Econometrics Final Paper: A Study of GDP, Military Expenditures and Educational Expenditures

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Introduction

This serves as an introduction to this research study

This study set out to understand the relationship between GDP growth, military expenditures, and educational expenditures. The reasoning for this is that, logically, there should be a decrease in military expenditures as educational expenditures increases. My thinking on this comes from the logic that as people are more educated, in theory, they will be more accepting of other people and thus need to spend less on military expenses. This then should, in turn, produce a positive GDP growth rate in a given year, because a more educated society typically makes more thus GDP growth rate should be positive.

This question has important implications in the society we live in today, given a few factors. The first, the rising cost of education, across the board from primary to higher-ed; coming from more expensive pensions, more bureaucrats and middle managers, to teacher shortages, to the rising operational costs of schooling. The second, the ballooning costs of militaries worldwide; this seems to be a constant news headline for a variety of reasons, so understanding its context is valuable. The third implication lays in the combination of these two because they are both realms where politicians incessantly argue about whether these are overfunded or underfunded. These implications give good context and dimensions to create a path to understanding how this can be studied.

The body of literature for this specific topic is not that large; however, there is a great body of literature that exists for the various macro-economic theories that are being tested interconnectedly. Most papers state that their respective topic or factor increases GDP and as a result GDP growth rates; however, generally more military expenditures do not increase GDP and GDP growth.

After looking at what other researchers have done and the implications outlined above, the following research plan was implemented. After forming a question and intermediate theory, literature was understood and reviewed to grasp the issue, which is outlined in the next section. Following the literature review process, the data could be gathered, cleaned, and analyzed. This step was critical because it is the step from which econometric results are created to be analyzed. Then the results were analyzed in the context of econometric issues, which is a critical step in deriving meaning and value from the data sets. The final step was then to draw conclusions on the findings and suggest how the study could be furthered in subsequent research or studies.

The main analysis that will be done on this data is econometric analysis, which is applying statistical and other quantitative techniques in the context of economics to deeply understand the meaning behind economic data. The main method of doing that which will be done in this paper is the use of regression analysis, because of its ability to understand relationships between numbers and as a result concept. Panel data was also used in this study. To estimate GDP growth rate, the following explanatory variables will be used: military expenditures (as a percentage of GDP), educational expenditures (as a percentage of GDP), population growth, real GDP as a 2010 constant, time (a year since 1969), total central government debt (as a percentage of GDP), and tax revenues(as a percentage of GDP). The next section, a review of the literature on this topic, will be used to explain the usage of these variables and why they were chosen to be used in the regression analyses.

Literature Review and Explanation of Theory

This section serves as an overview of the literature that was read as a part of this study

Understanding the body of literature that has been written about a topic is critical to any analysis because it is important to understand the underlying theory of a model as that is what drives the conclusions and makes application of the research feasible in terms of policy decisions and other kinds of decisions. This review takes the approach of justifying each independent variable to make the case for why it should be included in the model along with what other researchers have found with regards to significance for the variable. Many preceding studies have looked at the impact of government expenditures on GDP; however, few have analyzed it in the context of looking at the composition of such expenditures, which is the aim of this study.

In previous research by Castillo (Castillo et al. 2001), which found that there is not necessarily a positive relationship with output in terms of military expenditure inputs. However, their team was quick to note that a large part of modernization is the modernization of one's military, and this modernization does, in fact, lead to great increases on output. This research, while from 2001, fits the context of this study on the United States, Great Britain, and Japan as the study focuses on great military powers over time, and even though it focuses on those powers the research can be applied broadly. The theory of this paper is somewhat logical, but given that educational expenditures increase, military expenditures will decrease.

Hanushek ("Education and Economic Growth Eric A. Hanushek" n.d.) found that increases in educational spending found that increasing in educational spending led to an overall increase in output, which makes sense since they found that quality over quantity of education held very much true. This is important to compare against Military spending since hopefully the more that is spent on education in a given country, they will need to spend less on military as they are more accepting of other people's differences.

