Explaining Differences in Growth in Developing Countries

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Abstract

This analysis attempts to explain the differences in per-capita GDP growth in developing countries over the period 2000-2010. Using OLS estimators on an initial cross-section data sample of 30 developing countries, we find that growth rates are positively affected by savings rates in the decade, natural resource endowment, and inflation volatility, while they are hindered by population growth over the decade, savings rates over the previous decade, initial per-capita income, and tropical location. An expansion of economic freedom is found to quadratically relate to growth, at first increasing it and then having a negative effect. Income inequality and landlocked variables are not shown to significantly affect growth rates over this period. However, testing the model on a second sample of developing countries showed markedly different and insignificant explanatory power of the identical variables, suggesting the original model is not robust.

Introduction

Introduction

In the 1990s, the Washington Consensus attempted to provide a template of free-market policy decisions that would give developing economies a clear track to economic stability and growth. But as many previously poor countries emerge in the world economy, others stagnate and languish in poverty. This paper attempts to explain the differences in growth of developing countries over the decade 2000-2010. While free markets indeed influence economic growth, there are other important elements in the growth process. This paper attempts to identify and quantify the determinants of economic growth.

In the succeeding analysis, the explained dependent variable is the average annual growth rate of per-capita gross domestic product (GDP), a metric often used to describe standard of living. Independent variables include the initial GDP per capita, geographic location, natural resource endowment, inflation, inequality, economic freedom, population growth, and savings. Samples of 30 randomly selected developing countries are included in two cross-sectional data sets.

Literature

The topic of growth rate determinants has been investigated by seasoned Harvard economist Robert Barro (1991, 1998). Barro's empirical findings support the idea of conditional convergence – that lower initial levels of per-capita GDP make for higher growth rates given similar technology diffusion and availability in poor and rich countries – and that growth is "enhanced by higher initial schooling and life expectancy, lower fertility, lower government consumption, better maintenance of the rule of law, lower inflation, and improvements in the terms of trade." He also notes the impact on growth of political freedom and democracy.

Burger and du Plessis (2006) examined the tendency of African countries to experience slower growth. It was concluded that economic growth can be explained by numerous factors, including initial GDP, tropical location, primary school enrollments, work force growth, and openness to trade. They acknowledged that traditional growth determinants "systematically overpredicted" African growth rates, suggesting that Africa is somehow at a disadvantage compared to other continents. However, they criticized earlier studies that used an African dummy variable, especially Sala-i-Martin, Doppelhofer, and Miller (2004), asserting that the variable is not robustly significant and its presence was aided only because of model misspecification.

Wight (2011) recognizes many of the established sources of growth, specifically mentioning natural resources and geographical characteristics. However, his essay stresses the importance of crucial "instincts of betterment" – prudence, benevolence, and justice – in creating viable institutions. There are great intangible benefits from strong legal systems or the development and retention of local elite, for example. But Wight concedes that, "We nevertheless still lack a simple way to account for how public policies produce wealth or growth across the particular contexts in which growth occurs," because both formal rule (e.g., constitutions) and informal practices (e.g., customs) are not always similar or comparable. What can be identified are the success stories of nations that are more successful at unleashing these instincts of betterment.

The Model
Combining the contributions of the relevant literature with our independent thought, the model originally included seven independent variables in an attempt to explain real per-capita GDP growth. Upon closer study of literature and comprehensive review of theory, the final model was developed to include eleven independent variables based on nine characteristics. This updated model, which better fits the sample data, suggests that growth can be determined by a country's initial conditions, stability, neoclassical growth components, and economic freedom. The model's general functional form is shown below.

$$GROWTH_i = f(Y_i, T_i, L_i, N_i, R_i, Q_i, P_i, S_i, F_i)$$

Y_i, T_i, L_i, N_i, R_i, Q_i, P_i, S_i, and F_i represent GDP per capita, tropical status, landlocked status, natural resource endowment, inflation, inequality, economic freedom, population growth, and savings, respectively, and i indexes countries. The theoretical bases for inclusion of the explanatory variables are explained below, and their explicit specifications are contained in Figure 4 in Appendix 3. The formal hypotheses of all the explanatory variable coefficients are contained in Appendix 1.

Initial Conditions
The initial level of per-capita GDP is widely seen as an important element in growth models. The theory of convergence states suggests that, all else being equal, low-income countries have the potential to grow faster than higher-income countries, and this advantage slows as the poor countries "catch up" to wealthier ones. This is largely due to the ability of poor countries to quickly select and adopt the appropriate and most efficient technologies from rich countries instead of having to invent them internally. Convergence also draws on the diminishing returns to capital in neoclassical growth models. In diminishing production functions like the Solow neoclassical model represented in Figure 1, the marginal product of capital at low levels of capital per worker is relatively high compared with the marginal product of capital at higher levels of capital per worker. This allows poor countries, weakly endowed with physical or human capital, to "catch up" to richer countries, although this advantage decreases as capital per worker increases. Barro (1991, 1998), among others, has noted that although this initial level may have a substantial effect on growth rates, its impact may vary based on the degree of similarities between countries in "structural parameters for preferences and technology." In his analysis of growth rates for 1960 through 1985, Barro notes that this convergence effect was not typically observed. This may be due to the absence of ceteris paribus (or at least similarity), which is a key principle of convergence – poorer countries will only grow faster than their wealthier counterparts if they share similar characteristics. Instability, corrupt or closed governments, slow diffusion of technology, or a number of given features may lower the effect of convergence for lower-income countries.

One of these given characteristics, climate, can also be grouped under the umbrella of initial conditions. As climate affects many facets of daily life, it can be a prime determinant of the wealth (or lack thereof) of a country. As it is difficult to determine a variable specification that considers all important climactic elements, this model incorporates a tropical dummy variable as a proxy. Historically, most countries located between the Tropics of Cancer and Capricorn (at 23.5 degrees North and South latitude,

respectively) have not enjoyed high levels or growth of per-capita GDP (see Figure 2) compared to those located in temperate zones. Although disasters and unreliable weather present at all latitudinal levels, tropical climates must often contend with desert, poor soil quality, prevalence of tropical diseases like HIV/AIDS and malaria, and unfortunate circumstances such as drought, floods, hurricanes, and typhoons. These tropical disadvantages result in lower growth rates.

