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# **Military Expenditure and Economic Growth: A Meta-Analysis**

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# Military Expenditure and Economic Growth: A Meta-Analysis\*

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## Abstract

Meta analysis is conducted to review 32 empirical studies with 169 estimates to find the combined overall effect of military expenditure on economic growth. Using a meta fixed and random effects and regression analysis, our results show that there exists a “genuine” net effect of military expenditure on economic growth. The net combined effect is positive, and the magnitude is very small. The main sources of study-to-study variation in the findings of military expenditure and economic growth literature are attributable to the sample, time periods, and functional forms.

**JEL Classification:** C42, H5, O11, 041, 047

**Keywords:** military expenditure, economic growth, meta analysis

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# 1 Introduction

The effect of military expenditure on the economy is a controversial area of research among economists. There are several channels defined through which military expenditure may affect economic growth. Conceptually, each perspective may lead to different conclusions and thus the net effect is ambiguous. The issue then is an empirical one. However, the empirical findings have not produced a conclusive result either: their conclusions are that the effect may be negative or positive or insignificant.

Since late 1970s there has been a substantial research in this area. Arguably, the general view has been that even if there are positive effects, these effects would be offset by negative ones. Broadly defining, on the one hand there are security-related positive effects on economic factors and supply-side spillovers; on the other hand there is the negative effect of diverting resources away from the civilian economy.

This paper is the first to provide a substantial quantitative survey of military expenditure and economic growth literature by conducting a meta regression analysis.<sup>1</sup> Deger and Sen (1995), Ram (1995) and Dunne (1996) offer a detailed survey of the military expenditure-economic growth literature and conclude that the effect of military expenditure on economic growth varies depending on the design of empirical strategy. However, formally it has not been specified which are the factors that lead to differences among military expenditure-growth studies. Meta-analysis is a statistical tool that allows for a systematic analysis of diverse empirical findings, while accounting for differences among reported results of individual studies. In this paper, a meta-analysis technique is conducted to find an overall, statistically valid conclusion among the reported results of the military expenditure-economic growth literature.

There are two further important issues which are addressed in this survey: first, whether there exists a “genuine” relationship (to be defined) between military expenditure (milexp henceforth) and economic growth. Second, to examine the sources of variations in the milexp-growth literature. One can define the sources of variations into three sub categories; firstly, the choice of theoretical models, which provide the basis of the empirical channel to be tested i.e. demand-supply side, supply side, ad hoc and so forth; secondly, the design of the empirical study, i.e. sample, time

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<sup>1</sup>Nijkamp and Poot (2004) survey the studies that have examined the effect of disaggregated government expenditure on economic growth using a meta-analysis approach. The studies on the effect of military expenditure on economic growth are also included in the analysis. However, not only a few studies are included in the analysis, but also the meta-analysis used differs from the one conducted in this paper. Besides, their conclusion is that the net effect of military expenditure on economic growth is negative.

period and estimation technique; and finally the other control variables included. Thus, the aim is to account for all these study-to-study differences and quantify the net overall effect.

The paper is organised as follows. Section 2 provides an overview of conceptual considerations with the empirical specifications. This follows with a discussion of the primary studies included in the meta-regression in section 3. Section 4 summarizes the meta-analysis methodology and uses fixed and random effects and meta-regression analysis to assess the military expenditure-growth literature. Finally, section 5 presents some conclusions and suggestions for future research.

## 2 Main Conceptual and Econometric Approaches

Since 1990s, there is much discussion about the composition of government expenditure and which components of government expenditure are growth-enhancing. In effect, the impact of disaggregated government spending on growth is commonly studied, which includes *milexp*, see Aschauer (1989), Easterly and Rebelo (1993), Devarajan *et al.* (1996), Mulas-Granados *et al.* (2002), Bose *et al.* (2007). However, each segment of government spending may have varying effects on the long-run economic growth. Arguably the emerging view from these studies is that education, infrastructure and capital expenditure are among those with positive effect. These are commonly referred as the *productive* component of government expenditure. By and large, theoretically and empirically, the effect of *milexp* is expected to be negative.

Nevertheless, as already noted, the economic effects of *milexp* are too complex to draw a general consensus; *a priori*, the effect can go either way. There are many factors contributing to this such as the theoretical frameworks underlying the empirical studies. To obtain insight, three commonly conducted empirical specifications together with the theoretical frameworks are briefly reviewed in this section: namely the neo-classical supply-side model of Feder-Ram; the Keynesian demand and supply model; and Barro-type growth regressions. We discuss these in turn.

### 2.1 The Three Approaches

Feder (1983) develops a model to evaluate effects of import and export sectors' on growth. This model is extended by Ram (1986) and Biswas and Ram (1986) to look at defence and non-defence sectors and their impact on growth. This approach is developed to investigate the claims related to the positive externality effect of *milexp* on growth.<sup>2</sup>

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<sup>2</sup>Although this is one the main approaches used in this literature, the primary studies that apply this method are not included in the quantitative analysis due to the reasons discussed later in the paper.

The model assumes that there are two sectors in the economy, civilian ( $C$ ) and defence ( $M$ ). The inputs in both industry are labour ( $L$ ) and capital ( $K$ ) which are allocated to each sector. The production functions for each sector are:

$$M = M(L_M, K_M) \quad C = C(L_C, K_C, M)$$

The output of the economy is  $Y = M + C$ . The model also assume that the marginal productivities of capital and labour in each sector might differ:

$$\frac{M_K}{C_K} = \frac{M_L}{C_L} = 1 + \delta$$

In essence,  $\delta > 0$  implies that capital and labour inputs are more productive in the defence sector. Using this model, there are two issues that could be tested, namely a positive externality effect and question of whether resources are more productive in the defence sector or not. Two empirical specifications are used in the empirical literature of Feder-Ram model, one of which is:

$$\dot{Y} = \alpha \frac{\dot{I}}{Y} + \beta \dot{L} + \left( \frac{\delta}{1 + \delta} - \theta \right) \frac{M}{Y} \dot{M} + \theta \dot{M}$$

where a variable with dot notation is a rate of growth of the variable.  $\theta = C_M(\frac{M}{Y-M})$  is the elasticity of civilian output, ( $C$ ), with respect to military output, ( $M$ ), and  $C_M$ , the marginal product of military output, indicates the externality effect. Therefore, if  $C_M$  and  $\delta$  are positive, the effect of milexp on growth is expected to be positive. This model has been used by many; Alexander (1990), Atesoglu and Mueller (1990), Huang and Mintz (1991), (Ward and Davis, 1992), Cuaresma and Reitschuler (2004), among others. However Dunne *et al.* (2005) suggest that there are important shortcoming of the model in terms of the interpretation of results as well as econometric techniques.<sup>3</sup>

Although, there may be positive direct effects on the economy, either as a result of the positive spillovers or through a Keynesian aggregate demand model (Deger, 1986), there is the opportunity cost of milexp or the crowding-out effect. This argument is broadly associated with the limited resources being allocated to a sector that creates forgone opportunities in the other sector(s). Therefore, this effect is seen as the indirect negative effect of milexp on other government expenditure and the main argument evolves around the negative effect on total investment. Deger and Smith (1983) and Deger (1986) suggest a simultaneous equations model (SEM) that considers both supply and demand effects of milexp and allows for the assessment of direct and indirect effects of milexp on the civilian economy. In other words, due to the interrelation between growth, milexp

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<sup>3</sup>For a thorough discussion on Feder-Ram model see Dunne *et al.* (2005).

and investment, the application of a single-equation methodology is limited since it does not allow for quantifying the total effect of milexp on growth. A general model given here is a four-equations SEM:

$$\begin{aligned}
g_{it} &= a_0 + a_1 s_{it} + a_2 m_{it} + a_3 B_{it} + \sum_j \alpha_j^g x_{j,it}^g + u_{it}^g \\
s_{it} &= b_0 + b_1 m_{it} + b_2 g_{it} + b_3 B_{it} + \sum_k \alpha_k^s x_{k,it}^s + u_{it}^s \\
B_{it} &= c_0 + c_1 m_{it} + c_2 g_{it} + \sum_l \alpha_l^B x_{l,it}^B + u_{it}^B \\
m_{it} &= d_0 + \sum_n \alpha_n^m x_{n,it}^m + u_{it}^m
\end{aligned}$$

where  $g$  is the growth rate of income per capita,  $s$  is the saving ratio,  $m$  is the share of milexp in GDP,  $B$  is the trade balance,  $x$  denotes a set of predetermined variables in each equation, and  $u$  is the error term, (Deger and Sen, 1995). Based on this analysis the positive effect is through the coefficient,  $a_2$  and then the milexp variable in the second and third equations would allow to assess the indirect effect, which is expected to be negative. Deger (1986) argues that an increase in milexp might result in higher inflation or an increase in taxation and this in effect may result negative effect on investment. The negative effect on investment has knock-on effect on growth. There are a number of studies that applied SEM; see for instance Deger and Sen (1983), Deger (1986), Lebovic and Ishaq (1987), Gyimah-Brempong (1989), Dunne and Mohammed (1995) Galvin (2003).<sup>4</sup>

Finally, considerable empirical studies of milexp-growth apply some variant of Barro-type growth specifications.<sup>5</sup>

$$g_{it} = a_0 + a_1 m_{it} + \sum_j \alpha_j x_{j,it} + \sum_k \alpha_k z_{k,it} + u_{it}$$

where  $g$  is the growth rate of income per capita and  $m$  is the ratio of milexp to GDP.  $x_j$  is a set of common variables used in the economic growth literature and has theoretical foundations: these are investment, initial level of income, population growth and education.  $z_k$  is a set of variables of interest in milexp-growth literature such as square of milexp, dummy for war, threat and so on. This specification is commonly used in general growth literature. This reformulation of the

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<sup>4</sup>There are also numerous studies that focus on a potential feedback effect from growth to milexp using atheoretical models, such as Granger-causality and more recently vector autoregression models. Unlike the simultaneous-equation models, they do not impose *a priori* any causal relationship among milexp and growth. See for instance Joerding (1986), Chowdhury (1991) Dakurah *et al.* (2001), Abu-Bader and Abu-Qarn (2003), Dunne and Nikolaidou (2005), among others. For detailed discussion see Dunne and Smith (2010).

