endogeneity: 2SLS & GMM

Having considered non-linearity and endogeneity this paper moves onto the final robustness check, namely, endogeneity. In order to account for the endogeneity or identification problem, two econometric methods are employed. The first method is a Two-Staged Least Squares (2SLS) approach, using Dunne and Perlo-Freeman (2003)'s model on the determinants of military spending, while the second method uses the system Generalised Method of Moments (GMM) estimator.

In the first method, using 2SLS, military spending is instrumented using three variables and thus resolving the identification problem and providing consistent estimators of the structural parameters. It must be noted that for an instrumental variable (IV) estimator to be consistent, the instrument z_i has to satisfy two conditions:

1. The instrument z_i must be exogenous or uncorrelated with the unobserved error term $\nu_{i,t}$ in equation (18):

$$Cov(z_i, v_{i,t}) = 0 \tag{23}$$

often referred to as the exclusion restriction.

2. The instrument z_i must be correlated with the endogenous regressor, in this case, military expenditure or x_1:

$$Cov(z_i, x_1) \neq 0 \tag{24}$$

As asserted by Wooldridge (2009) the 2SLS approach is the most efficient (IV) estimator. The 2SLS method splits the estimation of military spending on economic growth into two regressions. The first stage regression uses all the instruments (more than one exogenous variable) for military expenditure in order to obtain the 2SLS estimator (predicted values for military expenditure), where the instruments satisfy equations (23) and (24). Well chosen instruments should be an amalgamation of a range of economic, political and strategic determinants of military spending (Dunne and Perlo-Freeman, 2003).

The equation for the first stage regression is as follows:

$$\hat{x}_{1,j,t} = \sum_{j=1}^{2} \delta_j \ln z_{j,i,t} + \delta_1 s_{1,i,t} + \eta_t + \mu_i + \epsilon_{i,t} \; ; i = 1, 2, ..., N; t = 1, 2, ..., T \tag{25}$$

where z_1 is the log of Trade; z_2 is the log of External Threat; and s_1 is a measure for Democracy. The variables η_t and μ_i measure time and country effects while $\epsilon_{i,t}$ is the error term.

The second stage regression is identical to equation (18), except, instead of using, x_1, military expenditure is being represented by the predicted values $(\hat{x_1})$ obtained from the first stage regressions. Since the estimation issues within the 2SLS method is virtually identical to that of panel estimates, these problems are navigated via the same approach as described in the estimation section, namely dynamic panel method techniques using fixed effects (FE-2SLS).

There is a second method commonly used by researchers to identify the endogeneity problem; the first-difference GMM estimator. Initially proposed by Arellano and Bond (1991), the first-difference GMM accounts for endogeneity by taking the first differences of the dynamic growth regression in order to remove the unobserved country specific effects. The variables on the right-hand-side of the first-differenced equation is then lagged two periods or more and are used as instruments in the regression. However, the number of instruments used within GMM estimations have become an important econometric question since large amounts of instruments overfits endogenous variables which leads to potentially "*false*" results (Roodman, 2009). For the purposes of this paper the number of lags is limited to three; resulting in instruments that are less than the total number of groups (countries) within the full sample and potentially bypassing the problem of instrument proliferation and improving the efficiency of the first-differenced GMM estimations..

By taking the first-differences of the original dynamic growth equation (18), the first-differenced GMM equation can be written as follows:

$$\ln y_{it} - \ln y_{i,t-1} = \gamma \Delta \ln y_{i,t-1} + \beta_1 \Delta \ln k_{it} + \beta_2 \Delta \ln(n+g+d) + \beta_3 \Delta \ln m_{it} + \eta_t - \eta_{t-1} + \Delta \nu_{it} \tag{26}$$

$$for \;\; i = 1, 2, ...N; t = 3, ...T$$

As suggested by Hou and Chen (2012), there are three assumptions that needs to be satisfied before the first-differenced GMM estimates are consistent and efficient. The first assumption stipulates that the transient errors must be serially uncorrelated; $E[\nu_{it}, \nu_{is}] = 0 \; for \; i = 1, ...N$ and

$t \neq s$. Secondly, the initial conditions must satisfy $E[\ln y_{it}\nu_{is}] = 0 \; for \; i \geq 2$. The values of $\ln y_{it-2}$or earlier are correlated with $\Delta \ln y_{i,t-1}$ but not with the error term $\Delta\nu_{it}$, thus making the values of the $\ln y_{it}$ lagged two or more periods valid instruments within the first-differenced growth equation. Finally, GMM treats all the regressors ($\ln k_{it,}$ $\ln(n+g+d)$ and $\ln m_{it}$) as endogenous variables and would need to satisfy $E(\Delta\nu_{it}\gamma_{it-r} = 0)$; $E(\Delta\nu_{it}X_{it-r} = 0)$ where $r = 2, ..., t-1$ and $t = 3, ..., T$. By satisfying these assumptions, the values of all the endogenous regressors, lagged two periods or more, are all valid instruments.