Geography affects growth in other ways. Landlocked nations may also encounter significant barriers. Isolation from major markets leads to higher transport costs and the decreases ability to participate in the global economy. Both imports and exports are more expensive, which in turn will decrease consumption and domestic investment. Costs associated with such disadvantages may be alleviated by solid infrastructure, skilled government planning, and natural resource abundance, but the obstacles faced by landlocked nations imply a negative relationship with growth.

The last initial condition variable used in this model is the endowment of natural resources. As mentioned earlier, a handsome endowment of natural resources may mitigate other disadvantages. But the benefits of resource abundance are not limited to diminishing the effect of other negative characteristics. Domestic industry's input costs are low, and exports create positive inflows that can be invested in more productive physical capital, human capital, or infrastructure. The development of the resource industry often creates linkages that stimulate further economic growth. In the event of recession, possession of necessary resources, particularly hydrocarbons like petroleum, provides a stable stream of income. It is important to note that the dependence of an economy on primary exports critically exposes it to price fluctuations, but fuel prices over the last decade have consistently increased, favoring those economies that produce and invest in oil, natural gas, and coal.

Stability

Inflation also affects growth, as it undermines the macroeconomic stability of a country. High inflation creates uncertainty and deters investment. However, a high rate of inflation may not be as damaging as a high variability in the rate of inflation. A stable rate of inflation, although relatively high, reduces uncertainty for investors and domestic consumers alike. Volatile inflation affects prices throughout the economy, contributing to financial insecurity and pricing that inaccurately reflects the true values of goods and services. States with prudent monetary policy and sound budget management are likely to experience higher levels of growth.

Stability may also be affected by inequality. High levels of inequality often lead to revolt or violence, as the masses entrenched in poverty see some of their neighbors live lavishly. High inequality creates "pockets" of development, where only certain enclaves of the population and economy are connected to markets, and standards of living do not greatly improve. This suggests a negative relationship between inequality and growth. However, some difference in incomes may actually encourage growth. Savings from wealthy individuals are invested in the economy, expanding opportunities for low-income groups and stimulating growth, suggesting a positive relationship between the two.

Neoclassical Growth Components

Population growth was incorporated as an independent variable because of its implications in the neoclassical growth model (Figure 1). The steady-state level of capital per worker (*k**) is at the intersection of the savings curve *s*f(k)* and population-depreciation line *(n+d)k.* This is where the amount of savings is just enough for the investment in capital to compensate for depreciation and population growth. The associated level of output per worker is the vertical value of this capital per worker on the production function *f(k)*. If the rate of population growth increases, line *(n+d)k* rotates counterclockwise, intersecting *s*f(k)* at a lower steady-state level of capital per worker (given the same savings rate), which corresponds to a lower steady-state level of output per worker. Hence, higher rates of population growth are expected to negatively affect growth.

The other main adjustable component of the neoclassical growth model is the savings rate. As the primary engine for investment, savings is important in determining growth. Its influence appears as the savings curve in Figure 1, denoted *s*f(k),* which is a constant proportion of the production function (output multiplied by rate of savings). Its intersection with the population-depreciation line *(n+d)k*, as mentioned above, occurs at the steady-state level of capital per worker. An increase in the savings rate, given a constant population growth rate, shifts the savings curve upward towards. The higher savings exceeds the rate necessary to maintain the steady-state capital per worker, and results in capital deepening (an increase in capital per worker), and therefore a higher level of output per worker. The gestation period of savings as it results in investment is difficult to ascertain. This challenge is described in more detail in later sections, but savings was split into two independent variables in order to account for some past and present savings.

Economic Freedom

Economic freedom is also expected to have a significant impact on growth. The Index of Economic Freedom, administered by the Heritage Foundation, accounts for many characteristics that affect individuals' basic decisions, such as labor freedom, openness to trade, strength of property rights, and lack of corruption. Labor freedom allows expertise, entrepreneurial ability, and other human capital to freely flow to its highest valued use. Openness to trade provides welfare gains (see Figure 3) because countries will specialize in production using the inputs they have in relative abundance. Established and enforced property rights, along with limited corruption, reduce potential costs of investment and ownership of assets. Although these freedom elements could be expected to have purely positive effects on growth, Barro's (1991, 1998) studies showed a polynomial relationship, concluding "once a moderate amount of democracy has been attained, any further expansion could result in slower or less growth." These findings, possibly due to excessive political deliberations or the lack of some level of authoritative control, were central in the second-degree polynomial specification of economic freedom in the model.

Drawing from the analysis of Burger and du Plessis (2004), certain regions experience much slower growth than other regions with similar characteristics (most notably Africa). Previous analyses have attempted to circumvent this enigma by including a regional African dummy variable to automatically downwardly adjust growth predictions. However, this analysis attempts to explain *why* such differences exist by identifying and estimating the impact of the characteristics that determine growth.

Thus, the explicit functional form of the model is as follows:

$$G_i = \beta_0 + \beta_1/Y_i + \beta_2 T_i + \beta_3 L_i + \beta_4 N_i + \beta_5 R_i + \beta_6 Q_i + \beta_7 P_i + \beta_8 SA_i + \beta_9 SB_i + \beta_{10} F_i + \beta_{11} F_i^2 + \varepsilon_i$$

Y denotes initial income, T is the dummy for tropical countries, L is the dummy for landlocked countries, N denotes natural resources, R denotes inflation, Q denotes inequality, P denotes population growth, S denotes savings, F denotes economic freedom, and ε is the classical error term. Exact specifications are explicitly defined in Figure 4 of Appendix 3.

