Inequality as a determinant of growth in a panel of high income countries

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INEQUALITY AS A DETERMINANT OF GROWTH IN A PANEL OF HIGH INCOME COUNTRIES

by

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ABSTRACT

This paper empirically examines the effect of income inequality on economic growth in a sample of 69 high income economies. It uses an improved inequality dataset developed by the World Institute for Development Economics Research and panel estimation techniques in an ordinary least squares regression. The results provide robust empirical evidence that rising levels of income inequality have adverse effects on growth in high income countries and indicate that, on average, a one standard deviation increase in income inequality will decrease growth by 67.91%. Results from the regression also suggest increases in human capital and international openness, decreases in the government consumption ratio, and more favorable terms of trade promote growth while higher initial per capita GDP and higher levels of investment retard growth.

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INTRODUCTION

Worldwide, the poorest 20% of individuals receive just 1.2% of world income (Milanovic 2010), amounting to just $552 billion out of a total $46 trillion.[1] This $552 billion, shown from another perspective, represents just 2% of the income share for the top decile, thus income disparities on a global scale are enormous. [2] This largely unequal distribution of income results in huge gaps in the standard of living between countries leading many researchers to examine the impact inequality has on human welfare.

Income inequality is defined as the existence of a disproportionate distribution of total income among households whereby the share going to the rich far exceeds that of which goes to the poor (Todaro 2009). Throughout the years, numerous empirical research studies have attempted to answer the question as to whether or not inequality tends to retard or promote growth. As of yet, researchers have no conclusive evidence to support either hypothesis. In fact, in a prominent article titled “Inequality and Growth in a Panel of Countries,” Robert Barro finds almost no relation between inequality and economic growth.

Still, several economic theories help to ascertain how inequality may affect economic conditions in any given society. ‘These theories can be classed into for broad categories: credit-market imperfections, political economy, social unrest, and savings rates (Barro 2000).’

[1] Statistics are from 2005 data.

[2] In 2005 the top decile received 55.5% of world income as shown by Milanovic (2010).

1. Credit-Market Imperfections

Investment opportunities are dependent upon the access to capital. In turn, models with imperfect credit markets create conditions in which the borrower's level of income is a primary factor in determining the availability of credit. In this situation, higher inequality tends to lower the level of investment in any given economy. Lower investment leads to fewer technological innovations and long run productivity diminishes, stunting growth; but it should be noted, if one assumes credit markets advance as a country develops then the effect of inequality should diminish in richer states.

2. Political Economy

In an economy such that the mean income is higher than the median income, a system of majority voting tends to favor the redistribution of assets from the rich to the poor (Barro 2000). There are two scenarios in which a redistribution of income will have adverse effects on the economy. In the first case, transfer payments such as welfare tend to lower workers labor productivity. More redistribution through the political process creates extreme economic distortions and will therefore reduce production and investment, slowing growth. The next case involves the wealthy lobbying to stop these redistribution policies from being enacted. With a higher degree of inequality, more energy and resources will be used to stop the transfer of income, again, leading to decreased economic performance.

3. Sociopolitical Unrest

Rising levels of income inequality may cause the poor to participate in criminal activities. This waste of resources such as time and energy on the part of the criminal (Barro 2000) and police officials are unproductive and inefficient, consequently decreasing economic growth.

4. Saving Rates

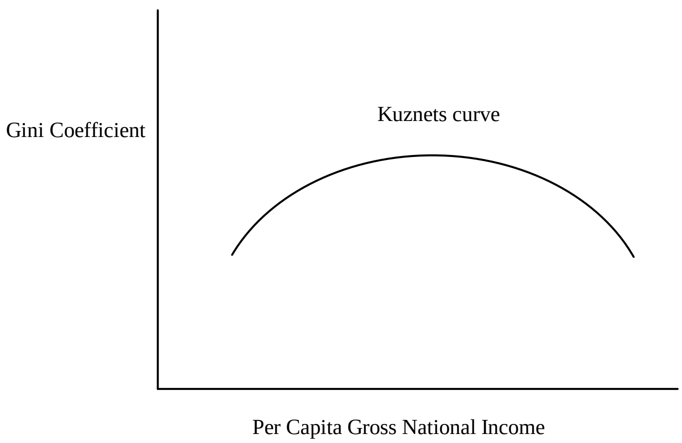
A number of economists acknowledge that private saving rates increase with household income. In this sense, rising levels of inequality will promote investment and lead to growth.

These theories shed some light on how economic performance could be affected by rising inequality; therefore, this paper will build upon prior research to validate the hypothesis that in a macroeconomic setting, inequality is indeed an influential determinant of economic growth.

PRIOR RESEARCH

The first individual to formulate a theory relating income inequality and economic growth was Simon Kuznets in 1955 with an idea now known as the Kuznets Inverted-U hypothesis. The Kuznets Hypothesis is shown graphically in figure 1.

Figure 1: The Kuznets Inverted-U Hypothesis



On the horizontal axis is per capita gross national income while the Gini coefficient is shown on the vertical axis. This diagram indicates that, in early stages of development, economic inequality increases as income increases, and only at later stages will inequality begin to decrease.

Kuznets concluded that, in the early stages of growth, structural changes such as those described in the Lewis two-sector model[3] explain how the distribution of income will tend to worsen and only at later stages of development will improve. This produced a surge of interest as to the effects of inequality on growth and over the years many economists have attempted measure this relationship in more depth.

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[3] In the Lewis model, an underdeveloped economy contains two sectors: an overpopulated rural subsistence sector and a highly productive urban industrial sector. The focus of the model is on the process in which labor is transferred from the rural sector to the modern sector leading to growth of output and employment (Todaro 2009).

In the late 1990s several authors confirmed rising levels of inequality lead to a decrease in economic growth.[4] This was shown when inequality was included in the list of independent variables in a regression formulated by Barro in his paper titled “Determinants of Economic Growth: A Cross-Country Empirical Study” (Forbes 2000). At the time, this conclusion was widely acknowledged as an empirical regularity but recently authors such as Kristin Forbes and Amparo Castelló-Climent argue otherwise. ‘Although most of these papers focus on theories establishing a negative effect of inequality on growth, a careful reading of this literature suggests that this negative relationship is far less definitive than generally believed (Forbes 2000).’

Forbes concludes although the Kuznets Hypothesis and other early works have found significant empirical evidence of a negative relationship between inequality and growth when using cross sectional data, there are three potential econometric shortcomings: first, measurement error can produce bias and have devastating effects on the significance of the results; second, cross sectional data does not control for country specific characteristics such as taste and technology which leads to omitted variable bias; and lastly, although cross sectional data will describe how initial inequality affects growth across countries in the long-run ; it does not properly tackle the important question of how inequality affects growth within a specific country in the short-run.

