TRADITIONAL INSTITUTIONS, TECHNOLOGY ADOPTION AND ECONOMIC GROWTH IN AFRICA: THE CASE OF ZIMBABWE

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ABSTRACT

While a commendable effort has been made in establishing world economic growth determinants, the war to establish the causes of a slow economic growth in Africa still rages on. This paper offers an alternative explanation to the causes of a slow economic growth in Zimbabwe. The findings demonstrate that the augmented Solow model of economic growth can equally explain the determinants of economic growth in Zimbabwe. However, we find evidence that the slow economic growth in Zimbabwe is a result of the slow rate of technology adoption by economic agents due to captivity in ancestral beliefs. The study establishes that the captivity or attachment of Africans to traditional beliefs makes the production systems in African countries inelastic to global technological progress hence leading to slow growth. The largest contributor of economic growth in Zimbabwe is the inherited technology or the historical factors of production.

Keywords: Growth, Africa, Traditional institutions, Technological progress

JEL Classifications: O40, O43, O55

INTRODUCTION

Most of the studies on the determinants of economic growth have been centered on the Solow growth model. Solow (1956) developed the idea that economic growth is a product of rates of human and physical capital accumulation, rate of technological change, initial level of income, and population growth. Much of the empirical work on growth determinants has been augmenting the Solow model of economic growth. Today there are over 145 established determinants of economic growth (Durlauf, Johnson, and Temple, 2005) but the slow growth of African economies is still persisting. What could explain this phenomenon? A number of empirical studies on growth determinants found that the Solow model fails to explain Africa's economic growth. The African dummy capturing Africa's ethnic heterogeneity has been found to be large, negative and significant in a number of cross-country studies (Barro, 1991; Barro and Lee, 1993; Mauro, 1995; Easterly and Levine, 1997; Temple and Johnson, 1998; Englebert, 2000). For instance, Mauro (1995) established that the African dummy reduces average annual per capita GDP growth by between 1.7% and 2.1% whereas Easterly and Levine (1997) found the reduction impact to be between 1.2% and 1.4%.

Sachs and Warner (1997) argue that the African dummy is a result of a mix of structural and policy variables in particular lack of openness whilst Barro (1997) attributed it to the ratio of government consumption to GDP. On the other hand, Englebert (2000) contends that the legitimacy or nature of African states is the main reason behind the dummy. Findings from Sachs and Warner, Barro and Englebert suggest that controlling for the effects of policy distortions and state legitimacy in growth regressions reduces the negative growth impact from being an African country to statistical insignificance. A study by Bertocchi and Canova (2002) found out that colonial variables capture the same effects of an African dummy and

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reduce its statistical significance when jointly included in a cross sectional regression of 98 countries. If Bertocchi and Canova's findings that colonization of Africa had a negative impact on growth in the continent then how can we explain the veracity that early independent Southern African countries are poorer than late independent countries. For instance, South Africa is the last country to attain independence in Southern Africa but its growth is far much higher and faster than any other African country. Secondly, how could we explain the slow growth being experienced by those African countries with over 60 years of independence? Even Sachs and Warner's findings that Africa's slow growth lies with natural factors such as limited access to sea, natural resource abundance, and the tropical climate are questionable given that some non-African countries with the same natural factors have been experiencing higher and faster growth than some African countries with access to the sea.

Burger and du Plessis (2002) argue that the African dummy result can be attributed to omitted variables. They found initial income, tropical location, primary school enrolments, and the growth rate of the working age population, trade openness, the black market premium and a neighbourbood effect to robustly explain changes in growth between 1960 and 2000. By including the variables used in Sachs and Warner (1997), Burger and du Plessis attested that the African dummy is not statistically significant. The findings show that growth in Africa is not attributable to structural differences between African countries and other regions, but to differences in the levels of variables that are vital for growth. Variables in the Solow model are found to be significant determinants of economic growth between 1960 and 2000.