Empirical Analysis

Sample 1

The original sample included 30 countries as cross-sectional units. In order to be selected, the country must be ranked by the Heritage Foundation in its Index of Economic Freedom. A random number was generated, and the country with the random number's freedom ranking was included in the sample. As the study only attempted to explain growth in developing countries, categorization of "high income" by the World Bank barred inclusion in the sample. The sample is included as Figure 5 in Appendix 3.

Sample 1 Data

Data were retrieved from numerous reliable sources. Economic freedom values were collected from the Heritage Foundation. World Bank World Development Indicators database supplied most other data, but was supplemented by the United Nations International Human Development Indicators database, the International Monetary Fund's World Economic Outlook database, and the United States Central Intelligence Agency Factbook. For each of the 30 selected countries, yearly data were gathered for years 2000 through 2010 and condensed into one value per variable per country for the time period (initial value or average rate depending on the variable).

Sample 1 Modifications

With many independent variables that are associated with standard of living, multicollinearity was a potential obstacle. For example, it would not be unreasonable to expect some degree of collinearity between a country's 1990s average savings rate and its 2000s average savings rate. When correlation coefficients were compared (see Figure 6), only nine of the 55 exceeded .50, and only one (the two components of economic freedom, F and F^2) was above .62. When any of the collinear variables were excluded, the estimated coefficients were badly altered, indicating the presence of some collinearity. Although it was less severe than expected considering the model's specification, modifications were considered. Because all of the collinear variables were solidly based in economic theory and there was no clear way to eliminate the collinearity via an alternative variable specification or combination of variables, none were removed from the model. Additionally, multicollinearity does not cause bias in the coefficient estimates as it does with standard errors. Therefore, no changes were made to the model on the basis of multicollinearity.

In many cross section analyses, heteroskedasticity is a concern. If so, the estimated standard errors could be biased, leading to unreliable hypothesis testing. This model was not expected to be an exception, so the White test was performed on the residuals (see Appendix 2). However, there was not sufficient evidence to reject the null hypothesis of homoskedasticity, which instilled confidence in the upcoming results (Figure 7). Nevertheless, Newey-West standard errors were calculated in order to obtain heteroskedasticity-corrected standard errors.

Sample 1 Results
OLS generated a regression based on the first 30-country sample. Results are presented in Figure 7 below, with t-statistics contained in adjacent parentheses.

Figure 7 – Empirical Results
Sample 1

Variable	Coefficient Estimate	t-statistic
Constant	-34.47	**(-4.52)
1/Y	3342.99	*(2.27)
T	-1.98	**(-2.83)
L	-0.13	(-0.13)
N	0.07	**(0.00)
R	0.12	**(3.83)
Q	0.04	(1.68)
P	-1.28	**(-3.83)
SA	-0.01	**(-4.05)
SB	0.15	**(4.57)
F	1.37	**(5.11)
F^2	-0.01	**(-5.36)

Adjusted R^2 = .78
The t-statistics (in parentheses) are calculated with heteroskedasticity-corrected standard errors. *significance at 5% level, **significance at 1% level.

Sample 1 Discussion
The model's estimated equation has significant overall fit as defined by the F-test ($p<.00001$, see Appendix 2), and approximately 78% of the dependent variable's variation around its mean is explained accounting for degrees of freedom. The coefficient estimates for the initial GDP/capita (inverse functional form), tropical dummy, natural resources, economic freedom (both polynomial components), population growth, and 2000s savings variables were of expected sign and significant at the 1% level. The coefficients of inequality (two-sided $p=.11$) and landlocked dummy ($p=.45$) were insignificant.

Characteristics of a country that can be affected by choice or policy, such as inequality, freedom, and savings, are important for growth. But the estimated coefficients of some of the initial condition variables highlight the significance of policy-independent attributes. For example, the estimated coefficient on the tropical dummy variable is -1.98 ($p<.01$). This provides strong evidence in support of the hypothesis that tropical countries

are inherently at a disadvantage. The estimated coefficient suggests that tropical countries, ceteris paribus, can expect to experience almost two percentage points lower per-capita GDP growth annually compared with non-tropical countries. Over ten years, a non-tropical country could then expect to grow almost 22% more than a tropical country with all else held constant. This is a considerable difference that is not the effect of human policy decisions.

The analysis of economic freedom's (F, F^2) coefficients reveals an intriguing insight. The second-degree polynomial nature of the freedom-growth relationship inherently contains a vertex that can by graphically represented in the two-dimensional Cartesian plane. Since F^2's estimated coefficient is negative, this vertex is an absolute maximum for the growth versus freedom function with all else held constant. When calculated using the estimated parameters, the maximum growth rate occurs when economic freedom reaches approximately 55 on its scale of zero to 100, a level categorized as "mostly unfree" by the Heritage Foundation. This may be a result of correlation between high-growth economies and freedom scores between 50 and 60, and not necessarily that "mostly unfree" economies help to achieve the fastest growth. The maximum of 55 closely resembles the value for China, whose 56.4 score in 2000 earned it a lowly rank of 113 out of the Heritage Foundation's 179 ranked countries, while it averaged a remarkable 9.8% annual per-capita GDP growth rate from 2000 to 2010. Correlation and causality are discussed further in later paragraphs.

Unsettling were the significant unexpected signs of the coefficients for 1990s savings ($p<.001$) and volatility of inflation ($p<.001$). Ceteris paribus, an increase of ten percentage points in a country's average 1990s domestic savings rate is expected to result in an approximate one percentage point decrease in average annual GDP growth in the 2000s, a sign that savings likely has complex lag effects that the model did not capture. Reciprocally, more volatile inflation is significantly associated with higher growth rates. This could again be an unfortunate result of the sample characteristics – for example, Angola was an extreme outlier in respect to inflation uncertainty at an astonishing five standard deviations above the sample mean of R (R's sample mean = 7.9, sample standard deviation = 17.1, Angola = 96.4). However, Angola averaged an impressive annual growth rate of 7.5% over the decade, in which it more than doubled its per-capita GDP.

Sample 2
In order to test the model for robustness, it was applied to a new set of countries. Using the same sampling procedure, 30 new developing countries were selected. These countries are shown in Figure 8 of Appendix 3. Data were collected from the same reliable sources.

