Effects of Military Expenditures on Economic Growth in the 93 Top Military Spenders of 2018

First Draft

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Abstract

The effect of military expenditures on economic growth has been studied by economists with the consensus now largely being that the effect is negative. Operating under this hypothesis, in this paper we examine this relationship using military expenditures data retrieved from the Stockholm International Peace Research Institute to confirm if our results are consistent with relevant literature. We first estimate this relationship through the use of a cross-section regression model, and then with a panel regression model using a pooled OLS model, a random effects model, then a fixed effects model. We determine that a robust fixed effects regression is the most appropriate model and find that military expenditures are negatively related to economic growth. This is consistent with the relevant literature and our hypothesis. We conclude with potential improvements and alterations to be made to the models in the next iteration of this paper.

A well-armed and well-trained military is a requirement for countries to defend their sovereignty and interests at home and abroad. Proponents of high military spending suggest that a large military is a necessary deterrent against adversarial nations and contributes to global peace and stability. Others assert that high military spending is a waste of government expenditures that could instead be allocated to fund public investments. While there is truth in both claims, arguments for and against the necessary level of military spending should depend on the relationship between military spending and economic growth. If the relationship is positive, then high military spending can be substantiated; if the relationship is negative, then the trade-off from higher military expenditures will be difficult to justify. This study aims to develop two models to discern if the effect of military expenditures on economic growth in the 93 top military spenders of 2018 is positive or negative while controlling for various factors. While it seems much of the relevant literature suggests that it is negative, we will examine the relationship with a cross-section regression model and a panel regression model that will estimate the relationship from the years 1999 to 2018 in order to confirm and compare. In what follows, Section I will present a review of relevant literature; Section II will provide our models, the hypotheses we intend to test, and the proposed estimation procedure; Section III will present our data sources and data analysis with descriptive statistics; Section IV will present the results from our econometric estimation; Section V will compare our results to other studies; and Section VI will conclude.

Section I

The relationship between military spending and its determinants has been a popular area of study for many economists as there is an extensive amount of literature on the subject. Nevertheless, there has yet to be a definitive consensus as to whether the effect is positive, negative, or insignificant due to the incredible complexity of the relationship and different empirical methods used. In their meta-analysis of 32 previously published studies, Alptekin and Levine (2012) studied four hypotheses. Ultimately, their findings indicated a positive, non-linear relationship between military spending and growth. However, a shortcoming of the meta-analysis was that the studies analyzed were published between the 1960s and 1980s. As such, their conclusion failed to consider more recent data.

D'Agostino et al. (2017) stressed the importance of using more recent data when studying the defence-growth relationship. Using data from 1970 to 2014, the authors argued they captured a more comprehensive dataset to evaluate the relationship because this data included post-Cold War military spending levels. Retrieving their data from the Stockholm International Peace Research Institute (SIRPI) databases and Penn World Tables, the authors created a model that used government spending as a share of GDP, military spending as a share of government spending, and investment as a share of GDP as independent variables.

However, Perlo-Freeman (2017) argued that, although the SIPRI dataset is an important tool for studying the defence-growth relationship, the data values before 1988 are flawed and should be excluded when conducting research. This is due to the values being recovered from secondary sources, or from being estimated, leading to the possibility of a potentially large margin of error. Still, the results of D'Agostino et al. (2017), using the data from 1970 to 2014, found that the defence spending-growth relationship was negative, and the size of the negative effect depended on a nation's development level (OECD, non-OECD, and African).

Chowdhury (1991) studied the causal relationship between economic growth and military spending in 55 developing countries from 1961-62 to 1984-87 depending on available data. Using the Granger-causality test, Chowdhury found that it may be erroneous to generalize the effects of military spending on economic growth across all countries. He noted that countries have different systems of government and socio-economic factors that will surely affect the defence-growth relationship in each individual case. However, according to Chowdhury, a multivariate test taking other variables into account may allow for a more generalized model to be reliable.

Dunne et al. (2005) assessed three multivariate growth models – the Feder-Ram model, the Augmented Solow model, and the Barro model – all of which are often used in military expenditures and economic growth studies. Through rigorous evaluation of each model, the authors determined that the Feder-Ram and Augmented-Solow models were inadequate and possessed significant weaknesses. They concluded that the Barro growth model was a more useful model because it allows researchers to account for security as a measure of military expenditures relative to threat level.

A similar Barro growth model was used by Aizenman and Glick (2006) in their study of the interaction between military spending, economic growth, and threat level. The authors highlighted similar results to other articles reviewed for this research proposal – there is a decrease in economic growth when a large percentage of GDP is spent on the military. Utilizing a data approach of non-linear relations among corruption, presence of external threats, military spending and while controlling for initial levels of per capita real GDP, education attainment, investment, and population growth, the result of the model indicated that military spending motivated by significant corruption and rent seeking had a negative impact on economic growth. Interestingly, a unique observation showed that when military spending and the presence of external threats were high, there was an increase in economic growth.

However, Araujo Jr. and Shikida (2008) contended the results obtained by Aizenman and Glick (2006). Their main criticism was the lack of homogeneity in the variable's time periods – not all variables used in the study by Aizenman and Glick (2006) were from the exact same range of time. Therefore, the authors deemed the estimation strategy and methodology used by Aizenman and Glick (2006) to be insufficient. Araujo Jr. and Shikida (2008) also noted that the Ordinary Least Squares (OLS) method used by Aizenman and Glick (2006) to run their model was inaccurate. Instead, the authors used the Two-Stage Least Squares method to reconfirm Aizenman and Glick's (2006) hypothesis and came to the same conclusion.

Next, Dunne and Tian (2015) analyzed the relationship between economic growth and military spending, focusing on group heterogeneity and nonlinearity using augmented Solow growth models. Their data were made up of 104 countries from 1988-2010 using figures from SIPRI and World Bank development indicators. Furthermore, they grouped their samples into 4 segments: income; foreign aid; natural resources; and openness to trade. The results of this research paper reinforced the impression that military expenditures have a negative impact on growth. However, military spending in countries with non-fuel natural resource abundance and low-aid recipient countries was not found harmful to growth.

Moreover, Dunne (2011), using cross-section panel data from 1988-2006, divided countries into four income levels as well a separate category for Sub-Saharan Africa. In general, the author found that all of the income level groups, with the exception of the upper middle-income group, drew conclusions of unfavorable short-run effects of military spending on the growth of GDP per capita. This is similar to the findings of Hou and Chen (2013) about developing countries. Through the test of 35 developing nations from 1975 to 2009 using a system GMM estimator, the authors concluded that military spending in developing countries led to a decrease in economic growth. For the Sub Saharan Africa group, Dune (2001) found that countries without conflict appeared to display only short-run effects while countries with conflict suggested there are potential long-term effects.

Using data from the World Bank's world development indicators and the African development indicators, D'Agostino et al. (2012) estimated the impact of military spending and level of corruption on economic growth in 53 African countries from 2003 to 2007. Their model examined military spending, government consumption, private investment as a percentage of GDP, and corruption while controlling for openness and stability. The authors concluded that while investment in both public and private sectors played an active role in growing the economy, increased spending in the military led to further corruption. The authors noted that the presence of corruption was directly correlated with increasing rent-seeking activity and pushed resources away from more economically beneficial sectors, such as public investments, and into less productive sectors.

Finally, Yakovlev (2007) examined the effects of military spending and arms trading on economic growth in 28 countries from 1965 to 2000. The paper also stated that the biggest arms traders are often the biggest military spenders and indicated that the relationship between military spending and growth may be conditional upon the net arms exports. Yakovlev concluded that military spending had a negative impact on growth. However, if a country had high military spending and was a net arms exporter, then the negative impact was reduced. Thus, if a country wanted to increase military expenditures, it helped if they were also a net arms exporter to reduce the negative effect. Based on the literature reviewed, our models will use the military spending – GDP ratio, the number of armed personnel in each country, net arms exports, perceived threat level, and corruption index as independent variables. The model will also control for income per capita, natural resources rent as a percentage of GDP, education attainment and the foreign direct investment inflows as a percentage of GDP ratio.

Section II:

Two models will be used: a cross-section regression model for average growth and panel regression model for more precision. They will include the same independent and control variables and measure for the GDP growth rate. However, the cross-section model will specifically estimate for the average twenty-year growth rate in GDP per capita. The cross-section regression model is as follows:

$$\frac{1}{T}[\ln(Y_{iT}) - \ln(Y_{i1})] = \beta_o + \beta_1 \ln(Y_{i,1}) + \gamma_1 MIL_{i,1} + \gamma_2 SIZE_{i,1} + \gamma_3 THRT_{i,1} + \gamma_4 CORR_{i,1} + \gamma_5 NETARM_{i,1} + \gamma_6 INCOME_{i,1} + \gamma_7 FDI_{i,1} + \gamma_8 EDUC_{i,1} + \gamma_9 NATRES_{i,1} + \varepsilon_{it}$$

In this cross-section regression model, β_o is the constant term and β_1 is the coefficient associated with the natural logarithm of initial GDP per capita [$\ln(Y_i)$]. The coefficients γ_1 to γ_9 are associated with the independent variables and the size of their marginal effects on the dependent variable. The variable MIL_i represents the percentage of military spending in GDP for a given country and we predict its impact to be negative on economic growth based on the literature reviewed. Next, $SIZE_i$ is the number of armed forces personnel in each country, and $NETARMS_i$ is a nation's arms trade balance. We expect $SIZE_i$ to have a negative impact and $NETARMS_i$ to have a positive impact on economic growth. Further, $THRT_i$ measures the threat level of a nation as defined by the number of conflict related deaths that have occurred during the twenty-year period. Finally, $CORR_i$ is the control of corruption estimate and is measured in units of normal distribution (approximately -2.5 to +2.5).

Four control variables will be used in the model. The first is $INCOME_i$ which measures the adjusted net national income per capita in constant 2010 USD. The second control variable is FDI_i which measures the net inflows of foreign direct investment as a percentage of GDP. Third is the education attainment level ($EDUC_i$) – specifically, the total percentage of the population over the age of 25 who have completed post-secondary education. Next, $NATRES_i$ accounts for total natural resources rents as a percentage of GDP. We expect all of these control variables to have a positive impact on economic growth. Finally, ε_{it} simply represents the error term.