Hoeffler (2002) applied the General Methods of Moments (GMM) to study growth determinants by testing the applicability of the Solow model to Sub-Saharan Africa using dynamic panel data. The results show that the commonly found result in the literature, that basic growth models are unable to account for Africa's low growth performance, was only supported by the Ordinary Least Squares (OLS) estimation. But in the GMM estimation, the coefficient on the African dummy was found to be statistically insignificant. Hoeffler's findings suggest that the augmented Solow model can fully account for Sub-Saharan Africa's low growth if unobserved country effects are accounted for. Hence the significance of the African dummy is a result of the application of inappropriate estimation techniques. Nkurunziza and Bates (2003) followed Hoeffler's methodology to examine whether augmenting the Solow growth model with political factors will improve its power to explain the growth process in Africa. Their results indicate that political variables improve the power of the Solow model in explaining African growth.

In a Bayesian panel data approach by Moral-Benito (2007), it was established that once the model uncertainty and other potential inconsistencies are accounted for, there exist economic, institutional, geographic and demographic factors that robustly affect growth. Investment cost and political rights were found to be among the most robust determinants. The majority of the factors in a number of economic growth studies are products of the Solow model and some are derived from the main determinants of growth in the model. For example, political variables, openness and economic policy included in studies by Sachs and Warner (1997), Abdulkadir *et al* (2010), and Nkurunziza and Bates (2003) directly influence the investment variable (physical capital accumulation) in the Solow model. Factors such as disease prevalence (malaria) directly influence labour productivity (human capital) and population growth in the Solow model.

Most of the reasons put forward to explain the African dummy (Sachs and Warner, 1997; Barro, 1997 and Englebert, 2000) are said to be the omitted factors highly correlated with capital accumulation (physical and human capital) and labour productivity in the Solow model. Despite the progress made in establishing the probable causes of the African dummy, little work has been done in investigating factors influencing technology adoption in African countries. Channels of transmission considered to be behind the existence of an African dummy are linked to capital and labour variables while ignoring the technology variable of the Solow model. The general consensus in a number of growth studies (Barro, 1997; Sachs and Warner, 1997; Block, 2000; Englebert, 2000; Hoeffler, 2002) is that the coefficient of the initial income variable is negative and statistically significant; substantial evidence for the convergence hypothesis. The convergence property is derived from a neoclassical theory of diminishing returns to capital. It simply says countries with identical preferences and technologies but with different initial human and physical capital stocks have asymptotically identical growth rates. Poor countries should grow faster than the rich. But why is this not the case for Africa? The reason is explained in the technology and preference assumptions.

In this paper, we consider a different approach by examining how ancestral bondage in African traditional institutions influences output response to technological progress. Allowing for several channels of transmission offers a more detailed picture of why Africa's economic growth has been slow. The study considers how African growth responds to traditional technologies. Higher rates of technological progress increase economic growth in the Solow model and a number of growth studies have established similar results. In Africa technological progress and industrialization processes have been very slow despite the world's recorded rapid technological growth. Can the slow growth in Africa be explained by the unresponsiveness of the traditional institutions to technological adoption?

The proportion of the traditional sector in most African countries is still significantly large. In Zimbabwe, over 50% of the population lives in rural areas mostly characterized by traditional systems of production. The rural sector has a significant contribution in the growth of the country. So it might be disastrous to study the determinants of economic growth in such economies without taking into consideration the characteristics of the traditional institutions. If economic agents mostly farmers in these traditional institutions are tied to their ancestral values then they are more likely to inherit the same traditional systems of production by disregarding or ignoring modern technologies. In countries where the contribution of the ancestral-bonded economic agents to national output is significant, the overall economic growth might be suppressed as the old means of production are used to produce output.

The remainder of the paper is organized as follows. Section 2 discusses the theoretical and empirical framework. Section 3 presents the empirical results and assesses the differences in the transmission mechanisms of growth in Africa. Lastly, section 4 concludes.

RESEARCH METHODOLOGY

Theoretical Framework

It is self-evident from the above discussion that the impact of inherited production systems on production has been taken for granted. The framework we develop in this study is based on the following assumptions:

1. Economic agents are rational; agents can only change to a new technology if it produces more output. This assumption has an implication that improvements in technologies have a positive influence on output or that modern technologies produce more output than traditional technologies. Secondly it implies that modern imported technologies are more superior to traditional African technologies.
2. Traditionalists (followers of spirit mediums/ancestral spirits) are associated with the traditional way of life; traditional production and consumption. This assumption is

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quite plausible for the rural sector in African economies since those who follow spirit mediums consult them when making decisions in most cases. This group of economic agents inherits their ancestors' way of life.