Sample 2 Modifications
Similarly to the first sample, multicollinearity was considered a potential obstacle, but it did not lead to changes in the model. Only seven of 55 simple correlation coefficients exceeded .50, and only two exceeded .54 (see Figure 9).

The White test was used to test the residuals for heteroskedasticity (see Appendix 2). Although there was again not sufficient evidence to reject the null hypothesis of homoskedasticity, Newey-West heteroskedasticity-corrected standard errors were calculated.

Sample 2 Results

OLS generated a regression based on the second 30-country sample. Results are presented in Figure 10 below, with t-statistics contained in adjacent parentheses.

Figure 10 – Regression Results
Sample 2

Variable	Coefficient Estimate	t-statistic
Constant	26.75	(1.70)
1/Y	2295.82	(1.10)
T	-1.40	(-0.68)
L	0.07	(0.07)
N	-0.06	(-0.88)
R	0.19	(1.00)
Q	-.03	(-0.88)
P	-0.95	(-1.20)
SA	-0.02	(-0.21)
SB	0.10	(0.80)
F	-0.91	(-1.58)
F^2	0.01	(1.66)

Adjusted R^2 = .19

The t-statistics (in parentheses) are calculated with heteroskedasticity-corrected standard errors. *significance at 5% level, **significance at 1% level.

Sample 2 Discussion

When the existing model was applied to the second sample of developing countries, the regression results were drastically different. None of the variables' estimated coefficients were significant at the 5% level. Together, all of the explanatory variables explained only 19% of GDP growth's variation. The F-test failed to support the model's significant overall fit (see Appendix 2).

General Discussion

Most statistical indicators, such as the adjusted R^2, coefficients' significance, and F-test, signaled the model's generally good fit for the initial sample of developing countries. However, when a second sample was selected to test for robustness, the results were much less significant. This may be attributed to the model's coincidental fit with the original sample but lack of overall power to consistently explain GDP growth rates.

It is also a possibility that an important relevant variable was omitted from this analysis. Entrepreneurial ability, education, or any other components of human capital are absent, and certainly they have a pronounced effect on per-capita GDP. So too do conflict measures like invasion, civil war, or other strife-related variables that severely undermine growth. There are many other possibilities as independent variables, that may not only substantially increase the model's explanatory power but also correct any omitted variable

bias. This describes the elusive "secret sauce" inherently missing from many growth models.

Even if all relevant variables are included in the model, exact specifications would be problematic to define, which is another reason why the secret sauce is so hard to capture. There may be considerable lag periods until the benefits of savings or education, for example, come to fruition. This model attempted to account for some gestation period of savings' maturation into investment by including both the 1990s average savings rate and the 2000s average savings rate, but it is still crudely specified. Education would be just as difficult, as a proper metric would be needed (enrollment, literacy, graduation are possibilities) along with its generational delay in pay-off.

Inclusion of many more independent variables would pose a threat to the already low number of degrees of freedom. Each sample's size is only 30, and with eleven independent variables, there are only 18 degrees of freedom. Increasing the sample size is a sensible step in the process of bettering the model, but is logically constrained by the number of developing countries, along with data availability and reliability.

Still yet are the concerns about simultaneous systems. As correlation does not necessarily imply causation, the one-way causal relationship between the independent variables and growth may not be as strong as the model suggests. Dual causality may be at work, as many of the independent variables are inter-related with growth. For example, although there may be considerable economic rationale for the positive effect of savings on growth, it is also justified that economic growth increases the amount available for savings. Thus, the two are correlated theoretically as well as empirically, but the causal nature is much less clear. It is reasonable to apply this concept to many of the other explanatory variables.

Conclusion

This econometric analysis attempted to explain the differences in growth rates in developing countries. A random sample of 30 developing countries was selected. Using OLS estimators, a regression equation was estimated with average annual per-capita GDP growth from 2000-2010 as its dependent variable and eleven independent variables.

The results indicate that growth in this period is encouraged by savings rates over the 2000s, endowment of hydrocarbon resources, and inflation uncertainty. Initial per-capita income, population growth, 1990s savings rates, and tropical location negatively affect growth. Estimated coefficients for income inequality and landlocked location were insignificant. There were complications in the analysis, including unexpected signs, possible omission of relevant variables, uncertainty of variable lag times, small sample size, and simultaneity. However, the equation had significant overall fit and explained over 78% of GDP growth's variation.

To test the robustness of the model, a second 30-country sample was selected. By most conventional statistical indicators, the model failed to robustly explain GDP growth rates for this sample. This may be attributed to differing sample characteristics and the difficulties of capturing growth's secret sauce. Referencing Wisconsin economist Stephen Durlauf, the *Economist* highlights the difficulties in analyzing growth rates: "Economists have found almost as many 'determinants of growth' (from coups to Confucianism) as there

are countries with data." These challenges demonstrate that further research and model development is necessary to successfully and robustly analyze economic growth.

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Appendix 1.1
Hypotheses
Coefficient Estimates
SAMPLE 1

n = 30, k = 11, df = 18
5% one-sided t-critical = 1.7340
5% two-sided t-critical = 2.1010

Variable: Initial GDP/capita
Functional Form: Inverse
$H_0: \beta_{1/Y} \leq 0$ t = 2.2654
$H_a: \beta_{1/Y} > 0$ Reject H_0

Variable: Tropical Dummy
Functional Form: Linear
$H_0: \beta_T \geq 0$ t = -2.8255
$H_a: \beta_T < 0$ Reject H_0

Variable: Landlocked Dummy
Functional Form: Linear
$H_0: \beta_L \geq 0$ t = -0.1253   insignificant at 5% level
$H_a: \beta_L < 0$ Fail to Reject H_0 p = .45

Variable: Natural resource rents as % of GDP
Functional Form: Linear
$H_0: \beta_N \leq 0$ t = 7.2897
$H_a: \beta_N > 0$ Reject H_0

Variable: Standard deviation of yearly inflation rates
Functional Form: Linear
$H_0: \beta_R \geq 0$ t = 3.8526   unexpected sign