Aside from these two main variables, variables of time (a year from 1969 to 2018), total central government debt as a percentage of GDP, tax revenues for a given country, and population growth were used to analyze this question. A concluding paragraph of this review will tie this all together but below are the explanations of the explanatory independent variables:

Lee and Gordon (Lee and Gordon 2005) discuss this with regard to how tax structure impacts overall economic growth. They found that the corporate tax rate is slightly negatively correlated with economic growth; however, this paper will seek to understand tax revenue as a percent of GDP to understand how they affect each other. This is an important study to note though because it outlines the general structure that taxation is an important component that impacts GDP.

Wesley and Peterson did research in 2017 (Peterson 2017) about how population growth impacts GDP growth. Their findings were that lower population growth and more limited migration actually led to greater GDP growth. This variable was intended to help explain maybe why educational expenditures go up; the thinking was that if the population is going up, then military expenditures and educational expenditures also have to go up, because there are more people that need to be educated or have money spent on them. It was hard to find a paper that justified that exact logic.

In 2004, Sims writes for the National Education Association (Sims 2004) about how each state in the United States spends its tax dollars in regard to education. This was a helpful paper to read to understand how politicians approach spending money on education. It is a little dated, and did not provide much in terms of econometrics that was relevant to this specific paper; however, the theory that it provided was helpful in understanding how politics shape how much gets spent on education.

Aghion, Boustan, Hoxby, and Vandenbussche in 2009 (Aghion et al. 2009) explored the impacts of educational spending on GDP growth rates. They also took into account tax revenues, which provides evidence that that is a legitimate explanatory variable. Their work is important to understand for this paper as they explored tax revenues as impacts on educational spending; that is a hallmark of this study that is trying to be understood.

In 2010 Gale sought out to understand how taxes impact economic growth (Gale and Samwick 2010). This paper is central to my thoughts because it investigated how people were incentivized to pay more taxes. That

fits into the context of the theory of this paper because that is a key tenet of the theory that as taxes rise education should theoretically improve.

Bivens work in 2010 (Bivens and Irons 2010) explored how government debt increased or decreased GDP growth. He asserts that debt is relative to those who also have debt; he points out as well that the composition and how the debt is used is of utmost importance. If the debt is used in a leveraged position, where the outcomes represent a higher rate of return, economic or financial, then it's a good thing. This was important to understand for this study.

Many in the media are very critical of the idea of expansionary military spending in light of shrinking educational spending. A prime example is this article from the Center on Budget and Policy Priorities, a think-tank, ("A Punishing Decade for School Funding" 2017) from 2017. However, they are not the only ones reporting on this; many classical news media outlets write about this topic regularly, which makes it interesting that there is not a large body of economic research on the topic in this exact composition.

After considering all of these facts and theories presented in these papers combined with the fact that not much has been studied about this exact idea, predicting the outcome can be tough; drawing upon the theory and literature as it is presented, it would make sense that everything but military expenditures contribute positively to GDP growth rates. Most factors drive up real GDP, thus, why would they not drive up the GDP growth rate. There is no suggestion in the literature or general economic theory that would otherwise.

Econometric Model and Data

This section will discuss the econometric models and the data that was used

Initial Findings

To reiterate the purpose of this study,

In terms of initial findings, I found that most of the time, unfortunately, educational and military expenditures, on average, we expect that all else equal, decrease GDP growth rates. However, military expenditures were not found to be statistically significant to the ordinary least squares model; thus, it is not proper to say whether or not it truly impacts GDP growth rate and the relationship between educational and military expenditures. More research and models would have to be built to fully understand and explore that relationship.

Baseline Ordinary Least Squares

Once theory was established and a research plan in place, the first step after gathering and cleaning data was to preapre an ordinary least squares model as a baseline for understanding the relationships within the variables. An ordinary least squares baseline model was generated as follows:

$$\begin{aligned} GDP_{growthrate} = \beta_0 &+ \beta_1 lnGDP_{2010USD} - \beta_2 MilitaryExpenditures_{GDP} \\ &+ \beta_3 EducationExpenditures_{GDP} + \beta_4 PopulationGrowth_{annualpercent} \\ &+ \beta_5 Time + \beta_6 TotalDebt + \beta_7 TaxRevenue \end{aligned}$$

The dependent variable is the GDP growth rate, and the independent variables are the log of real GDP (at the 2010 United States Dollar constant), military expenditures as a percentage of GDP, educational expenditures as a percentage of GDP, population growth, time (a year from 1969 to 2018), total debt of the central government as a percentage of GDP, and tax revenue as a percentage of GDP. These create a baseline linear regression model that further econometric tests can be performed to understand the data and draw conclusions.