Table 10 provides the estimations of the two econometric techniques on the full sample of countries. Beginning with FE-2SLS, the first stage estimates of military expenditure (*clm*) is constructed using three exogenous instruments, log of trade (*ltrade*), log of threat (*lthreat*) and democracy (*democracy*). The results of the first stage can be found in Table A3 in the appendix, where the three variables provide statistically significant results. Democracy has a negative and significant effect on military spending, indicating that democratic countries on average spend less on military than autocratic countries. The variable log of trade also has a negative effect on military spending, which is in-line with Rosh (1988) findings. Finally, log of threat, the main instrument of concern, has a positive and significant impact on military spending. The estimation results from the first stage regression are consistent with the determinants of military spending literature and that of previous attempts to find instruments for military spending. Before using the predicted values of military expenditure (*clm*) in the second-stage FE-2SLS equation the Hausman test needs to be performed in order to see whether the FE-2SLS approach is indeed preferred to the original panel estimates. With a p-value of 0.000, the Hausman test shows a strong rejection of the null hypothesis, indicating that the original panel is inconsistent and FE-2SLS method provides more consistent estimators.

The estimation results from the second stage FE-2SLS (Column 1, Table 10) is consistent with those from the previous section, with all the variables being of the expected sign. Capital stock has a positive and significant impact on economic growth while population and the lagged level of per capita GDP is negative and significant. Having accounted for endogeneity, military burden in the short run is negative and significant at the 10 percent level while military burden in the long-run is negative and significant at the 5 percent level. With the instrumented variables of military spending recording negative and significant effects on economic growth the next task is to run an over-identification test to test for the validity of the chosen instruments. The resultant p-value of 0.093 indicates an inability to reject the null hypothesis; the instruments are valid at the 10 percent significance level. It must be noted that the number of observations in the FE-2SLS drops to 1620 due to the threat variable only having data between the years 1988-2006.

Table 10: Growth Effects of Military Expenditure, FE-2SLS and GMM

	1	2	3
	FE-2SLS	A-B GMM	A-B GMM
Variables	All Countries	All Countries	All Countries
cly1		-0.1281***	-0.1184***
		(-3.81)	(-3.38)
clk	0.0335***	0.0443**	0.3004
	(4.67)	(2.19)	(1.42)
clm	-0.0526*	-0.0804***	-0.0687**
	(-1.72)	(-3.04)	(-2.28)
lngdpop	-0.0298***	-0.0286**	-0.0221*
	(-2.94)	(-2.36)	(-1.73)
ly1	-0.1449***	-0.5303***	-0.5499***
	(-13.91)	(-9.14)	(-9.31)
lk1	0.0266***	0.0577***	0.0425***
	(4.57)	(4.48)	(3.04)
lm1	-0.0083**	-0.0951***	-0.0801**
	(-2.34)	(-2.98)	(-2.24)
year	0.0036***	0.0090***	0.0100***
	(13.07)	(5.15)	(5.41)
Constant	-6.1908***	-13.7092***	-15.3753***
	(-12.31)	(-4.31)	(-4.59)
Observations	1620	1946	1441
R-Squared	0.157	-	-
Instruments		103	86
Wald Chi-Squared	-	271.03	219.80
Sargan Test (p-val)	0.093	0.331	0.231
A-Bond Test (p-val)	-	0.134	0.140

*Significant levels: ***p<0.01, ** p<0.05, *p<0.1*

t-ratios in parenthesis

The Arellano-Bond two step GMM estimator uses robust standard errors.

All independent variables are treated as endogenous and their lagged first-differences (3 lags) are used as instruments.

The null hypothesis in the Arellano-Bond test is no second order auto correlation in the residual.

A-Bond Test reports the p-value of the Arellano-Bond autocorrelation test

Table 10 also provides results from two separate Arellano-Bond GMM regressions. Column 2 presents the standard first-differenced GMM with three lags and Column 3 follows the same procedure but uses log of trade, democracy and log of threat as additional instrumental variables. Following the recommendations of Yaffee (2003), in the presence of heteroscedasticity, autocorrelation and endogeneity, this paper implements the GMM estimations with robust (White, Newy-West) panel standard errors.

Furthermore, as a matter of empirical consistency specification tests are performed to check the validity of the instruments in the GMM estimations. First, the Arellano-Bond autocorrelation test is performed to identify whether any second-order autocorrelation exists in the first-differenced residuals. A rejection the null hypothesis would prove that there is no second-order autocorrelation and the GMM estimator is consistent. The second specification test applied is the Sargan test for over-identification, this tests the null hypothesis of instrument validity, where a failure to reject the null hypothesis concludes that the instruments are valid. The final choice made on the first-differenced GMM specification is to choose between the one-step or two-step Arellano-Bond GMM estimator. While Arellano and Bond (1991) recommend using the one-step GMM estimator for coefficient inferences in the face of small sample sizes, the two-step procedure is asymptotically more efficient. In the case of the full sample (1946 and 1441 observations for Column 2 and 3 respectively) this paper believes it is large enough to implement the two-step GMM estimator. Thus the two-step Arellano-Bond GMM estimator is used for both coefficient inference and autocorrelation and instrument validity inference.