3. Freedom of choice. Economic agents are free to choose technology they want, traditional or modern, as long as the technology is affordable.

In this study we modify the Cobb Douglas production function with constant returns to scale. The general Cobb-Douglas production function from which we derive the modified model takes the following form:

$$Q_t = A_t K_t^{1-\alpha} L_t^{\alpha} \tag{1}$$

where Q_t is the output in time *t*, K_t *and* L_t are capital and labour in time *t*, respectively, A_t is the input productivity, that is, the productivity of labour and capital, α is the percentage of income going to workers and $1-\alpha$ is the percentage of income going the owners of capital. Input productivity is a function of the technologies used and labour quality. In this Cobb-Douglas production function current output produced is a function of current technologies. This type of relationship applies to all other types of production functions. Hence, this modification can also apply to any other type of a production function.

In the modification, we take current output produced as a function of both current/modern technologies and historical/traditional technologies. The right hand side of the Cobb-Douglas function is retained as it is but with a slight modification in order to accommodate the influence of traditional bondage on current output in economies characterized by traditional sectors. We express the production function as:

$$Q_t = \left(A_t K_t^{1-\alpha} L_t^{\alpha}\right)^{\theta} Q_{t-s}^{1-\theta} \tag{2}$$

where Q_{t-s} captures traditional technologies and θ is the percentage degree of response by economic agents to new/modern technologies or the percentage of income going to modern factor inputs. Land is taken as part of capital while education influences labour quality hence its productivity, captured in A_t.

If $\theta=0$ then the current production is simply the inherited production level from period *t-s*. Based on the first assumption and the Cobb-Douglas modified model, it is clear that economic growth is attained through increasing θ. The larger is the value of θ, the more responsive is the economy to technological changes and the larger is the output to be produced. In other words it is the choice of θ that determines growth. A combination of a large time lag or a large value of *s* and a small value of θ imply a non-growing economy. In the case of increasing returns to scale, that is, $\theta>1$, the widely established convergence result occurs.

If economic agents are bonded to traditional technologies, that is, if they are rigid to changes in technology then the level of output produced will be determined by the historical levels of output. The major hypothesis of the study is therefore that African countries with a significant rural sector are more likely to suffer from slow economic growth since technology adoption is slow. The study hypothesizes that the continued slow growth in African countries is caused by economic agents' bondage to traditional/ancestral beliefs. Unlike the previous studies which have associated the African dummy to factors influencing labour and investment, this study considers an alternative transmission channel; factors influencing technology adoption.

Figure 1 illustrates the study framework. We begin by assuming an initial output in time *t-s*. Traditionalists will inherit the traditional technologies and continue with slow growth. This is because the strong bonds they have with their ancestors make them follow exactly what their ancestors used to do. In Zimbabwe, spirit mediums known as *vadzimu* in *Shona* language are used as the media of information transfer from the ancestors to new generations. So those tied to ancestral beliefs or those worshiping the *vadzimu* are expected to take time in adopting new technologies that have an impact of distorting their cultural beliefs. As such, this group of economic agents is more likely to experience the same low output experienced by their lineage.