Deininger and Squire (World Bank Economic Review, 10(3), 565-591.) undertook the first potential problem, indicating the method of selecting Gini coefficients could produce biased

[4] Examples of these papers include Ronald Benabou’s 1996 paper on Inequality and Growth and Alesina and Perotti in their 1996 paper titled “Income Distribution, Political Instability, and Investment.”

estimators for the sample. They presented a new dataset based upon three selection criteria that address the issues in prior studies:

1. Use of Household or Individuals as Unit of Observation: It was required that data on inequality be based on observation of individuals from household surveys rather than from national accounts that use assumptions concerning how income is distributed.

2. Comprehensive Coverage of the Population: It was required that data on inequality be based on a representative sample covering all of the population because data from a non-representative subset of the populations may lead to biased estimates.

3. Comprehensive Measure of Income or Expenditure: It was required that measures of inequality be based on comprehensive coverage of different income sources as well as of population groups. This is stressed because inequality measures based solely on wage income can have dramatic effects on the estimated level of inequality, especially if non wage workers are included.

Since the construction of this dataset the World Institute for Development Economics Research has created an updated database known as the World Income Inequality Database. The most recent dataset in the database is called WIID2.[5] The main principles and quality measures of Deininger and Squire are still adhered to in WIID2. WIID2 differs in that some estimates from earlier datasets have been deleted due to quality issues, other estimates have been added, and

[5] WIID2 is a revision of WIID1 and the Deininger and Squire dataset.

even a new Gini coefficient (New Gini) is included.[6] Inequality estimates in this paper come from WIID2.

The second and third econometric shortcomings of early research have been addressed in articles written by Forbes in the *American Economic Review* (90(4), 869–887) and Castelló-Climent in her paper published in the *Journal of Economic Inequality* (8(3), 293-321). Castelló-Climent claims omitted variable bias because of failure to control for country specific characteristics can lead to significant problems in a cross-country growth regression. 'If a variable that helps explain growth is correlated with any of the regressors and is not included in the regression, then coefficient estimates and standard errors will be biased (Forbes 2000).' This and the problem of specifically estimating how a change in inequality can change an individual country's growth rate can be resolved by analyzing panel data. Panel estimation controls for differences in specific regional factors and give a definite measure of the actual impact inequality has on an individual country.

Early literature on inequality was plagued with measurement error and insufficient data analysis techniques, but with new methods of analyzing data more accurate results can be obtained. A prominent paper written by Robert Barro titled, "Inequality and Growth in a Panel of Countries," used data from the Deininger and Squire Dataset to assess the relation between inequality and growth in a panel of countries. In total, 84 countries were used in the analysis. The main findings indicate there is little overall relation between inequality and growth although

[6] The "New Gini" is calculated by WIDER using methods developed by Tony Shorrocks and Guang Hua Wan. The New Gini could only be calculated if quintile or decile shares were available. The original Gini coefficient given in the original sources, namely "Reported Gini," is included as a backup measure if the New Gini could not be calculated.

there seems to be an inverse relation between inequality and growth in poorer countries and a positive correlation in richer countries. He claims the reason for a closely zero relation is a result of the offsetting theories discussed in section 1 of this paper.

These findings were significant for further research on growth theory and after gathering empirical data to show that inequality is not a significant factor of economic growth, Barro provided new evidence as to the most significant determinants of economic growth in a panel of countries (Barro 2003). The sample consisted of 87 countries with 240 observations over three ten year periods. Variables considered the most significant determinants of growth are as follows:

1. Log of Initial Real Per Capita GDP: In the neoclassical growth model one theory is absolute convergence. It states that poorer economies tend to grow faster than richer, more advanced economies and eventually catch up because 'imitation is typically cheaper then invention (Barro 1997).'[7] The hypothesis implies that initial per capita GDP in period t would be inversely related to the growth rate of per capita GDP in period t.

2. Educational Attainment: Human capital has been emphasized as an extremely important factor in determining economic progress. It is defined as the average years of male secondary schooling plus male higher schooling and is observed at the start of each period.[8] It is assumed education promotes technological innovation hence higher levels of educational attainment should increase growth.

[7] For a complete analysis of the absolute convergence hypothesis and its effect on growth refer to the 1997 article, Technological Diffusion, Convergence, and Growth" by Barro and Sala-i-Martin.

[8] Attainment for both sexes and females are not significantly related to growth (Barro 2003).

3. Life Expectancy: The regression includes the reciprocal of life expectancy at age in 1960 for the 1965-1975 period and so on for the next two periods. Barro explains ‘these values would correspond to the mortality rate per year if mortality were independent of age.’ A higher mortality rate representing adverse health conditions is expected to be inversely related to economic growth.

4. Fertility Rate: This variable is entered into the equation as the log of total live births for the typical woman over her expected lifetime in 1960 for the 1965-1975 period and so on. Assuming the Demographic transition theory holds, discussed in detail in the next section, one should expect as an economy grows the fertility rate will decrease.

5. Government Consumption Ratio: The ratio of real government consumption to real GDP is adjusted by subtracting spending on defense and education because these are seen as investment rather than consumption. This variable enters into the model as an average for each period. Because government consumption in no way increases productivity, a negative coefficient is expected.

6. Rule of Law: This variable was first proposed and used in a growth regression by Knack and Keefer in 1995. It ‘reflects the degree to which the citizens of a country are willing to accept the established institutions to make and implement laws and adjudicate disputes. Higher scores indicate sound political institutions, a strong court system, and provisions for an orderly succession of power. Lower scores indicate a tradition of depending on physical force or illegal means to settle claims (Knack and Keefer 1995).’ Barro adjusted the data to a zero-to-one scale

and entered initial values for each period into the regression. An increase in rule of law should be positively correlated with economic growth.

7. Democracy: This variable refers to electoral rights, seen as an alternative measure of civil liberties and is based on a scale from zero-to-one where one indicates representative democracy and zero, a totalitarian system. As such, it is expected that an increase in democracy leads to an increase in economic growth. The variable enters into the equation as the initial value for each period.

8. International Openness: This variable is defined as the ratio of exports plus imports to GDP and is entered as an average over each period. Openness can have adverse effects on the standard of living in developing countries with largely labor-intensive production. Specialization in these industries will slow technological advances which hinders growth in the long run (Appleyard 2010). In more developed countries, the level of international openness is heavily dependent on the land area and population. 'Large countries tend to be less open because internal trade offers a large market that can substitute effectively for international trade (Barro 2003).' The offsetting effect of openness on any given country's growth leads to ambiguous conclusions as to whether or not it will promote or retard growth.

9. Terms of Trade: This variable is defined as the interaction between the growth rate of a country's terms of trade (the ratio of export prices to import prices) and the average ratio of exports plus imports to GDP, entered as an average for each period. As the price of exports rise relative to import prices, one finds that every unit of exports can now buy a larger amount of imports. More goods lead to higher utility and overall welfare increases (Appleyard 2010). This

means that an increase in the terms of trade variable should lead to an increase in economic growth.

10. Investment Ratio: This is defined as the ratio of real gross domestic investment (private plus public) to real GDP and is averaged over each ten year period. This variable measures the effect of a country's savings rate. A higher savings rate promotes more investment and since investment is one of the four components of GDP, and increase in investment should lead to an increase in growth.