<sup>5</sup>Some also apply the augmented Solow growth model, such as Knight *et al.* (1996), and Yakovlev (2007).

Barro model is used by Brumm (1997), Stroup and Heckelman (2001), Aizenman and Glick (2006), Yakovlev (2007), among others.

## 2.2 Criteria for selecting the empirical studies for the meta-analysis

In selecting the studies to be included in the meta-analysis of milexp and growth literature we use the following criteria: (i) The studies considered in the meta-analysis are those which look at the direct effect of milexp on economic growth; in which milexp is measured as the percentage of GDP and in the regression analysis, the dependent variable is economic growth and the independent variable is milexp. Thus, studies that use the growth rate of milexp as a regressor are left out, i.e. Feder-Ram and Granger causality based studies. Furthermore, as discussed above, studies may have taken different channels to analyse direct and indirect effects of milexp on the economy. Although, the studies that apply a simultaneous equations model are included in the analysis, it was not possible to consider the net effect from these studies. As a result, the direct effect is used in the analysis. (ii) Both published or unpublished studies are used in this analysis. Arguably, it is expected that there are relatively small errors in peer-reviewed studies, and therefore these studies are somehow preferred in the meta-analysis. However, this selection criteria is generally criticised, since there may be a tendency towards significant studies only to be published.<sup>6</sup> (iii) Finally, since the empirical studies are only included and the *effect size* statistic is the partial correlation coefficient, each reported empirical result should also provide information such as the t-statistic or standard error and degrees of freedom or sample size. This will allow to calculate a correlation coefficient for individual estimates. As result, the studies that only report the estimated coefficient are left out, even though they satisfy (i) and (ii) above.

Having looked at the commonly used econometric specifications and defined the criteria for selecting studies for the analysis, the next section provides a discussion of empirical studies that are used in the meta-analysis. In the appendix, a list of studies used in the meta-analysis is given in table 5 with underlying conceptual models, data types and periods.

## 3 Review of the Studies Included in the Meta Analysis

The first empirical milexp growth study is Benoit (1973, 1978). Benoit (1978) studies 44 less-developed countries (LDCs) to look at the milexp and growth relationship empirically and he

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<sup>6</sup>This is known as the *publication bias*. A “funnel plot” is used to check for possibility of publication bias. This will be explored in detail later in the paper.



finds a positive link. Benoit (1978) proposes a neo-classical supply side explanations: milexp can affect growth in two directions; negatively by taking away the resources which may be better used in civilian economy and positively by providing jobs and increasing employment, involving in infrastructure, training and research and development, (R&D). In the case of LDCs the benefits of milexp offset the negative ones.

The methodology and conclusions of Benoit (1973, 1978) is criticised for being a fairly intuitive and informal, see Deger (1986). There are also some critiques about the sample of Benoit's study being biased towards LDCs. Biswas and Ram (1986), in particular, revisit Benoit's methodology and apply it to poorer LDCs. The findings show the inverse relationship between milexp and growth in poorer LDCs is strong. However Benoit's work induced more research and the subsequent research has been greatly influenced by the postulates of Benoit.

In a modified Harrod-Domer growth model, Lim (1983) re-examines Benoit's study. He expands the sample from 44 LDC's to 54 for the period of 1965-73 and conducts a cross-country regression method. Lim (1983) assumes that milexp and investment are negatively related and introduces foreign capital inflow (FCI), where FCI may control investment and milexp together. Thus positive relationships do not mean that milexp would not crowd out investment. Based on the results obtained from his estimations he concludes that there is a negative effect of milexp on growth.

As one of the claims of Benoit (1978) for having a positive correlation between milexp and growth is because of an increase in utilisation of unused capital,<sup>7</sup> Faini et al. (1984) attest this claim, whereby a capacity utilisation rate and absorptive capacity limit variables are defined. Faini *et al.* (1984) apply a demand side Keynesian model using national account equation. They show that milexp can influence investment negatively, hence growth of output, through absorptive capacity. They carry out a panel fixed-effect estimation method using data from 69 countries over the period of 1952-70 and the results indicate an increase in milexp lowers growth.

As noted in the preceding section, the interaction between milexp and investment can have a knock-on effect on growth. Deger (1986) and others use demand-supply models to address this issue. Deger (1986) sets out three equations with endogenous variables being growth, investment, and milexp. Using three-stage least squares (3SLS), she estimates a model for 50 LDCs for the period of 1965-73. The findings show that investment and milexp has a positive direct effect on growth, but there is a negative relationship between milexp and investment. Then, the overall net

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<sup>7</sup>The reasoning is based on aggregate demand, an increase in government expenditure via increase in milexp results use of unemployed resources, which affects growth positively.

effect of *milexp* on growth is found to be negative.

The simultaneity/interdependence issue is one of the problems associated with a single equation cross-country model. The other weakness associated with this type of approach is the heterogeneity issue. To accommodate this, time-series studies of a single country and panel studies are commonly used. Faini *et al.* (1984), Chan (1988), Antonakis (1997), Heo and DeRouen (1998) and DeRouen (2000) are among those carry out a time-series analysis. Whereas, Cappelen *et al.* (1984), Landau (1986), Lipow and Antinori (1995), Blomberg (1996), Stroup and Heckelman (2001), Kollias *et al.* (2007), Yakovlev (2007), apply a cross-country time series model. Furthermore, some studies consider relatively more homogenous samples. These are studies by Cappelen *et al.* (1984) and Landau (1996), in which both use a sample of OECD countries and Kollias *et al.* (2007) concentrates on EU countries. Gyimah-Brempong (1989) and Dunne and Mohammed (1995) particularly look at a sample of African countries rather than a general of sample LDCs. Gyimah-Brempong (1989) applies a cross-section time series data methodology to a sample of 39 Sub-Saharan African countries between 1973 to 1983. There is no significant direct effect but significant indirect negative effect of *milexp* on growth.

Due to the mixed findings, some researchers claim that there exists a non-linear relationship between *milexp* and growth. A number of recent empirical studies appears to support this; Landau (1993), Stroup and Heckelman (2001), Aizenman and Glick (2006) and Kalaitzidakis and Tzouvelekas (2007). Stroup and Heckelman (2001) consider a non-linear relationship between *milexp* and growth. They extend the Barro-type growth model to include *milexp* and apply panel estimations using data from 44 African and Latin American countries from 1975 to 1989. To capture the non-linearity of *milexp* on growth, squared *milexp* is included in the estimation specification. The main postulate is that the positive effect of *milexp* on economic growth would diminish as *milexp* continues to increase. Furthermore the net effect of high *milexp* could be negative as a result of the opportunity cost of diverting resources away from the civilian sector.<sup>8</sup> Therefore, they use a quadratic form and include the squared value of *milexp*. By applying panel estimation they take into account the cross-country variations in lost human capital and public sector inefficiencies. The findings support a non-linear relation between growth and *milexp* - low level of *milexp* increases growth and high level of *milexp* results in a reduction in growth.

Although Stroup and Heckelman (2001) advocate the non-linear relationship between growth

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<sup>8</sup>The positive effect of *milexp* may be arising from providing security would not be sufficient to respond the opportunities foregone.

and milexp, both the studies do not account for threat; therefore it may not actually reflect those countries with a high level of threat, which in turn results in a high milexp. In a study by Aizenman and Glick (2006) however, non-linearity between growth and milexp is associated with the degree of security and this is related to the level of threat. This view raises questions of whether it is possible to determine the level of demand for milexp. The demand for milexp for each country may differ; it may go up in the presence of wars, regional conflicts, internal or external uncertainties, the possibility of future threats or it may be completely due to the political requirements of the present regime. If, arguably, the role of the military is only to safeguard the country from possible threats, then if there is no hazard either at present or in the foreseeable future then demand for milexp should be reduced and spending more on military would be a bad allocation of resources. The model specifies that if there is a threat (and resulting insecurity) above a threshold value, then a country benefits by increasing its milexp. The results of their study show that introducing milexp into the growth equation together with the threat variable seems to justify government spending on defence when there is a high level of threat. However, the threat variable fails to take into account civil and ethnic wars.<sup>9</sup>

In a model of endogenous growth, Kalaitzidakis and Tzouvelekas (2007) re-examine the potential non-linear effect of milexp on economic growth and empirically test the predictions of the model for 17 OECD and 38 Non-OECD countries for the period of 1980-1995. The results are presented for the whole sample of developed and developing countries and two sub-samples; i.e. OECD and Non-OECD. The findings confirm the inverse U-shaped relationship among milexp and economic growth. Blomberg (1996) also uses a model of endogenous growth model to investigate the linkages among military expenditure, political instability and economic growth. In the model, milexp and political instability are expected to affect economic growth negatively. In addition, a positive *spin-off* effect of milexp on economic growth is expected since milexp is seen as an insurance against political instability. In a panel of 70 countries over the period of 1967 to 1982, Blomberg (1996) show that *crowding out* effect is greater than the *spin-off* effect and there is a weak effect of milexp on growth.