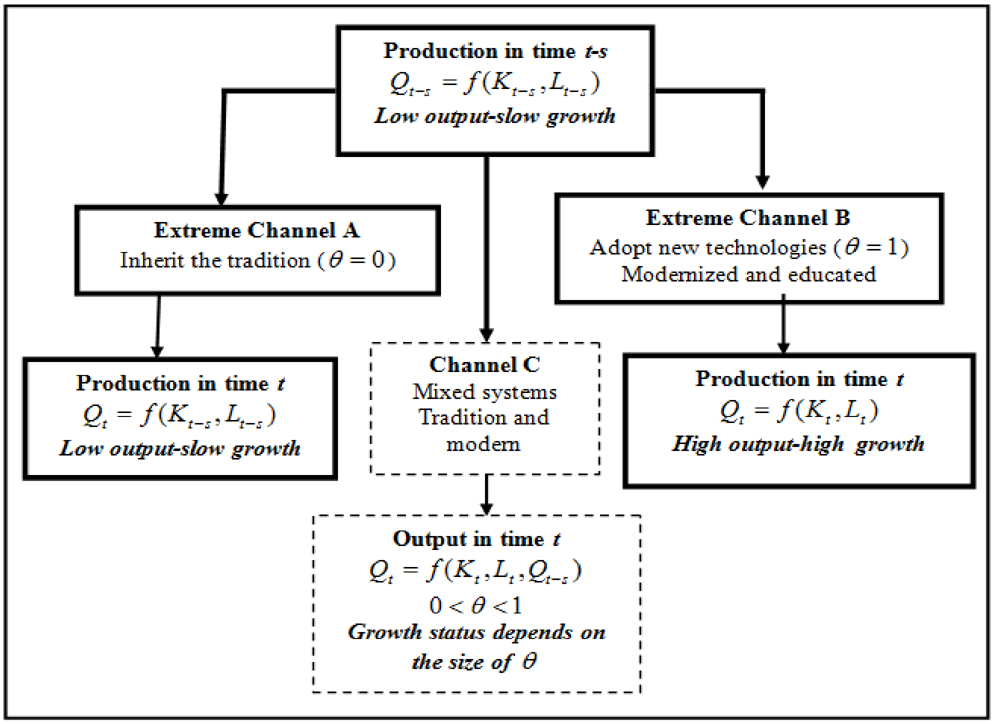

Figure 1. Tradition and Modernization impacts on production

While a number of studies have concentrated on factors affecting labour and capital in the Solow model, this study considers factors influencing the technology variable. We test the hypothesis that economies trapped in slow growth have a very small θ. Economies with a significant share of the rural sector are likely to have a small θ and therefore associated with slow growth.

The Model

The empirical model to be applied in this paper is based on the modified Cobb-Douglas production function in equation (2). By linearizing the model, we obtain:

$$\log Q_t = \theta \log\left[A_t K_t^{\alpha} L_t^{1-\alpha}\right] + (1-\theta)\log Q_{t-s} \quad (3)$$

$$\log Q_t = \theta \log A_t + \theta\alpha \log K_t + \theta(1-\alpha)\log L_t + (1-\theta)\log Q_{t-s} \quad (4)$$

Equation (4) indicates that the impact of a marginal unit of current input on output is weighted by the rate of technology adoption by economic agents (θ). The closer to zero is θ the more likely is the inability of the Solow model to explain economic growth if inputs of the model are at current levels. Convergence occurs when $\theta > 1$, that is, when the production function exhibits increasing returns to scale. While a number of studies on growth have included the lagged income variable for convergence purposes only, in this study we also consider it to represent production technologies used during the period *t-s*. In other words, $1-\theta$ can be interpreted as a measure of the responsiveness of current output to traditional technologies.

We make use of output, capital and labour in this study. The proxy for the capital variable in equation (4) is investment share and labour is approximated by population growth. We assume the rate of technological progress and depreciation to be constant at 0.05 as is conventional. The model is augmented with the schooling variable (human capital). We also consider investment as endogenously determined. The model is therefore expressed as follows:

$$\log GDP_t = \lambda_0 + \lambda_1 \log GDP_{t-s} + \lambda_2 \log Invest_t + \lambda_3 \log School_t + \lambda_4 \log(n+g+d)_t + \varepsilon_t \qquad (5)$$

$$\log Invest_t = \beta_0 + \beta_1 \log GDP_t + \beta_2 \log Investpr_t + \beta_3 \log Openness_t + \beta_4 \log GDP_{t-1} + v_t \qquad (6)$$

Where *GDP* is the Gross Domestic Product or Gross National Income; *Invest* is the investment share in total output; *School* is the average years of schooling; *Investpr* is the price of investment; *Openness* is trade openness; n is population growth, g is the rate of technological progress and d is the rate of depreciation. Since technological progress and depreciation are assumed to be constant at 0.05, we augment the log of the population growth by 0.05. The terms ε_t and v_t in equations (5) and (6) are the error terms, capturing omitted variables and $\text{cov}(\varepsilon, v) = 0$. These error terms fail to satisfy the usual assumptions of the Classical Linear Regression Model (CLRM) if the investment variable is endogenous. Hence in the case that investment is endogenous we cannot apply the usual Ordinary Least Squares (OLS) method; instead we apply the Two Stage Least Squares (2SLS) method. The paper is concerned about the results of equation (5), the growth equation. It is the size of λ_1 that we want to assess given varying sizes of s. The study varies s from 1 to 5, 10, 15 up to 40.