The initial estimates using the first-difference GMM estimator is shown in Table 10, Column 2. A total of 103 instruments are employed in the regression, one less than the number of groups within the sample, and thus satisfying the initial restriction. The dependent variable is growth in GDP per capita while all explanatory variables are expressed in first-differences and lagged first-differences. All the variables in Column 2 are statistically significant and have the expected signs, the first-differenced GDP per capita and the lagged first-difference of GDP per capita are negative, confirming the presence of conditional convergence. Moreover, the two capital stock variables and the time trend variable are positive and significant. The variable of concern, military spending, both in the short and long-run are negatively and significantly related to growth. These results, together with the non-rejection of the null in the Sargan over-identification and Arellano and Bond autocorrelation test, suggest that the first-difference Arellano and Bond GMM regression with endogenous regressors is in agreement with the previous findings in the dynamic panel fixed effects regression and also the FE-2SLS regression.

While the first-differenced Arellano and Bond estimates provide support to both the FE-2SLS and dynamic panel analysis, the results should be interpreted with care. As identified in Bond, Hoeffler and Temple (2001) the first-differenced GMM estimates are biased. The reason being an inability to distinguish between strong and weak instruments, thus instruments (first differences) that are initially thought to be strong are actually weak. The solution to this problem is to either use the system GMM estimator developed by Arellano and Bover (1995) and Blundell and Bond (1998) or strengthen the existing instrument set with variables that are not included in the regression. However, the difficulties in finding relevant and strong instruments for military expenditure has been regarded as one of the most challenging aspects within the literature, hence the numerous amounts of studies that employ system GMM as the alternative estimator. Since the instruments (log of trade, log of threat and democracy) used within the FE-2SLS regression performed quite well this paper shall attempt to supplement the existing set of instruments with these three additional instruments. Table 10, Column 3 displays the results of the first-differenced Arellano-Bond GMM estimators with additional instruments.

By introducing the variable democracy (*lthreat*) the number of observations decreases from Column 2's 1946 to 1441[30]. Furthermore, through first-differencing, the two-step Arellano-Bond GMM estimator discards information for two periods, hence the observation decline as compared to the FE-2SLS regression. The Arellano-Bond GMM estimator in Column 3 uses 86 instruments, which is less than the number of groups within the sample. Similar to the estimates in Column 2 the Arellano-Bond GMM estimators provide coefficient estimates of the expected sign and significance. The lagged dependent variable and the first-differenced lagged dependent variable are both negative and significant. The short-run feedback effect of capital stock is positive but insignificant while the long-run feedback effect is positive and significant. Population growth has a negative impact on economic growth, but this is only significant at the 10 percent level and the time trend is positive and significant. Military burden, after adding three extra instruments, remains negative and significant. The Sargan test for over-identifying restrictions (Table 10, Column 3) shows that the instruments chosen to identify military spending could not be rejected. As a further robustness check, the results in Column 3 were run using the same specified Arellano-Bond GMM regression but replacing the instrument (*lthreat*) with conflict. The rationale behind replacing the variable threat with conflict is to test whether the drop in observations between the two first-differenced GMM estimators is significantly different[31]. The results of this regression (Table A4, in Appendix) are consistent with the two GMM regressions in Columns 2 and 3; all the variables are of the expected sign and all are statistically significant, suggesting that the drop in observations between the two GMM estimators is not a cause for concern.

Having considered for potential non-linearity, group heterogeneity and endogeneity; it is an

[30] The drop in observations is due to the democracy variable being limited to the years 1988-2006.

[31] The choice of using conflict as the substitute IV stems from past research, whereby conflict has often been used by researchers to identify military spending.

ideal time to summarise the results from the Solow style regressions. There are essentially three main conclusions that can be made from these results. First, estimates for the military spending variables are remarkably robust (compared to the overall sample) after stratifying for different levels of income, development, conflict experience, natural resource abundance, aid and openness. Of the 29 regressions, 25 showed military spending to have a negative impact on economic growth, 4 estimated military spending to have no effect, while none suggest military spending to have a positive effect. Apart from the overwhelming evidence supporting the negative effect of military burden, the fact that, in general, there is no evidence to suggest a positive effect may have profound implications on both the validity of past research and the direction of future research.