The second model that we will consider uses the panel regression equation. It is identical to the cross-section regression equation, but the dependent variable is now simply the annual growth rate of real GDP per capita. The original equation is as follows:

$$[\ln(Y_{i,t}) - \ln(Y_{i\,t-1})] = \beta_o + \beta_1 \ln(Y_{i,t-1}) + \gamma_1 MIL_{i,t} + \gamma_2 SIZE_{i,t} + \gamma_3 THRT_{i,t} + \gamma_4 CORR_{i,t} + \gamma_5 NETARM_{i,t} + \gamma_6 INCOME_{i,t} + \gamma_7 FDI_{i,t} + \gamma_8 EDUC_{i,t} + \gamma_9 NATRES_{i,t} + \varepsilon_{it}$$

Based on the literature and the two models, we hypothesize that overall military expenditures have a negative impact on economic growth and thus the military spending – GDP ratio will have a negative coefficient. We also hypothesize that in countries with high levels of corruption, the negative effect will be intensified as described by Aizenman and Glick (2006) and D'Agostino et al. (2012) and that corruption will also have a negative coefficient. Moreover, in countries that are net arms exporters, or have a high external threat level, the negative effect will be reduced. More specifically, we hypothesize that net arms exports and threat level will have a positive coefficient. This is supported by Yakovlev (2007) and Aizenman and Glick (2006). We believe that all of the control variables – income per capita, foreign direct investment, educational attainment, and natural resources rent – will all have positive coefficients. These hypotheses will be tested using an Ordinary Least Squares (OLS) regression with both models. For the panel regression model, we will conduct a pooled OLS regression in addition to random effects and fixed effects regressions. This will be done to optimize the model. We believe that this approach is an appropriate synthesis of the methods used in the reviewed literature and will yield suitable results which capture the complexity of the relationship between military spending and economic growth.

Section III: Heading

Reliable data sources are needed to ensure the model is sound. An important data source that will be used is the Stockholm International Peace Research Institute (SIPRI) which releases numerous databases. This paper will employ the SIPRI Military Expenditures Database to measure military spending as a share of GDP (MIL) from 1999 to 2018. The SIPRI Trend Indicator Values (TIV) database on arms imports and exports to determine the value for net arms exports in millions of dollars ($NETARM$) for the same period. To measure the number of armed forces personnel in tens of thousands ($SIZE$), we will use data retrieved from the World Bank, specifically, the World Development Indicators (WDI) Database.

The WDI Database will also be employed to assess: income per capita ($INCOME$); foregin direct investment (FDI); education attainment ($EDUC$); and natural resources rent ($NATRES$). The WDI

Database will also be used to find the GDP per capita (Y_i). The other World Bank database we will use is the Worldwide Governance Indicators Database. This will be used to determine the corruption level of each country ($CORR$). These World Bank databases have information available from 1999 to 2018 but have missing values for some countries. Specifically, the data for $EDUC$ is sparse since many countries only release this data after a census while other release the data more frequently. To obtain data for the threat variable ($THRT$) we will again use the World Bank's WDI Database which houses the number of battle-related deaths in a country. Data is available from 1999 to 2018.

We will analyze the data for our two models separately. Beginning with the cross-section regression, the descriptive statistics of the independent variables and dependent variable are available in the table below:

Table 1: This table lists the descriptive statistics for the independent variables and dependent variable in the cross-section regression model. See Appendix 4 for the STATA code and output.

VARIABLE	***N***	***MEAN***	***S.D.***	***MIN***	***MAX***
$\frac{1}{T}[ln(Y_{iT}) - ln(Y_{i1})]$	92	0.0238	0.0166	-0.00633	0.0779
$ln(Y_{i,1})$	93	8.777	1.469	5.255	11.379
$MIL_{i,1}$	92	0.0273	0.025	0.00461	0.173
$SIZE_{i,1}$	93	25.493	51.289	0.14	382
$THRT_{i,1}$	18	2706.5	7130.463	1	30,704
$CORR_{i,1}$	0	-	-	-	-
$NETARM_{i,1}$	77	42.091	1512.264	-1697	11,340
$INCOME_{i,1}$	83	12,681.55	15,258.67	-550.866	65,152.25
$FDI_{i,1}$	91	4.929	7.367	-1.333	46.364
$EDUC_{i,t}$	0	-	-	-	-
$NATRES_{i,t}$	93	4.197	7.791	0.000372	39.907

We can see from **Table 1** above that no data are available for *CORR* and *EDUC* in 1999 for all 93 countries in the sample. Therefore, we must clean our data by dropping these variables when running the cross-section regression model. Moreover, there are only 18 observations for *THRT* in 1999. In order to have a sufficient number of observations in the model, we must clean the data by dropping *THRT* as well. This is unfortunate since *THRT* is an important determinant of military expenditures, however the model would be poor if it were included.

Correlating the remaining variables (see A.II.1), we find that ln(Y_1) and *INCOME* are highly correlated – approximately 89% correlated according to the table. This is likely because initial GDP per capita and income per capita are incredibly similar measurements, an oversight when developing the models and gathering data. Since these two variables are highly correlated, one must be removed in order to ensure a reliable result. We have opted to remove ln(Y_1) as an independent variable because it is represented in the dependent variable; *INCOME* will continue to be used in the model as it is an important control variable. No other independent variables are correlated at such a level that would justify dropping them from the regression. Therefore, the revised cross-section regression model is:

$$\frac{1}{T}[\ln(Y_{iT}) - \ln(Y_{i1})] = \beta_o + \gamma_1 MIL_{i,1} + \gamma_2 SIZE_{i,1} + \gamma_5 NETARM_{i,1} + \gamma_6 INCOME_{i,1} + \gamma_7 FDI_{i,1} + \gamma_9 NATRES_{i,1} + \varepsilon_{it}$$

Further, we can examine the scatter plots of the variables to determine if the relationships between the dependent and independent variables are linear or non-linear. Referring to Appendix II (see A.II.2), we can see that many of the independent variables seem to interact with the dependent variable non-linearly. We can attempt to account for this non-linearity by changing the functional form of the model and applying the natural logarithm to certain explanatory variables. These results are displayed in Appendix II (see A.II.3) and will be used in Section IV for the determination of the best functional form for the cross-section model. We can see that applying the natural logarithm to certain independent variables can drastically change their distribution when plotted against the dependent variable.

Next, we will analyze the data for the panel regression model. The descriptive statistics for the independent variables and dependent variable are listed in the table below:

Table 2: This table displays the descriptive statistics of the dependent variable and independent variables of the panel regression data. See Appendix IV for the STATA output and codes.

VARIABLE	*N*	*MEAN*	*S.D.*	*MIN*	*MAX*
$[\ln(Y_{i,t}) - \ln(Y_{i\,t-1})]$	1858	0.0246	0.0364	-0.155	0.235
$\ln(Y_{i,t-1})$	1859	9.021	1.396	5.234	11.626
$MIL_{i,t}$	1859	0.0223	0.0169	0.00289	0.173
$SIZE_{i,t}$	1761	24.134	48.809	0.14	391
$THRT_{i,t}$	357	740.9524	2330.999	0	30,704
$CORR_{i,t}$	1674	0.244	1.052	-1.523	2.469
$NETARM_{i,t}$	1652	44.709	1240.029	-5364	11,526
$INCOME_{i,t}$	1790	14,769.26	16,410.75	-1956.749	82,834.16
$FDI_{i,t}$	1848	5.145	14.017	-58.323	280.132
$EDUC_{i,t}$	660	23.977	13.078	1.83	79.02
$NATRES_{i,t}$	1859	5.995	10.049	0.000188	61.949

We can see from **Table 2** that there is a low number of observations for *EDUC*, with only 660, and *THRT*, with only 357. In order to ensure that the panel regression incorporates as many observations as possible, we will drop $EDUC_{i,t}$and $THRT_{i,t}$for this model as we did with the cross-section model. Unlike in the cross-section model, $CORR_{i,t}$ provides an adequate number of observations for this model. However, when analyzing the correlation between the variables, we find that $CORR_{i,t}$ is highly correlated with $INCOME_{i,t}$ – approximately 86% correlated according to the table – and is also highly correlated with $\ln\left(Y_{i,t-1}\right)$ – approximately 84% correlated . This would indicate that either $CORR_{i,t}$ or $\ln\left(Y_{i,t-1}\right)$ or $INCOME_{i,t}$ should be removed from the model. On the other hand, we believe $CORR_{i,t}$ to be a vital explanatory variable for estimating the economic growth and military expenditures relationship, thus we have opted to keep it in the model for this iteration of our research paper. Furthermore, we again find that $\ln\left(Y_{i,t-1}\right)$ and $INCOME_{i,t}$ are approximately 87% correlated because of their similar measurements. As we did in the cross-section model, we will drop $\ln\left(Y_{i,t-1}\right)$ as an explanatory variable, even though it is slightly less correlated with $CORR_{i,t}$ than is $INCOME_{i,t}$. Refer to Appendix II for the correlation table (see A.II.4). Thus, the revised estimated panel regression model is:

$$\left[\ln\left(Y_{i,t}\right) - \ln(Y_{i\,t-1})\right] = \beta_o + \gamma_1 MIL_{i,t} + \gamma_2 SIZE_{i,t} + \gamma_3 CORR_{i,t} + \gamma_4 NETARM_{i,t} + \gamma_5 INCOME_{i,t} + \gamma_6 FDI_{i,t} + \gamma_7 NATRES_{i,t} + \varepsilon_{it}$$

Next, we will examine the scatter plots of the independent variables in the panel model. Referring to Appendix II (see A.II.5), we can examine the relationships between economic growth and the independent variables; many of these relationships appear to be relatively linear. However, we can apply the natural logarithm to certain explanatory variables to visualize if changing the functional form yields a better distribution. The results are displayed in Appendix II (see A.II.6) and again demonstrate how applying the natural logarithm can significantly alter the plots of the independent variables. For some variables, it may be best to apply the natural logarithm in the regression, while for others it may be best to maintain the linear functional form. This will be explored in the following section as we determine the best estimated model.