Likely Problems

Econometric problems fall into one of two categories: issues causing inefficiency or issues causing bias. There does not initially seem to be issues causing inefficiency, because model inefficiency is often caused by a model having an issue with its dependent variable, multicollinearity, measurement error of the dependent variable, heteroscedasticity, or autocorrelation with a ρ close to zero. These do not appear to be issued in my case because there are not many of the classic indicators that would lead me to believe that they exist. This is discussed further in the next section about the results.

To discuss potential bias in the model, there is a reason to believe this may exist. Potential sources in terms of standard econometric analysis techniques include autocorrelation, incorrect functional form, measurement error, omitted variables, and simultaneity (also known as reverse causality). There was a reason to believe that there was evidence for most of these issues. There are many classic, formally tested, and subtle indicators of these that were explored as a part of the econometric analysis for this study; they will be reported on in more detail in the results section of this paper that addresses how econometric issues were handled.

About The Data

All of the data used in this study comes from the World Bank's World Development Indicators data bank that has seemingly endless amounts of data in it since 1969 and includes nearly every country on earth. The breadth and depth of the World Development Indicators database were particularly useful in this study because it allowed panel data to be used. Panel data, in this case, involved data for every country for every year from 1969 to 2018 for each of the variables. While not every country had data for every year for every variable, this amazing breadth and depth allowed panel data to be employed. Panel data is the ideal type

of data to be used in this type of econometric analysis because it allows for time series analysis across a variety of different individuals. Additionally, panel data is the preferred type to use because tests can be performed that control for unobserved heterogeneity; they are fixed effects, first difference, and fixed effects with clustered standard error models. Those are discussed further in the results section.

Summary Statistics

Summary statistics are an important aspect of analysis because they allow the researchers and audiences to gain an insight into the data that is hard to do from just scrolling through it. It synthesizes and condenses the data into a very readable format. This is especially useful for panel data of this size where the main data table has over 12000 rows in it.

Table 1: Summary Statistics

Statistic	TotalDebt	GDPcons	GDPgrow	TaxRev	MilExpGDP	EduExpGDP	PopGrow
Mean	56.92	2.42e+11	3.89	17.05	2.83	4.37	1.82
Standard Error	2.15	1.05e+10	0.07	0.12	0.04	0.03	0.01
Median	48.15	1.48e+10	3.88	16.50	1.97	4.27	1.78
Standard Deviation	79.37	9.94e+11	6.39	7.52	3.41	1.94	1.64
Sample Variance	6298.94	9.88e+23	40.87	56.60	11.65	3.75	2.68
Range	2006.07	1.73e+13	214.02	65.38	117.35	44.33	30.55
Minimum	1.89	2.14e+07	-64.05	0.04	0.00	0.00	-10.96
Maximum	2007.96	1.73e+13	149.97	65.42	117.35	44.33	19.60
Count	1360.00	9.00e+03	9077.00	3908.00	6940.00	3706.00	12473.00

Results

This section discusses the results of the analysis that was done for this study

Models

To aid in understanding the relationships outlined in this study, the econometric analysis of panel data was conducted. Since the data used was in a panel format and unobserved heterogeneity wanted to be controlled for, four different models were generated under these conditions. The first was an Ordinary Least Squares model, which could be considered a classical linear model or regression. Following that model's construction, a Fixed Effect model was constructed, which was followed by two more models: Wooldridge's First Difference model and a Fixed Effects model with Clusters. These two models were constructed after the first Fixed Effects model based on the ρ calculated therein.