11. Inflation Rate: This variable enters as an average for each period to measure macroeconomic stability.

Results from the regression indicate increased human capital and investment, a more democratic system, a lower mortality rate, increased international openness, and a lower government consumption ratio promote growth while higher initial per capita GDP and inflation, higher fertility rates, less favorable terms of trade, and a lower rule of law retard growth in the sample of countries.

There are many differing results from numerous research articles on this topic. These include Barro, Castelló-Climent, Forbes, and many others who all have unique results. Barro claims there is almost no relationship between inequality and growth, whereas Castelló-Climent and Forbes both find a negative relationship in developing countries and a positive relationship in advanced economies. The only way to increase our understanding is to research and add to previous literature by formulating our own hypotheses. The claim of this paper is that earlier works explaining the connection between inequality and growth are not definitive due to two issues. First, erroneous data collection may lead to biased results. The majority of countries have not collected data on inequality at regular intervals and when data has been gathered it is typically untrustworthy, coverage is usually not comprehensive throughout the population, and there is altogether an inconsistency as to the underlying definition of income. Using an improved dataset in this paper, each of these problems will have been overcome. This paper uses the WIID2 database produced by WIDER for income inequality. When possible, the New Gini was used to give the data a uniformly calculated value. When this measure was not available, sources that had a Reported Gini calculated from disposable individual household income were used to establish a consistent definition of income throughout the sample, and finally Gini coefficients are only reported in the new dataset if it is comprehensive to the population.

Second, a vast amount of previous literature includes both underdeveloped and developed economies in their samples; but recently, Castelló-Climent (2010) points out the role of income inequality changes with the economy's level of development. [9] Including both underdeveloped and developed economies in the sample leads to offsetting results, therefore; the sample in this paper will be restricted to only high income countries with data ranging from 1970 to 1999. This will give the reader a more accurately estimated beta coefficient for inequality in advanced economies.

The remainder of the study is broken up into four sections: The first section will describe the data and the regression used in the analysis; next, an in-depth statistical analysis will be

[9] Castelló-Climent found that inequality has a negative impact on growth for developing countries and a positive effect in advanced economies.

performed; and the last two sections will explain the regression results and final conclusions respectively.

THE EMPIRICAL MODEL

Growth is estimated as a function of income inequality, the mortality rate, the government consumption ratio, the log of the fertility rate, the log of initial per capita GDP, the investment rate, the international openness ratio, the inflation rate, the terms of trade ratio and the level of education. The empirical model is as follows:

$$Growth = \beta_0 + \beta_1 Gini + \beta_2 Mort + \beta_3 Gov + \beta_4 \log fert + \beta_5 logGDP + \beta_6 Invest + \beta_7 Open + \beta_8 Inflat + \beta_9 Trade + \beta_{10} Education + \varepsilon$$

To eliminate short run disturbances caused by fluctuation of the business cycle, the range of years will be grouped into five year intervals including 1970-1974, 1975-1979, 1980-1984, 1985-1989, 1990-1994, and 1995-1999. Countries are classified as high income if the average per capita incomes are $12,294 or more.[10] In total, the number of countries in the sample is 69. Certain countries did not have enough information to be used in the regression. The countries not included are the Cayman Islands, Curacao, Gibraltar, North Mariana Islands, Sint Maarten, St. Martin, and the Virgin Islands.

Variables

The dependent variable, Growth, is defined as the growth rate of real per capita Gross Domestic Product in constant 2000 U.S. dollars.[11] This variable is averaged over each of the 6 periods.

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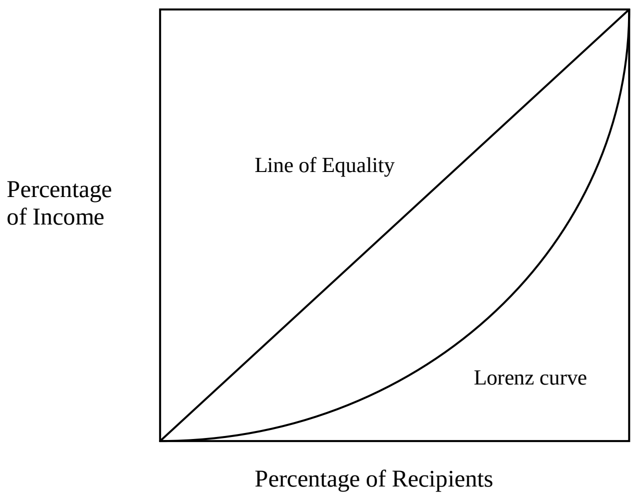
[10] Based on reports by the World Bank.

[11] Growth is calculated as a decimal rather than a growth rate percentage.

To maintain consistency with previous literature, the type of inequality referred to in this paper is the size distribution of income. A common way of analyzing the extent of inequality within a country is to construct a Lorenz curve, shown graphically in figure 2.

Figure 2: Lorenz Curve



The diagram to the left shows the distribution of income in an economy. On the horizontal axis is the percentage of the population and the vertical axis indicates the percentage of income. The bowed curve represents the Lorenz curve. Inequality rises in an economy as the Lorenz curve moves down and to the right away from the Line of Equality.

This curve shows the relationship between the percentage of income recipients and the percentage of the total income received. Both axes range from 0 to 100%. The diagonal line represents the line of equality and, at any point on this line, the percentage of income recipients is equal to the percentage of income received (perfect equality). As the Lorenz curve moves away from the line of equality, the area between the two gives the measure of inequality within the total population (Todaro 2009). The area of the enclosed region divided by the total lower triangular region is called the Gini coefficient (Gini) and can be mathematically expressed as:

$$\int_0^1 (x - f(x))dx$$

A strong negative relationship is expected since inequality leads to economic inefficiency due to imperfect capital markets, the political process in which the redistribution of income is favored, and social unrest. An offsetting factor which could contribute to an opposite sign would be the Keynesian theory of savings as discussed in section 1. Gini is averaged over each period.

Following Todaro, life expectancy at birth, measured in total years, stems from improvements in health conditions, the proliferation of health facilities, improved nutrition, and clean water supplies (Todaro 2009). The reciprocal of life expectancy at birth (Mort) corresponds to the mortality rate if mortality were independent of age (Barro 2003). This mortality rate variable is entered into the model as an average over each of the 6 periods and a decrease in the mortality rate should lead to an increase in growth.

The government consumption ratio (Gov) is the ratio of government consumption to GDP and includes all government expenses for goods and services (including compensation to employees). It also includes most expenditures on national defense and security but excludes government military expenditures that involve productivity. This will be slightly high if compared to Barro (2003) due to inclusion of education expenditures in this paper. Barro was able to adjust for education by subtracting the ratio of education expenditures to GDP from the government expenditures ratio. This variable is calculated as the average value in each period. It is expected as government consumption increases, growth in per capita GDP will decrease.