Section IV:

We will first run the revised cross-section model which uses a linear function form for all explanatory variables. The result of the estimated regression is shown below in **Table 3**. Examining the output, we find that 69 observations were used to run the model, indicating that 24 countries were excluded due to missing data. In this estimated cross-section model, the explanatory variables $MIL_{i,t}$, $SIZE_{i,t}$, and $INCOME_{i,t}$ are all significant at the 1% significance level, however the coefficient for $INCOME_{i,t}$ is incredibly small ($-6.05e^{-7}$) and therefore has a low marginal effect. The models shows that $FDI_{i,t}$ is significant at the 10% significance level while $NETARM_{i,t}$ and $NATRES_{i,t}$ are insignificant. The signs of coefficients of the explanatory variables are also interesting. As expected, $MIL_{i,t}$ has a negative coefficient and $FDI_{i,t}$ has a positive coefficient. However, contrary to our hypotheses, $INCOME_{i,t}$, $NETARM_{i,t}$, and $NATRES_{i,t}$ have negative coefficients and $SIZE_{i,t}$ has a positive coefficient. Intuition suggests that a higher income per capita, higher net arms exports, and higher natural resources rent would correspond to a higher growth rate in GDP per capita. Moreover, since higher military expenditures are negatively correlated with GDP per capita growth, one would expect that a higher number of armed forces personnel would also be negatively correlated.

Table 3: This table shows the results for the estimated cross-section regression. The standard errors are in parentheses. See Appendix IV for the STATA code and output.

VARIABLES	$\frac{1}{T}[ln(Y_{iT}) - ln(Y_{i1})]$
MIL	-0.309*** (0.0964)
SIZE	0.000108*** ($2.33e^{-5}$)
NETARM	$-7.25e^{-7}$ ($8.49e^{-7}$)
INCOME	$-6.05e^{-7}$*** ($1.01e^{-7}$)
FDI	0.000327* (0.000195)
NATRES	-0.000428 (0.000334)
CONSTANT	0.0344*** (0.00321)
N	69
R^2	0.548

*****P <0.01, **P<0.05, *P<0.1**

As shown in Appendix IV (see A.IV.7), the *F-Test* confirms that the independent variables reliably predict the dependent variable. Further, in this model we have a coefficient of determination of $R^2 = 0.548$. In other words, approximately 55% of the average variation in the growth of GDP per capita is explained by the independent variables. However, since this model will be compared with another, we must use the adjusted R^2. Based on the STATA output, $\bar{R}^2 = 0.505$ which means that approximately 51% of the average variation in the growth of GDP per capita is explained by the independent variables. Further, conducting a Breusch-Pagan/Cook-Weisberg test for heteroskedasticity finds that this estimated cross-section model does not exhibit heteroskedasticity, so a correction with a robust regression is not needed. Next, finding the variance inflation factors in STATA, we determine that there is no multicollinearity among the independent variables since they *VIF* values are quite low. This is consistent with our findings in the correlation table after $\ln(Y_{i1})$ was removed.

We will modify the linear model by applying the natural logarithm to some variables in order to capture possible nonlinear relationship between some independent variables and the dependent variable and have more significant explanatory variables. Through rigorous testing of many variations, we ultimately decided to apply the natural logarithm to foreign direct investment and income per capita, creating $\ln(FDI_{i,1})$ and $\ln(INCOME_{i,1})$. Therefore, the final version of the cross-section model is:

$$\frac{1}{T}[\ln(Y_{iT}) - \ln(Y_{i1})] = \beta_o + \gamma_1 MIL_{i,1} + \gamma_2 SIZE_{i,1} + \gamma_5 NETARM_{i,1} + \gamma_6 \ln(INCOME_{i,1}) + \gamma_7 \ln(FDI_{i,1}) + \gamma_9 NATRES_{i,1} + \varepsilon_{it}$$

We believe these amendments to the functional form of these variables improve upon the cross-section estimation demonstrated by the results below in **Table 4**. Through analysis, we notice that 68 observations were used to run the model, one observation less than in the previous estimation; therefore, 25 countries were not included. Next, the results show that $MIL_{i,t}$, $SIZE_{i,t}$, $\ln(FDI_{i,1})$ and $\ln(INCOME_{i,1})$ are all significant at the 1% level, and $NATRES_{i,t}$ is now significant at the 10% level. However, $NETARM_{i,t}$ continues to be insignificant, although the p-value is smaller in this estimation than in the previous estimation (p-value = 0.219 vs. p-value = 0.397) which is an improvement. Further, the signs in front of the sample coefficients are the same as they were in the previous estimation, but their values have changed due to the new specifications of foreign direct investment and income per capita.

Table 3: This table shows the results for the cross-section estimation with natural logarithm on *FDI* and *INCOME*. Standard errors are in parentheses. See Appendix IV for the STATA code and output.

VARIABLES	$\frac{1}{T}[\ln(Y_{iT}) - \ln(Y_{i1})]$
MIL	-0.251*** (0.0935)
SIZE	0.0000966*** ($2.30e^{-5}$)
NETARM	$-1.01e^{-6}$ ($8.17e^{-7}$)
ln(INCOME)	-0.00699*** (0.00107)
ln(FDI)	0.000327*** (0.000106)
NATRES	-0.000659* (0.000333)
CONSTANT	0.0856*** (0.0101)
N	68
R^2	0.585

*****P <0.01, **P<0.05, *P<0.1**

Based on the STATA output, shown in Appendix IV (see A.IV.7), the *F-Test* confirms that the independent variables in this new estimation reliably predict the dependent variable. Since we are comparing this model to the previous model, we can ignore the R^2 value ($R^2 = 0.585$). Using the adjusted R^2 ($\bar{R}^2$), the fit of this estimation can be compared with the one previous where $\bar{R}^2 = 0.505$. In this new estimation, the adjusted R^2 is $\bar{R}^2 = 0.544$. Therefore, approximately 54% of the variation in the average growth rate of GDP per Capita is explained by the independent variables whereas the previous model only explained approximately 51% of the average variation. While this is only a slight increase, it is still evidence that the new estimation is an improved model. Next, conducting a Breusch-Pagan/Cook-Weisberg test for heteroskedasticity in STATA finds that this estimated cross-section model does not exhibit heteroskedasticity, so a correction with a robust regression is not necessary. Finally, using STATA to find the variance inflation factors, we conclude that there is no multicollinearity among the explanatory variables.

Ultimately, we feel that both of these cross-section models provide adequate estimations of the military spending and economic growth relationship with preference towards the model with the natural logarithm specifications applied to foreign direct investment and income per capita. Both models estimate that there is a negative relationship between military expenditures and economic growth, and that foreign direct investment is estimated to have a positive relationship. This is consistent with what was hypothesized. Nevertheless, it is surprising to see that net arms exports, income per capita, and natural resources rent are all negatively related to economic growth while military size is positively related. Next, we will determine how the results in the cross-section models differ from the panel regression model.

Beginning with a pooled OLS panel regression, 1369 observations were used in the estimation meaning that 490 observations were dropped. This model also shows that all of the explanatory variables are significant at 1% level with the exception of $NETARM_{i,t}$ which, as in the cross-section estimations, is insignificant and has an incredibly small marginal effect. Also, although $INCOME_{i,t}$ is significant at the 1% level, its marginal effect on GDP per capita growth is minimal ($-8.11e^{-7}$). Indeed, in this estimated panel regression, we find that $MIL_{i,t}$, $NETARM_{i,t}$, and $INCOME_{i,t}$ are negatively related to GDP per capita growth and $FDI_{i,t}$ and $SIZE_{i,t}$ are positively related – this is consistent with the cross-section estimations. On the other hand, $NATRES_{i,t}$ is now positively related to estimated GDP per capita growth. Also, the coefficient of $CORR_{i,t}$ is unexpected positive as one would expect a higher corruption level to lead to reduced economic growth. Refer to Appendix III for the results of the estimation (see A.III.1).

The pooled OLS estimation passes the *F-Test* so the independent variables reliably predict the dependent variable. However, the coefficient of determination in this estimation is incredibly low: $R^2 = 0.114$. Therefore, approximately 11% of the variation in the average growth of GDP per capita is explained by the model. Next, using the Breusch-Pagan/Cook-Weisberg test for heteroskedasticity in STATA, we find that the pooled OLS model exhibits heteroskedasticity. To correct for this issue, we perform a robust pooled OLS regression, the results of which are available in **Table 4**. By accounting for heteroskedasticity, the coefficients of each independent variable change, but their signs remain the same. Moreover, foreign direct investment becomes insignificant while natural resources rent becomes less significant, now at the 5% level. Next, the robust regression passes the *F-Test* and the R^2 value remains the same. Finally, testing for multicollinearity, we find somewhat high *VIF* values for income per capita and corruption level: $VIF_{INCOME} = 4.39$ and $VIF_{CORR} = 4.63$. This was expected due to their high correlations and provides further evidence that one of these variables will need to be dropped in future iterations of the estimation.

Next, we conduct the Breusch-Pagan Lagrange Multiplier test in STATA to determine if a random effects model is superior to the pooled OLS model and conclude that the RE regression is preferred. The results of the random effects estimation are in Appendix III (see A.III.2). In the random effects estimation, we find that 1369 observations were used in the regression. All independent variables are significant at the 1% level except for $FDI_{i,t}$ which is significant at the 5% level and $NETARM_{i,t}$ which is once again insignificant. Moreover, $NETARM_{i,t}$ and $INCOME_{i,t}$ have very small marginal effects while $MIL_{i,t}$ has a larger marginal effect. Holding the other explanatory variables fixed, a one-unit increase in $MIL_{i,t}$ will result in an approximate decrease in 0.56 units of GDP per capita growth. Nonetheless, according to the *F-Test*, the independent variables reliably explain the dependent variable. Testing for multicollinearity, as with the other estimations, we expectedly find high *VIF* values for corruption and income per capita.

Now the random effects regression must be compared with the fixed effects regression to determine which is a better model for our data. Conducting a Hausman test in STATA, we find that the fixed effects regression is better suited. The results of the FE estimation are in Appendix III (see A.III.3). With 1369 observations used, the results show that $NATRES_{i,t}$ and $CORR_{i,t}$ are significant at the 1% level; $MIL_{i,t}$, $SIZE_{i,t}$, and $INCOME_{i,t}$ are significant at the 5% level; and $NETARM_{i,t}$ and $FDI_{i,t}$. According to the *F-Test*, the independent variables reliably estimate the dependent variable. While the signs remain the same, using fixed effects, we find that the size of coefficients of the independent variables change – for example, under fixed effects, a one-unit increase in $MIL_{i,t}$ would cause the estimated average growth of GDP per capita to decrease by approximately 0.47 units instead of 0.56 units under random effects. Further, using a modified Wald test for groupwise heteroskedasticity in the fixed effects regression model, we find that there is heteroskedasticity and a robust regression must be done as a correction. We will also do a robust regression on the random effects model for consistency.