Finally, several studies analyse milexp-growth nexus together with the other government expenditure, i.e. investment, education, health, etc. In a recent paper, Bose *et al.* (2007), look at the disaggregated government expenditure using panel of 30 developing countries. They define six

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<sup>9</sup>Civil wars may have a negative effect on economic growth more than international wars, see Murdoch and Sandler (2002), Collier and Hoeffler (2002) and Kang and Meernik (2005).

expenditure variables; namely capital, current, education, transport and communication, defence, other expenditures. Their findings imply a positive significant impact of milexp on growth.

## 4 Meta Analysis

The work of Benoit had a big impact; not only was it the first empirical investigation of milexp-growth nexus, but the positive significant results were not expected. Since then, Benoit's study has been under criticism and more studies have emerged to challenge his results. Although the subsequent studies find the adverse effect of milexp on growth, this conclusion has not been statistically robust. In a survey, Dunne (1996) suggests that the empirical work considering both supply and demand side effects could be considered to reach a limited consensus that the net effect is negative. However the tendency among researchers to look more favorably on findings with a negative, statistically significant effect of milexp on growth could lead to partial conclusions.

The aim of this section is to address whether the diverse research findings of milexp-growth studies are "genuine", in the sense described in the next sub-section and, if so, to draw an overall conclusion by conducting a formal quantitative approach, known as the meta analysis. To start, the empirical studies that investigate the possible effects of milexp on economic growth are systematically reviewed. Then, the main statistics and conclusions are identified from the extant literature and converted into a comparable metric form. In doing so, initially reviewed studies are classified based on some attributes that we define below.

The meta-analysis provides statistical tools to compare a pool of studies. To allow for comparisons among each independent study, an *effect size* statistic is calculated.<sup>10</sup> Once the *effect size* statistic is estimated for individual studies then they become comparable, as it allows one to convert results in a common scale.<sup>11</sup> There are different types of effect sizes; standardized mean difference, odds-ratio, correlation coefficient and so forth. The *effect size* statistic used here is the *partial correlation coefficient* (PCC).

Dunne (1996) emphasizes that the results among studies may vary due to sample size, method applied, time period, other control variables and the functional form used. Therefore, the empirical studies must be interpreted with underpinning hypotheses tested and the other conditioning variables used. In narrative surveys it is not possible to take into account differences among studies that are testing the same hypotheses, whereas meta-analysis allows us to consider the specifica-

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<sup>10</sup>The effect size will become clearer in subsequent analysis.

<sup>11</sup>Effect size has no dimensionality and the t-statistic or partial correlation are often used in meta-analysis.

tions used which, in turn, produces a relatively more rigorous overall result. In the light of this, the impact of differences in methodology, data and time periods among milexp-growth studies is explored thoroughly by means of the meta-regression analysis.

#### 4.1 Overview of Meta-Analysis

Hunter and Schmidt (1990) argue that a “good” review of earlier studies should make use of all the information available from each study reviewed. Meta-analysis is one of the methods that allows one to synthesize the results of other scholars in a common metric and statistically comparable form.<sup>12</sup>

The *effect size* (henceforth ES) is constructed using the information provided in each study. The information necessary depends on the choice of ES statistic. For instance, if PCC is the chosen ES, the information required from each study is t-values and degrees of freedom. Based on Greene (1993), suppose that in a regression analysis there is a dependent variable,  $y$ , and independent variables,  $x_m$ ,  $m = 1, 2 \dots M$ . Assume further that the effect of  $x_1$  on  $y$  is of interest. If we have a regression result with t-statistics and the degrees of freedom then the formula below is used to compute the partial correlation between  $y$  and  $x_1$ :

$$r_{yx_1} = \sqrt{\frac{t_{x_1}^2}{t_{x_1}^2 + df}} \quad (1)$$

where  $r_{yx_1}$  is the *ES* to be calculated from individual studies. The computed effect sizes are then used as the dependent variable in the meta-regression analysis. The other characteristics of individual studies; i.e. all the other independent variables, the sample size, the time frame, the method of estimation, the sources used, the year of the publication, the type of publication, and so forth, may further constitute the regressors for the meta-regression analysis.

#### Analysing the Effect Sizes

Having reviewed all the relevant studies in a specific literature and determined the ES statistic, there are three steps to assess the overall ES. Firstly, the weighted mean for overall effect is calculated using fixed effects meta-analysis. Assume that  $ES_{ij}$  is the estimate of ES  $i$  in study  $j$ ,  $SE_{ij}$  is the standard error of estimated effect  $i$  in study  $j$ . The inverse variance is chosen as the weight.<sup>13</sup> In

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<sup>12</sup>Lipsey and Wilson (2001) provide a good review of meta-analysis methodology and this part is mainly drawn from their study.

<sup>13</sup>Sample size or the inverse standard deviation may also be used.

what follows, the weighted mean ES is given by:

$$\overline{ES}_{fixed} = \frac{\sum(w_{ij}ES_{ij})}{\sum w_{ij}} \quad (2)$$

where  $ES_{ij}$  is the value of the ES statistic used,  $w_{ij} = \frac{1}{(SE_{ij})^2}$  is the inverse variance weight for the size  $ij$ . This is a model of fixed effects meta-analysis due to using the inverse variance of the estimates as a weight. Secondly, the standard error of the mean is computed. The square root of the sum of inverse variance weights is the standard error of the mean ES.<sup>14</sup>

$$SE_{\overline{ES}_{fixed}} = \sqrt{\frac{1}{\sum w_{ij}}}$$

where  $SE_{\overline{ES}_{fixed}}$  is the standard error of the ES mean,  $w_{ij}$  is the inverse variance weight associated with  $ij$ 'th estimate's ES.<sup>15</sup> Finally, a homogeneity test is performed to assess the validity of the fixed effects meta-analysis. The fixed effects analysis is based on the assumption that all the effect sizes that are drawn from individual studies estimate the same population ES. In other words using the formula (2) to estimate the weighted mean is valid if homogeneity of distribution of effect sizes are guaranteed.<sup>16</sup> To attest how realistic this assumption is, a test based on the  $Q$  – *statistic* is used. The  $Q$  – *statistic* is distributed as a  $\chi^2$  with  $I - 1$  degrees of freedom with  $I$  being the number of effect sizes:

$$Q = \sum w_{ij}(ES_{ij} - \overline{ES}_{fixed})^2 \sim \chi_{I-1}^2$$

as before,  $ES_{ij}$  is individual ES for  $i = 1, \dots, I$  and  $j = 1, \dots, J$ ,  $\overline{ES}_{fixed}$  is the weighted mean for  $ES_{ij}$ .  $Q$  gives the total variance and  $df = I - 1$  gives the expected variance, hence the difference,  $Q - I - 1$  is the excess variance.<sup>17</sup> If  $Q$  exceeds the critical value for a  $\chi^2$  with  $I - 1$  degrees of freedom, then the null hypothesis of homogeneity is rejected.

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<sup>14</sup>See Hedges and Olkin (1985)

<sup>15</sup>Also, the confidence interval for  $\overline{ES}_{fixed}$ :

$$(\overline{ES}_L)_{fixed} = \overline{ES}_{fixed} - z_{(1-\alpha)}(SE_{\overline{ES}_{fixed}}) \quad \text{and} \quad (\overline{ES}_U)_{fixed} = \overline{ES}_{fixed} + z_{(1-\alpha)}(SE_{\overline{ES}_{fixed}})$$

where  $(\overline{ES}_L)_{fixed}$  is lower,  $(\overline{ES}_U)_{fixed}$  upper boundaries,  $z_{(1-\alpha)}$  is the critical value for the  $z$ -*distribution* and  $\alpha$  is the significance level. Then, a  $z$  – *test* is performed to test the statistical significance of the mean ES:

$$z = \frac{|\overline{ES}_{fixed}|}{SE_{\overline{ES}_{fixed}}}$$

The formula is distributed as a standard normal variate. Hence if it exceeds test statistic 1.96 it is statistically significant with  $p \leq 0.05$ , and if it exceeds test statistic 2.58, it is significant with  $p \leq 0.01$ .

<sup>16</sup>If it is rejected then the formula in equation (2) is used with alteration in the way weights are defined. This is the model of random effects and it is further explored below.

<sup>17</sup>In the fixed effects between study variation is 0, i.e.  $Q \leq I - 1$ , hence variation among study is due to within study variation.