The fertility rate (logFert), entered as the initial value in each time period, and is calculated as the log of total live births per woman over her expected lifetime. The demographic transition explains how developed economies passed through three stages of population growth. It is the process by which fertility rates eventually decline as a country grows. The first stage classifies countries as having stable growth rates as a result of high birth rates and similarly high mortality rates. Countries enter stage two as health facilities advance and people begin to maintain healthier diets due to increasing incomes. In this stage, population rates increase rapidly as fertility rates continue to grow but mortality rates fall. The final stage is entered when modernization leads to increased female job opportunities causing a decline in fertility. Using this thought process; the expectation is that as logfert increases, growth will decrease in developed countries.

The log of real per capita GDP (logGDP) is defined as the log of initial real per capita GDP in each period. A theory in the neoclassical model is absolute convergence. It states that poorer economies tend to grow faster than richer economies and eventually catch up because 'imitation is typically cheaper then invention (Barro 1997).'[12] The hypothesis implies that initial per capita GDP in period t would be inversely related to the growth rate of per capita GDP in period t.

The investment ratio (Invest) is real gross investment to real GDP and includes the fixed assets plus changes in the level of inventory. Fixed assets are defined as plant, machinery, and equipment; and the construction of roads, railways, schools, offices, hospitals, residential homes, and commercial and industrial buildings. Inventories are stocks of goods held by firms to meet temporary or unexpected fluctuations in production or sales, and "work in progress" (definition from World Bank). The variable is taken as a one period lagged average and because investment

[12] For a complete analysis of the absolute convergence hypothesis and its effect on growth, refer to the 1997 article, Technological Diffusion, Convergence, and Growth" by Barro and Sala-i-Martin.

increases long term productivity, it is expected to have positive relationship with economic growth.

International Openness (Open) is calculated as the ratio of exports plus imports to GDP. It is included as a one period lagged average. According to the theory of comparative advantage, a country can gain from international trade since it enables countries to specialize and leads to a more efficient use of resources. It is expected increased international openness leads to higher growth rates.

Terms of Trade (Trade) is defined as the change in the price of exports over the price of imports. This variable is averaged over each period. As the price of exports rise relative to import prices, one finds that every unit of exports can now buy a larger amount of imports. More goods lead to higher utility and overall welfare increases (Appleyard 2010). This means that an increase in the terms of trade variable should lead to an increase in economic growth.

Human capital has been emphasized as an extremely important factor in determining economic progress. The proxy for human capital in this paper is the average number of years of total schooling for the entire population (Education) in each period. It is assumed education promotes technological innovation and investment hence higher levels of educational attainment should increase growth.

The inflation variable is the change in the price level from year to year averaged over each period and is used to measure macroeconomic stability.

The error term, ε, represents the difference between the actual level of growth, y, and the estimated value, ŷ. The residual indicates the extent of the movement in the dependent variable that is not explained by the independent variables (Rao 1971).

Several variables could have been added to this regression but this simplified model was chosen for two reasons: the first being, the proposed model is similar to that of previous studies that estimate inequality's impact on growth, so any differences between this paper and previous literature cannot be explained by the underlying design of the model; and secondly, as with most cross country regressions, the research is hindered by the availability of data so the simplified model helps to maximize the degrees of freedom.

STATISTICAL ANALYSIS

This section statistically analyzes the underlying sample introduced in this paper using the statistical software package, STATA. The sample consists of 69 countries over a 30 year period from 1970-1999. In total the sample began with 414 observations.

To begin the analysis, a pairwise correlation matrix was created, found in table 1, to find all possible relations between the variables. At a significance level, $\alpha = 0.05$, the correlation matrix finds that growth is highly correlated to all but two of the independent variables. LogFert and education had p-values of 0.419 and 0.282 respectively. The matrix also showed that multicollinearity could be a possible factor in my sample due to high correlation between several of the independent variables.

Table 1: Pairwise Correlation Matrix

Variable	growth	lagopen	educat~n	logfert	gini	gov	loggdp	laginv~t	inflat	mort	trade
growth	1.000	0.134	-0.073	0.050	0.258	-0.229	-0.308	0.159	-0.145	0.255	0.692
(p)		(0.061)	(0.282)	(0.419)	(0.001)	(0.000)	(0.000)	(0.026)	(0.012)	(0.000)	(0.000)
lagopen	0.134	1.000	-0.357	0.049	0.382	-0.259	-0.086	0.221	-0.060	0.038	-0.082
(p)	(0.061)		(0.000)	(0.485)	(0.000)	(0.000)	(0.229)	(0.002)	(0.399)	(0.585)	(0.442)
education	-0.073	-0.357	1.000	-0.575	-0.020	0.150	0.304	-0.168	-0.053	-0.567	0.031
(p)	(0.282)	(0.000)		(0.000)	(0.797)	(0.024)	(0.000)	(0.024)	(0.429)	(0.000)	(0.772)
logfert	0.050	0.049	-0.575	1.000	0.391	0.210	-0.266	-0.061	0.000	0.601	0.166
(p)	(0.419)	(0.485)	(0.000)		(0.000)	(0.001)	(0.000)	(0.389)	(0.995)	(0.000)	(0.113)
gini	0.258	0.382	-0.020	0.391	1.000	-0.443	-0.054	0.102	-0.046	0.149	-0.256
(p)	(0.001)	(0.000)	(0.797)	(0.000)		(0.000)	(0.473)	(0.225)	(0.543)	(0.043)	(0.019)
gov	-0.229	-0.259	0.150	0.210	-0.443	1.000	0.040	-0.289	0.136	0.126	-0.018
(p)	(0.000)	(0.000)	(0.024)	(0.001)	(0.000)		(0.533)	(0.000)	(0.032)	(0.044)	(0.862)
loggdp	-0.308	-0.086	0.304	-0.266	-0.054	0.040	1.000	-0.265	-0.147	-0.595	-0.269
(p)	(0.000)	(0.229)	(0.000)	(0.000)	(0.473)	(0.533)		(0.000)	(0.011)	(0.000)	(0.010)
laginvest	0.159	0.221	-0.168	-0.061	0.102	-0.289	-0.265	1.000	0.147	-0.005	0.096
(p)	(0.026)	(0.002)	(0.024)	(0.389)	(0.225)	(0.000)	(0.000)		(0.038)	(0.942)	(0.370)
inflat	-0.145	-0.060	-0.053	0.000	-0.046	0.136	-0.147	0.147	1.000	0.048	0.042
(p)	(0.012)	(0.399)	(0.429)	(0.995)	(0.543)	(0.032)	(0.011)	(0.038)	(0.000)	(0.433)	(0.694)
mort	0.255	0.038	-0.567	0.601	0.149	0.126	-0.595	-0.005	0.048	1.000	0.335
(p)	(0.000)	(0.585)	(0.000)	(0.000)	(0.043)	(0.044)	(0.000)	(0.942)	(0.433)		(0.001)
trade	0.692	-0.082	0.031	0.166	-0.256	-0.018	-0.269	0.096	0.042	0.335	1.000
(p)	(0.000)	(0.442)	(0.772)	(0.113)	(0.019)	(0.862)	(0.010)	(0.370)	(0.694)	(0.001)	

A formal method for detecting multicollinearity is to calculate the variance inflation factor (VIF) for each beta parameter. VIF's greater that 10 indicate multicollinearity exists in the model (Mendenhall 2003). The results are shown in the second column of Table 2.