The results for the robust fixed effects and random effects regressions are located in **Table 4** below which also shows the results of the robust pooled OLS estimation for comparison. For the robust random effects estimation, all independent variables are significant at the 1% level except for $NATRES_{i,t}$ which is significant at the 5% level, while $FDI_{i,t}$ and $NETARM_{i,t}$ are insignificant. These are the same significance levels that were found under the robust pooled OLS model. However, under the robust fixed effects estimation, $MIL_{i,t}$, our variable of interest, is no longer significant. Moreover, $SIZE_{i,t}$ and $INCOME_{i,t}$ decrease in their level of significance, now at the 10%. $CORR_{i,t}$ also decreases, becoming significant at the 5% level, but $NATRES_{i,t}$ remains significant at the 1% level. While it is not ideal that our variable of interest is insignificant, the modified Wald test and Hausman test substantiate the robust fixed effects estimation is the appropriate model to use. Finally, the robust fixed effects estimation has a coefficient of determination of $R^2 = 0.045$, an extremely low value.

Table 4: This table lists the estimation results from running the robust fixed effects model, robust random effects model, and the robust pooled OLS model. Robust standard deviations are in parenthesis. See Appendix IV for the STATA codes and outputs.

VARIABLES	FIXED EFFECTS	RANDOM EFFECTS	POOLED OLS
MIL	-0.469	-0.558***	-0.445***
	(0.299)	(0.116)	(0.0690)
SIZE	0.000276*	0.000147***	0.000132***
	(0.000154)	($2.37e^{-5}$)	($1.38e^{-5}$)
CORR	0.0170**	0.00934***	0.00531***
	(0.00820)	(0.00312)	(0.00187)
NETARM	$-3.82e^{-7}$	$-7.98e^{-8}$	$-2.04e^{-7}$
	($2.09e^{=6}$)	($6.85e^{-7}$)	($5.61e^{-7}$)
INCOME	$-1.09e^{-6}$*	$-1.04e^{-6}$***	$-8.11e^{-7}$***
	($5.54e^{-7}$)	($2.08e^{-7}$)	($1.11e^{-7}$)
FDI	0.000149	0.000201	0.000262
	(0.000333)	(0.000201)	(0.000238)
NATRES	0.00163***	0.000695**	0.000347***
	(0.000398)	(0.000342)	(0.000163)
CONSTANT	0.0285***	0.0410***	0.0383***
	(0.0133)	(0.00395)	(0.00233)
N	1396	1396	1396
R^2	0.045	-	0.114
# OF COUNTRIES	93	93	-

*****P<0.01, **P<0.05, *P<0.1**

We will perform one final fixed effects regression and change the functional form of certain independent variables in order to increase the significance of $MIL_{i,t}$. As we did with the cross-section model, we apply the natural logarithm to income per capita and foreign direct investment. We also add it to $SIZE_{i,t}$ making ln ($SIZE_{i,t}$). Therefore, the revised fixed effects panel model is:

$$[\ln(Y_{i,t}) - \ln(Y_{i\,t-1})] = \beta_o + \gamma_1 MIL_{i,t} + \gamma_2 \ln(SIZE_{i,t}) + \gamma_3 CORR_{i,t} + \gamma_4 NETARM_{i,t} + \gamma_5 \ln(INCOME_{i,t}) + \gamma_6 \ln(FDI_{i,t}) + \gamma_7 NATRES_{i,t} + \varepsilon_{it}$$

Immediately testing this estimation, we find that there is heteroskedasticity, so we run the robust fixed effects regression. The results of this estimation are below in **Table 5**. The estimation uses 1307 observations, a slight decrease from the previous estimations. This is most likely due to the application of the natural logarithm causing some data values to be deleted. Importantly, this version of the model results in $MIL_{i,t}$ being significant at the 5% level, an improvement from the original fixed effects estimation. $NATRES_{i,t}$ and $CORR_{i,t}$ are also significant at the 5% level; $\ln(SIZE_{i,t})$, $\ln(INCOME_{i,t})$, and $\ln(FDI_{i,t})$ are all significant at the 1% level. Unfortunately, $NETARM_{i,t}$ remains insignificant under this specification.

Table 5: This table lists the estimation results from running the robust fixed effects model with the natural logarithm applied to certain independent variables. Robust standard deviations are in parenthesis. See Appendix IV for the STATA codes and outputs.

VARIABLES	$[\ln(Y_{i,t}) - \ln(Y_{i\,t-1})]$
MIL	-0.639** (0.302)
ln(SIZE)	0.0172*** (0.00586)
CORR	0.0165** (0.00782)
NETARM	-1.56e-6 (1.80e-6)
ln(INCOME)	-0.0189*** (0.00632)
ln(FDI)	0.00626*** (0.00148)
NATRES	0.000913** (0.000385)
CONSTANT	0.153** (0.0584)
N	1307
COUNTRIES	93
R^2	0.077

*****P <0.01, **P<0.05, *P<0.1**

Overall, it seems that the panel regression models are favourable to the cross-section models. The panel estimations use many more observations which allows for a more accurate picture of the relationship between military expenditures and economic growth. Heteroskedasticity only needs to be corrected for in the panel estimations whereas it is not an issue in the cross-section estimations. All estimations pass the *F-Test*. In both the cross-section and panel models, when the natural logarithm is applied to income per capita and foreign direct investment (and number of armed forces personnel in the panel model), the estimations provide better results than when the linear functional form is used for all explanatory variables. Finally, in the cross-section estimations, natural resources rent is negatively related to the average growth of GDP per capita whereas it is positively related in the panel estimations.

Section V: Heading

Our results concerning the relationship between military expenditures and economic growth are consistent with the literature that we reviewed: that military spending is negatively related economic growth. The only study to suggest a positive relationship was Alptekin and Levine (2012) who claimed there was a positive, non-linear relationship between military spending and growth. However, as noted in Section I, the authors used data between the 1960s and 1980s while our data is from 1999 to 2018. The 1960s to the 1980s were a time of incredibly high military spending due to the Cold War, which may be the reason Alptekin and Levine (2012) found a positive relationship.

D'Agostino et al. (2012) noted the negative impact of corruption and military spending on economic growth. Surprisingly, in our panel model, corruption is positively related with economic growth. One possible reason for this is that our measurement of corruption measures the control of corruption in units of standard deviation in a range of -2.5 to +2.5. D'Agostino et al. (2012) measured corruption on a scale from 0 to 100 and was retrieved from the World Bank's WDI Database while our data was retrieved from the World Bank's World Governance Indicators Database. It seems that the data that D'Agostino et al. (2012) used are no longer available from the World Bank's WDI Database, therefore we cannot retest our models with the 0-100 scale for corruption. Moreover, the study by D'Agostino et al. (2012) focused only on 53 African nations while our data is from 93 countries and not geographic specific. Overall, African countries are less developed than countries in Europe, North America, Asia, and the Middle East. The African focus of D'Agostino et al. (2012) likely plays a part in the discrepancy between the results.

Yakovlev (2007) suggested in his study that the negative effect of military expenditures on economic growth was reduced if the country was a net arms exporter. However, the study also concludes that net arms exports are themselves negatively related to growth. This is consistent with our findings since net arms exports are negatively related to economic growth in all of our estimations. Based on our models though, we cannot determine if the conclusion of Yakovlev (2007) that the negative impacts of military spending on growth are reduced when a country is a net arms exporter is consistent with our results because *NETARM* is not significant in any of the reported estimations. We also cannot corroborate the results of Aizenman and Glick (2006) and Araujo Jr. and Shikida (2008) where both studies concluded that high military spending coupled in countries with high threat levels was actually positively related to economic growth. Due to an insufficient number of observations for the *THRT* variable, it was dropped from our models.

It is difficult to compare our findings with some of the other reviewed literature. For example, Dunne and Tian (2015) found that military expenditures do not have a negative impact on growth in countries with non-fuel natural resource abundance. Our model uses natural resources rent as an explanatory variable and includes fuel-type natural resources. Furthermore, Hou and Chen (2013) and Dunne (2011) split up countries by geographic location or by income and development levels which were then compared. As previously stated, our data is an amalgamation of countries all over the world of varying income and development levels and are all included in the dataset that was used to run the models.

The discrepancy between our results and the results of the literature can perhaps be explained by Chowdhury (1991) who argued that each country has unique and complex socio-economic and political structure that influences economic growth and the determinants of military expenditures. For example, a developed economy such as Canada spends less on its military due to its nearness to the U.S, whereas a developing Middle Eastern nation may need to spend more on defence due to terrorism and neighbouring threats. However, Chowdhury (1991) does hypothesize that a reliable general model is possible, which is what we are striving to develop in this paper. Some amendments will need to be made to our models that we will discuss in the next section.

Section VI:

While we are satisfied that our models indeed show that there is a negative relationship between military expenditures and economic growth, there is still more to be done to ensure our model is accurate. Although the correlation table and variance inflation factors showed that income per capita and the corruption estimate was high, we opted to keep corruption in the models. In future iterations, it may be best to replace corruption with another measurement. A possible alternative is to use a measurement of political stability in its place as an independent variable and then test its correlation to income to ensure it is not highly correlated. On the other hand, we could interact corruption with another explanatory variable such as *MIL* in hopes of reducing its correlation with income per capita. Another possibility is to replace income per capita with another measurement that will act as a control variable such as population growth rate or openness to trade.

Next, in all of our estimations, the net arms exports variable was found to be insignificant. Although the significance varied depending on the model, it failed to ever be significant, even at the 10% level. We must try to fix this in future iterations since, according to Yakovlev (2007), arms trading can be an important factor in estimating the defence spending and economic growth relationship. A potential solution is instead of calculating the difference between arms imports and exports to obtain the arms trade balance, we can focus solely on arms exports and ignore the arms import figures to see if this can improve the significance level.

Another potential change is to separate the countries into appropriate groups. For example, splitting them into NATO and non-NATO countries, developed and developing, or by geography. This has the potential to make our estimations more precise since there is considerable variation in size, location, and economy in most of the 93 countries used in this paper. For example, many NATO countries are developed economies and must allocate a certain amount of their GDP towards military expenditures while non-NATO countries are free to allocate as much of their GDP as they wish towards the military. We may also find that, for example, military expenditures are negatively related with economic growth in Europe, but positively related in North America. These topics could be explored in the next iteration of this paper.