Heterogeneous distribution implies that the variability among effect sizes is larger than then one would expect merely from sampling error. Therefore, the weighted mean for overall effect is re-calculated using the random effects meta-analysis model.<sup>18 19</sup>

In this case, each observed ES differs from the population mean by subject-level sampling error and random error term. Hence the weight in the random effects model is given by:

$$w_{ij}^* = \frac{1}{\nu_{ij}^*}$$

where  $\nu_{ij}^*$  is the variance associated with the random model and is given by:

$$\nu_{ij}^* = \tau^2 + \nu_{ij}$$

$\nu_i = (SE_{ij})^2$  is as before, the variance associated with subject-level sampling error, and  $\tau^2$  is the between study variance:

$$\tau^2 = \frac{Q - k - 1}{\sum w_{ij} - (\sum w_{ij}^2 / \sum w_{ij})}$$

The associated weighted mean and the standard error of random effects model are:

$$\overline{ES}_{random} = \frac{\sum (w_{ij}^* ES_{ij})}{\sum w_{ij}^*} \quad \text{and} \quad SE_{\overline{ES}_{random}} = \sqrt{\frac{1}{\sum w_{ij}^*}}$$

## 4.2 The Meta-Analysis Results

### 4.2.1 Effect Sizes Analysis: Fixed and Random Effects

The studies that look at the relationship between milexp (that is measured as a percentage of GDP) and economic growth (growth rate of income per head) are assembled. Recall that the studies considered for meta analysis are those which regress economic growth on milexp, i.e. economic growth is the dependent variable and milexp is the explanatory variable. The ES, as the basis of comparisons across milexp-growth studies, is chosen to be the partial correlation calculated from individual studies.<sup>20</sup>

There are 32 studies that are included in the meta-analysis with a total of 169 estimates, i.e. in total there are 169 partial correlations. 40% of the 169 estimates find a negative relationship with only 38% statistically significant; whereas, 60% of the 169 estimates find a positive relationship between milexp and growth, with almost half of these are statistically significant.<sup>21</sup>

<sup>18</sup>According to Lipsey and Wilson (2001), the homogeneity test examines whether the fixed effect model is applicable statistically. Therefore, they suggest that although homogeneity may not be rejected statistically, one can still assume conceptually (not statistically), rejection of homogeneity and use a random effects model.

<sup>19</sup>Fixed and random effects in meta-analysis should not be confused with panel data models of fixed and random effects. They are not related.

<sup>20</sup>The meta-analysis is performed using Microsoft Excel, and Stata.

<sup>21</sup>Figure 2 shows the histogram of partial correlation coefficients in the sample.

Table 1 represents the results of the weighted mean effect sizes within individual studies and the mean ES,  $\overline{ES}$ , for overall 169 estimates. Effect sizes,  $ES_i$  and  $\overline{ES}$  are calculated using the formula given by equation (1) and (2) respectively. Based on the empirical studies in table 1 the overall ES is found to be 0.056, which indicates a small positive relationship between milexp and growth. We use the interpretation provided by Cohen (1988).<sup>22</sup> This estimate is valid if the assumption of homogeneity is not violated and there is no publication or selection bias.

To investigate the robustness of fixed effects results, a homogeneity test is performed. The null hypothesis is that the true ES is the same for all the milexp-growth studies in the sample, versus the alternative hypothesis that at least one of the effect sizes differs from the rest of the sample.<sup>23</sup> The result of Q-test is produced in table 2. The test result is highly significant implying that the assumption of a homogenous distribution of effect sizes is not valid for the milexp-growth studies.<sup>24</sup> In what follows, the test implies that there are variations among effect sizes that is beyond the sampling error. Hence, a random effects model must be used. Table 2 shows both the fixed and random effects models for the milexp-growth studies. The mean ES for the random effect model,  $\overline{ES}_{random}$ , is found to be 0.056, which is slightly greater than  $\overline{ES}_{fixed}$  and still very small.

Stanley (2005) indicates that researchers may consider either statistically significant results or incline towards a specific direction and magnitude of an effect. Drawing upon this, the effect sizes are further investigated for the possibility of publication bias. A funnel plot is used to graphically examine this issue. The graph is a scatter plot of effects sizes against their precision or sample size. There may be no publication bias if it emerges a shape of an inverted funnel with no asymmetries. Figure 1 is the funnel plot of the estimated effect sizes of milexp-growth studies against their precision,  $\frac{1}{SE_i}$ . The vertical solid line at the center of the graph indicates the weighted mean effect size, 0.056. The visual inspection of the funnel graph does not shows much sign of asymmetries with reference to the center line. This may suggest that there is no publication bias in the milexp-growth studies. However, it should be noted that at the lower level of the graph the effects sizes on the left tail are much more dispersed than the right tail. There is some clustering of effect sizes on the right hand side of the graph. This visual inspection of the funnel graph alone will not guarantee

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<sup>22</sup>Cohen (1988) suggests that if the ES based on correlation coefficient the absolute value of mean effect sizes are;  $r \leq 0.10$  small,  $r = 0.25$  medium, and  $r \geq 0.40$  large.

<sup>23</sup>This assumption is a very strict as it has been discussed in narrative review that the results vary enormously in empirical findings of milexp-growth, therefore employing random effects, this assumption is relaxed.

<sup>24</sup>In general, it is highly likely that this assumption is violated in empirical economics. See other meta-analysis examples in empirical economics like Abreu *et al.* (2005), Doucouliagos and Ulubasoglu (2006), Nijkamp and Poot (2004), de Dominicis *et al.* (2008), and also the special issue on meta-analysis in the Journal of Economic Surveys 2005, volume 19, issue 3.



Study	No. of Estimates within the study	Average Effect Size
Benoit (1978)	3	0.383
Deger & Smith 1983	5	0.131
Lim (1983)	9	0.078
Deger & Sen (1983)	1	0.146
Faini et. al. (1984)	1	-0.120
Cappelen et. al. (1984)	8	0.079
Landau (1986)	12	0.060
Biswas & Ram (1986)	6	0.198
Deger (1986)	5	0.330
Lebovic & Ishaq (1987)	4	-0.129
Chan (1988)	3	0.089
Grobar & Porter (1989)	5	0.128
Gyimah-Brempong (1989)	2	0.038
Looney (1989)	2	-0.284
Landau (1993)	29	0.173
Dunne & Mohammed	3	0.006
Lipow & Antinori (1995)	2	0.192
Blomberg (1996)	1	-0.042
Knight et. al. (1996)	4	-0.100
Landau (1996)	11	0.285
Brumm (1997)	2	0.316
Antonakis (1997)	2	-0.456
Heo & DeRouen (1998)	5	-0.101
DeRauen (2000)	1	0.168
Stroup & Heckelmen (2001)	5	0.202
Galvin (2003)	9	-0.156
Aizenman & Glick (2006)	7	-0.205
Bose et. al. (2007)	4	0.278
Kalaitzidakis & Tzouvelekas (2007)	3	0.095
Kollias et. al. (2007)	2	0.156
Yakovlev (2007)	10	-0.148
Looney & McNab (2008)	3	-0.129
Total	169	
Fixed Effects		0.056
Random Effects		0.066

Table 1: Average Effect within each study and overall combined fixed and random effects

Model		Fixed effects	Random effects
Number of Studies		169	169
Mean Effect size			
	Point estimate	0.056	0.066
	Lower limit (95% interval)	0.043	0.037
	Upper limit (95% interval)	0.069	0.095
Test of null			
	Z-value	8.35	4.46
	P-value	0.00	0.00
Heterogeneity Test			
	Q-value	593.135	
	df (Q)	168	

Table 2: Results of Fixed and Random Effects Meta Analysis

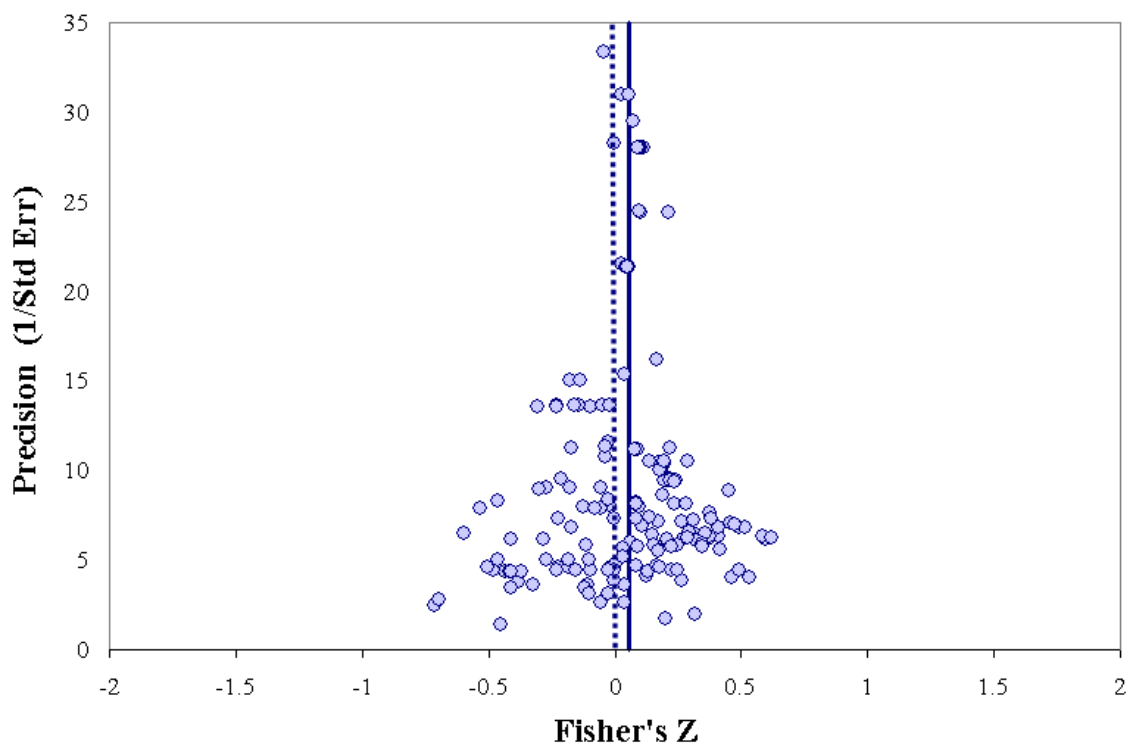


Figure 1: Publication Bias: Funnel plot of precision by Fisher's Z

that the literature is free of publication bias. However, the initial conclusion is that publication bias might not be present in milexp-growth studies.<sup>25</sup>

To explore this thoroughly, a more formal test is conducted. Stanley and Jarrell (1989) suggest the funnel asymmetry test (FAT). The test is based on the  $t$  – statistics.

$$t_{ij} = \beta_0 + \beta_1(1/SE_{ij}) + e_{ij} \quad (3)$$

where  $t_{ij}$  is the t-value of the estimated coefficient from estimate  $i$  of study  $j$ . The intercept,  $\beta_0$ , and slope,  $\beta_1$ , coefficients are to be tested if they are statistically different from zero. There is publication bias, if  $\beta_0$  is statistically different from zero at conventional significance levels, this is known as the FAT.  $\beta_0$  also gives the direction of bias.<sup>26</sup> Table 3 reports the results of FAT test using the weighted least squares (WLS), clustered data analysis (CDA), and hierarchical linear model (HLM).<sup>27</sup> CDA is used to obtain robust standard errors since there is a problem of dependency in the data. Therefore the estimated coefficients in CDA do not differ from WLS. However, the preferred estimation method is HLM since it models both within study variation and between study. The columns 1, 2 and 3 present the results for equation (3) using WLS, CDA and HLM respectively. The intercept,  $\beta_0$ , is statistically insignificant in all models estimated. Thus, the results suggest that there is no publication bias in milexp-growth studies, which is consistent with the funnel graph 1.