Table 2: Variance Inflation Factor

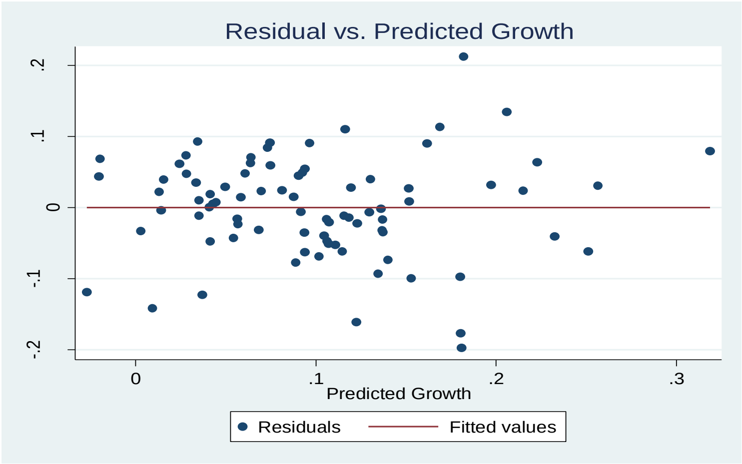
Variable	VIF	1/VIF
gov	3.77	0.264983
mort	3.47	0.288337
gini	3.45	0.289460
loggdp	3.32	0.301470
invest		
L1.	2.27	0.441363
open		
L1.	2.09	0.477560
logfert	1.78	0.561577
inflat	1.72	0.579750
education	1.70	0.587028
trade	1.31	0.763608
Mean VIF	2.49	

The VIF for each beta parameter was < 4, which suggest multicollinearity is not an issue.

The next step in the statistical analysis is to conduct a residual analysis since the validity of the inferences associated with a regression analysis depends on the error term, ε (Mendenhall 2003). Least squares regression analysis assumes ε is normally distributed with a mean of zero, all pairs of ε are uncorrelated, and the variance of each independent variable, σ^2, is homoscedastic (Mendenhall).[13] A two way graph of ε vs. ŷ confirms the mean of ε = 0 by the line of best fit, shown in figure 3.

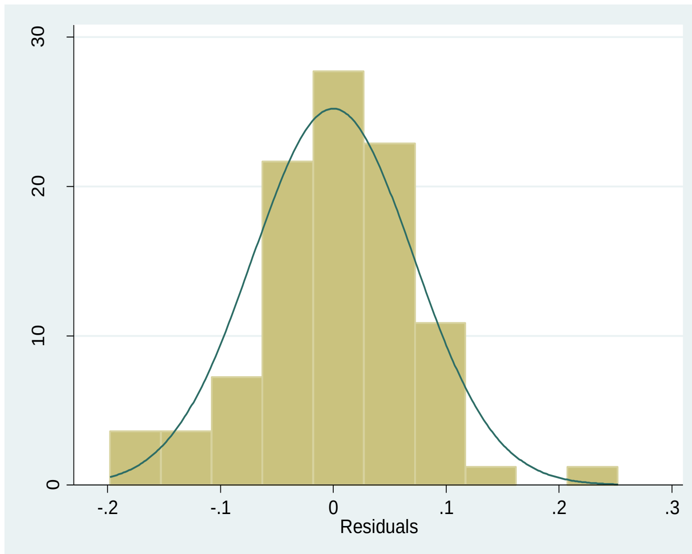
[13] Constant σ^2 for all levels of the independent variables are said to be homoscedastic.

Figure 3: Residual Plot



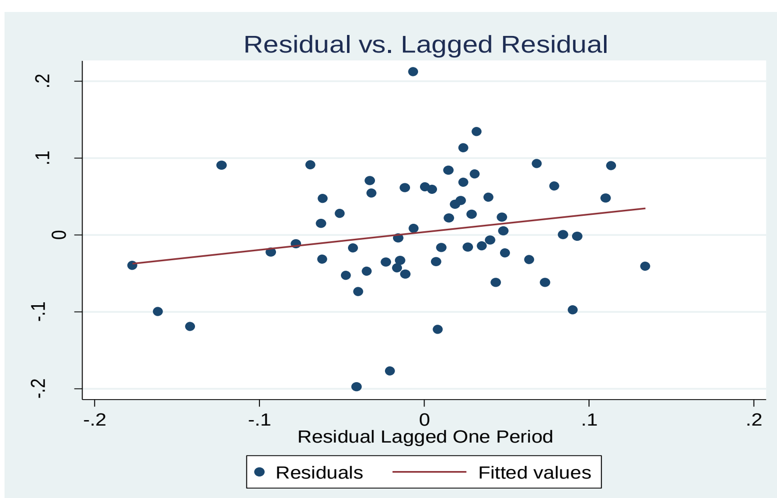
The graph shows no clear patterns as ŷ increases, thus there seems to be no signs of heteroscedasticity. This is to be expected since a robust regression was run which accounts for any heteroscedasticity. To check the normality assumption, a Skewness/Kurtosis test for normality was used. A p-value of 0.3140 indicated the there is no evidence to reject the null hypothesis that the residuals are normally distributed. The histogram in figure 4 confirms the normality assumption.

Figure 4: Histogram of Residuals



The final assumption, no correlation among the error terms, was tested by plotting the ε against a one period lagged ε, shown in figure 5. A trend would indicate there is dependence between different pairs of residuals.

Figure 5: Residual Lag Plot



There seems to be a positive correlation between the residuals, so to find the significance of this correlation a pairwise correlation matrix was used. The correlation is .2026 with a significance level of 0.1239; therefore, at $\alpha = 0.05$, there is no reason to reject the null hypothesis that the residuals are independent, thus the slight positive trend should not be an issue.

It is important to detect outliers in any sample used in a regression. Outliers can arise any number of ways including measurement error and incorrectly inputted data. These outliers can have dramatic effects on the dependent variable. Depending on the severity of influence these observations have, one should consider omitting them from the final dataset.[14]

A residual plot is used to detect possible residual outliers. An observation with standardized residual > 3 standard deviations from the mean, zero, is considered an outlier (Mendenhall 2003). It is easily confirmed from the graph in figure 3 that no outliers exist. In fact, with the exception of one observation all residuals lie within 2 standard deviations of the mean.

From here, output statistics are obtained to identify highly influential observations. Leverage values, h_i, measure the influence the dependent variable, y, has on the predicted value, $\hat{y}$. The larger h_i, the more influence y has on $\hat{y}$. A rule of thumb for detecting high influence is to flag observations with a leverage value greater than $2(k+1)/n$ where k is the number of β's in the model, excluding β_0, and n is the number of observations used in the sample (in this case $k = 10$ and $n = 83$). Table 3 shows observations flagged for high leverage (i.e. $h_i > 0.2651$).