The most surprising results from our estimations were that income per capita and net arms exports were negatively related to economic growth. Intuition suggests that income per capita would increase with average GDP per capita growth. Moreover, a positive net arms exports value means a country exports arms more than it imports arms, suggesting that this would be beneficial to economic growth. It is also interesting to note that in the cross-section estimations, natural resources rent is unexpectedly negatively related with growth. However, in the panel estimations, it becomes positively related to economic growth. This is most likely due to the increased number of data points changing the direction of the relationship.

With the improvements and alterations listed above, we hope that in the next iteration of this paper that our cross-section regression and panel regression models will provide an accurate, reliable, comprehensive, and significant estimation of the relationship between economic growth and military expenditures that can be better compared to the relevant literature.

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Appendix I – Countries Used Listed in Order of Military Expenditures

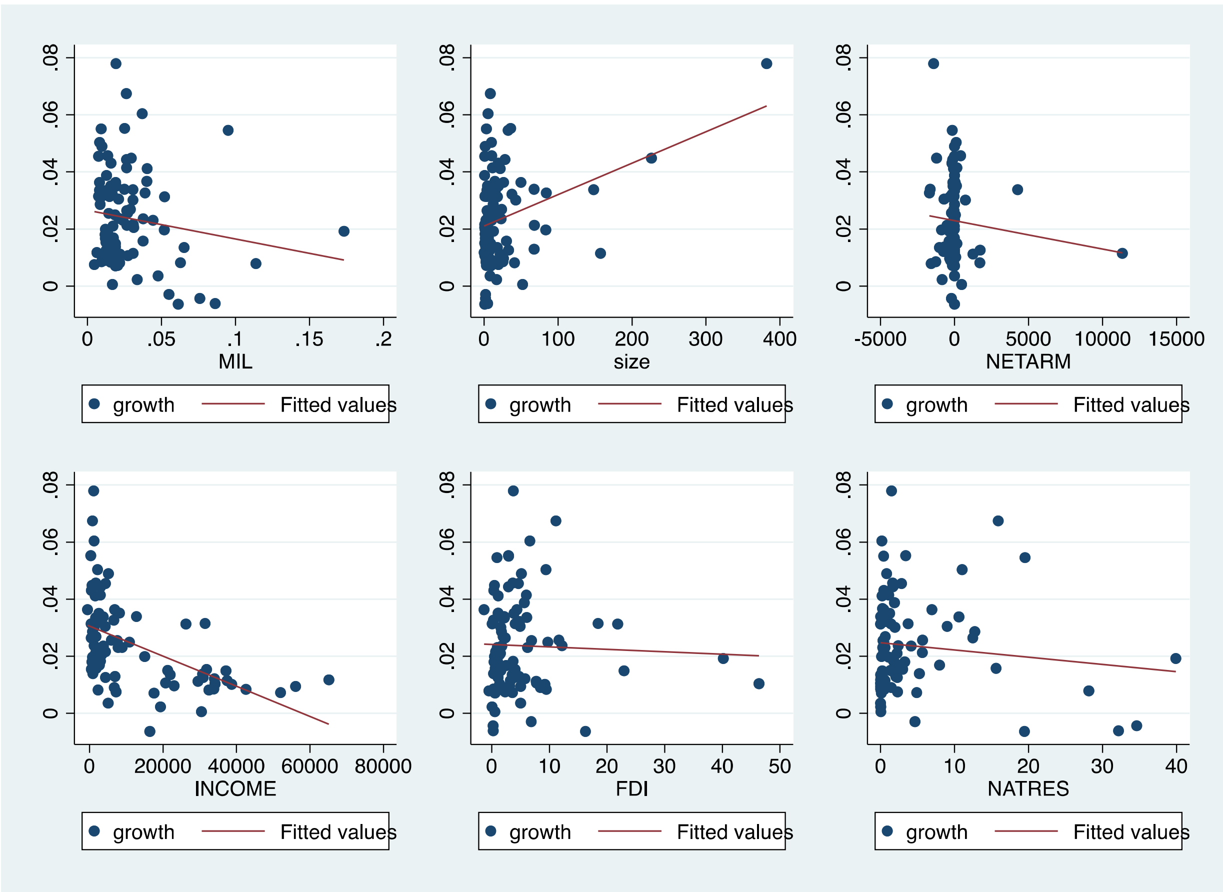
1. USA
2. China
3. Saudi Arabia
4. India
5. Russia
6. France
7. UK
8. Japan
9. Germany
10. South Korea
11. Brazil
12. Italy
13. Australia
14. Canada
15. Israel
16. Turkey
17. Spain
18. Poland
19. Pakistan
20. Iran
21. Netherlands
22. Singapore
23. Colombia
24. Algeria
25. Oman
26. Indonesia
27. Kuwait
28. Norway
29. Thailand
30. Mexico
31. Greece
32. Sweden
33. Chile
34. Belgium
35. Switzerland
36. Denmark
37. Portugal
38. Romania
39. Ukraine
40. Argentina
41. Finland
42. Morocco
43. Bangladesh
44. South Africa
45. Malaysia
46. Austria
47. Egypt
48. Philippines
49. Lebanon
50. Czechia
51. Peru
52. Ecuador
53. New Zealand
54. Nigeria
55. Angola
56. Jordan
57. Hungary
58. Sri Lanka
59. Azerbaijan
60. Kazakhstan
61. Bahrain
62. Slovakia
63. Uruguay
64. Kenya
65. Ireland
66. Lithuania
67. Croatia
68. Bulgaria
69. Tunisia
70. Serbia
71. Latvia
72. Belarus
73. Tanzania
74. Bolivia
75. Armenia
76. Estonia
77. Dominican Republic
78. Cambodia
79. Slovenia
80. Ethiopia
81. Botswana
82. Mali
83. Namibia
84. Cyprus
85. Cameroon
86. Nepal
87. Uganda
88. Luxembourg
89. Paraguay
90. Senegal
91. Honduras
92. Brunei
93. Georgia

Appendix II: Tables and Graphs for Data Analysis

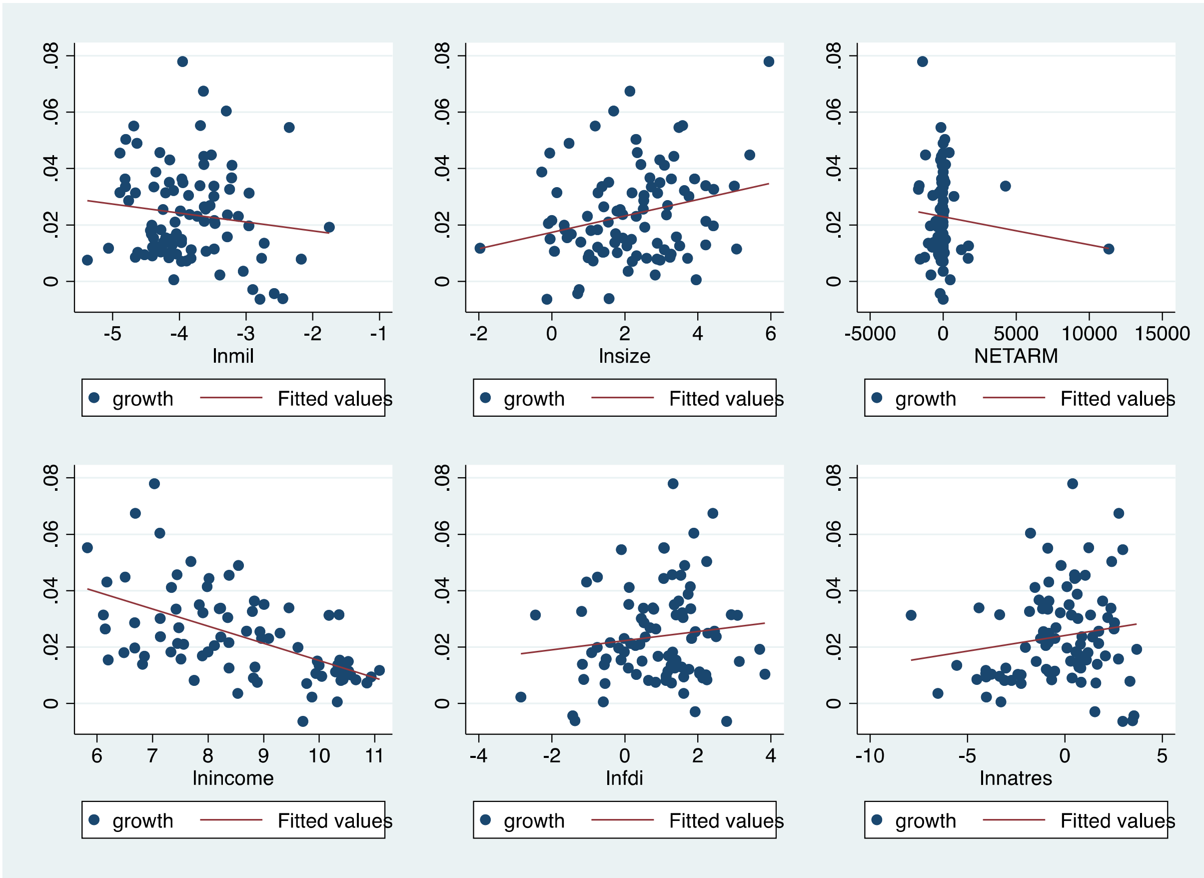
A.II.1: Correlation Table of the Cross-Section Variables

	$GROWTH$	$ln(Y_{i,1})$	$MIL_{i,1}$	$SIZE_{i,1}$	$NETARM_{i,1}$	$INCOME_{i,1}$	$FDI_{i,1}$	$NATRES_{i,t}$
$GROWTH$	1.0							
$ln(Y_{i,1})$	-0.573	1.0						
$MIL_{i,1}$	-0.160	-0.0996	1.0					
$SIZE_{i,1}$	0.438	-0.247	0.131	1.0				
$NETARM_{i,1}$	-0.123	0.163	0.0145	0.179	1.0			
$INCOME_{i,1}$	-0.554	0.888	-0.1404	-0.165	0.191	1.0		
$FDI_{i,1}$	-0.102	0.336	0.0012	-0.169	-0.0005	0.318	1.0	
$NATRES_{i,t}$	0.0125	-0.273	0.145	-0.0064	0.0290	-0.301	-0.0292	1.0