H_a: $\beta_R < 0$ Fail to Reject H_0

Variable: Inequality: top decile's income share divided by bottom decile's income share
Functional Form: Linear

H_0: $\beta_Q = 0$ t = 1.6815   insignificant at 5% level
H_a: $\beta_Q \neq 0$ Fail to Reject H_0 p = .11

Variable: Population growth rate
Functional Form: Linear

H_0: $\beta_P \geq 0$ t = -3.8264
H_a: $\beta_P < 0$ Reject H_0

Variable: Savings rates
Functional Form: Linear

H_0: $\beta_{SA} \leq 0$ t = -4.0473   unexpected sign
H_a: $\beta_{SA} > 0$ Fail to Reject H_0

H_0: $\beta_{SB} \leq 0$ t = 4.5702
H_a: $\beta_{SB} > 0$ Reject H_0

Variable: Index of Economic Freedom
Functional Form: Polynomial (parabolic)

H_0: $\beta_F \leq 0$ t = 5.1050
H_a: $\beta_F > 0$ Reject H_0

H_0: $\beta_{F^2} \geq 0$ t = -5.3553
H_a: $\beta_{F^2} < 0$ Reject H_0

Appendix 1.2
Hypotheses
Coefficient Estimates
SAMPLE 2

$n = 30, k = 11, df = 18$
5% one-sided t-critical = 1.7340
5% two-sided t-critical = 2.1010

Variable: Initial GDP/capita
Functional Form: Inverse
$H_0: \beta_{1/Y} \leq 0$ t = 1.1011   insignificant at 5% level
$H_a: \beta_{1/Y} > 0$ Fail to Reject H_0 p = .14

Variable: Tropical Dummy
Functional Form: Linear
$H_0: \beta_T \geq 0$ t = -0.6832   insignificant at 5% level
$H_a: \beta_T < 0$ Fail to Reject H_0 p = .25

Variable: Landlocked Dummy
Functional Form: Linear
$H_0: \beta_L \geq 0$ t = 0.0702   insignificant at 5% level
$H_a: \beta_L < 0$ Fail to Reject H_0 p = .47

Variable: Natural resource rents as % of GDP
Functional Form: Linear
$H_0: \beta_N \leq 0$ t = -0.8833   insignificant at 5% level
$H_a: \beta_N > 0$ Fail to Reject H_0 p = .19

Variable: Standard deviation of yearly inflation rates
Functional Form: Linear
$H_0: \beta_R \geq 0$ t = 1.0046   insignificant at 5% level

H_a: $\beta_R < 0$ Fail to Reject H_0 p = .16

Variable: Inequality: top decile's income share divided by bottom decile's income share
Functional Form: Linear
H_0: $\beta_Q = 0$ t = -0.8761   insignificant at 5% level
H_a: $\beta_Q \neq 0$ Fail to Reject H_0 p = .39

Variable: Population growth rate
Functional Form: Linear
H_0: $\beta_P \geq 0$ t = -1.1992   insignificant at 5% level
H_a: $\beta_P < 0$ Fail to Reject H_0 p = .12

Variable: Savings rates
Functional Form: Linear
H_0: $\beta_{SA} \leq 0$ t = -0.2084   insignificant at 5% level
H_a: $\beta_{SA} > 0$ Fail to Reject H_0 p = .42

H_0: $\beta_{SB} \leq 0$ t = 0.7963   insignificant at 5% level
H_a: $\beta_{SB} > 0$ Fail to Reject H_0 p = .22

Variable: Index of Economic Freedom
Functional Form: Polynomial (parabolic)
H_0: $\beta_F \leq 0$ t = -1.5804   insignificant at 5% level
H_a: $\beta_F > 0$ Fail to Reject H_0 p = .07

H_0: $\beta_{F^2} \geq 0$ t = 1.6569   insignificant at 5% level
H_a: $\beta_{F^2} < 0$ Fail to Reject H_0 p = .06

Appendix 2
Hypotheses
Additional Tests

SAMPLE 1

Heteroskedasticity Test	df	= 11	
White Test	χ^2_{crit}	= 19.68	(5%)
H_0: homoskedasticity	NR^2	= 9.41	
H_a: heteroskedasticity	p	= .68	

Fail to reject H_0 of homoskedasticity.
Note: no cross-terms used due to degrees of freedom.

Overall Significance	df	= 11/18	
F-test	F_{crit}	= 2.38	(5%)
H_0: $\beta_1 = \beta_2 = ... = \beta_{11} = 0$	F	= 10.71	
H_a: H_0 is not true	p	< .00001	

Reject H_0, the equation has significant overall fit.

SAMPLE 2

Heteroskedasticity Test	df	= 11	
White Test	χ^2_{crit}	= 19.68	(5%)
H_0: homoskedasticity	NR^2	= 13.95	
H_a: heteroskedasticity	p	= .24	

Fail to reject H_0 of homoskedasticity.
Note: no cross-terms used due to degrees of freedom.

Overall Significance	df	= 11/18	
F-test	F_{crit}	= 2.38	(5%)
H_0: $\beta_1 = \beta_2 = ... = \beta_{11} = 0$	F	= 1.62	

H_a: H_0 is not true   p   = .1750

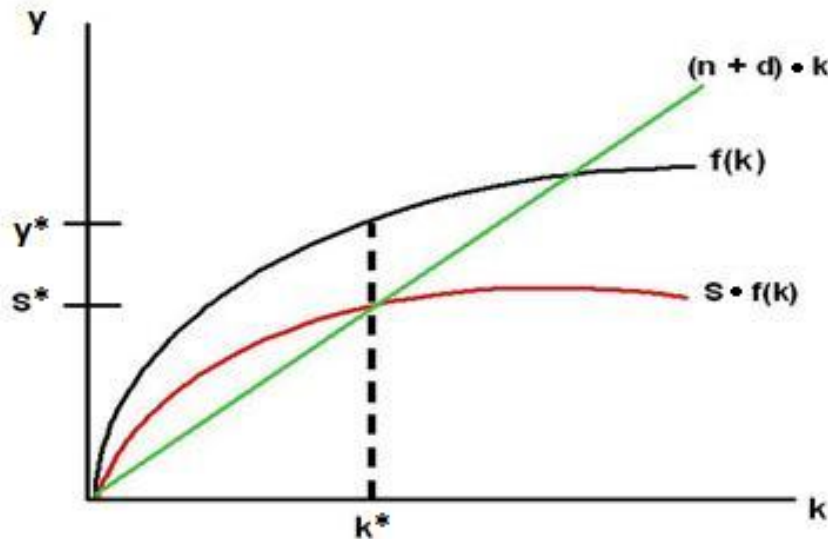Fail to reject H_0, the equation does not have significant overall fit.