[14] There is no clear-cut rule that states whether or not an observation should be omitted. The final decision will be based upon the number of times an observation has been flagged.

Table 3: Leverage Values

leverage	id
.278661	309
.2878073	226
.2915115	225
.3146643	364
.3216101	388
.332729	340

The next test is the Cook's Distance test. Cook's D values, D_i, are a measure of the overall influence an outlying observation has on the β coefficient estimates. A rule of thumb is that any $D_i > 1.0$ indicates substantial influence (Mendenhall 2003). Table 4 shows the five most influential observations.

Table 4: Cook's D Values

cooksd	id
.1274891	198
.1339767	387
.1513811	340
.1558611	388
.2030164	180

The final test for influential observations is to calculate a statistic known as the Studentized deleted residual (Rstudent). The test compares the regression results using all n observations to the results with the i^{th} observation deleted, giving a measure as to how much influence a particular observation has on the analysis. This Studentized deleted residual, d_i, is defined as the difference between $y_{(i)} - \hat{y}_{(i)}$ over the standard error of d_i. Table 5 includes observations with flagged Rstudent values.

Table 5: Rstudent Values

rstudent	id
1.321945	341
1.603786	411
1.85829	340
1.913733	178
3.186978	198

Using these three tests, an accurate description is obtained as to which variables are considered highly influential. Observation 198 and 388 were flagged in one of the three tests and observation 340 was flagged in two of three tests. There is no clear-cut rule that states whether or not an observation should be omitted. The final decision is based upon the number of times an observation has been flagged. Therefore observations 198 and 388 will remain in the model while observation 340 will be omitted. Observation 340 turned out to be Singapore in the period 1985.

RESULTS

This section estimates the determinants of growth at a significance level of α = 0.05. The model is estimated using an ordinary least squares approach. Out of the original 414 observations over six 5 year periods, 82 observations are included in the final sample and table 6 contains regression results for the empirical model. The effect of the Gini coefficient on growth will be explained at the end of the section.

Table 6: Regression Results

Linear regression

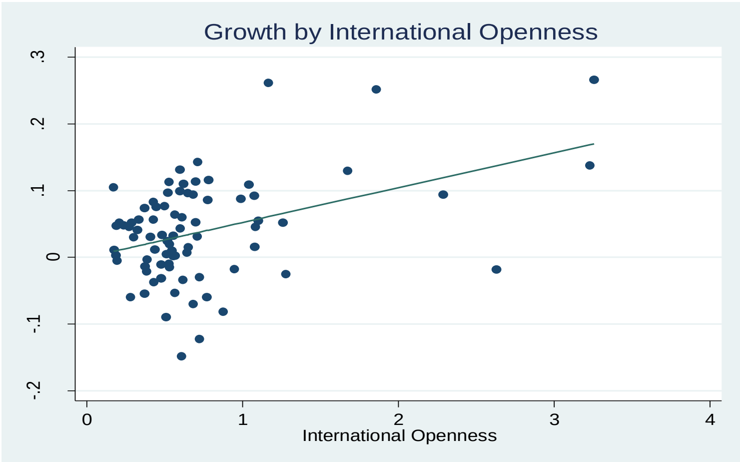
Number of obs	= 82
F(10, 71)	= 6.27
Prob > F	= 0.0000
R-squared	= 0.4759
Root MSE	= .07474

growth	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
lagopen	.0606835	.0182421	3.33	0.001	.0243099	.0970572
education	.0108947	.0041581	2.62	0.011	.0026037	.0191857
logfert	-.1097885	.1174484	-0.93	0.353	-.3439739	.124397
gini	-.6791378	.2924114	-2.32	0.023	-1.26219	-.0960861
gov	-1.209618	.4186792	-2.89	0.005	-2.04444	-.3747953
loggdp	-.1617739	.0762472	-2.12	0.037	-.3138064	-.0097413
laginvest	-.6019198	.2943823	-2.04	0.045	-1.188902	-.0149381
inflat	-.0022988	.0027089	-0.85	0.399	-.0077002	.0031025
mort	35.0104	30.81081	1.14	0.260	-26.42461	96.44541
trade	1.14113	.3645945	3.13	0.003	.4141495	1.868111
_cons	.7518928	.6320461	1.19	0.238	-.5083714	2.012157

The lagged variable, open, has a statistically significant estimated coefficient of 0.0607 (0.0182) indicating, on average, a one unit increase in the standard deviation of the level of international openness will increase growth by 6.07%, holding all other variables constant.

Figure 6 graphically shows the partial relation between growth and open.[15] There is strong statistical evidence that increased openness promotes growth in this sample.

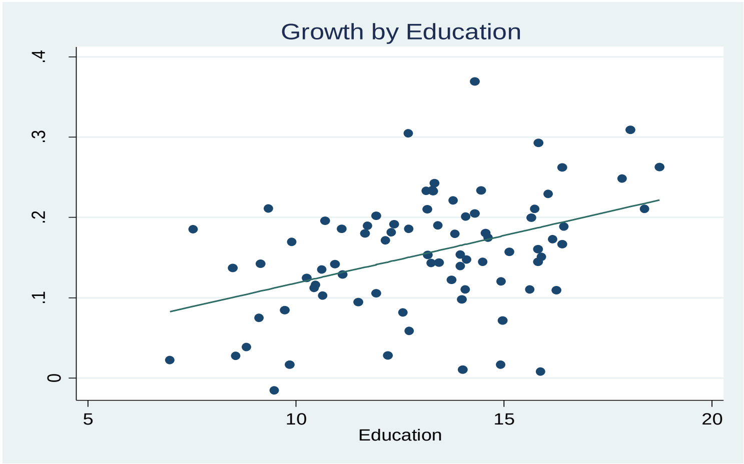
Figure 6: Partial Relation between Growth and Lagged International Openness



Education has an estimated coefficient of 0.0109 (0.0042) indicating, on average, a one unit increase in the level of education will increase growth by 1.09%, holding all other variables constant. Figure 7 shows the partial relation between growth and education.

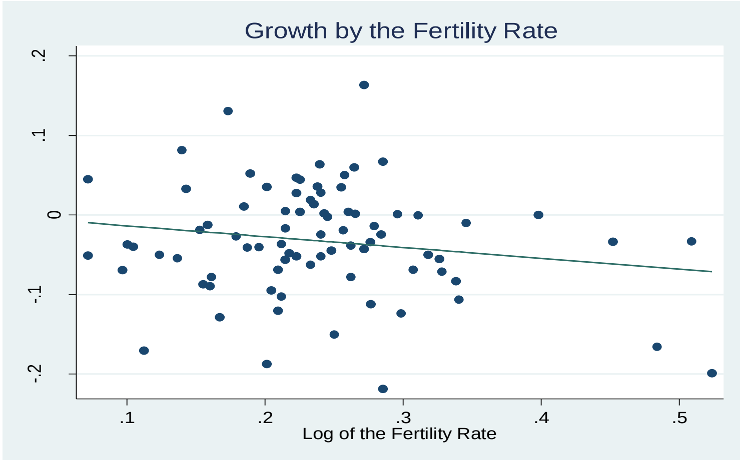
[15] A partial relation accounts for all other independent variables giving the true effect of the observed variable on growth.