DATA AND RESULTS

The data used in this paper are obtained from the Penn World Table 7.1 except the average years of schooling obtained from World Bank data base and the Zimbabwe Statistics Agency (Zimstat). All the data used in this paper are stationary at the 5% level of significance when expressed in logarithms and detrended. Following this, logs were applied and trends removed through detrending. Stationarity tests were carried out using the augmented Dickey-Fuller test.

Results in models 1(a) and (b) for the investment function in appendix A indicate that the accelerator theory fails to explain investment in Zimbabwe. Economic growth as measured by GDP is statistically insignificant in explaining investment. Therefore we treat the investment variable as non-endogenous in the growth model of equation (5). In model 1(a) besides the intercept, investment is solely explained by historical investment and all the other factors including trade openness are statistically insignificant. When the lagged investment variable is removed as in model 1(b), trade openness becomes a key determinant of investment in Zimbabwe, that is, it becomes statistically significant at the 1% level. But the model becomes weaker as the coefficient of variation drops from 56% to only 34%. This only gives a hint on the importance of inheritance in African countries.

Because of the absence of simultaneity between GDP and investment, we consider investment as any other exogenous variable in the growth model. While a number of cross sectional studies on growth have found the coefficient of the lagged income variable to be negative and significant approving the convergence property, our findings rather disapproves the convergence property. The coefficient of the lagged income variable in model 2(a) in appendix B is found to be positive and statistically significant at the 1% level and its magnitude is 0.992017 implying that θ is only 0.007983. The value of θ is approximately equal to the sum of all the other coefficients in the model which sum to 0.016351. In model 2(a) all the other Solow model variables that have been used in this paper are statistically insignificant at the 5% level; a common result of studies that have found the African dummy to be negative and statistically significant. Such a finding is expected in countries characterised by strong inheritance in production systems. When technological progress is very low as in this case where adoption rate is less than 1% we expect to see no significant differences in current technologies and technologies used during the previous year hence no significant differences in output levels. The insignificance of all the other variables and the very high coefficient of variation from only one significant variable in model 2(a), display the power of inheritance in African countries.

The findings in models 2(b) to 2(h) show that historical production technologies or inherited technologies play a major role in African growth. In Zimbabwe, the technologies used 5 years; 10 years up to 40 years ago are statistically significant in explaining growth in Zimbabwe. When historical technologies are included as part of the explanatory variable vector, some of the variables in the Solow model become significant. For example, the coefficient of the sum of technological progress, depreciation and population growth (n+g+d) is positive and statistically significant when technologies used in periods *t-5, t-10, t-15, t-20*, and *t-40* are included as possible explanatory variables. The study finds this coefficient to be positive despite the negative sign established in a number of studies (Hoeffler, 2002; Nkurunziza and Bates, 2003). The reason might be from the size of the assumed conventional rate of depreciation and technological progress which is 5% much bigger than the rate of population growth. The positive sign might also be a result of increased labour supply from population growth. The schooling variable is found to be statistically insignificant at the 5% level except in model 2(h) where the technologies used during 40 years ago are included as possible determinant of economic growth and in model 2(f) where the sign is negative (unexpected). By including very old technologies in the estimation, for example, technologies used 25 and 30 years ago the coefficient of the investment variable becomes positive and statistically significant at the 5% and 10% levels, respectively (models 2(f) and 2(g) in appendix B).

CONCLUSIONS

The rate at which Africans adopt technology is of paramount importance in explaining the slow growth in Africa. In this paper we have established that economic growth in Zimbabwe is largely explained by inherited production technologies. Studies that have found the Solow model inapplicable to African growth might have included only a one year growth lag in their models. In Africa where technological progress is very slow due to captivity in the traditional systems, it is more likely that the output produced this year is not much different from the output produced during the previous year. As a result a model that includes one year lagged output at the right hand side as an explanatory variable is likely to render the other explanatory variables insignificant in explaining growth (the case with model 2(a)). If such a degree of inheritance is controlled for, or if we disregard the one year growth lag as in model 3, then the variables in the Solow model will equally explain economic growth in Africa (see model 3 in appendix C). The use of large lags to capture the traditional technologies will control for the effects of inheritance on economic growth thereby improving the applicability of the Solow model of growth in Africa.