The issues of heterogeneity and publication bias are statistically necessary to explore and understand variation among reported research findings. However, in the milexp-growth literature the issue of whether there is a “genuine” relationship or not emerges to be more important for policy-makers. To test the “genuine” empirical effect, a *precision effect test* (PET) is conducted.

The PET test is based on the slope coefficient,  $\beta_1$ , in equation (3). The test implies that if there is an “genuine” empirical effect the slope coefficient is statistically different from zero.<sup>28</sup> In

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<sup>25</sup>Note that in the funnel plot, the ES is not the partial correlations but the Fisher’s Z transformation. The reason for this is to avoid large partial correlations to be assigned more weights. To convert the partial correlations,  $r$ , into the Fisher’s Z the following formula is used with  $N$  being the sample size:

$$\text{Fisher's Z} \quad Z = \frac{1}{2} \ln\left(\frac{1+r}{1-r}\right) \quad \text{Variance of Fisher's Z} \quad var_Z = \frac{1}{N-3}$$

<sup>26</sup>Stanley (2005) claims that  $1/SE_{ij}$  is an estimated value thus it contains some level of random sampling error, which produces a bias result when it is estimated using an ordinary least squares (OLS) regression. To overcome this it is suggested to use the square root of the sample size or degrees of freedom as an alternative to inverse standard errors,  $1/SE_{ij}$ .

<sup>27</sup>The high correlation between square root of sample size ( $N$ ) and  $1/SE_{ij}$  suggests square root of sample size is a good proxy. The calculation are run again with square root of sample size and results do not change.

<sup>28</sup>There is another test for testing significant empirical effect, meta-significance test (MST). The test is based on

Funnel Asymmetry Test (FAT) & Precision Effect Test (PET)

Dependent variable:  $t - statistic$

Variable	Weighted Least Squares (1)	Cluster Data Analysis (2)	Hierarchical linear model (3)
$1/se_i$	0.049 (2.12)*	0.049 (1.71)	0.099 (3.48)**
Constant	0.112 (0.43)	0.112 (0.31)	-0.476 (1.10)
no. of estimates	169	169	169
no. of studies		32	32
$R^2$	0.03	0.03	

Note: Absolute value of t statistics in parentheses; \* significant at 5%; \*\* significant at 1%.

Table 3: FAT-PET tests results

what follows, table 3 also reports the results for PET. Table 3 shows that there exists a “genuine” empirical effect but this is very small, which is the same results as in the random-effects meta analysis.

#### 4.2.2 A Meta-regression Analysis: Explaining the sources of heterogeneity

As noted in the preceding section, the assumption of homogenous ES is invalid for the milexp-growth studies. In other words, in the milexp-growth studies, the differences among ES are not due to sampling error alone. The aim of this section is to identify these factors that cause heterogeneity among ES. To model ES heterogeneity, a meta-regression analysis (henceforth, MRA) is used, this is also known as moderator variables analysis. The moderator variables refer to systematic variations in the original studies. These may emerge from the use of different theoretical reasoning, methodological issues or some other characteristics of empirical studies. For instance, in the milexp-growth literature, demand side theories expect a negative effect (via trade-off within other government expenditure) and supply side a positive one (via technological spillover and positive externalities). Keynesian demand and supply models, for instance, expect a negative association

the following regression specification:

$$\ln(|t_{ij}|) = \alpha_0 + \alpha_1 \ln(df_{ij}) + \epsilon_{ij}$$

where the natural logarithm of absolute t-values,  $\ln(|t_{ij}|)$ , is regressed on the natural logarithm of degrees of freedom,  $\ln(df_{ij})$ . If the slope coefficient,  $\alpha_1$  in MST is greater than zero then there exists a “genuine” empirical effect. The intuition behind this is that for the existence of a “genuine” relationship between milexp-growth, the magnitude of standardized test statistics, that is t-value in milexp-growth studies, varies positively with degrees of freedom, see Stanley (2001) and Stanley (2005). The results of the test are not reported here but they support the proposition of “genuine” empirical effect.

of milexp on growth through crowding out of other beneficial government expenditure; investment, health and education. However, there is also an expectation of a positive effect through Keynesian multiplier effects.<sup>29</sup> The neo-classical Feder-Ram supply-side models expect a positive effect or no economic effect.

Furthermore, a moderator analysis allows for closer examination of individual studies. In what follows each study is reviewed and the main characteristics of individual studies are coded, which are then compared across all the studies. This provides variables that can be used as the moderating variables in the MRA. In other words, moderator variables allow us to segregate the role of other control variables and theoretical-methodological issues on the study-to-study findings.

A variant of the Stanley and Jarrell (1989) model of meta-regression is employed to model the heterogeneity.<sup>30</sup> The specification is:

$$ES_{ij} = \beta + \sum_k \gamma_k Z_{k,ij} + e_{ij} \quad i = 1, 2, \dots, I \quad j = 1, 2, \dots, J \quad (4)$$

where  $ES_{ij}$  is the partial correlation for estimate  $i$ , study  $j$ ,  $Z$  denotes the individual study characteristics, and  $\gamma_k$  are the coefficients to be estimated, where each coefficient provides the estimated effect of a particular characteristic on the correlation coefficient.

Commonly, OLS is used to estimate equation (4). OLS is consistent if the estimates of primary studies used to construct the sample are independent from one to another. However, some primary studies provide more than one estimate, in which case the independency among estimates can be questioned (de Dominicis *et al.*, 2008). Some meta-analytic reviews use one estimate from each study to deal with this issue and subsequently use OLS, (Doucouliagos and Ulubasoglu, 2006). Instead of undertaking such selection procedure, equation (4) is estimated using a hierarchical model, also known as a multi-level model. The main reason for this is to use all the available information from each study. Hence, the equation to be estimated is:

$$ES_{ij} = \beta + \sum_{k=1}^K \alpha_k Z_{ijk} + u_j + e_{ij} \quad i = 1, 2, \dots, I; \quad j = 1, 2, \dots, J \quad (5)$$

where  $i$  and  $j$  represent the individual estimate and the study respectively.  $k$  is number of regressors. Also,  $u_j$  is the study level error term, that allows each study to have varying intercept. Therefore, it is also known as a random intercept model. The error terms are assumed to have a normal

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<sup>29</sup>As mentioned in the narrative review milexp is one of the components of government expenditure and an increase in government expenditure through milexp can stimulate the economy via Keynesian multiplier.

<sup>30</sup>The difference between this MRA and a generic meta-regression model defined by Stanley and Jarrell (1989) is the ES choice, which is the t-statistics in their model. Whereas in this study the preferred ES is the PCC.

distribution;  $e_{ij} \sim N(0, \sigma_e^2)$  and  $u_j \sim N(0, \sigma_u^2)$ . For this study  $I = 169$  and  $J = 32$ . Finally, the error terms are independent, thus the total variance is given by;  $\sigma_u^2 + \sigma_e^2$ .<sup>31</sup>

## Results of Meta-regression Analysis

The dependent variable is the estimated partial correlations between milexp and growth. Based on the discussion in sections 2 and 3, there are identified three broad areas of methodological differences that may influence the investigation of milexp-growth effect: (a) econometric specifications, (b) underlying theoretical models, and (c) other control variables in the primary study. In total, there are identified twenty-one potential moderator variables.<sup>32</sup> The definition of individual variables that are used in meta-regressions is given in table 6. All the independent variables used are dummies with the exception of the natural logarithm of the number of observations and number of years in the primary study.

Table 4 reports the results of the ordinary least squares (OLS), clustered data analysis (CDA) and hierarchical linear model (HLM). There are two specifications, general and specific. Odd columns provide results for more general specifications and even columns general-to-specific. The discussion here is mainly based on HLM results. OLS and CDA are given only for comparison purpose.

First, the effects of the number of observations and number of years are considered. Most of the previous studies conduct a cross-country analysis and cover very short-time periods, which may be due to the fact that in the long-run there are much less variations in the milexp series. Therefore in addition to the sample size variable, the number of years is used to see if this will cause any significant effect among reported results of the primary studies. Both, in the general and specific models, the sample-size variable is statistically significant at 1% level and the number-of-years variable is insignificant.