In Wooldridge,[1] the Ordinary Least Squares model is what is known widely as a linear regression model, where the coefficients are determined by using calculus to minimize the sum of squared residuals (SSR). The Fixed Effects model is used in the presence of panel data to help control the inevitable factor of unobserved heterogeneity. This is accomplished by giving each variable in the regression of its own intercept instead of one for the whole model. It is used to help minimize bias in a model. In addition, this test produces a rho value (ρ), which is used to determine the presence of autocorrelation in the model. If ρ is ~0, then the first effects model should be used to help mitigate the bias of autocorrelation in the model. If the ρ is ~1, then the first differences model should be used to help mitigate the bias of autocorrelation in the model. If ρ is somewhere in between ~0 and ~1, then the Fixed Effects with Clustering model should be used to help mitigate the bias introduced in the model as a result of autocorrelation.

Wooldridge[2] also discusses the First Difference model, which is used for time series analysis of panel data. It is a mathematical process that subtracts the differences in adjacent time periods. This is used to difference out the constant, which is useful because it uses the fixed effects model to help adjust the model for autocorrelation. Fixed Effects with Clustering is used when ρ is between ~0 and ~1 and is important to test as well, as it helps control for heteroscedasticity and autocorrelation.

Table of Results

Below a table of the models can be viewed.

Table 2: Regression Analyis Results

Method	OLS	FE	FD	CLUS
	GDPr	GDPr	GDPr	GDPr
ln(GDP)	-0.169***	3.752**	68.337***	3.752**
MilExp[1]	-0.019	-0.286	-0.18	-0.286
EduExp[1]	-0.631***	-0.906***	-0.973***	-0.906***
PopGrow	0.402***	0.062	-0.964**	0.062
Time	0.011	-0.166***	-2.323***	-0.166***
TotDebt[1]	-0.017***	-0.001	0.008	-0.001
TaxRev[1]	0.052**	0.154*	-0.122	0.154*
Intercept	-11.184	241.146***		241.146***
Sample Size	723	723	550	723
R^2	0.124	0.073	0.379	0.073

These are the definitions of the astrisks in the table:

- "*" = significant at the 0.1 level

[1] Wooldridge
[2] Wooldridge

- "**" = significant at the 0.05 level
- "***" = significant at the 0.01 level

Econometric Issues with Baseline Ordinary Least Squares Model

Econometric issues cause either inefficiency in a model or bias in a model. Autocorrelation (when ρ is ~0), heteroscedasticity, multicollinearity, and measurement error (in the dependent variable) are markers of inefficiency in a model. Autocorrelation (when ρ is ~1), incorrect functional form, measurement error (in the independent variables), omitted variables, and simultaneity (reverse causality) are markers of bias in a model. Some of these cause either inefficiency or bias in the ordinary least squares model and will be discussed below.

In terms of inefficiency in the ordinary least squares model, there are some markers that it does exist. The presence of autocorrelation causing inefficiency is very unlikely to non-existent given that ρ is ~1 ($\rho = 0.912$); in order for autocorrelation causing inefficiency to be present, ρ would have to be closer to ~0. Multicollinearity is not present given that no Variance Inflation Factor (VIF) was greater than 5, and the mean was about 1.16. In determining the presence of heteroscedasticity, the Breusch-Pagan test was performed; this test yielded a Chi-squared (χ^2) value of 37.6981683 and a p-value of 3.4579387×10^{-6} . This means that due to a low p-value there is not evidence of heteroscedasticity. Measurement error, in the dependent variable, GDP growth rate, does not seem to be a major issue given that GDP, and its growth rate, as a result, are widely reported and studied.

In terms of econometric issues that bias the model, there are some markers that the ordinary least squares model was biased. This centered around the fact that there was autocorrelation and that ρ was close to one (0.912). This demonstrates autocorrelation causing bias as ρ is about one, whereas had ρ been ~0 then autocorrelation as a matter of inefficiency would have been the case. The incorrect functional form was present, given that real GDP was included in the model; therefore, the natural log of GDP as a constant of the 2010 US dollar was taken. This corrected the incorrect functional form. There is always the risk that variables have been omitted from an equation; however, given the research in the literature, the model seems sound with the tested independent variables. There is more discussion on variables that a future researcher might want to explore in a future study in the concluding thoughts section. Simultaneity, also known as reverse causality, did not seem to be an issue given that the dependent variables and independent variables did not seem to be interdependent. Measurement error in the independent variables seems very likely, given that relying on countries to accurately report figures like tax revenues and expenditures.

