Institutions and Economic Growth: A Systems Approach*

Mehmet A. Ulubasoglu† and Chris Doucouliagos‡

2 February 2004

Abstract

In a simultaneous equations with error components framework, we analyze the institutions-growth relationship. We address individual heterogeneity in cross-country production functions, and endogeneize factor inputs in order to disentangle the direct and indirect effects of institutions on economic growth. We find that the effects of political freedom on total factor productivity and human capital accumulation are positive and significant, but they are negative and significant on physical capital accumulation and labor force growth. Economic freedom, on the other hand, has positive and significant effects on total factor productivity, physical and human capital accumulation, and labor force growth. The total effects (direct and indirect) of both political and economic freedom on growth are positive.

*Preliminary Draft.

†Corresponding author: School of Accounting, Economics and Finance, Deakin University. e-mail: maulubas@deakin.edu.au

‡School of Accounting, Economics and Finance, Deakin University. e-mail: douc@deakin.edu.au

1 Introduction

The relationship between institutions and economic growth is a critical yet controversial area. There is currently an ongoing debate in the literature on the relative importance of institutions, geography and trade as being leading determinants of economic growth. However, within their own strand researchers of institutions have failed to find conclusive evidence on a sharp direct evidence between political freedom and growth. Further, the literature on economic freedom and growth has been found to be contaminated with poor specification of the production process.[1] The debate is not less severe regarding the channels through which institutional effects operate on growth. It has been found that while the effects of democracy on human capital investment are positive, its effects on physical capital investment is inconclusive.[2] Economic freedom is found to have positive effects on both, but detailed studies show that more rigorous research is needed to understand the exact process (De Haan, 2003).

Partly due to these results, it is felt that an element of contentment and concord is missing in this literature. In conducting their studies researchers often miss the point that growth involves an outward expansion in the 'production function', and that freedom of any kind mainly adds to the atmosphere in which production occurs.[3] This is more important when the focus turns to long-run growth. In proceeding, one should realize the following: institutions are the established rules and organs that drive the production atmosphere, and they ably influence both factor productivity and the accumulation of factors of production. The specification of the empirical models in the literature, however, mostly ignores the latter, because the regressions are generally specified in an augmented Solow specification format.[4] This only captures the 'marginal' effect of some categorical institutional variable on growth, after accounting for its structural determinants predicted by certain growth models. The literature names this relationship the *direct* relationship between institutions and growth. In particular, this is the effect of institutions on the factor productivity or an efficiency variable, which is commonly denoted as "A" in the neoclassical growth model. In general, indirect effects are ignored, or are not given enough importance. Using this rather restrictive approach, the evidence on the relationship between democracy and

[1]For the former, see the reviews of Sirowy and Inkeles (1990), Przeworski and Limongi (1993) and Alesina and Perotti (1994); for the latter see Sturm and De Haan (2001) and De Haan (2003).

[2]For example, while De Haan (1995) and Tavares and Wacziarg (2001) established a negative relationship, Barro (2000) found a positive but insignificant correlation. Additionally, Helliwell (1994) found a positive and significant relationship.

[3]North (1990) argues that it is ultimately a friendly environment and policies that drive the economies to prosperity. The study of Hall and Jones (1999), for example, is totally based on social infrastructure to explain growth.

[4]Levine and Renelt (1992) find that some 50 different variables are related to growth. Although core variables suggested in Solow (1956) model such as investment rate are robustly estimated in the growth regressions, the inclusion of others or the combinations in which they exist in the specifications result in unrobust results.

growth, for instance, is inconclusive.

Additional overriding problems in the growth equations are the long-discussed endogeneity of most right-hand side variables, and the heterogeneity of the environment in which production takes place.[5] The former is persistently present because of the nature of a variable like growth, which is conceptually very comprehensive. Physical and human capital, size of government, opennesss, and even democracy and population growth have been shown to be endogenously determined with growth.[6] The heterogeneity issue has received less attention. Empirically testable growth models (such as neo-classical growth models) assume identical production functions and technologies across countries, whether they are developing or developed. When out-of-steady state dynamics are tested for instance, this results in a correlation between the initial income variable and country-specific effects in the growth regression. Omission of these effects in turn leads to biased and inconsistent estimates of the coefficient of initial income. Because of the inverse link between this coefficient and the factor shares in production and speed of convergence, the analyses have so far delivered conflicting results on these essential magnitudes (Mankiw *et al.* 1992, Islam 1995, and Caselli *et al.* 1996).

At this point it is pertinent to ask why researchers do not look at the institutions-growth relationship from a broader window that encompasses the indirect-channel and direct relationships between freedom and production. Some researchers do realize the association (or channel) between the accumulation of factors of production and institutions, but the majority choose to explore these through reduced-form equations, i.e., with single-equation estimations. Researchers who aim to investigate the channel effects do so by focusing on the size and significance of the variables on inputs and the fit of the regressions, after augmenting a single-equation production function with an institutional variable.[7]This is a pushy approach at best, and demands a lot from a single variable. In this case it is difficult to disentangle the direct and indirect effects of institutions on growth. A limited number of researchers (such as Mauro 1995 and Dawson 1998) specify separate investment models to test the indirect effects of freedom, but they do not run systems. Consequently the information between two equations remains unexploited. Further, the simultaneity problem is not adequately addressed in this way.