Second, the effect of econometric specifications is considered. The following control variables are used to capture this effect: time periods, data sources, sample of countries, and estimation types. The effect of time periods are captured using five dummies; 1950s (D50), 1960s (D60), 1970s (D70), 1980s (D80), and 1990s (D90). 1970s is used as the base. The period dummies are also important to attest whether the estimated milexp-growth effect is time invariant. Both specifications in columns (5) and (6) show that the time periods contribute significantly to the variations in the reported findings. In the general specification, the dummies for 1960s 1980s and

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<sup>31</sup>A detailed description of multilevel techniques can be found in Goldstein (1995) and Hox (2002).

<sup>32</sup>Note that not all these identified control variables are used in the regressions.

Meta-Regression Analysis of Milexp-Growth Studies

Dependent variable: Partial Correlation Coefficient (PCC)

Variable	Ordinary Least Squares		Clustered Data Analysis		Hierarchical linear model	
	General (1)	Specific (2)	General (3)	Specific (4)	General (5)	Specific (6)
<b>Number of observations and years in the primary study</b>						
lnobs	0.053 (2.41)*	0.051 (2.85)**	0.053 (2.97)**	0.051 (2.46)*	0.058 (2.62)**	0.061 (3.10)**
lnyear	0.052 (0.90)		0.052 (0.99)		0.044 (0.63)	
<b>Econometric specifications and underlying theoretical models used in the primary study</b>						
D50	0.251 (3.70)**	0.229 (4.50)**	0.251 (3.92)**	0.229 (5.74)**	0.272 (3.47)**	0.253 (4.02)**
D60	-0.113 (1.67)		-0.113 (2.07)*		-0.095 (1.23)	
D80	-0.012 (0.11)		-0.012 (0.10)		-0.005 (0.04)	
D90	-0.211 (3.87)**	-0.236 (6.00)**	-0.211 (3.70)**	-0.236 (8.86)**	-0.217 (3.57)**	-0.226 (4.33)**
ACDA	-0.096 (1.48)		-0.096 (1.39)		-0.100 (1.46)	
Developed Countries	0.182 (2.45)*	0.158 (2.96)**	0.182 (1.71)	0.158 (3.08)**	0.212 (2.61)**	0.185 (2.86)**
Africa	-0.076 (1.16)		-0.076 (1.13)		-0.079 (1.26)	
Panel	-0.123 (1.83)	-0.074 (1.55)	-0.123 (1.36)	-0.074 (1.02)	-0.151 (2.00)*	-0.106 (1.88)
Single Country	-0.162 (1.65)	-0.116 (1.53)	-0.162 (1.53)	-0.116 (1.17)	-0.196 (1.81)	-0.179 (1.88)
SEM	0.024 (0.41)		0.024 (0.31)		0.056 (0.90)	
Growth theory	0.027 ((0.37)		0.027 (0.31)		0.054 (0.66)	

Continued: Meta-Regression Analysis of Milexp-Growth Studies

Dependent variable: Partial Correlation Coefficient (PCC)

Variable	Ordinary Least Squares		Clustered Data Analysis		Hierarchical linear model	
	General (1)	Specific (2)	General (3)	Specific (4)	General (5)	Specific (6)
<b>Other control variables used in the primary study</b>						
Aid	-0.065 (0.82)		-0.065 (1.09)		-0.047 (0.56)	
Dem	0.120 (1.39)		0.120 (1.86)		0.120 (1.35)	
FDI	0.173 (2.60)*	0.120 (2.14)*	0.173 (2.62)*	0.120 (1.76)	0.164 (2.32)*	0.115 (1.77)
NME	0.161 (2.01)*		0.161 (1.82)		0.158 (2.04)*	
Edu	-0.029 (0.48)		-0.029 (0.35)		-0.008 (0.13)	
Non-linear functional forms	0.095 (1.77)	0.160 (3.81)**	0.095 (1.88)	0.160 (3.37)**	0.085 (1.67)	0.129 (2.74)**
Constant	-0.191 (1.72)	-0.154 (2.20)*	-0.191 (1.62)	-0.154 (1.75)	-0.211 (1.67)	-0.172 (2.14)*
no. of estimates	169	169	169	169	169	169
no. of studies			32	32	32	32
$R^2$	0.41	0.35	0.41	0.35		

Note: Absolute value of t statistics in parentheses; \* significant at 5%; \*\* significant at 1%.

Table 4: Meta-regression Analysis Results of Milexp-Growth Studies



1990s produce a larger negative milexp-growth effect, whereas the period of 1950s has a significant positive effect on the partial correlation of milexp and growth. For the year dummies 1990s and 1950s, the same conclusions emerge from the specific model reported in column (6). These suggest that the milexp-growth effect changes over time.

The milexp data used in the empirical studies are mainly from two sources; the United States Arms Control and Disarmament Agency (ACDA) and the Stockholm International Peace Research Institute (SIPRI). Although, both ACDA and SIPRI use the NATO definition of milexp, they differ somewhat. ACDA is included in the MRA analysis with SIPRI as the base. However, the use of different data sources does not affect the reported milexp-growth effect.<sup>33</sup>

Also, a set of dummy variables are defined to capture the effect of the type of data, namely “Single Country” for the time series data; “Panel” for the panel data. Using the cross-section data as the base, columns (5) and (6) shows that both dummies are negative and significant. Also, the dummy variables “Developed countries” and “Africa” are used to assess the effect of a specific group of countries. The variable “Developed Countries” is positive and significant at 1% level in both specifications and “Africa” is negative but statistically insignificant. In accordance to these findings, it can be argued that much research is necessary to investigate homogenous samples at regional or country level.

Third, three dummy variables are considered for theoretical models. “Growth theory” is a dummy variable taking the value 1 if the theoretical model is either the endogenous or exogenous (neo-classical) growth model. The effect of conducting a Keynesian demand-supply model on the correlation coefficient is captured by another dummy variable, simultaneous-equation model (SEM). “Growth other” is a dummy variable taking value 1 for all other models.<sup>34</sup> Using “Other model” dummy variable as the base, the dummy variables for growth theory and SEM are included in the MRA. Both dummies are statistically insignificant in all specifications. However, two points should be noted. First, it was not possible to include the net effect from individual studies that apply the SEM. Hence, the direct effect is only considered. Second, it would have been ideal to sub-divide competing growth theories. Since conceptually, the aggregated/disaggregated government

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<sup>33</sup>It should be noted that two of the international institutions, namely the NATO and the UN, provide a definition of milexp that differ in some levels. The NATO definition of milexp includes expenditure on police forces and the UN peace forces but these are excluded from the UN definition of milexp. On the contrary, the UN includes military aid but not the NATO (Brzoska, 1995). None of the studies included in this meta-analysis uses data from the UN.

<sup>34</sup>See table 5 in which the studies that apply the Keynesian demand-supply model are classified as *approach* †, the studies that apply the formal economic growth models are classified as *approach* § and other approaches are classified as *approach* O.

expenditure (including milexp) can hamper/boost economic growth, In the neo-classical growth theory, government expenditure does not influence the long-run economic growth, whereas the endogenous growth models show that fiscal policy has important implications on the long-run growth, Barro (1990).

Finally, six dummy variables are considered to account for the other control variables used in the primary studies. These are aid (Aid), democracy (Dem), foreign direct investment (FDI), neighbouring countries' milexp (NME), education (Edu) and non-linear functional forms (or interaction term). The dummy variables Aid, Dem and Edu are statistically insignificant in all specifications. In the general specification (column 5) FDI, NME and non-linear functional forms dummy variables are all positive and significant at conventional levels. Moreover, in the specific model (column 6), FDI and the "non-linear functional forms" dummy variables remain significant at 10% and 1% respectively. The non-linear effect of milexp on growth is discussed more commonly in recent empirical studies. This finding appears to complement that discussion. This means the studies that account for a non-linear relationship find a stronger link between growth and milexp.

Overall, in the MRA, the use of OLS, CDA or HLM produces similar conclusions. In other words, there are no significant differences among the results of all three specific models reported in even columns. As expected, the differences are merely in estimated standard errors.

## 5 Summary

This paper provides a meta-analytic review of military expenditure (milexp) and economic growth literature. It consists of 32 empirical studies and 169 estimates. The following conclusions emerge from the meta-regression analysis (MRA). First, using a fixed and random effects meta analysis, the combined effects of milexp-growth studies are estimated to be 0.056 and 0.066 respectively. These imply a direct small positive impact of milexp on economic growth. Second, there is a "genuine" empirical effect of milexp on economic growth and there is no publication bias. Third, the main methodological differences in the primary studies that contribute to the variations in the findings of the existing literature are the sample, time-periods, and functional forms. To some extent, the findings of this complementary approach support formally the general conclusions of the earlier qualitative surveys, see Dunne (1996) and Ram (1995).

We have identified a number of shortcomings in the literature, which may help defining possible routes for future search. First, only a few primary studies of the milexp-growth include more recent time periods. Most of the primary studies use the time period of data covering 1960s, 1970s and

1980s. Therefore, the future research should focus on extending the time periods to cover 1990s and onwards. After all, with the end of the Cold War in 1990s, the perceived threat is reduced across nations and a knock-on effect on milexp seems plausible. Second, although the argument of a negative effect of milexp on growth is stronger for the poorer LDCs, it was not possible to run a separate MRA due to the small sample for this category. Third, as suggested in many recent studies and also in our meta-analysis, the non-linear functional forms appear to be an important issue. Clearly, there is a scope to continue exploring this in future research. Finally, in this MRA, the milexp-growth *effect size* is the partial correlation coefficient between economic growth and the level of milexp. Therefore, the studies that analyse the growth of milexp and economic growth are left out in this meta-analysis, i.e the Granger causality and Feder-Ram based studies. Hence, the conclusions drawn from this MRA should be carefully interpreted and a separate meta analysis of Feder-Ram based studies could offer further insights.