Appendix 3
Figures

Figure 1 – Solow neoclassical growth model. The intersection of the savings curve *s*f(k)* and the population-depreciation line *(n+d)*k* results in steady-state equilibrium. The steady state level of capital per worker occurs at k* with the corresponding output per worker at y*.
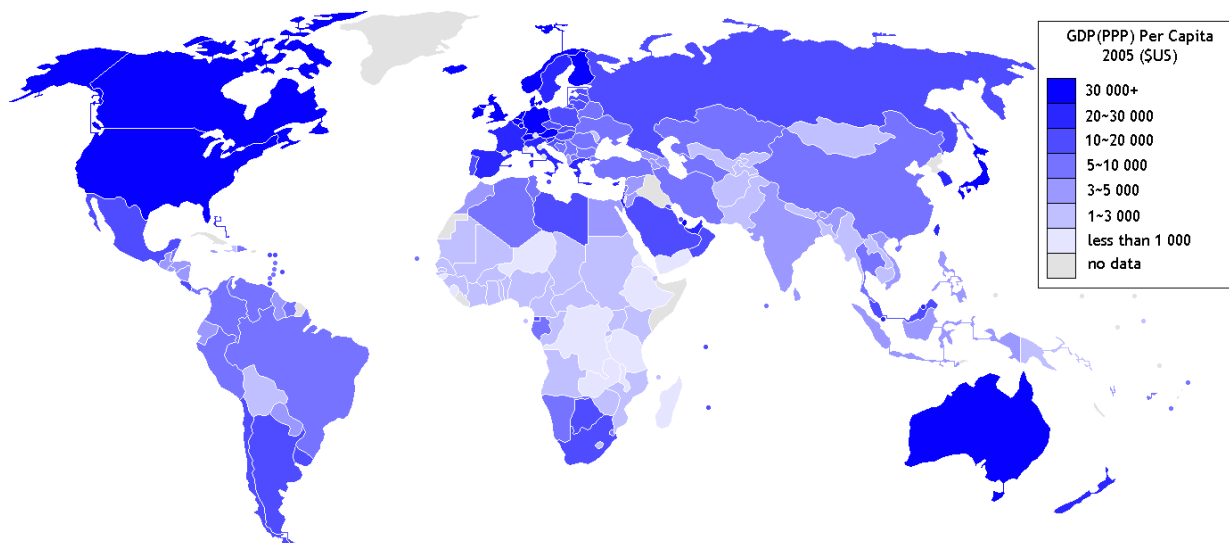
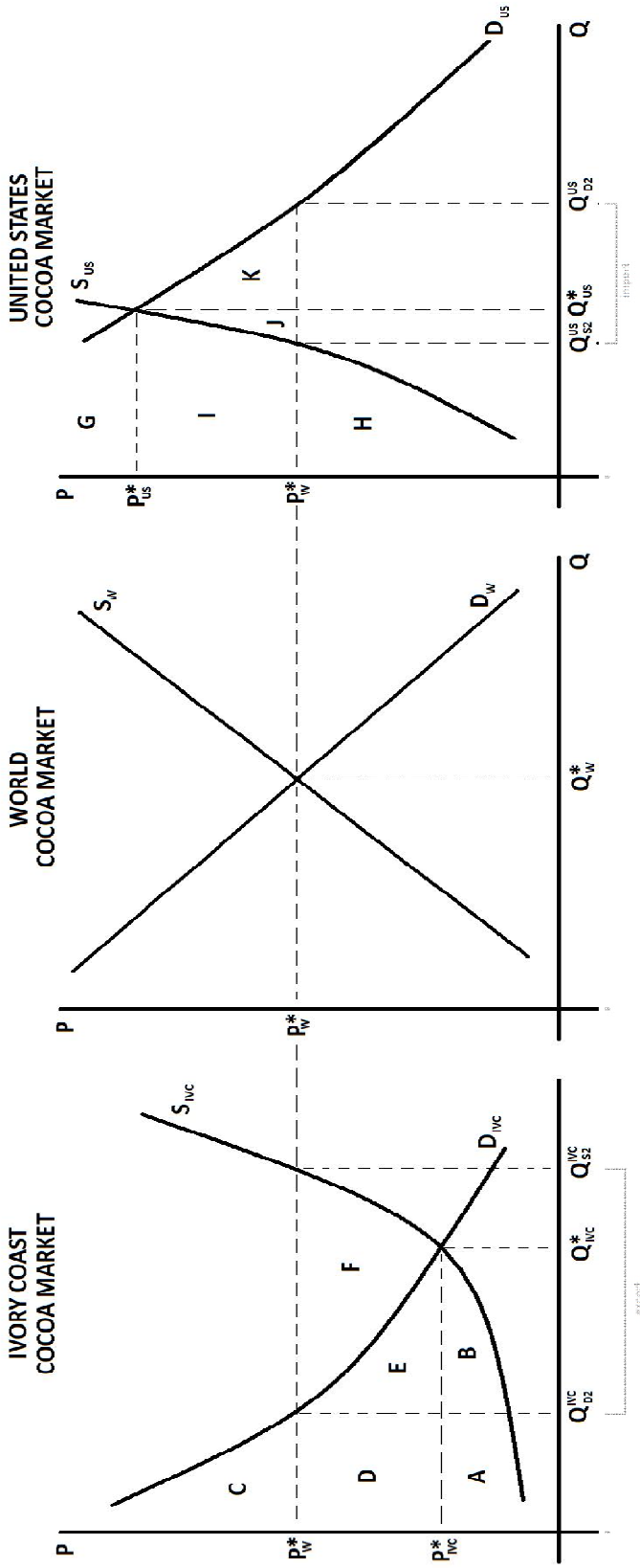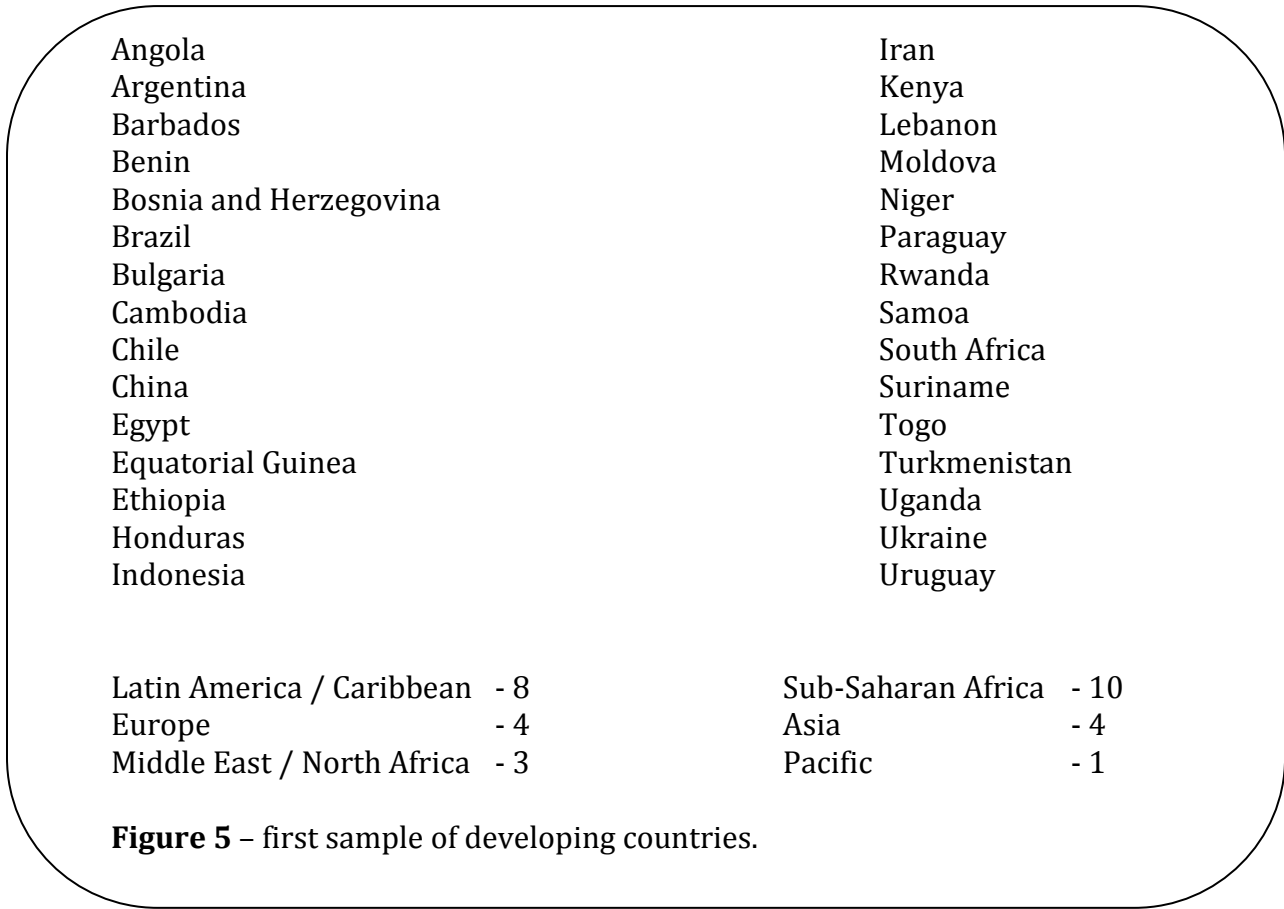**Figure 2** – World map of GDP/capita.