The findings in this paper clearly show that a significant proportion of Zimbabwe's economic growth is inherited from the country's lineage. The rate of technological progress in Zimbabwe is very low with a θ of 0.8% only in model 2(a), therefore from the methodological point of view, these results call for a greater incorporation of traditional institutions into the study of economic growth. The conventionally assumed rate of technological progress is not realistic for most African countries because of attachment to ancestral values. As a result, findings from cross country studies might not be suitable for explaining African growth, but instead time series analysis might be more appealing.

Despite the less impressiveness of the results derived from the investment equation, the findings provide an important clue as to why economic growth has been so slow in Africa. We suggest several possible directions for future research. There is need to re-assess the influence of traditional institutions on economic growth in different countries and in particular districts of a given country. It might also be important to study the link between traditional institutions in Africa and political leadership. Nkurunziza and Bates (2003) established autocracy and democracy as key determinants of economic growth; as factors behind the African dummy. But the study remained silent on the reasons why autocracy is more common in African countries. The reason might be within the operations of the traditional institutions (inheritance systems). This is an interesting area for future research; most people wonder why most autocratic leaders in Africa enforce traditional laws.

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APPENDIX-A

Model 1 (a)

Dependent Variable: LOG(INVEST)
Method: Least Squares
Date: 02/03/13 Time: 10:28
Sample (adjusted): 1955 2010
Included observations: 56 after adjustments

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
C	0.695170	0.324842	2.140027	0.0373
LOG(OPENNESS)	0.067558	0.061086	1.105949	0.2740
LOG(GDP)	-0.218328	0.346199	-0.630643	0.5311
LOG(GDP(-1))	0.164972	0.342590	0.481544	0.6322
LOG(INVEST(-1))	0.581161	0.115798	5.018768	0.0000
DLOG(INVESTPR)	-0.123525	0.088486	-1.395980	0.1689
R-squared	0.558004	Mean dependent var		1.346016
Adjusted R-squared	0.513804	S.D. dependent var		0.323213
S.E. of regression	0.225369	Akaike info criterion		-0.041197
Sum squared resid	2.539563	Schwarz criterion		0.175805
Log likelihood	7.153518	Hannan-Quinn criter.		0.042934
F-statistic	12.62462	Durbin-Watson stat		1.643378
Prob(F-statistic)	0.000000			

Model 1 (b)

Dependent Variable: LOG(INVEST)
Method: Least Squares
Date: 02/02/13 Time: 16:24
Sample (adjusted): 1955 2010
Included observations: 56 after adjustments

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
C	1.438842	0.350996	4.099309	0.0001
LOG(OPENNESS)	0.197214	0.067211	2.934265	0.0050
DLOG(INVESTPR)	-0.123015	0.107440	-1.144967	0.2576
LOG(GDP(-1))	-0.218751	0.405480	-0.539486	0.5919
LOG(GDP)	0.101131	0.413188	0.244757	0.8076
R-squared	0.335343	Mean dependent var		1.346016
Adjusted R-squared	0.283213	S.D. dependent var		0.323213
S.E. of regression	0.273643	Akaike info criterion		0.331058
Sum squared resid	3.818894	Schwarz criterion		0.511893
Log likelihood	-4.269617	Hannan-Quinn criter.		0.401167
F-statistic	6.432833	Durbin-Watson stat		0.791243
Prob(F-statistic)	0.000286			

APPENDIX-B

Model 2 (a)

Dependent Variable: LOG(GDP)
Method: Least Squares
Date: 02/02/13 Time: 16:33
Sample (adjusted): 1955 2010
Included observations: 56 after adjustments

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
C	-0.137538	0.239730	-0.573719	0.5687
LOG(INVEST)	-0.006680	0.044253	-0.150943	0.8806
DLOG(SCHOOL)	0.025879	0.136962	0.188950	0.8509
LOG(N+G+D)	0.134690	0.068969	1.952914	0.0563
LOG(GDP(-1))	0.992017	0.014209	69.81798	0.0000
R-squared	0.994561	Mean dependent var		7.099905
Adjusted R-squared	0.994134	S.D. dependent var		1.202934
S.E. of regression	0.092132	Akaike info criterion		-1.846153
Sum squared resid	0.432899	Schwarz criterion		-1.665318
Log likelihood	56.69230	Hannan-Quinn criter.		-1.776044
F-statistic	2331.316	Durbin-Watson stat		2.095471
Prob(F-statistic)	0.000000			