The second important conclusion is the confirmation of the endogeneity problem. In the case of endogeneity, instrumental variables are needed to identify military spending, thus the FE-2SLS and the two-step Arellano-Bond GMM estimators are better suited for estimating the Solow growth model than dynamic panel estimators. Furthermore, the Hausman and Sargan tests confirm the validity and preference of the FE-2SLS and Arellano-Bond estimators. Although both estimators produce compatible results to the papers earlier estimates, the choice of which estimator is "best" for assessing the military spending growth relation is often up to the researcher. While, a FE-2SLS estimator that controls for heteroscedasticity and autocorrelation can be considered more efficient than the Arellano-Bond GMM estimator - which reduces observations through differencing –, a generalised method of moments estimator can improve in large samples over standard panel data methods such as the FE-2SLS (Wooldridge, 2001). Considering that the Arellano-Bond GMM estimator reduces the sample from 1620 (FE-2SLS) to 1441 observations – an insignificant drop in observations -, this paper has equal preference regarding the FE-2SLS or Arellano-Bond GMM as the most efficient and consistent estimator.

Finally, while the first two conclusions suggest uniformity in the effects of military spending and the need to account for endogeneity in future estimates, the third conclusion is the most intriguing and potentially provides the most likely avenue to future research. By stratifying the overall sample into different groups, unique results emerged, suggesting that for certain types of countries, military spending has no significant impact on growth. These countries are classified as either medium-income, medium-income with conflict experience, non-fuel resource rich or low aid recipients. While the cross-country studies provided within this paper provide valuable robustness checks and support the view that military spending adversely affects growth, if researchers are to fully understand the dynamics regarding the military spending growth relation, country-based case-studies would need to be considered.

5 CONCLUSION

Military spending by governments is indeed important in the influence it has, especially when it leads to or facilitates conflict. As a result the economic impact of such spending is of great concern. Using the most comprehensive post-Cold War dataset for the period 1988-2010, this paper continues the exploration into the military spending and economic growth literature using the modelling framework suggested by Dunne et al (2005). The prime objective of this paper is to investigate the robustness of the results within the military spending growth relation by considering possible sample non-linearities, heterogeneities and endogeneity. The estimation results using the dynamic first order model with fixed effects provide surprisingly strong support for the negative impact of military burden on growth for both the short and long-run.

When countries were grouped into developed and developing, only the long-run effect for developed countries was insignificant. Consistent results are observed when countries are divided into three income groups, with the short-run coefficient (change in the log of military spending) estimate negative and significant for all three groups and the long-run coefficient (lagged level of military spending) estimate negative and significant for the low and high-income groups.

While military expenditure on growth for conflict and non-conflict affected countries was both negative and significant, the expected differences in the effects of military spending on growth in civil and interstate wars was not apparent. Surprisingly, when the sample is divided to consider the type of conflict, both civil and interstate war groups showed military spending to have a negative and significant effect on growth[32]. Further stratification of the conflict sample by income led to insignificant results for medium income countries while military burden remained negative and significant for the low and high-income countries. It has been seen that conflict experience (civil and interstate war) since 1988 has affected a wide range of countries and regions. With this in mind; these results suggests that military spending, in conjunction with conflict, irrespective of type or location, dampens economic growth.

The results from stratifying for conflict and income potentially provides some important implications for future development prospects. For countries that experienced conflict, the aftermath is often a process of post-conflict reconstruction. It is through this process of reconstruction that most likely leads to cuts in military spending. Thus the obvious question to economists or politicians is the economic impact of this cut in military spending. The estimation results presented in this paper firmly suggest that cutting military spending is generally a good thing, by diverting resources

[32] Albeit, only at the 10 percent level for the short-run interstate war sample.

away from military to more developmental orientated goals, the outcome would potentially be an increase in economic growth.

Similarly, consistent results in support of the above hypothesis were found when countries were stratified by their natural resource endowment, aid dependence and trade openness. However, just as with the income and conflict groupings, discoveries were made on unique groups of countries - non-fuel resource rich or low aid recipients - where military spending had no impact on economic growth. Furthermore, once medium-income countries were removed from the non-fuel resource rich group[33] the long-run effect of military spending became negative and significant. These results, while minor, support the initial group stratification findings, where long-run military burden had no effect on growth within developed, medium-income, or medium-income with conflict experience countries.

Having witnessed consistent results from the robustness checks of non-linearity and group heterogeneity a final robustness check - on endogeneity - is implemented using FE-2SLS and Arellano-Bond GMM estimators. The estimation results of the overall sample conform to estimates seen throughout this paper; military expenditure has a negative and significant effect on economic growth. Moreover, the Hausman and Sargan test confirm the existence of endogeneity, validating the FE-2SLS and Arellano-Bond GMM as the preferred estimators. Through the process of creating a structural model, to identify the exogenous determinants of military spending, this paper came across a set of variables (democracy, threat, trade and conflict) that together seemed to be valid instruments for military spending. While the task of identifying military spending is far from complete the work done in this paper will no doubt help point future researchers in the right direction in terms of choosing valid instruments and econometric techniques.

The empirical results in this paper provide valuable robustness checks and support strongly the view that military expenditure has an adverse effect on economic growth. Through the use of post-Cold War data and the development of better estimation models and econometric techniques, it is possible to see this outcome developing as a consensus view. However, while a compelling conclusion can be drawn across countries, issues do remain. For certain groups of countries (i.e. middle-income, non-fuel resource rich and low aid recipients) military spending was found to have no impact on growth. However, one could argue that a more compelling finding was no evidence suggesting military spending as having any significant positive effects.