Figure 7: Partial Relation between Growth and Education



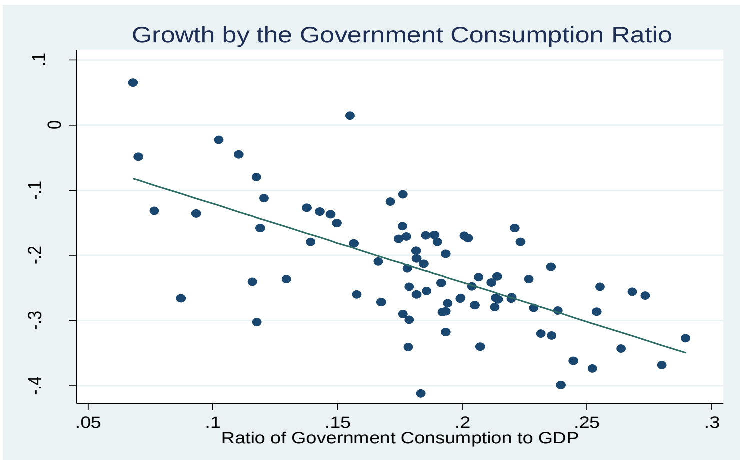
The variable, logFert, was expected to have a negative effect on growth in the sample of developed countries. The regression results seem to indicate this negative effect is far less significant than researchers had previously thought. This could be due to the fact only developed countries were used in the sample which points to conclusion that the fertility rates in developed countries do not have as large an impact on changes in per capita income as they do in developing countries. The estimated coefficient is -0.1097 (0.1174) and figure 8 shows the partial relation between growth and logFert.

Figure 8: Partial Relation between Growth and logFert



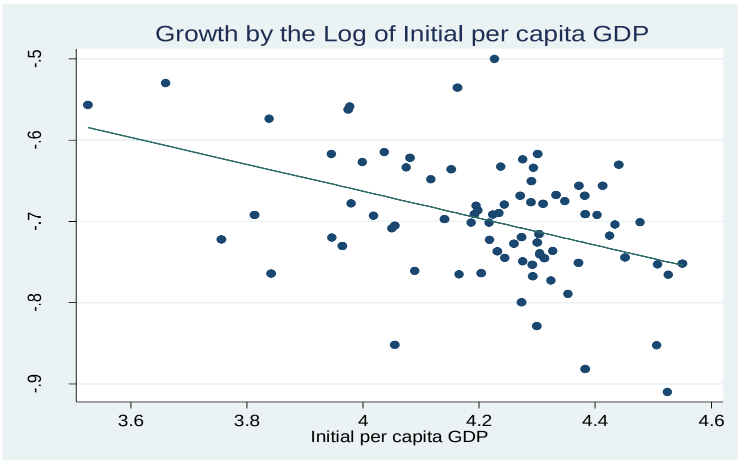
The government consumption coefficient is -1.2096 (0.4187) which is highly significant and indicates that, on average, a one unit increase in the government consumption variable (gov) decreases growth by 120.96%, holding all other variables constant. This negative coefficient was expected and figure 9 shows the partial relation between the government consumption ratio and growth.

Figure 9: Partial Relation between Growth and the Government Consumption Ratio



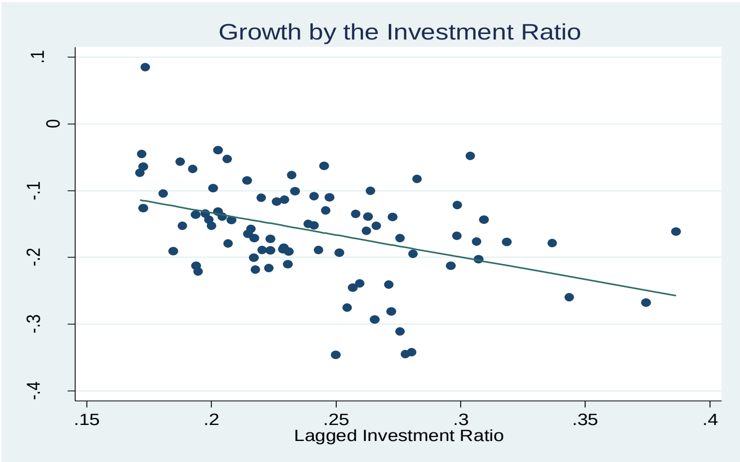
The logGDP is highly significant, which empirically confirms the theory of conditional convergence in growth theory. This indicates that countries with high initial per capita GDP grow at a slower rate than those with a lower starting per capita GDP. The estimated coefficient -0.1618 (0.0762) implies that a one unit increase in the log of initial per capita GDP will, on average, decrease growth rates by 16.18%, holding all other variables constant. Figure 10 gives a graphical description.

Figure 10: Partial Relation between Growth and Initial per capita GDP



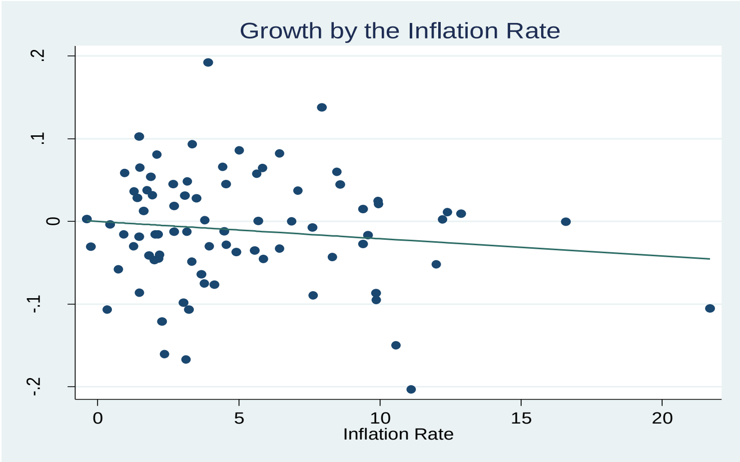
The investment ratio, lagged one period was expected to have a positive relation to growth but regression results point towards a statically significant negative coefficient of -0.6019 (0.2944) implying, on average, a one unit increase in investment will decrease growth by 60.19%. This is quite shocking and could be the result of omitted variable bias. When an independent variable from the true relation is omitted, part of its influence in explaining the movements of the dependent variable is captured by the other independent variables (Rao 1971). This can lead to opposite signs than were expected. Another possible factor could be the limited dataset not capturing the full effect of investment. Figure 11 shows the partial relation between growth and investment.