These issues are all correctable given that there are tests for autocorrelation; they can be seen in the next section.

Intermediate Models

As previously stated, four models were used to explore this question of educational and military expenditures affecting GDP growth rates: the Ordinary Least Squares model, the Fixed Effects model, the First Differences model, and the Fixed Effects with Standard Error Clustering model. Below are the equations for the various models.

Ordinary Least Sqaures

$$\begin{aligned} GDP_{annualpercent} = &-33.29 - 0.2 lnGDP_{2010USD} - 0.01 MilitaryExpenditures_{GDP} \\ &- 0.68 EducationExpenditures_{GDP} + 0.38 PopulationGrowth_{annualpercent} \\ &+ 0.02 Time + -0.02 TotalDebt + 0.06 TaxRevenue \end{aligned}$$

Fixed Effects Model

$$\begin{aligned} GDP_{annualpercent} = &241.15 + 3.75 lnGDP_{2010USD} - 0.29 MilitaryExpenditures_{GDP} \\ &- 0.91 EducationExpenditures_{GDP} + 0.062 PopulationGrowth_{annualpercent} \\ &- 0.17 Time - 0.0001 TotalDebt + 0.15 TaxRevenue \end{aligned}$$

This model was important to build because this model provides a value of ρ which determines the best model to use to correct for autocorrelation.

First Difference Model

$$\begin{aligned} GDP_{annualpercent} = 68.33 lnGDP_{2010USD} - 0.18 MilitaryExpenditures_{GDP} \\ - 0.97 EducationExpenditures_{GDP} - 0.96 PopulationGrowth_{annualpercent} \\ - 2.32 Time - 0.0008 TotalDebt - 0.122 TaxRevenue \end{aligned}$$

Notice that there is not an intercept or β_0, since there it is a first difference model and the whole point is to difference out the intercept. This is the one that will be used as the preferred model given that ρ is closer to one ($\rho = 0.912$).

Fixed Effects with Clustered Errors Model

$$\begin{aligned} GDP_{annualpercent} = 241.15 + 3.75 lnGDP_{2010USD} - 0.29 MilitaryExpenditures_{GDP} \\ - 0.91 EducationExpenditures_{GDP} + 0.062 PopulationGrowth_{annualpercent} \\ - 0.17 Time - 0.0001 TotalDebt + 0.15 TaxRevenue \end{aligned}$$

Since ρ was not in between ~0 and ~1, 0.7 for example, this model will not be used; as well, there was no need to use this model, which is why it nearly matches the standard Fixed Effects model. Had ρ been closer to the value where this model would have been used, it would have been a lot more reflective.

Preferred Model

Using the Fixed Effect's ρ value to determine which model to use, since autocorrelation and unobserved heterogeneity must be corrected for, the First Difference model stood out as the preferred model. This was due to a ρ of 0.912, which is very close to 1. It led to the following equation:

Equation

$$\begin{aligned} GDP_{annualpercent} = 68.33 lnGDP_{2010USD} - 0.18 MilitaryExpenditures_{GDP} \\ - 0.97 EducationExpenditures_{GDP} - 0.96 PopulationGrowth_{annualpercent} \\ - 2.32 Time - 0.0008 TotalDebt - 0.122 TaxRevenue \end{aligned}$$

Interpretations

The following interpretations are drawn based upon the model and statistical significance:

As real GDP goes up by one percent, then we expect, on average, all else being equal, that GDP annual percent change increases by 68.337 percentage points.

As educational expenditures as a percentage of GDP increases by one percentage point, then we expect, on average, all else being equal, that GDP annual percent change decreases by 0.97 percentage points.

As the population grows annually by one percentage point, then we expect, on average, all else being equal, that GDP annual percent change decreases by 0.91 percentage points.

As time naturally increases over time, GDP annual percent change decreases by 2.23 percentage points.

An R^2 value of 0.379 was achieved under this model. Unfortunately, Military Expenditures as a percentage of GDP, total debt obligations of the central government as a percentage of GDP, and tax revenues were found to be statistically insignificant.

The spike in $lnGDP_{2010constantUSD}$ makes a lot of sense given that the point of the first-difference model is to adjust for differences in a time series.