Figure 3 depicts the cocoa market for the Ivory Coast, United States, and world to graphically represent the gains from trade.

-In the Ivory Coast domestic market, the outward nature of the cocoa supply curve, SI_{VC}, reflects the large capacity to produce cocoa cheaply, while the low demand curve, D_{IVC}, reflects the low Ivorian demand. If all cocoa is produced and consumed domestically, the equilibrium price and quantity are P_{IVC}^* and Q_{IVC}^*, respectively.

-In the United States domestic market, demand (D_{US}) for cocoa is high and supply (S_{US}) is very low, resulting in a high domestic equilibrium price (P_{US}^*) and low domestic equilibrium quantity (Q_{US}^*).

-If both countries open to trade, they are subject to the world equilibrium cocoa price, P_W^*, which is communicated to the domestic markets. At this world price, Ivorian cocoa producers are willing to increase their quantity supplied from Q_{IVC}^* to $QIVC_{S2}$, while Ivorian consumers decrease their quantity demanded from Q_{IVC}^* to $QIVC_{D2}$, allowing a surplus of $[QIVC_{S2} - QIVC_{D2}]$ to be available for export.

-American consumers respond to the decrease in price from P_{US}^* to P_W^* by increasing their quantity demanded of cocoa from Q_{US}^* to QUS_{D2}, while producers lower quantity supplied to QUS_{S2}, creating a cocoa shortage of $[QUS_{D2} - QUS_{S2}]$ to be imported.

-If the nations engage in cocoa trade, both benefit from welfare gains. In the Ivorian market, areas A and B represent the producer surplus before trade that still exists as producer surplus after trade. Area C was consumer surplus before trade and remains such. Areas D and E are a transfer of welfare from consumers to producers; that is, D+E was consumer surplus before trade and is now producer surplus. Area F, however, is new producer surplus gained from trade that did not previously exist. Thus, the Ivorian economy experienced a net welfare gain equal to area F.