## References

- Abreu, M., de Groot, H. L. F., and Florax, R. J. G. M. (2005). A meta-analysis of  $\beta$ -convergence: the legendary 2%. *Journal of Economic Surveys*, **19**(3), 389–420.
- Abu-Bader, S. and Abu-Qarn, A. S. (2003). Government expenditures, military spending and economic growth: causality evidence from egypt, israel, and syria. *Journal of Policy Modeling*, **25**(6-7), 567–583.
- Aizenman, J. and Glick, R. (2006). Military expenditure, threats, and growth. *Journal of International Trade & Economic Development*, **15**(2), 129–155.
- Alexander, W. (1990). The impact of defence spending on economic growth: A multi-sectoral approach to defense spending and economic growth with evidence from developed economies. *Defence Economics*, **2**, 39–55.
- Antonakis, N. (1997). Military expenditure and economic growth in greece, 1960-90. *Journal of Peace Research*, **34**(1), 89–100.
- Aschauer, D. A. (1989). Is public expenditure productive? *Journal of Monetary Economics*, **23**(2), 177–200.
- Atesoglu, H. S. and Mueller, M. J. (1990). Defence spending and economic growth. *Defence Economics*, **2**, 19–27.

- Barro, R. J. (1990). Government spending in a simple model of endogenous growth. *Journal of Political Economy*, **98**(5), S103–26.
- Benoit, E. (1973). *Defence and Economic Growth in Developing Countries*. Boston: Lexington Books.
- Benoit, E. (1978). Growth and defense in developing countries. *Economic Development and Cultural Change*, **26**(2), 271–80.
- Biswas, B. and Ram, R. (1986). Military expenditures and economic growth in less developed countries: An augmented model and further evidence. *Economic Development and Cultural Change*, **34**(2), 361–72.
- Blomberg, S. B. (1996). Growth, political instability and the defence burden. *Economica*, **63**(252), 649–72.
- Bose, N., Haque, M. E., and Osborn, D. R. (2007). Public expenditure and economic growth: A disaggregated analysis for developing countries. *Manchester School*, **75**(5), 533–556.
- Brumm, H. (1997). Military spending, government disarray, and economic growth: A cross-country empirical analysis. *Journal of Macroeconomics*, **19**(4), 827–838.
- Brzoska, M. (1995). World military expenditures. In K. Hartley and T. Sandler, editors, *Handbook of Defense Economics*, volume 1, chapter 3, pages 45–67. Elsevier.
- Cappelen, A., Gleditsch, N. P., and Bjerkholt, O. (1984). Military spending and economic growth in the OECD countries. *Journal of Peace Research*, **21**(4), 361–373.
- Chan, S. (1988). Defense burden and economic growth: Unraveling the taiwanese enigma. *The American Political Science Review*, **82**(3), 913–920.
- Chowdhury, A. (1991). A causal analysis of defense spending and economic growth. *Journal of Conflict Resolution*, **35**, 80–97.
- Cohen, J. (1988). *Statistical Power Analysis in Behavioural Sciences*. Hillsdale: Erlbaum, 2nd edition.
- Collier, P. and Hoeffler, A. (2002). Military expenditure - threats, aid, and arms races. Policy research working paper series, The World Bank.

- Cuaresma, J. C. and Reitschuler, G. (2004). A non-linear defence-growth nexus? evidence from the US economy. *Defence and Peace Economics*, **15**(1), 71–82.
- Dakurah, A. H., Davies, S. P., and Sampath, R. K. (2001). Defense spending and economic growth in developing countries: A causality analysis. *Journal of Policy Modeling*, **23**(6), 651–658.
- de Dominicis, L., Florax, R. J. G. M., and de Groot, H. L. F. (2008). A meta-analysis on the relationship between income inequality and economic growth. *Scottish Journal of Political Economy*, **55**(5), 654–682.
- Deger, S. (1986). Economic development and defense expenditure. *Economic Development and Cultural Change*, **35**(1), 179–96.
- Deger, S. and Sen, S. (1983). Military expenditure, spin-off and economic development. *Journal of Development Economics*, **13**(1-2), 67–83.
- Deger, S. and Sen, S. (1995). Military expenditure and developing countries. In K. Hartley and T. Sandler, editors, *Handbook of Defense Economics*, pages 275–307. Elsevier.
- Deger, S. and Smith, R. (1983). Military expenditure and growth in less developed countries. *The Journal of Conflict Resolution*, **27**(3), 335–353.
- DeRouen, K. J. (2000). The guns-growth relationship in israel. *Journal of Peace Research*, **37**(1), 69–83.
- Devarajan, S., Swaroop, V., and Heng-fu, Z. (1996). The composition of public expenditure and economic growth. *Journal of Monetary Economics*, **37**(2-3), 313–344.
- Doucouliafos, C. and Ulubasoglu, M. A. (2006). Economic freedom and economic growth: Does specification make a difference? *European Journal of Political Economy*, **22**(1), 60–81.
- Dunne, J. P. (1996). Economic effects of military spending in LDCs: A survey. In N. P. Gleditsch, A. Cappelen, O. Bjerkholt, R. Smith, and P. Dunne, editors, *The Peace Dividend (Contributions to Economic Analysis Series)*, pages 439–64. Amsterdam: North Holland.
- Dunne, J. P. and Nikolaidou, E. (2005). Military spending and economic growth in greece, portugal and spain. *Frontiers in Finance and Economics*, **2**(1), 1–17.
- Dunne, J. P. and Smith, R. P. (2010). Military expenditure and granger causality: A critical review. Discussion papers, University of the West of England, Department of Economics.

- Dunne, J. P., Smith, R., and Willenbockel, D. (2005). Models of military expenditure and growth: A critical review. *Defence and Peace Economics*, **16**(6), 449–461.
- Dunne, P. and Mohammed, N. (1995). Military expenditure in sub-saharan africa: Some evidence for 1967-85. *Journal of Peace Research*, **32**(3), 331–343.
- Easterly, W. and Rebelo, S. (1993). Fiscal policy and economic growth: An empirical investigation. *Journal of Monetary Economics*, **32**(3), 417–458.
- Faini, R., Annez, P., and Taylor, L. (1984). Defense spending, economic structure, and growth: Evidence among countries and over time. *Economic Development and Cultural Change*, **32**(3), 487–98.
- Feder, G. (1983). On exports and economic growth. *Journal of Development Economics*, **12**(1-2), 59–73.
- Galvin, H. (2003). The impact of defence spending on the economic growth of developing countries: A cross-section study. *Defence and Peace Economics*, **14**(1), 51–59.
- Goldstein, H. (1995). *Multilevel Statistical Models*. London: Edward Arnold, second edition.
- Greene, W. H. (1993). *Econometric Analysis*. Prentice Hall, second edition.
- Grobar, L. M. and Porter, R. C. (1989). Benoit revisited: Defense spending and economic growth in LDCs. *The Journal of Conflict Resolution*, **33**(2), 318–345.
- Gyimah-Brempong, K. (1989). Defense spending and economic growth in sub-Saharan africa: An econometric investigation. *Journal of Peace Research*, **26**(1), 79–90.
- Hedges, L. V. and Olkin, I. (1985). *Statistical Methods for Meta-Analysis*. Academic Press, Inc.
- Heo, U. and DeRouen, K. (1998). Military expenditures, technological change, and economic growth in the east asian NICs. *The Journal of Politics*, **60**(830), 846.
- Hox, J. J. (2002). *Multilevel Analysis Techniques and Applications*. Lawrence Erlbaum Associates.
- Huang, C. and Mintz, A. (1991). Defence expenditures and economic growth: The externality effect. *Defence Economics*, **3**(1), 35–40.
- Hunter, J. E. and Schmidt, F. L. (1990). *Methods of Meta-Analysis: Correcting Error and Bias in Research Findings*. Sage Publications.

- Joerding, W. (1986). Economic growth and defense spending : Granger causality. *Journal of Development Economics*, **21**(1), 35–40.
- Kalaitzidakis, P. and Tzouvelekas, V. (2007). Military spending and the growth-maximizing allocation of public capital: A cross-country empirical analysis. Working Papers 0722, University of Crete, Department of Economics.
- Kang, S. and Meernik, J. (2005). Civil war destruction and the prospects for economic growth. *Journal of Politics*, **67**(1), 88–109.
- Knight, M., Loayza, N., and Villanueva, D. (1996). The peace dividend : military spending cuts and economic growth. Policy Research Working Paper Series 1577, The World Bank.
- Kollias, C., Mylonidis, N., and Suzanna-Maria, P. (2007). A panel data analysis of the nexus between defence spending and growth in the european union. *Defence and Peace Economics*, **18**(1), 75–85.
- Landau, D. (1986). Government and economic growth in the less developed countries: An empirical study for 1960-1980. *Economic Development and Cultural Change*, **35**(1), 35–75.
- Landau, D. (1993). The economic impact of military expenditures. Policy Research Working Paper Series 1138, The World Bank.
- Landau, D. (1996). Is one of the 'peace dividends' negative? military expenditure and economic growth in the wealthy oecd countries. *The Quarterly Review of Economics and Finance*, **36**(2), 183–195.
- Lebovic, J. H. and Ishaq, A. (1987). Military burden, security needs, and economic growth in the middle east. *The Journal of Conflict Resolution*, **31**(1), 106–138.
- Lim, D. (1983). Another look at growth and defense in less developed countries. *Economic Development and Cultural Change*, **31**(2), 377–84.
- Lipow, J. and Antinori, C. M. (1995). External security threats, defense expenditures, and the economic growth of less-developed countries. *Journal of Policy Modeling*, **17**(6), 579–595.
- Lipsey, M. W. and Wilson, D. B. (2001). *Practical Meta-Analysis*. Sage publications.
- Looney, R. and McNab, R. M. (2008). Can economic liberalization and improved governance alter the defense-growth trade-off? *Review of Financial Economics*, **17**(3), 172–182.