More macro conclusions, given the interpretations of the coefficients, means that the GDP growth rate "starts" at 68.33 percentage points, given that is the value of the log of real GDP and is then "equalized" by the other various factors of educational expenditures, population growth, and time. This makes sense given that there are a lot of factors that go into a GDP growth rate and those various factors help understand how the various variables affect GDP growth.

Summary and Conclusions

This serves as a summary and conclusion of the study

Differentiation

This research was different from many macroeconomic papers because it focused on the composition of expenditures, educational and military expenditures, where most papers would isolate and be focused on only one element or factor impacting GDP. This is important to understand because globally governments should want to optimize their spending and be sure to spend their tax dollars wisely. Understanding how other factors like tax revenues, central government debt, time, and population growth impact GDP growth is also central to this paper, given the interconnectedness of each of those variables to educational spending and military spending. If the population is growing, naturally, more will need to be spent on education and military because there are more people to protect and to educate. Likewise, if the government has more money in the form of tax revenues the more it is able to spend on things like the military and educating its people. As well, if the government is saddled with more debt it likely took on that debt to further the welfare of its people.

This paper sought to understand the interconnections that exist within those macro-economic topics that all impact GDP growth. It did a fairly effective job of doing that and more specific applications can be found in the following paragraph that outlines the general and most important findings of the paper.

General Findings

This paper produced very interesting results. Unfortunately, some of the findings are statistically insignificant and most are inconsistent with the expected sign as a result of the extensive literature and theory review that was done as the foundation of this paper. A First Differences model was used to understand these factors and how they affect GDP growth rates; it was used over a Fixed Effects Model or Ordinary Least Squares model due to having a ρ being very close to 1 (0.912). Using panel data ensures that unobserved heterogeneity exists, which is why the Fixed Effects model was used to help correct for autocorrelation in the model. It is key to note that the First Difference model cannot explain the sources of unobserved heterogeneity, but it is able to mathematically adjust for it and allow interpretations based on the coefficients of the model to be incredibly accurate; they are far more accurate and superior of an analysis compared to Ordinary Least Squares in the presence of unobserved heterogeneity.

Beyond adjusting for the econometric issues that exist within this data, there was rich interpretation to be understood. Unfortunately, the key variable of military expenditures was not found to be significant in any of the models (Ordinary Least Squares, Fixed Effects, First Differences, or Fixed Effects with Standard Error Clustering). For the preferred model, the First Difference model, unfortunately, total debt obligations of the central government as a percentage of GDP, and tax revenues were found to be statistically insignificant, along with military expenditures. This left the log of Real GDP, educational expenditures, population growth and time as significant coefficients that impact GDP growth. The log of Real GDP had the greatest coefficient at 68.33, and all of the other significant coefficients were relatively small. This logically means that the GDP growth rate for a given country in a given year starts at 68.33 percentage points, then the other factors decrease that large number to arrive at the predicted GDP growth rate.

Implications

This research has broad implications in policy. Policymakers could use this to determine the best way to compose expenditures and potentially take a more holistic view of how expenditures. Combine this with the rich research on tax revenues, population growth, and central debt and policymakers have a lot of resources to understand how these numbers are interconnected in a yearly scale and at the global level. They could use this information to understand how to best spend money, but also do long term planning and projections into the future to help predict future needs of a nation given the breadth and depth of this model.

Further Research

Further research would absolutely improve the models presented in this study. The first recommendation the researcher would make would be to explore how military expenditures impact GDP growth in both peacetime and times of intense conflict; this is an important factor that would deeply affect the model because those times stretch the budgets and needs of a nation in different and major ways. Another potential variable to explore could be how active the military of the given country is, maybe as a scale or rating or series of binary variables; there's a big difference in the United State's military activity versus that of saying Switzerland who maintains only the most essential of military functions. This would help improve the model and better serve policymakers because they could use it to foresee and do long term projections while also understanding the past of their country. Globally, this research could be used by bodies like the United Nations, World Bank, and International Monetary Fund to determine whether or not each country is doing their "fair share." As with most macro-economic topics, and research in general, there is almost always more and more research that can be done on a given topic.

Appendix

See STATA code attached at the end, other figures are embedded in the paper.

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