Model 2 (b)

Dependent Variable: LOG(GDP)
Method: Least Squares
Date: 02/02/13 Time: 16:34
Sample (adjusted): 1959 2010
Included observations: 52 after adjustments

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
C	-0.542705	0.565708	-0.959339	0.3423
LOG(INVEST)	0.028304	0.109548	0.258374	0.7972
DLOG(SCHOOL)	0.511000	0.389785	1.310978	0.1962
LOG(N+G+D)	0.581395	0.168457	3.451288	0.0012
LOG(GDP(-5))	0.952032	0.032832	28.99745	0.0000
R-squared	0.967116	Mean dependent var		7.256352
Adjusted R-squared	0.964318	S.D. dependent var		1.100103
S.E. of regression	0.207807	Akaike info criterion		-0.213205
Sum squared resid	2.029630	Schwarz criterion		-0.025586
Log likelihood	10.54334	Hannan-Quinn criter.		-0.141277
F-statistic	345.5702	Durbin-Watson stat		0.492064
Prob(F-statistic)	0.000000			

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Model 2 (c)

Dependent Variable: LOG(GDP)
Method: Least Squares
Date: 02/02/13 Time: 16:36
Sample (adjusted): 1964 2010
Included observations: 47 after adjustments

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
C	0.178544	0.777301	0.229698	0.8194
LOG(INVEST)	-0.341892	0.141448	-2.417082	0.0201
DLOG(SCHOOL)	0.665989	0.513760	1.296303	0.2019
LOG(N+G+D)	0.898444	0.236456	3.799620	0.0005
LOG(GDP(-10))	0.876268	0.047448	18.46786	0.0000
R-squared	0.931180	Mean dependent var		7.451710
Adjusted R-squared	0.924626	S.D. dependent var		0.967323
S.E. of regression	0.265573	Akaike info criterion		0.286432
Sum squared resid	2.962212	Schwarz criterion		0.483256
Log likelihood	-1.731148	Hannan-Quinn criter.		0.360498
F-statistic	142.0717	Durbin-Watson stat		0.439075
Prob(F-statistic)	0.000000			

Model 2 (d)

Dependent Variable: LOG(GDP)
Method: Least Squares
Date: 02/02/13 Time: 16:38
Sample (adjusted): 1969 2010
Included observations: 42 after adjustments

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
C	0.415285	0.962816	0.431323	0.6687
LOG(INVEST)	-0.358243	0.153882	-2.328030	0.0255
DLOG(SCHOOL)	0.366545	0.556397	0.658784	0.5141
LOG(N+G+D)	1.290870	0.285667	4.518792	0.0001
LOG(GDP(-15))	0.790497	0.060718	13.01924	0.0000
R-squared	0.883649	Mean dependent var		7.676530
Adjusted R-squared	0.871071	S.D. dependent var		0.750299
S.E. of regression	0.269408	Akaike info criterion		0.326161
Sum squared resid	2.685478	Schwarz criterion		0.533027
Log likelihood	-1.849391	Hannan-Quinn criter.		0.401986
F-statistic	70.25096	Durbin-Watson stat		0.533199
Prob(F-statistic)	0.000000			

Model 2 (e)

Dependent Variable: LOG(GDP)
Method: Least Squares
Date: 02/02/13 Time: 16:39
Sample (adjusted): 1974 2010
Included observations: 37 after adjustments

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
C	1.442776	1.023413	1.409768	0.1683
LOG(INVEST)	-0.101949	0.155469	-0.655753	0.5167
DLOG(SCHOOL)	-0.254577	0.546764	-0.465607	0.6447
LOG(N+G+D)	1.212424	0.302068	4.013751	0.0003
LOG(GDP(-20))	0.667231	0.071509	9.330781	0.0000
R-squared	0.800148	Mean dependent var		7.875347
Adjusted R-squared	0.775167	S.D. dependent var		0.541762
S.E. of regression	0.256885	Akaike info criterion		0.244713
Sum squared resid	2.111680	Schwarz criterion		0.462405
Log likelihood	0.472804	Hannan-Quinn criter.		0.321460
F-statistic	32.02964	Durbin-Watson stat		0.320537
Prob(F-statistic)	0.000000			