Considering the above mentioned conclusions, a potential extension to this paper is to individually estimate the sample countries and by taking the average of the individual estimates; conclusions can be drawn both at a country and general level. Moreover, this paper recommends researchers

[33] Similar technique was not possible for the low aid recipients due to insufficient observations.

to recognise the importance of issues regarding non-linearity, group heterogeneity and endogeneity. Future focus should be to either find other variables that can instrument for military spending, create structural models (endogenous growth model) to identify military spending, or consider case-studies to investigate the unique set of countries where military spending seems to have no effect on economic growth.

6 REFERENCE

Abu-Qarn, A. S. (2010) The Defence-Growth Nexus Revisited: Evidence From the Israel-Arab Conflict. *Defence and Peace Economics,* **21**(4) 291-300.

Aizenman, J. and Glick, R. (2006) Military Expenditure, Threats and Growth. *Journal of International Trade and Economic Development,* **15**(2) 129-155.

Alexander, W. Robert. J. (1995) Defence Spending: Burden or Growth-Promoting? *Defence and Peace Economics,* **6** 13-25.

Antonakis, N. (1999) Guns versus Butter: A Multisectoral Approach to Military Expenditure and Growth with Evidence from Greece, 1960-1993. *Journal of Conflict Resolution,* **43** 501-520.

Arellano, M. and Bond, S. (1991) Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations. *Review of Economic Studies,* **58**(2) 277-297.

Benoit, E. (1973) *Defense and Growth in Developing Countries.* Boston, MA: Heath, Lexington Books.

Benoit, E. (1978) Growth and Defense in Developing Countries. *Economic Development and Cultural Change,* **34**(2) 261-275.

Biswas, B. and Ram, R. (1986) Military Expenditure and Economic Growth in the Less Developed Countries: An Argument Model and Further Evidence. *Economic Development and Cultural Change,* **34**(2) 261-275.

Bond, S., Hoeffler, A. and Temple, J. (2001) GMM Estimation of Empirical Growth Models. *Economic Papers 2001-W21*, Economics Group, Nuffield College, University of Oxford.

Brauer, J. (2002) The Arms Industry in Developing nations: History and Post-Cold War Assessment. In *Arming the South: The Economics of Military Expenditure, Arms Production and Trade in Developing Countries,* edited by J. Brauer and J.Paul. Dunne. Palgrave, 101-127.

Brauer, J. and Dunne, Paul. J. (2010) Macroeconomics and Violence. In *Handbook on the Economics of Conflict, Chpater 14,* edited by D. Braddon and K. Hartley. Cheltenham, UK: Elgar.

Burnside, C. and Dollar, D. (2000) Aid, Policies and Growth. *The American Economic Review,* **90**(4) 847-868.

Chan, S. (1987) Military Expenditures and Economic Performance. In *World Military Expenditures and Arms Transfers.* US Arms Control and Disarmament Agency, US Govt Printing Office.

Collier, P. (1999) On the Economic Consequences of Civil War. *Oxford Economic Papers,* **51** 168-183.

Collier, P. and Hoeffler, A. (2004) Greed and Grievance in Civil War. *Oxford Economic Papers,* **56(**4) 563-595.

Collier, P. and Hoeffler, A. (2006) Military Expenditure in Post-Conflict Societies. *Economics of Governance,* **7**(1) 89-107.

Dunne, Paul. J. (1996) Economic Effects of Military Expenditure in Developing Countries: A Survey. In *Making Peace Pay,* edited by N. P. Gleditsch. Claremont, CA: Regina Books, 15.

Dunne, Paul. J. (2012) Military Spending, Growth, Development and Conflict. *Defence and Peace Economics,* iFirst Article 1-9.

Dunne, Paul. J., and Coulomb, F. (2009) Peace, War and International Security: Economic Theories. In *War Peace and Security,* edited by J. Fontanel and M. Chatterji. Emerald: Bingley, 13-36.

Dunne, Paul. J., Nikolaidou, E. and Smith, R. (2002) Military Spending, Investment and Economic Growth in Small Industrialising Economies. *South African Journal of Economics,* **70**(5) 789-790.

Dunne, Paul. J., Smith, R. and Willenbockel, D. (2004) Theoretical and Econometric Issues in Analysing the Military Expenditure-Growth Nexus. *Mimegraph.* Available at http://carecon.org.uk/Armsproduction/Papers/DirkPaulRonpap3.pdf.

Dunne, Paul. J., Smith, R. and Willenbockel, D. (2005) Models of Military Expenditure and Growth: A Critical Review. *Defence and Peace Economics,* **16**(6) 449-461.

Dunne, Paul. J. and Smith, R. (2010) Military Expenditure and Granger Causality: A Critical Review. *Defence and Peace Economics,* **21**(5-6) 427-441.