A.II.2: Scatter Plots of CS Independent Variables against the Dependent Variable with Fitted Values



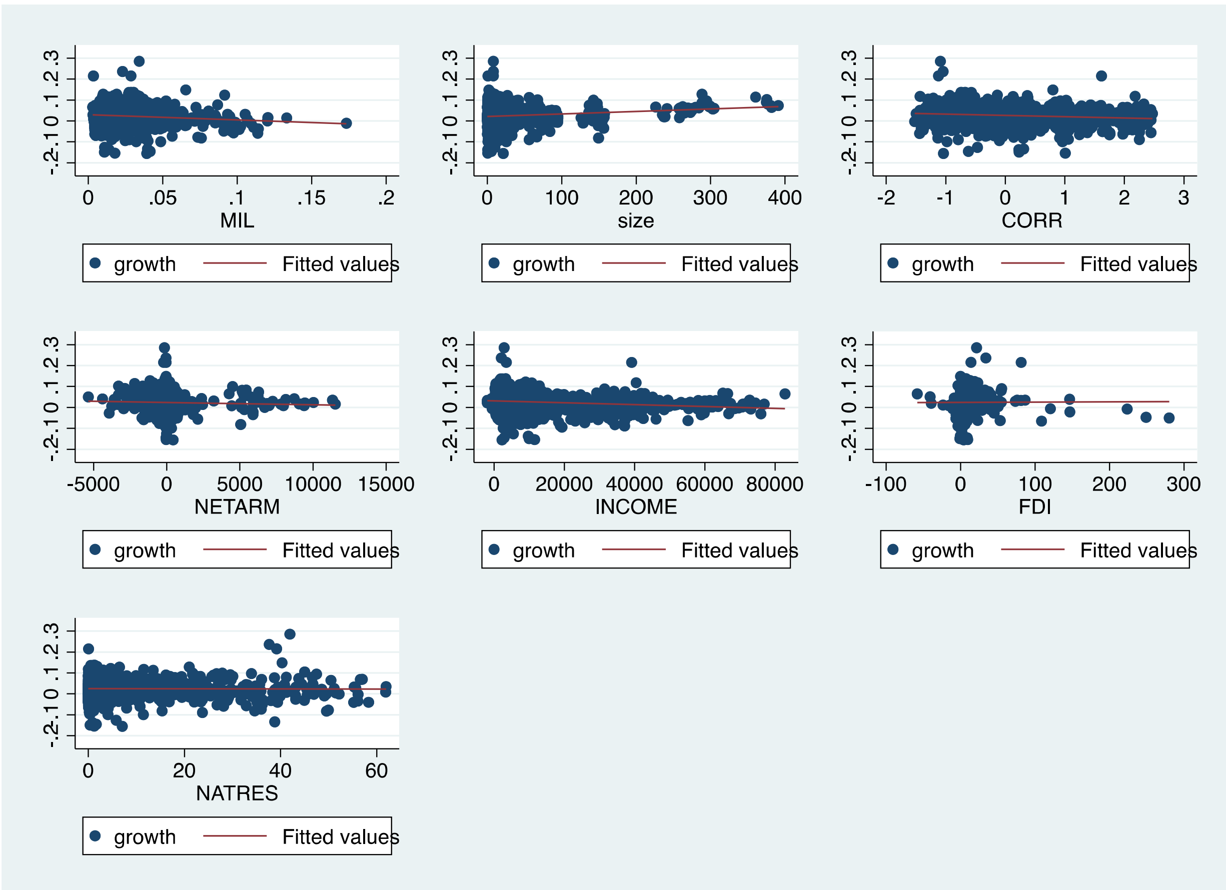
A.II.3: Scatter Plots of CS Natural Log Independent Variables against the Dependent Variable



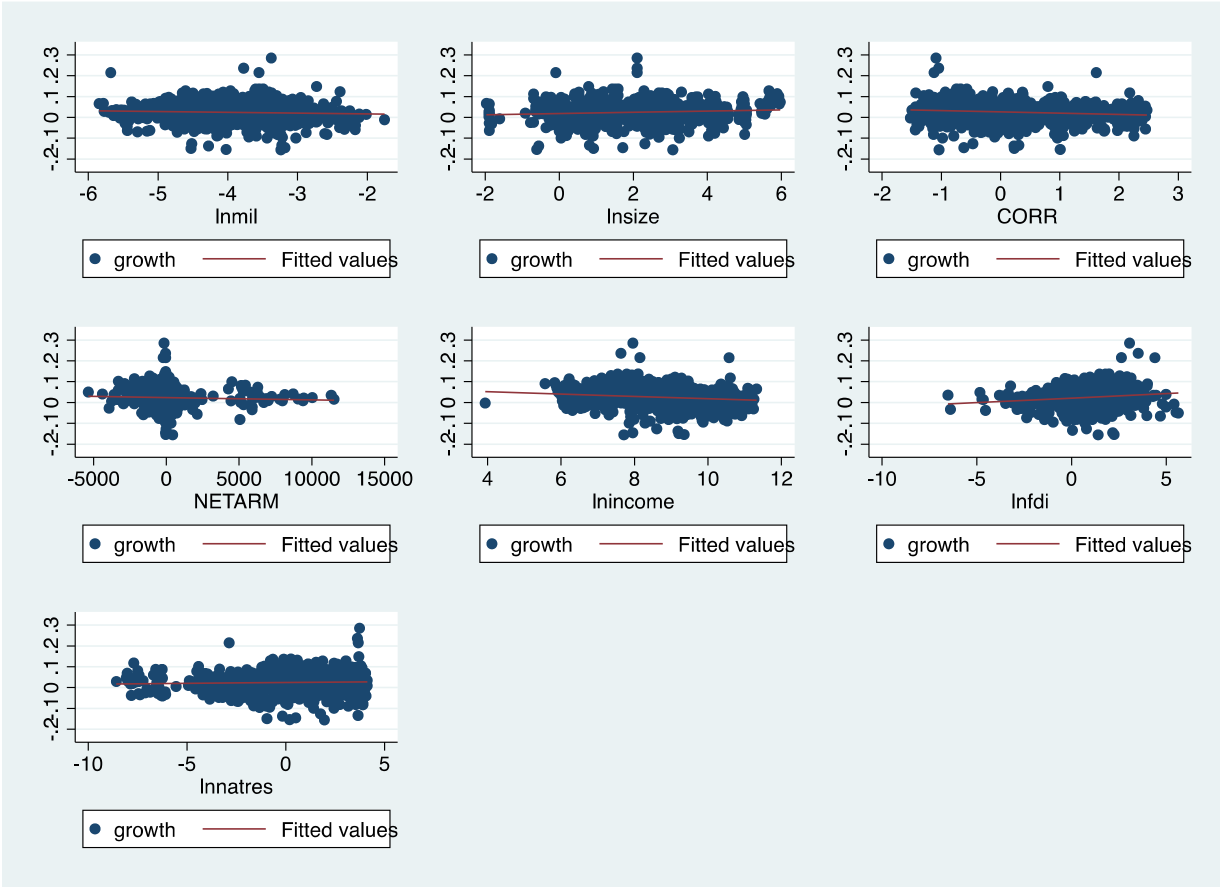
A.II.4: Panel Correlation Table of Variables

	$GROWTH$	$ln(Y_{i,1})$	$MIL_{i,1}$	$SIZE_{i,1}$	$CORR_{i,1}$	$NETARM_{i,1}$	$INCOME_{i,1}$	$FDI_{i,1}$	$NATRES_{i,t}$
$GROWTH$	1.0								
$ln(Y_{i,1})$	-0.256	1.0							
$MIL_{i,1}$	-0.104	-0.0211	1.0						
$SIZE_{i,1}$	0.179	-0.192	0.109	1.0					
$CORR_{i,1}$	-0.186	0.828	-0.124	-0.204	1.0				
$NETARM_{i,1}$	-0.0549	0.198	0.0265	0.098	0.101	1.0			
$INCOME_{i,1}$	-0.234	0.856	-0.145	-0.159	0.863	0.199	1.0		
$FDI_{i,1}$	0.040	0.146	-0.049	-0.097	0.157	-0.0063	0.149	1.0	
$NATRES_{i,t}$	0.0191	-0.129	0.472	-0.007	-0.318	-0.051	-0.204	-0.063	1.0

A.II.5: Panel Scatter Plots of Independent Variables Against Dependent Variable with Fitted Values



A.II.6: Panel Scatter Plots of Natural Log Variables Against the Dependent Variable with Fitted Values



Appendix III – Regression Results

A.III.1: Pooled OLS Estimation Results

VARIABLES	$[\ln(Y_{i,t}) - \ln(Y_{i\ t-1})]$
MIL	-0.445*** (0.0672)
SIZE	0.000133*** (0.0000191)
CORR	0.00531*** (0.0019)
NETARM	$-2.04e^{-7}$ $(7.87e^{-7})$
INCOME	$-8.11e^{-7}$*** $(1.21e^{-7})$
FDI	0.000262*** (0.000081)
NATRES	0.000347*** (0.000115)
CONSTANT	0.0383*** (0.00227)
N	1369
R^2	0.1144
*****P <0.01, **P<0.05, *P<0.1**	

A.III.2: Random Effects Estimation Results

VARIABLES	$\left[\ln(Y_{i,t}) - \ln(Y_{i\ t-1})\right]$
MIL	-0.558*** (0.103)
SIZE	0.000147*** (0.0000337)
CORR	0.00934*** (0.00286)
NETARM	$-7.98e^{-8}$ ($1.25e^{-6}$)
INCOME	$-1.04e^{-6}$*** ($1.86e^{-7}$)
FDI	0.000201** (0.0000875)
NATRES	0.000695*** (0.000164)
CONSTANT	0.0409*** (0.00368)
N	1369
R^2	0.0383
*****P <0.01, **P<0.05, *P<0.1**	

A.III.2: Fixed Effects Estimation Results

VARIABLES	$\left[\ln(Y_{i,t}) - \ln(Y_{i\ t-1})\right]$
MIL	-0.469** (0.205)
SIZE	0.000276* (0.000164)
CORR	0.0169*** (0.00595)
NETARM	$-3.82e^{-7}$ ($2.40e^{-6}$)
INCOME	$-1.09e^{-6}$** ($4.91e^{-7}$)
FDI	0.000149 (0.0000954)
NATRES	0.00163*** (0.000164)
CONSTANT	0.0285** (0.0113)
N	1369