- Mulas-Granados, C., Baldacci, E., Clements, B. J., and Gupta, S. (2002). Expenditure composition, fiscal adjustment, and growth in low-income countries. IMF Working Papers 02/77, International Monetary Fund.
- Murdoch, J. and Sandler, T. (2002). Economic growth, civil wars, and spatial spillovers. *Journal of Conflict Resolution*, **46**, 91–110.
- Nijkamp, P. and Poot, J. (2004). Meta-analysis of the effect of fiscal policies on long-run growth. *European Journal of Political Economy*, **20**(1), 91–124.
- Ram, R. (1986). Government size and economic growth: a new framework and some evidence from cross-section and time series data. *American Economic Review*, **76**, 191–203.
- Ram, R. (1995). Defense expenditure and economic growth. In K. Hartley and T. Sandler, editors, *Handbook of Defense Economics*, pages 251–274. Elsevier.
- Stanley, T. D. (2001). Wheat from chaff: Meta-analysis as quantitative literature review. *Journal of Economic Perspectives*, **15**(3), 131–150.
- Stanley, T. D. (2005). Beyond publication bias. *Journal of Economic Surveys*, **19**(3), 309–345.
- Stanley, T. D. and Jarrell, S. B. (1989). Meta-regression analysis: A quantitative method of literature surveys. *Journal of Economic Surveys*, **3**, 54–67.
- Stroup, M. D. and Heckelman, J. C. (2001). Size of the military sector and economic growth: A panel data analysis of africa and latin america. *Journal of Applied Economics*, **IV**(2), 329–360.
- Ward, M. D. and Davis, D. R. (1992). Sizing up the peace dividend: Economic growth and military spending in the united states, 1948-1996. *The American Political Science Review*, **86**(3), 784–755.
- Yakovlev, P. (2007). Arms trade, military spending, and economic growth. *Defence and Peace Economics*, **18**(4), 317–338.

## 6 Appendix



Study	Approach	Data Type	Data Period
Benoit (1978)	<i>O</i>	Cross section (linear)	1950-1965
Deger & Smith (1983)	‡	Cross section (linear)	1965-1973
Lim (1983)	§	Cross section (linear)	1950-1973
Deger & Sen (1983)	‡	Cross section (linear)	1965-1973
Faini et. al. (1984)	<i>O</i>	Time series (linear)	1950-1972
Cappelen et. al. (1984)	<i>O</i>	Panel (linear)	1960-1980
Landau (1986)	<i>O</i>	Panel (linear)	1960-1980
Biswas & Ram (1986)	<i>O</i>	Cross section (linear)	1960-1977
Deger (1986)	‡	Cross section (linear)	1965-1973
Lebovic & Ishaq (1987)	‡	Panel (linear)	1973-1982
Chan (1988)	<i>O</i>	Time series (linear)	1961-1985
Grobar & Porter (1989)	<i>O</i>	Cross section (linear)	1950-1965
Gyimah-Brempong (1989)	‡	Panel ( linear)	1973-1983
Looney (1989)	<i>O</i>	Cross section (linear)	1970-1982
Landau (1993)	<i>O</i>	Panel (nonlinear)	1969-1989
Dunne & Mohammed (1995)	‡	Panel (linear)	1967-1985
Lipow & Antinori (1995)	<i>O</i>	Cross section (linear)	1974-1989
Blomberg (1996)	§	Panel (linear)	1967-1982
Knight et. al. (1996)	§	Cross section & Panel (linear)	1971-1985
Landau (1996)	<i>O</i>	Panel (nonlinear)	1950-1990
Brumm (1997)	§	Cross section (linear)	1974-1989
Antonakis (1997)	<i>O</i>	Time series (linear)	1960-1990
Heo & DeRouen (1998)	<i>O</i>	Time series(linear)	1961-1990
DeRauen (2000)	<i>O</i>	Time series (linear)	1953-1992
Stroup & Heckelmen (2001)	§	Panel (nonlinear)	1975-1989
Galvin (2003)	‡	Cross section (linear)	1999
Aizenman & Glick (2006)	§	Cross section (nonlinear)	1989-1998
Bose et. al. (2007)	§	Panel (linear)	1970-1989
Kalaitzidakis & Tzouvelekas (2007)	§	Panel (nonlinear)	1980-1995
Kollias et. al. (2007)	<i>O</i>	Panel (linear)	1961-2000
Yakovlev (2007)	§	Panel (linear-nonlinear)	1960-2000
Looney & McNab (2008)	<i>O</i>	Panel (linear)	1999-2003

Approach ‡ represents a model that is based on either the short-run Keynesian demand-supply model of Deger-Smith or SEM methods.

Approach § represents that the empirical specification is derived from either the long-run Solow or Barro type growth model.

Approach *O* represents the other models, which do not fall in to either category ‡ or § .

Table 5: Military expenditure - growth studies included in the Meta Analysis

<b>Variables</b>	<b>Definition</b>
No. Observation in primary study (lnobs)	Natural logarithm of number of observation in the primary study.
No. Years in primary study (lnyear)	Natural logarithm of number of years in the primary study.
Dummy 1950s (D50)	Takes value 1 if the primary study includes data from 1950s, otherwise 0.
Dummy 1960s (D60)	Takes value 1 if the primary study includes data from 1960s, otherwise 0.
Dummy 1980s (D80)	Takes value 1 if the primary study includes data from 1980s, otherwise 0.
Dummy 1990s (D90)	Takes value 1 if the primary study includes data from 1990s, otherwise 0.
ACDA	Takes value 1 if the data used in the primary study comes from ACDA, otherwise 0.
Developed countries	Takes value 1 if the primary study data is from developed countries, otherwise 0.
LDCs	Takes value 1 if the primary study use data only from LDC's, otherwise 0.
Africa	Takes value 1 if only African countries data is used, otherwise 0
Single country study	Takes value 1 if a single time series analysis of a country is done, otherwise 0.
Simultaneous Equations Model (SEM)	Takes value 1 if the method of estimation is simultaneous equations approach, otherwise 0.
Panel	Takes value 1 if the method of estimation is panel data in the primary study, otherwise 0.
Growth theory	Takes value 1 if the model is based on economic growth model, otherwise 0.
Aid	Takes value 1 if the primary study control for AID, otherwise 0.
Non-linear functional forms	Takes value 1 if the primary study control for non-linear or interaction terms, otherwise 0.
Democracy (Dem)	Takes value 1 if the primary study control for democracy, otherwise 0.
Education (Edu)	Takes value 1 if the primary study control for education, otherwise 0.
Instability or war	Takes value 1 if the primary study control for instability or war, otherwise 0.
Foreign direct investment (FDI)	Takes value 1 if the primary study control for FDI, otherwise 0.
Neighbouring countries' milexp (NME)	Takes value 1 if the primary study control for NME, otherwise 0.

Table 6: Meta-Regression Analysis Variables

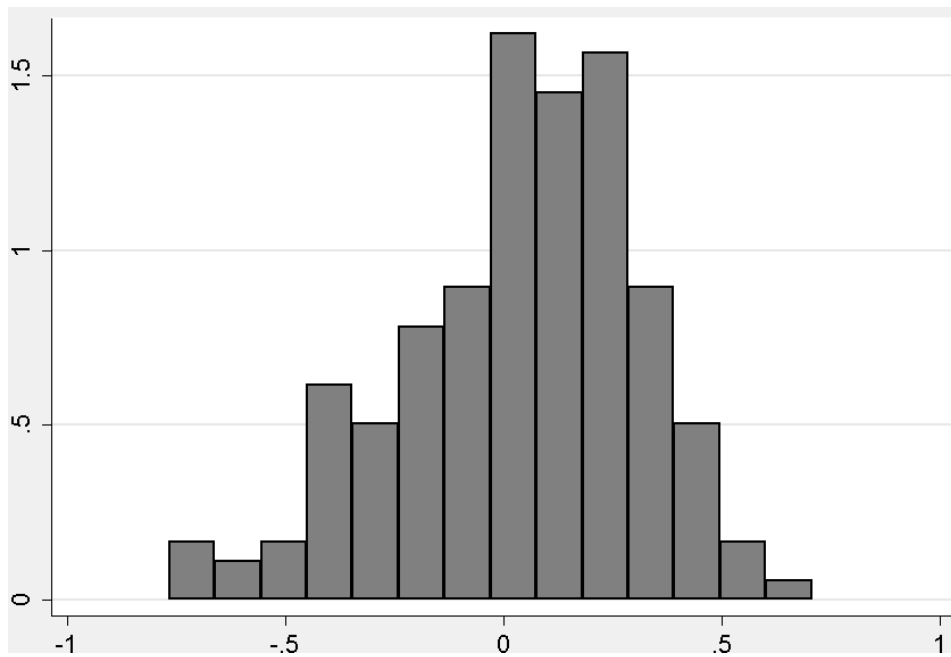


Figure 2: Distribution of partial correlation coefficient