Dunne, Paul. J. and Uye, M. (2010) Military Spending and Development. In *The Global Arms Trade,* edited by A. Tan. London: Routledge.

Dunne, Paul. J. and Tian, N. (2013) Military Spending and Growth in Developing Economies: A Survey. *Forthcoming 2013 in Economics of Peace and Security.*

Dollar, D. and Kraay, A. (2004) Trade, Growth and Poverty. *Economic Journal,* **114**(493) 22-49.

Easterly, W., Levine, R. and Roodman, D. (2004) Aid, Policies, and Growth: Comment. *The American Economic Review,* **94**(3) 774-780.

Edwards, S. (1998) Openness, Productivity and Growth: What Do We Really Know? *Economic Journal,* **108** 383-389.

Farzanegan, M. R. (2012) Military Spending and Economic Growth: The Case of Iran. *Defence and Peace Economics,* 1-23.

Feder, G. (1983) On Exports and Economic Growth. *Journal of Development Economics,* **12** 59-73.

Feder, G. (1986) Growth in Semi-Industrial Countries: A Statistical Analysis. In *Industrialization and Growth: A Comparative Study,* edited by H. Chenery, S. Robinson, and M. Syrquin. New York: Oxford University Press, 263-282.

Frankel, Jeffrey. A. and Romer, D. (1999) Does Trade Cause Growth? *The American Economic Review,* **89**(3) 379-399.

Gleditsch, N. P., Cappelen, A., Bjerkholt, O., Smith, R. and Dunne, Paul. J. (edited) (1996). In *The Peace Dividend,* Amsterdam, North Holland.

Habibullah, M. S., Law, S. H. and Dayang-Affizzah, A. M. (2008) Defense Spending and Economic Growth in Asian Economies: A Panel Error Correction Approach. *MPRA Paper,* **12105.**

Hagland, D. (2011) Blessing or Curse? The Rise of Mineral Dependence Among Low-and Middle-Income Countries. Oxford Policy Management. Oxford, UK.

Hansen, H. and Tarp, E. (2000) Aid Effectiveness Disputed. *Journal of International Development,* **12**(3) 375-398.

Herbst, J. (1991) War and the State in Africa. *International Security,* **14**(4) 117-139.

Hirnissa, M. T., Habibullah, M. S. and Baharom, A. H. (2009) Military Expenditure and Economic Growth in Asean-5 Countries. *Journal of Sustainable Development,* **2**(2) 192-202.

Hou, N. and Chen, Bo. (2012) Military Expenditure and Economic Growth in Developing Countries: Evidence from System GMM Estimates. *Defence and Peace Economics.*

Huang, C. and Mintz, A. (1991) Defence Expenditures and Economic Growth: The Externality Effect. *Defence Economics* **3** 35-40.

Islam, N. (1995) Growth empirics: A panel data approach. *Quarterly Journal of Economics,* **110**(4) 1127–1170.

Keller, K., Poutvaara, P. and Wagener. A. (2009) Military Draft and Economic Growth in OECD Countries. *Defence and Peace Economics,* **20**(5) 373-393.

Knight, M., Loayza, N. and Villanueva, D. (1996) The peace dividend: Military spending cuts and economic growth. *IMF Staff Papers* **43** 1–44.

Malizard, J. (2012) Opportunity Cost of Defense: An Evaluation in the Case of France. *Defence of Peace Economics,* 1-13.

Mankiw, Gregory. N., Romer, D. and Weil, David. N. (1992) A Contribution to the Empirics of Economic Growth. *The Quarterly Journal of Economics,* **107**(2) 407-437.

Murdoch, J., Pi, C. and Sandler. T. (1997) The impact of defense and non-defense public spending on growth in Asia and Latin America. *Defence and Peace Economics*, **8**(2) 205-224.

Nikolaidou, E. (1999) Military Spending and Economic Growth in Greece: A Multi-Sector Analysis, 1961-1996. *Middlesex University Business School Economics Discussion Paper* No.72.

Ozsoy, O. (2008) Defence Spending and the Macroeconomy: The Case of Turkey. *Defence and Peace Economics,* **19**(3) 195-208.

Pieroni, P. (2007) Military Spending and Economic Growth. *Discussion Papers* **0708**, University of the West of England, Department of Economics.

Parlow, A. (2009) Economic Growth. Defense Spending and Conflict: A Case Study of the US. *Mimegraph.* Available at https://pantherfile.uwm.edu/aparlow/www/papers/conflict_1.pdf

Ram, R. (1995) Defense Expenditure and Economic Growth. In *Handbook of Defense Economics,* edited by K. Hartley and T. Sandler. Amsterdam: Elsevier, 251-273.

Rodriguez, F. and Rodrik, D. (2000) Trade Policy and Economic Growth: A Skeptic's Guide to the Cross-National Evidence. In *Macroeconomics Annual 2000,* edited by B. Bernanke and K, Rogoff. MIT Press for NBER.