R^2	0.0451
*****P <0.01, **P<0.05, *P<0.1**	

Appendix IV – STATA Codes and Output

A.IV.1: Cross-Section Descriptive Statistics

```
. sum

    Variable |        Obs        Mean    Std. Dev.       Min        Max
-------------+---------------------------------------------------------
         mil |         92    .0272947    .0250487   .0046099   .1733469
        size |         93    254935.1    512898.5       1400    3820000
        thrt |         18      2706.5    7130.463          1      30704
        corr |          0
      netarm |         77    42.09091    1512.264      -1697      11340
-------------+---------------------------------------------------------
      income |         83    12681.55    15258.67  -550.8655   65152.25
         fdi |         91    4.929852    7.366761  -1.332574   46.36411
        educ |          0
      natres |         93    4.197011    7.790847   .0003718   39.90728
      growth |         92    .0237587    .0165987  -.0063318   .0779441
```

A.IV.2: Cross-Section Correlation Table

```
. corr growth lny1 mil size netarm income fdi natres
(obs=69)

             |   growth     lny1      mil     size   netarm   income      fdi   natres
-------------+------------------------------------------------------------------------
      growth |   1.0000
        lny1 |  -0.5730   1.0000
         mil |  -0.1603  -0.0996   1.0000
        size |   0.4377  -0.2467   0.1311   1.0000
      netarm |  -0.1231   0.1634   0.0145   0.1786   1.0000
      income |  -0.5540   0.8883  -0.1404  -0.1647   0.1906   1.0000
         fdi |  -0.1023   0.3356   0.0012  -0.1688  -0.0005   0.3175   1.0000
      natres |   0.0125  -0.2730   0.1445  -0.0064   0.0290  -0.3010  -0.0292   1.0000
```

A.IV.3: Cross-Section Scatter Plot Codes

```
. twoway (scatter growth mil) (lfit growth mil), name(milscatter)

. scatter growth mil

. twoway (scatter growth size) (lfit growth size), name(sizescatter)

. twoway (scatter growth netarm) (lfit growth netarm), name(netarmscatter)

. twoway (scatter growth income) (lfit growth income), name(incomescatter)

. twoway (scatter growth fdi) (lfit growth fdi), name(fdiscatter)

. twoway (scatter growth natres) (lfit growth natres), name(natresscatter)

. graph combine milscatter sizescatter netarmscatter incomescatter fdiscatter natressca
> tter
```

A.IV.4: Panel Regression Descriptive Statistics

```
. sum
```

Variable	Obs	Mean	Std. Dev.	Min	Max
mil	1,859	.0222549	.0168654	.0028947	.1733469
thrt	357	740.9524	2330.999	0	30704
corr	1,674	.243781	1.051771	-1.522685	2.469991
netarm	1,652	44.70944	1240.029	-5364	11526
income	1,790	14769.26	16410.75	-1956.749	82834.16
fdi	1,848	5.144888	14.01753	-58.32288	280.1318
natres	1,859	5.99452	10.04992	.0001876	61.94915
lnyt1	1,859	9.020771	1.395749	5.233868	11.62597
growth	1,858	.0245911	.0363755	-.1552444	.2851567
size	1,761	24.13431	48.80906	.14	391
educ_real	660	23.97733	13.07771	1.83	79.02

A.IV.5: Panel Regression Correlation Code and Output

```
. corr growth lnyt1 mil size corr netarm income fdi natres
(obs=1,369)
```

	growth	lnyt1	mil	size	corr	netarm	income	fdi
growth	1.0000							
lnyt1	-0.2563	1.0000						
mil	-0.1040	-0.0211	1.0000					
size	0.1797	-0.1923	0.1093	1.0000				
corr	-0.1859	0.8382	-0.1239	-0.2038	1.0000			
netarm	-0.0549	0.1984	0.0265	0.0979	0.1013	1.0000		
income	-0.2338	0.8654	-0.1452	-0.1592	0.8633	0.1990	1.0000	
fdi	0.0404	0.1455	-0.0490	-0.0974	0.1566	-0.0063	0.1493	1.0000
natres	0.0191	-0.1291	0.4721	-0.0070	-0.3175	-0.0505	-0.2037	-0.0625

	natres
natres	1.0000

A.IV.6: Panel Scatter Plot Code

```
. twoway (scatter growth mil) (lfit growth mil), name(milscatter)

. twoway (scatter growth size) (lfit growth size), name(sizescatter)

. twoway (scatter growth corr) (lfit growth corr), name(corrscatter)

. twoway (scatter growth netarm) (lfit growth netarm), name(netarmscatter)

. twoway (scatter growth income) (lfit growth income), name(incomescatter)

. twoway (scatter growth fdi) (lfit growth fdi), name(fdiscatter)

. twoway (scatter growth natres) (lfit growth natres), name(natresscatter)

. graph combine milscatter sizescatter corrscatter netarmscatter incomescatter fdiscatt
> er natresscatter

.
```

A.IV.7: Cross-Section Regression, Heteroskedasticity Test, Multicollinearity Test

```
. reg growth mil size netarm income fdi natres

      Source |       SS           df       MS      Number of obs   =        69
-------------+----------------------------------   F(6, 62)        =     12.54
       Model |   .00838668         6   .00139778   Prob > F        =    0.0000
    Residual |  .006911939        62  .000111483   R-squared       =    0.5482
-------------+----------------------------------   Adj R-squared   =    0.5045
       Total |  .015298619        68   .00022498   Root MSE        =    .01056

------------------------------------------------------------------------------
      growth |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         mil |   -.309084   .0964152    -3.21   0.002    -.5018153   -.1163526
        size |   1.08e-08   2.33e-09     4.61   0.000     6.10e-09    1.54e-08
      netarm |  -7.25e-07   8.49e-07    -0.85   0.397    -2.42e-06    9.73e-07
      income |  -6.05e-07   1.01e-07    -6.00   0.000    -8.07e-07   -4.04e-07
         fdi |   .0003274   .0001946     1.68   0.098    -.0000617    .0007164
      natres |  -.0004276   .0003343    -1.28   0.206    -.0010958    .0002406
       _cons |   .0343768   .0032086    10.71   0.000     .0279628    .0407907
------------------------------------------------------------------------------
```

```
. estat hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of growth

         chi2(1)      =     1.82
         Prob > chi2  =   0.1771
```

```
. vif

    Variable |       VIF       1/VIF
-------------+----------------------
    lnincome |      1.37    0.731517
      natres |      1.20    0.831929
        size |      1.17    0.854629
       lnfdi |      1.11    0.900558
      netarm |      1.11    0.904322
         mil |      1.05    0.950337
-------------+----------------------
    Mean VIF |      1.17
```

A.IV.8: Cross-Section Regression with Natural Logarithm Specificaiton

```
. reg growth mil size netarm lnincome lnfdi natres

      Source |       SS           df       MS      Number of obs   =        68
-------------+----------------------------------   F(6, 61)        =     14.31
       Model |  .008837409         6  .001472901   Prob > F        =    0.0000
    Residual |  .006276776        61  .000102898   R-squared       =    0.5847
-------------+----------------------------------   Adj R-squared   =    0.5439
       Total |  .015114184        67  .000225585   Root MSE        =    .01014

------------------------------------------------------------------------------
      growth |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         mil |  -.2513018   .0934947    -2.69   0.009     -.438256   -.0643476
        size |   .0000966    .000023     4.20   0.000     .0000507    .0001426
      netarm |  -1.01e-06   8.17e-07    -1.24   0.219    -2.65e-06    6.19e-07
    lnincome |  -.0069916   .0010745    -6.51   0.000    -.0091402   -.0048429
       lnfdi |   .0032696   .0010648     3.07   0.003     .0011403    .0053988
      natres |  -.0006591   .0003333    -1.98   0.052    -.0013255    7.34e-06
       _cons |   .0855764   .0101381     8.44   0.000     .0653041    .1058487
------------------------------------------------------------------------------
```

A.IV.9: Pooled OLS, Heteroskedasticity Test, and Multicollinearity Test

```
. reg growth mil size corr netarm fdi income natres

      Source |       SS           df       MS      Number of obs   =     1,369
-------------+----------------------------------   F(7, 1361)      =     25.12
       Model |  .212392096         7  .030341728   Prob > F        =    0.0000
    Residual |  1.64404269     1,361  .001207967   R-squared       =    0.1144
-------------+----------------------------------   Adj R-squared   =    0.1099
       Total |  1.85643479     1,368  .001357043   Root MSE        =    .03476

------------------------------------------------------------------------------
      growth |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         mil |  -.4454587   .0672075    -6.63   0.000    -.5773001   -.3136173
        size |   .0001325   .0000191     6.95   0.000     .0000951    .0001698
        corr |   .0053144   .0019006     2.80   0.005     .0015861    .0090427
      netarm |  -2.04e-07   7.87e-07    -0.26   0.795    -1.75e-06    1.34e-06
         fdi |   .0002617   .0000808     3.24   0.001     .0001032    .0004202
      income |  -8.11e-07   1.21e-07    -6.69   0.000    -1.05e-06   -5.73e-07
      natres |   .0003468   .0001154     3.01   0.003     .0001205    .0005731
       _cons |   .0382667    .002272    16.84   0.000     .0338098    .0427236
------------------------------------------------------------------------------
```

```
. estat hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of growth

         chi2(1)      =    24.81
         Prob > chi2  =   0.0000
```

```
. vif

    Variable |       VIF       1/VIF  
-------------+----------------------
        corr |      4.63    0.216183
      income |      4.39    0.227836
      natres |      1.51    0.660757
         mil |      1.36    0.734261
        size |      1.09    0.916736
      netarm |      1.09    0.919659
         fdi |      1.03    0.968926
-------------+----------------------
    Mean VIF |      2.16
```