Model 2 (f)

Dependent Variable: LOG(GDP)
Method: Least Squares
Date: 02/02/13 Time: 16:48
Sample (adjusted): 1979 2010
Included observations: 32 after adjustments

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
C	5.664339	0.983782	5.757716	0.0000
LOG(INVEST)	0.383852	0.164026	2.340189	0.0269
DLOG(SCHOOL)	-1.183674	0.549747	-2.153124	0.0404
LOG(N+G+D)	0.199599	0.267915	0.745009	0.4627
LOG(GDP(-25))	0.257098	0.079371	3.239194	0.0032
R-squared	0.671256	Mean dependent var		8.046710
Adjusted R-squared	0.622554	S.D. dependent var		0.337915
S.E. of regression	0.207604	Akaike info criterion		-0.163771
Sum squared resid	1.163680	Schwarz criterion		0.065250
Log likelihood	7.620337	Hannan-Quinn criter.		-0.087857
F-statistic	13.78272	Durbin-Watson stat		0.735498
Prob(F-statistic)	0.000003			

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Model 2 (g)

Dependent Variable: LOG(GDP)
Method: Least Squares
Date: 02/02/13 Time: 16:50
Sample (adjusted): 1984 2010
Included observations: 27 after adjustments

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
C	6.778863	0.833493	8.133073	0.0000
LOG(INVEST)	0.276206	0.143720	1.921828	0.0677
DLOG(SCHOOL)	2.928557	1.794074	1.632350	0.1168
LOG(N+G+D)	-0.065984	0.200169	-0.329640	0.7448
LOG(GDP(-30))	0.183704	0.071633	2.564529	0.0177
R-squared	0.587253	Mean dependent var		8.157656
Adjusted R-squared	0.512208	S.D. dependent var		0.212872
S.E. of regression	0.148674	Akaike info criterion		-0.808546
Sum squared resid	0.486287	Schwarz criterion		-0.568576
Log likelihood	15.91537	Hannan-Quinn criter.		-0.737190
F-statistic	7.825360	Durbin-Watson stat		0.854060
Prob(F-statistic)	0.000442			

Model 2 (h)

Dependent Variable: LOG(GDP)
Method: Least Squares
Date: 02/02/13 Time: 16:53
Sample (adjusted): 1994 2010
Included observations: 17 after adjustments

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
C	6.936320	0.444596	15.60141	0.0000
LOG(INVEST)	-0.001506	0.077818	-0.019347	0.9849
DLOG(SCHOOL)	3.863511	2.122057	1.820644	0.0937
LOG(N+G+D)	0.265968	0.109006	2.439932	0.0312
LOG(TCGDP(-40))	0.152193	0.058117	2.618747	0.0224
R-squared	0.458064	Mean dependent var		8.269670
Adjusted R-squared	0.277418	S.D. dependent var		0.075858
S.E. of regression	0.064483	Akaike info criterion		-2.404913
Sum squared resid	0.049896	Schwarz criterion		-2.159850
Log likelihood	25.44176	Hannan-Quinn criter.		-2.380553
F-statistic	2.535706	Durbin-Watson stat		2.175289
Prob(F-statistic)	0.094958			

APPENDIX-C

Model 3

Dependent Variable: LOG(GDP)

Method: Least Squares

Date: 02/02/13 Time: 17:13

Sample: 1954 2010

Included observations: 57

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
LOG(SCHOOL)	2.506191	0.087788	28.54827	0.0000
LOG(N+G+D)	1.833648	0.136232	13.45976	0.0000
LOG(INVEST)	0.433286	0.178460	2.427922	0.0185
R-squared	0.864425	Mean dependent var		7.060574
Adjusted R-squared	0.859404	S.D. dependent var		1.228571
S.E. of regression	0.460667	Akaike info criterion		1.338913
Sum squared resid	11.45956	Schwarz criterion		1.446442
Log likelihood	-35.15903	Hannan-Quinn criter.		1.380703
Durbin-Watson stat	0.582203			