Romer, P. (1989) Capital Accumulation in the Theory of Long Run Growth. In *Modern Business Cycle Theory,* edited by R.J. Barro. Cambridge, MA: Harvard University Press, 51-127.

Roodman, D. (2009) A Note on the Theme of Too Many Instruments. *Oxford Bulletin of Economics and Statistics,* **71**(1) 135-158.

Rosh, Robert. M. (1988) Third World Militarisation: Security Webs and the States they Ensnare. *Journal of Conflict Resolution,* **32**(4) 671-698.

Sandler, T. and Hartley, K. (1995) Introduction. In *Handbook of Defense Economics,* edited by T. Sandler and K. Hartley. Elsevier, 1-11.

Sarr, M., Bulte, E., Meissner, C., and Swanson, T. (2011) On the Looting of Nations. *Public Choice,* **148** 353-380.

SIPRI (Stockholm International Peace Research Institute), various years. *Yearbooks World Armament and Disarmament,* Oxford: Oxford University Press.

Smaldone, Joseph. P. (2006) African Military Spending: Defense versus Development? *African Security Review.* **15**(4) 18-32.

Smith, R. (2000) Defence Expenditure and Economic Growth. In *Making Peace Pay: A Bibliography on Disarmament and Conversion,* edited by N.P. Gleditsch, G. Lindgren, N. Mouhleb, S. Smit and I. de Soysa. Claremont, CA: Regina Books, 15-24.

Smith, J. S. and Tuttle, M. H. (2008) Does Defense Spending Really Promote Aggregate Output in the United States? *Defence and Peace Economics.* **19**(6) 435-447.

Solow, Robert. M. (1956) A Contribution to the Theory of Economic Growth. *The Quarterly Journal of Economics*, **70**(1) 65-94.

Ward, Michael. D., Davis, David. R., and Chan, S. (1993) Military Spending and Economic Growth in Taiwan. *Armed Forces and Society* **19**, 533-50.

Wooldridge, Jeffery. M. (2009) Introductory Econometrics: A Modern Apporach 4th Ed. South-Western, Cengage Learning.

Yaffee, R. (2003) *Connect: Information Technology at NYU,* Available at http://www.nyu.edu/its/socsci/Docs/pda.pd

Yakovlev, P. (2007) Arms Trade, Military Spending, and Economic Growth. *Defence and Peace Economics,* **18**(4) 317-338.

Yang, A. J.F., Trumbull, W. N., Chin Wei Yang, C. W. and Huang, B. N. (2010) On the Relationship Between Military Expenditure, Threat and Economic Growth: A Nonlinear Approach. *Defence and Peace Economics,* DOI: 10.1080/10242694.2010.497723.

Yanikkaya, H. (2003) Trade Openness and Economic Growth: A Cross-Country Empirical Investigation. *Journal of Development Economics,* **72** 57-89.

Yilgor, M., Karagol, E. T. and Saygili, C. A. (2012) Panel Causality Analysis Between Defence Expenditure and Economic Growth in Developing Countries. *Defence and Peace Economics,* 1-11.

7 APPENDIX

7.1 TABLES

Table A1: List of countries in full sample

Africa	**N & S. America**	**Asia & Oceania**	**Europe**	**Middle East**
Algeria	Argentina	Australia	Albania	Bahrain
Angola	Belize	Bangladesh	Austria	Egypt
Botswana	Bolivia	Brunei	Belgium	Iran
Burkina Faso	Brazil	Cambodia	Bulgaria	Israel
Burundi	Canada	China, P. R.	Cyprus	Jordan
Cameroon	Chile	Fiji	Denmark	Kuwait
Djibouti	Colombia	India	Finland	Lebanon
Ethiopia	Dominican Rep.	Indonesia	France	Oman
Ghana	Ecuador	Japan	Germany	Saudi Arabia
Kenya	El Salvador	S. Korea	Greece	Syria
Lesotho	Guatemala	Malaysia	Hungary	
Madagascar	Jamaica	Mongolia	Ireland	
Malawi	Mexico	Nepal	Italy	
Mali	Nicaragua	New Zealand	Luxemborg	
Mauritania	Panama	Pakistan	Malta	
Mauritius	Paraguay	P. New Guinea	Netherlands	
Morocco	Peru	Philippines	Norway	
Mozambique	United States	Singapore	Poland	
Namibia	Uruguay	Sri Lanka	Portugal	
Rwanda	Venezula	Thailand	Romania	
Senegal			Russia	
Seychelles			Spain	
Sierre Leone			Sweden	
South Africa			Switzerland	
Swaziland			Turkey	
Tansania			UK	
Tunisia				
Uganda				

Table A2: The Growth Effects of Military Expenditure, Stratifying for Natural Resource: Removing Medium Income Countries

	1
Sample	Non-Fuel
Variables	cly
clk	0.0436***
	(2.70)
clm	-0.0022
	(-1.24)
lngdpop	-0.0208
	(-1.28)
ly1	-0.1713***
	(-6.68)
lk1	0.0369***
	(2.48)
lm1	-0.0203**
	(-2.07)
year	0.0039***
	(6.06)
Constant	-6.6339***
	(-5.60)
Observations	260
Number of id	13
R-squared	0.227