-The United States is the reciprocal scenario. Area G was and still is consumer surplus, and area H was and still is producer surplus. Area I is the transfer from producer to consumer surplus, while areas J and K are added consumer surplus. Thus, the United States experiences a net welfare gain equal to area J + K.

-Both countries benefit from the trade of cocoa.

Figure 4 – Variable Specifications

	Variable	Specification
G_i	Growth of GDP/capita	Average annual growth rate of GDP per capita of country i from 2000 to 2010
Y_i	Starting level of GDP/capita	Inverse of initial GDP per capita of ith country, 2005 dollars at PPP
T_i	Tropical status	Dummy variable with $T_i = 1$ if more than half of ith country is located in tropics, 0 otherwise
L_i	Landlocked status	Dummy variable with $L_i = 1$ if i^{th} country is landlocked, 0 otherwise
N_i	Natural resources	Average yearly rents obtained from coal, oil, natural gas, and minerals, as % of GDP
R_i	Inflation	Standard deviation of yearly inflation rates in country i
Q_i	Inequality	Share of country i's income generated by richest 10% divided by share of poorest 10%
P_i	Population growth	Average annual population growth rate from 2000 to 2010 in country i
SA_i	Savings, 1990s	Average gross domestic savings rate of country i from 1990 to 1999, as % of GDP
SB_i	Savings, 2000s	Average gross domestic savings rate of country i from 2000 to 2010, as % of GDP
F_i	Economic freedom	Polynomial functional form of Index of Economic Freedom score for country i in 2000

Angola
Argentina
Barbados
Benin
Bosnia and Herzegovina
Brazil
Bulgaria
Cambodia
Chile
China
Egypt
Equatorial Guinea
Ethiopia
Honduras
Indonesia

Iran
Kenya
Lebanon
Moldova
Niger
Paraguay
Rwanda
Samoa
South Africa
Suriname
Togo
Turkmenistan
Uganda
Ukraine
Uruguay

Latin America / Caribbean - 8
Europe   - 4
Middle East / North Africa - 3

Sub-Saharan Africa - 10
Asia   - 4
Pacific   - 1

Figure 5 – first sample of developing countries.

	F	P	SA	SB	VR	1/Y	N	Q	T	L	F²
F	1.00										
P	-.27	1.00									
SA	-.00	-.21	1.00								
SB	-.12	.06	.62	1.00							
VR	-.51	.26	.09	.09	1.00						
1/Y	-.21	.58	.29	-.36	.00	1.00					
N	-.51	.15	.41	.57	.23	-.12	1.00				
Q	-.00	.24	.17	.13	.58	-.25	.07	1.00			
T	-.07	.62	-.18	-.07	.18	.48	-.13	.27	1.00		
L	-.18	.16	-.00	-.21	-.07	.58	.16	-.06	.07	1.00	
F²	.99	-.09	.04	-.08	-.41	-.26	.46	.08	-.08	-.21	1.00

Figure 6 – simple correlation coefficients between the eleven independent variables for sample 1.

Figure 7 – Empirical Results
Sample 1

Variable	Coefficient Estimate	t-statistic
Constant	-34.47	**(-4.52)
1/Y	3342.99	*(2.27)
T	-1.98	**(-2.83)
L	-0.13	(-0.13)
N	0.07	**(0.00)
R	0.12	**(3.83)
Q	0.04	(1.68)
P	-1.28	**(-3.83)
SA	-0.01	**(-4.05)
SB	0.15	**(4.57)
F	1.37	**(5.11)
F^2	-0.01	**(-5.36)

Adjusted R^2 = .78
The t-statistics (in parentheses) are calculated with heteroskedasticity-corrected standard errors. *significance at 5% level, **significance at 1% level.

Albania	Malawi
Algeria	Mali
Bhutan	Myanmar
Botswana	Namibia
Costa Rica	Panama
Cote D'Ivoire	Peru
Dominican Republic	Philippines
Georgia	Romania
Guatemala	Swaziland
Guinea	Syria
Haiti	Tajikstan
Latvia	Tanzania
Lithuania	Uzbekistan
Macedonia	Venezuela
Madagascar	Zambia

Latin America / Caribbean	- 7	Sub-Saharan Africa	- 10
Europe	- 6	Asia	- 5
Middle East / North Africa	- 2	Pacific	- 0

Figure 8 – second sample of developing countries.

	1/Y	T	L	N	R	Q	P	SA	SB	F	F²
1/Y	1.00										
T	.36	1.00									
L	.24	-.21	1.00								
N	-.07	-.27	.15	1.00							
R	.43	.05	-.02	.18	1.00						
Q	-.24	.51	-.20	-.17	-.09	1.00					
P	.44	.58	.18	.11	-.17	.19	1.00				
SA	-.36	.02	.05	.32	-.02	.11	-.04	1.00			
SB	-.37	.01	-.08	.54	-.23	-.01	.11	.73	1.00		
F	-.37	.32	-.01	-.49	-.51	.31	-.03	.14	.14	1.00	
F²	-.40	.32	-.00	-.46	-.52	.33	-.03	.17	.16	.99	1.00

Figure 9 – simple correlation coefficients between the eleven independent variables for sample 2.

Figure 10 – Regression Results
Sample 2

Variable	Coefficient Estimate	t-statistic
Constant	26.75	(1.70)
1/Y	2295.82	(1.10)
T	-1.40	(-0.68)
L	0.07	(0.07)
N	-0.06	(-0.88)
R	0.19	(1.00)
Q	-.03	(-0.88)
P	-0.95	(-1.20)
SA	-0.02	(-0.21)
SB	0.10	(0.80)
F	-0.91	(-1.58)
F²	0.01	(1.66)

Adjusted R^2 = .19

The t-statistics (in parentheses) are calculated with heteroskedasticity-corrected standard errors. *significance at 5% level, **significance at 1% level.