Figure 11: Partial Relation between Growth and Lagged Investment



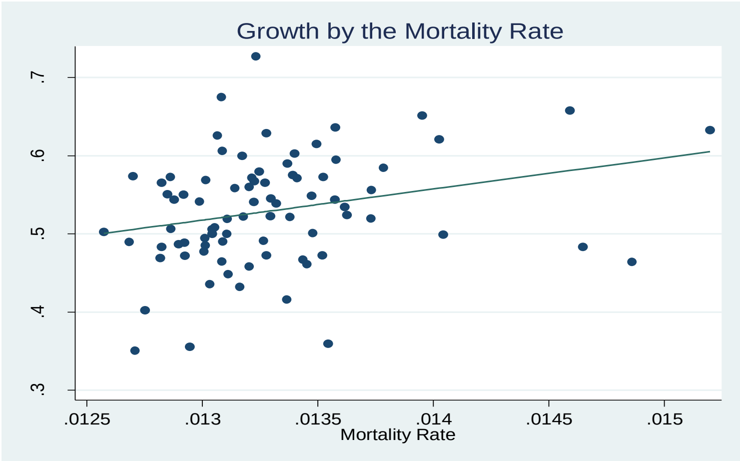
Inflation was used in the model to measure macroeconomic stability. The variable coefficient, -0.0023 (0.0027), implies that, on average, a one unit increase in the inflation rate will decrease growth by 0.23%. This variable is highly insignificant and indicates the inflation rate is not a significant determinant of growth the sample of high income countries. Figure 12 shows the partial relation between growth and the inflation rate.

Figure 12: Partial Relation between Growth and the Inflation Rate



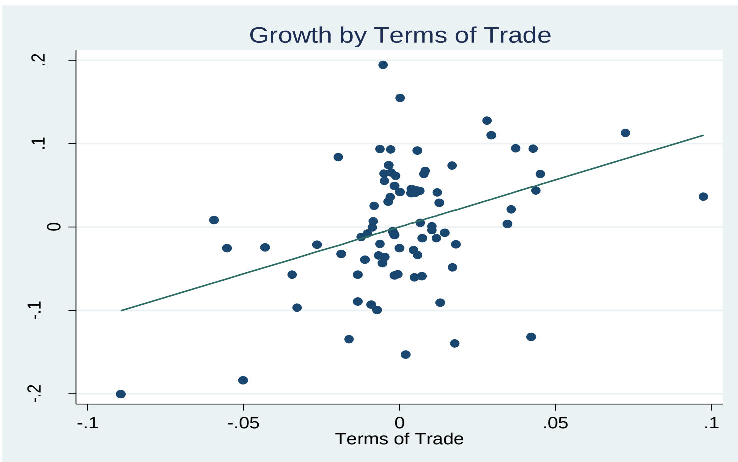
The mortality variable (mort) was expected to have a negative relation to changes in per capita GDP because advancements in healthcare correspond to increased longevity. To the contrary, it has a positive effect on growth in this sample with an estimated coefficient of 35.0104 (30.8108). The coefficient is insignificant with a p-value of 0.26. The partial relation between mort and growth is shown in Figure 13.

Figure 13: Partial Relation between Growth and the Mortality Rate



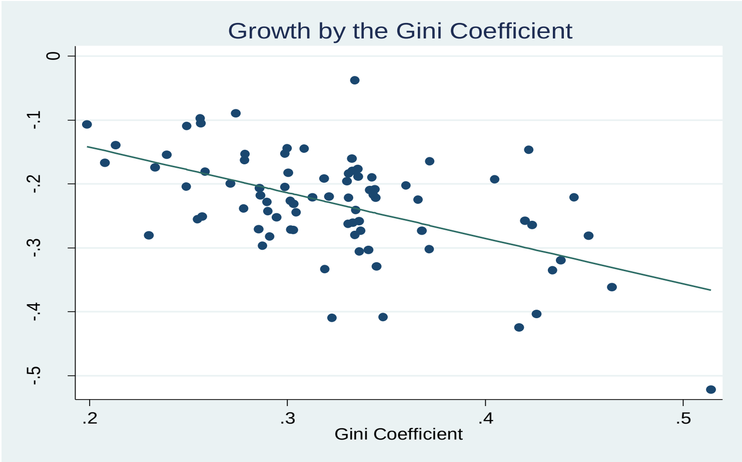
Changes in a country's terms of trade can have significant impacts on individual welfare as discussed earlier. This leads many researchers to believe it is a fundamental determinant of growth. Regression results confirm this belief. The estimated coefficient is 1.1411 (0.3646) indicating, on average, a one standard deviation increase in a country's terms of trade will increase growth in per capita income by 114.11%. This is highly significant and the partial relation between growth and trade is shown in figure 14.

Figure 14: Partial Relation between Growth and Changes in Terms of Trade



Throughout the years, numerous empirical research articles have attempted to answer the question as to whether or not inequality tends to retard or promote growth. The claim of this paper stated that in a macroeconomic setting, inequality is indeed an influential determinant of economic growth since it leads to economic inefficiency due to imperfect capital markets, the political process in which the redistribution of income is favored, and increases in criminal activity. The regression results confirm this hypothesis. The estimated coefficient of inequality (Gini) is -0.6791 (0.2924) indicating, on average a one standard deviation increase in income inequality decreases growth by 67.91%. I'm 95% confident that the true value of inequality lies between -1.2622 and -0.0961. Figure 15 shows this relationship graphically.

Figure 15: Partial Relation between Growth and the Gini Coefficient



These results show that when panel data is estimated using an ordinary least squares approach including time series data, inequality has adverse effects economic performance.

CONCLUSION

The results provide robust empirical evidence that Gini has adverse effects on growth in high income countries and indicate that, on average, a one standard deviation increase in income inequality will decrease growth by 67.91%. Previous work on this topic was hindered by several issues including the use of cross sectional data, limited inequality statistics, and inclusion of both underdeveloped and developed economies. This paper has accounted for these shortfalls by using panel data, a new and improved dataset, and by limiting the sample to include only high income countries.

Results from the regression suggest increases in human capital and international openness, decreases in the government consumption ratio, and more favorable terms of trade promote growth while higher initial per capita GDP and higher levels of investment retard growth. The research also concluded that a higher fertility rate and inflation rate decrease growth while increases in the mortality rate promote growth. These results were largely insignificant and imply that these variables are not noteworthy determinants of growth in the sample of high income countries.

One unsettling result of the final regression is the negative relationship between investment and growth. This could be the result of omitted variable bias in which investment is capturing the effects of other omitted variables leading to an opposite sign than was expected. Another possible factor could be the limited dataset not capturing the full effect of investment.

There are many differing results from numerous research articles on this topic. These include Barro, Castelló-Climent, Forbes, and many others who all have unique results. Barro claims there is almost no relationship between inequality and growth, whereas Castelló-Climent and Forbes both find a negative relationship in developing countries and a positive relationship in advanced economies. The only way to truly understand the actual relationship is to investigate further into this area. Accessibility of reliable inequality measures is still a major issue and to gain a better understanding of the true effect income inequality has on individual welfare more reliable data must be retrieved.

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