Dependent variable: Growth rate of real per capita GDP (cly)

Standard Errors in parentheses

*Significant levels: ***p<0.01, ** p<0.05, *p<0.1*

Table A3: First Stage for Endogenous Variable *(clm)*

	1
	All Countries
Variables	clm
ltrade	-0.1448***
	(-9.79)
Democracy	-0.0132***
	(-5.04)
lthreat	0.1373***
	(2.93)
Constant	4.3972***
	(12.16)
Observation	1768
R-Squared	0.106
Hausman Test (p-value)	0.000
Over-identifying Restrictions (p-value)	0.093

Dependent variable: Growth rate of military expenditure (clm)

Standard Errors in parentheses

*Significant levels: ***p<0.01, ** p<0.05, *p<0.1*

Table A4: Growth Effects of Military Expenditure, GMM

	1
	A-B GMM
Variables	All Countries
cly1	-0.1152***
	(-3.74)
clk	0.0435**
	(2.28)
clm	-0.0715**
	(-2.54)
lngdpop	-0.0225
	(-1.56)
ly1	-0.5503***
	(-9.58)
lk1	0.0553***
	(3.83)
lm1	-0.0832***
	(-2.58)
year	0.0098***
	(5.41)
Constant	-14.8818***
	(-4.56)
Observations	1829
R-Squared	-
Instruments	87
Wald Chi-Squared	226.39
Sargan Test (p-val)	0.500
A-Bond Test (p-val)	0.151

*Significant levels: ***p<0.01, ** p<0.05, *p<0.1*

t-ratios in parenthesis

The Arellano-Bond two step GMM estimator uses robust standard errors.

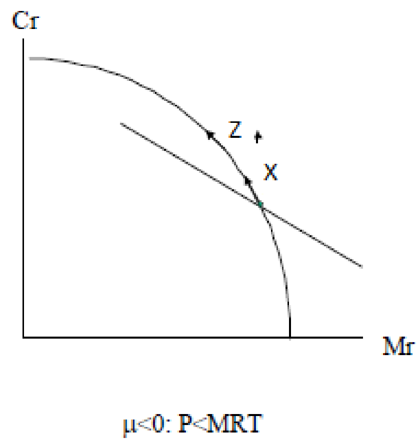
All independent variables are threated as endogenous and their lagged first-differences (3 lags) are used as instruments.

The null hypothesis in the Arellano-Bond test is no second order auto correlation in the residual.

A-Bond Test reports the p-value of the Arellano-Bond autocorrelation test

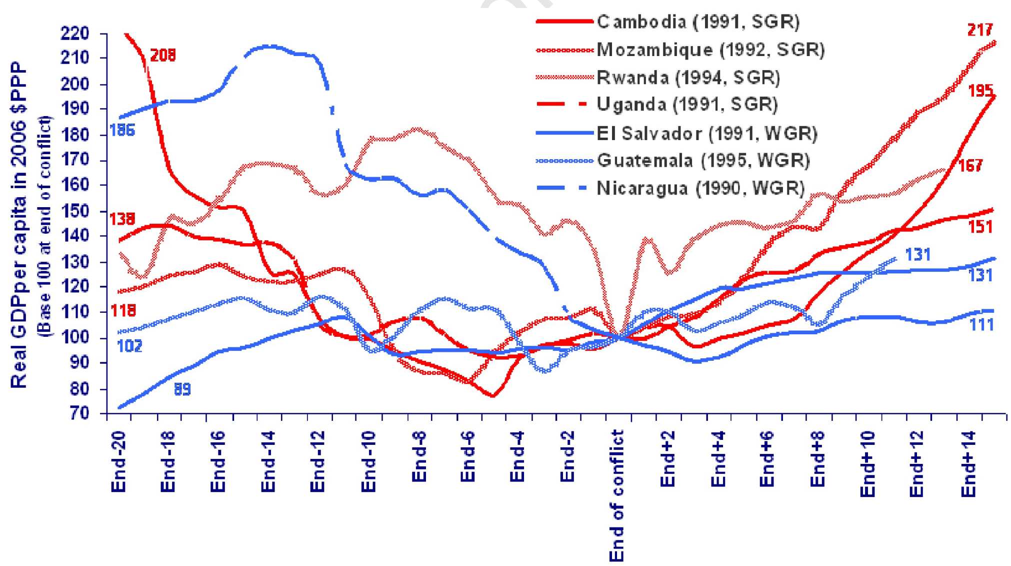
7.2 FIGURES

Figure A1: Production of civilian vs. military goods in a production possibility frontier.



Source: Dunne et al (2004, p. 8, Figure 1)

Figure A2: GDP per captia im selected civil war states.



Source: UNDP (2008, p. 111, Figure 4.2).