A.IV.10: Robust Pooled OLS and Multicollinearity Test

```
. reg growth mil size corr netarm fdi income natres, r

Linear regression                               Number of obs     =      1,369
                                                F(7, 1361)        =      46.07
                                                Prob > F          =     0.0000
                                                R-squared         =     0.1144
                                                Root MSE          =     .03476

------------------------------------------------------------------------------
             |               Robust
      growth |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         mil |  -.4454587   .0689942    -6.46   0.000    -.5808052   -.3101122
        size |   .0001325   .0000138     9.57   0.000     .0001053    .0001596
        corr |   .0053144   .0018697     2.84   0.005     .0016466    .0089822
      netarm |  -2.04e-07   5.61e-07    -0.36   0.716    -1.30e-06    8.97e-07
         fdi |   .0002617   .0002378     1.10   0.271    -.0002048    .0007282
      income |  -8.11e-07   1.11e-07    -7.34   0.000    -1.03e-06   -5.95e-07
      natres |   .0003468   .0001632     2.12   0.034     .0000266    .0006671
       _cons |   .0382667    .002328    16.44   0.000     .0336998    .0428335
------------------------------------------------------------------------------
```

```
. vif

    Variable |       VIF       1/VIF
-------------+----------------------
        corr |      4.63    0.216183
      income |      4.39    0.227836
      natres |      1.51    0.660757
         mil |      1.36    0.734261
        size |      1.09    0.916736
      netarm |      1.09    0.919659
         fdi |      1.03    0.968926
-------------+----------------------
    Mean VIF |      2.16
```

A.IV.11: Random Effect Regression:

```
. xtreg growth mil size corr netarm fdi income natres, re

Random-effects GLS regression                   Number of obs     =      1,369
Group variable: cy                              Number of groups  =         93

R-sq:                                           Obs per group:
     within  = 0.0383                                         min =          1
     between = 0.3326                                         avg =       14.7
     overall = 0.1094                                         max =         17

                                                Wald chi2(7)      =      87.55
corr(u_i, X)   = 0 (assumed)                    Prob > chi2       =     0.0000

------------------------------------------------------------------------------
      growth |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         mil |  -.5584169   .1025577    -5.44   0.000    -.7594262   -.3574075
        size |    .000147   .0000337     4.36   0.000     .0000809    .0002131
        corr |   .0093391   .0028685     3.26   0.001     .0037169    .0149613
      netarm |  -7.98e-08   1.25e-06    -0.06   0.949    -2.53e-06    2.37e-06
         fdi |   .0002006   .0000875     2.29   0.022     .0000291    .0003722
      income |  -1.04e-06   1.86e-07    -5.60   0.000    -1.41e-06   -6.77e-07
      natres |   .0006953    .000164     4.24   0.000     .0003739    .0010166
       _cons |   .0409552   .0036813    11.13   0.000       .03374    .0481704
-------------+----------------------------------------------------------------
     sigma_u |  .01333138
     sigma_e |  .03261135
         rho |  .14318557   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

A.IV.12: Breusch-Pagan Lagrange Multiplier Test

```
. xttest0

Breusch and Pagan Lagrangian multiplier test for random effects

        growth[cy,t] = Xb + u[cy] + e[cy,t]

        Estimated results:
                         |       Var     sd = sqrt(Var)
                ---------+-----------------------------
                  growth |    .001357       .0368381
                       e |   .0010635       .0326114
                       u |   .0001777       .0133314

        Test:   Var(u) = 0
                             chibar2(01) =    74.87
                          Prob > chibar2 =   0.0000
```

A.IV.13: Test for Multicollinearity

```
. vif, uncentered

    Variable |       VIF       1/VIF
-------------+----------------------
      income |      5.02    0.199228
        corr |      4.07    0.245828
         mil |      2.58    0.388318
      natres |      2.05    0.488962
        size |      1.34    0.748116
         fdi |      1.18    0.846082
      netarm |      1.05    0.950635
-------------+----------------------
    Mean VIF |      2.47
```

A.IV.14: Fixed Effect Regression

```
. xtreg growth mil size corr netarm fdi income natres, fe

Fixed-effects (within) regression               Number of obs     =      1,369
Group variable: cy                              Number of groups  =         93

R-sq:                                           Obs per group:
     within  = 0.0451                                         min =          1
     between = 0.1095                                         avg =       14.7
     overall = 0.0558                                         max =         17

                                                F(7,1269)         =       8.57
corr(u_i, Xb)  = -0.5202                        Prob > F          =     0.0000

------------------------------------------------------------------------------
      growth |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         mil |  -.4694613   .2050932    -2.29   0.022    -.8718204   -.0671022
        size |   .0002755   .0001643     1.68   0.094    -.0000468    .0005979
        corr |   .0169764    .005954     2.85   0.004     .0052956    .0286572
      netarm |  -3.82e-07   2.40e-06    -0.16   0.874    -5.10e-06    4.34e-06
         fdi |   .0001488   .0000954     1.56   0.119    -.0000384     .000336
      income |  -1.09e-06   4.91e-07    -2.22   0.027    -2.05e-06   -1.25e-07
      natres |   .0016274   .0002909     5.59   0.000     .0010567     .002198
       _cons |   .0284874   .0112735     2.53   0.012     .0063707    .0506042
-------------+----------------------------------------------------------------
     sigma_u |  .02181076
     sigma_e |  .03261135
         rho |  .30906069   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0: F(92, 1269) = 3.01                    Prob > F = 0.0000
```

A.IV.15: Hausman Test

```
. hausman fe re

Note: the rank of the differenced variance matrix (5) does not equal the number of
        coefficients being tested (7); be sure this is what you expect, or there may be
        problems computing the test.  Examine the output of your estimators for
        anything unexpected and possibly consider scaling your variables so that the
        coefficients are on a similar scale.

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |       fe           re         Difference          S.E.
-------------+----------------------------------------------------------------
         mil |   -.4694613    -.5584169        .0889556        .1776096
        size |    .0002755      .000147        .0001285        .0001608
        corr |    .0169764     .0093391        .0076373        .0052175
      netarm |   -3.82e-07    -7.98e-08       -3.02e-07        2.05e-06
         fdi |    .0001488     .0002006       -.0000518         .000038
      income |   -1.09e-06    -1.04e-06       -4.61e-08        4.54e-07
      natres |    .0016274     .0006953        .0009321        .0002403
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(5) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =       22.37
                Prob>chi2 =      0.0004
```

A.IV.16: Robust Fixed Effect Regression

```
. xtreg growth mil size corr netarm fdi income natres, fe r

Fixed-effects (within) regression               Number of obs     =      1,369
Group variable: cy                              Number of groups  =         93

R-sq:                                           Obs per group:
     within  = 0.0451                                         min =          1
     between = 0.1095                                         avg =       14.7
     overall = 0.0558                                         max =         17

                                                F(7,92)           =       3.59
corr(u_i, Xb)  = -0.5202                        Prob > F          =     0.0018

                                  (Std. Err. adjusted for 93 clusters in cy)
------------------------------------------------------------------------------
             |               Robust
      growth |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         mil |  -.4694613   .2985736    -1.57   0.119    -1.062454    .1235317
        size |   .0002755   .0001538     1.79   0.076    -.0000299     .000581
        corr |   .0169764   .0082012     2.07   0.041      .000688    .0332648
      netarm |  -3.82e-07   2.09e-06    -0.18   0.856    -4.54e-06    3.78e-06
         fdi |   .0001488   .0003331     0.45   0.656    -.0005128    .0008104
      income |  -1.09e-06   5.64e-07    -1.93   0.057    -2.21e-06    3.38e-08
      natres |   .0016274   .0003981     4.09   0.000     .0008366    .0024181
       _cons |   .0284874   .0132696     2.15   0.034     .0021329     .054842
-------------+----------------------------------------------------------------
     sigma_u |  .02181076
     sigma_e |  .03261135
         rho |  .30906069   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

A.IV.17: Robust Random Effect Regression

```
. xtreg growth mil size corr netarm fdi income natres, re r

Random-effects GLS regression                   Number of obs     =      1,369
Group variable: cy                              Number of groups  =         93

R-sq:                                           Obs per group:
     within  = 0.0383                                         min =          1
     between = 0.3326                                         avg =       14.7
     overall = 0.1094                                         max =         17

                                                Wald chi2(7)      =      75.32
corr(u_i, X)   = 0 (assumed)                    Prob > chi2       =     0.0000

                                     (Std. Err. adjusted for 93 clusters in cy)
------------------------------------------------------------------------------
             |               Robust
      growth |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         mil |  -.5584169   .1159294    -4.82   0.000    -.7856343   -.3311994
        size |    .000147   .0000237     6.21   0.000     .0001006    .0001934
        corr |   .0093391   .0031158     3.00   0.003     .0032322     .015446
      netarm |  -7.98e-08   6.85e-07    -0.12   0.907    -1.42e-06    1.26e-06
         fdi |   .0002006   .0003286     0.61   0.541    -.0004434    .0008446
      income |  -1.04e-06   2.08e-07    -5.02   0.000    -1.45e-06   -6.34e-07
      natres |   .0006953   .0003422     2.03   0.042     .0000245     .001366
       _cons |   .0409552   .0039485    10.37   0.000     .0332163    .0486941
-------------+----------------------------------------------------------------
     sigma_u |  .01333138
     sigma_e |  .03261135
         rho |  .14318557   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

A.IV.18: Robust Fixed Effect Regression with Natural Logarithm Specifications

```
. xtreg growth mil lnsize corr netarm lnfdi lnincome natres, fe r

Fixed-effects (within) regression               Number of obs     =      1,307
Group variable: cy                              Number of groups  =         93

R-sq:                                           Obs per group:
     within  = 0.0775                                         min =          1
     between = 0.2348                                         avg =       14.1
     overall = 0.0809                                         max =         17

                                                F(7,92)           =       6.86
corr(u_i, Xb)  = -0.7035                        Prob > F          =     0.0000

                                     (Std. Err. adjusted for 93 clusters in cy)
------------------------------------------------------------------------------
             |               Robust
      growth |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         mil |  -.6386845   .3015299    -2.12   0.037    -1.237549   -.0398202
      lnsize |   .0171795   .0058582     2.93   0.004     .0055446    .0288144
        corr |   .0164888   .0078216     2.11   0.038     .0009545    .0320231
      netarm |  -1.56e-06   1.80e-06    -0.87   0.388    -5.13e-06    2.01e-06
       lnfdi |   .0062604   .0014773     4.24   0.000     .0033263    .0091945
    lnincome |  -.0188991   .0063223    -2.99   0.004    -.0314558   -.0063424
      natres |    .000913   .0003843     2.38   0.020     .0001497    .0016762
       _cons |   .1530703   .0584083     2.62   0.010     .0370663    .2690743
-------------+----------------------------------------------------------------
     sigma_u |  .02526097
     sigma_e |  .03079204
         rho |  .40227589   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```