Our premise in this paper is the following: if economic and/or political regimes are to influence long-run growth, their effects should work through both the inputs into the production (physical and human capital accumulation and growth of working population/labor supply) and total factor productivity. In this sense, the link between institutions and determinants of production merits a more explicit analysis.[8]

[5]The whole focus of Caselli *et al.* (1996) is on these two issues.

[6]See Helliwell (1994), Minier (1996), and the surveys of Temple (1999) and Aron (2000).

[7]For a concise exposition on this issue, see Dawson (1998).

[8]Brunetti and Weder (1995) implicitly criticize the lack of such attempts in the literature by noting that the studies do not take into account the "investors' problem" . See also Aron (2000),

Therefore, in this paper we estimate a system whose main equation is a neo-classical production function, the estimation of which is standardized by Mankiw *et al.* (1992). In this system we explicitly channel the relationship between the institutions and the arguments of production function in structural equations. A multi-equation specification like this also allows for joint determination of certain important variables.

There are several good reasons to specify the relationships in this way. First, we place the problem in its natural form, and explicitly assign every variable the credit that it deserves in functioning its effects. In other words, the indirect effects of institutions on the production function are modeled via endogeneizing the factors of production, and so the institutional variable in the growth equation is left to determine the total factor productivity only. Secondly, a system captures cross-equation information in the error terms and provides more efficient estimates. Then, the indirect effects can be quantified more meaningfully. Thirdly, instrumental variables estimation to resolve the resultant simultaneous equations bias addresses the measurement error problem that exists in the institutional variables, an issue that has been largely ignored in the literature.[9]

We conduct this analyis by using a panel data set, which makes the investigation of country-specific effects possible. This is particularly important in order not to impose the same production function onto all economies. In particular, we estimate a system of equations using the Error Components Three-Stages Least Squares (EC3SLS) of Baltagi (1981) and the Error Components Generalized Method of Moments (ECGMM) techniques. In this sense, our effort is one of the first to apply this econometric technique to the growth literature, and use it to address long-standing and relevant problems.

One study that is close to ours is Helliwell (1994) in that he uses a two-equation simultaneous equations system in which growth and democracy are jointly determined. Also, Tavares and Wacziarg (2001) use a six-equation simultaneous equations system to look at the effects of democracy and growth. While Heliwell uses the Mankiw *et al.* framework, Tavares and Wacziarg define a more general production function. However, the focus of both studies is only on the effects of democracy and growth, and the former does not take into account the individual country heterogeneity. Additionally, Tavares and Wacziarg treat the whole effects of democracy on growth as indirect effects. Another, yet closer, study to ours is that of Dawson (1998), who realizes the fixed effects in institutions-augmented Mankiw *et al.* (1992) framework, but carries out his analysis with separate equations without addressing the simultaneity

who discuss the implications of using augmented Solow specification.

[9]Measurement error is inherent in the construction of institutional measures, because these measures are attempts to quantify a continuum of established norms and organs. Both subjective and controversial techniques are used in their construction. Moreover, there is another type of measurement error in these measures, which takes the form of ordinality in the variables. Categorical indices that exist in the literature do not represent the cardinal ranking of the countries in freedom, but their ordinal rankings.

problem.[10,11]

The paper is organized as follows. In section 2, we provide a brief discussion on institutions, growth, and the institutions-growth relationship. In section 3, we introduce our data, in section 4 we conduct an analysis that comprises the textbook Solow model and its human capital-augmented version without institutions. Then we proceed with our simultaneous equations analysis in section 5. In section 6, we augment this system with institutions, and section 7 concludes.

2 Theory

2.1 Institutions

It is important to clarify what we mean by institutions. The empirical literature pools economic freedom, political rights and civil liberties together, and names them institutions. This is of course influenced by the availability of the relevant data. But, it is only a short-cut. For a definition of institutions, Rodrik (2000) quotes Lin and Nugent (1995: 2306-7): "institutions are broadly a set of humanly devised behavioral rules that govern and shape the interactions of human beings, in part by helping them to form expectations of what other people will do". In particular, Rodrik defines five types of market-supporting institutions: property rights, regulatory institutions, institutions for macroeconomic stabilization, institutions for social insurance, and institutions of conflict management. These institutions operate in a wide range of economic and social activities, such as protecting and encouraging asset accumulation, preventing fradulent and anti-competitive behavior, managing fiscal and monetary organs, providing people with life-time economic security and confidence, and bridging and coordinating different income and ethnic groups. "Good" institutions are acquired by entrenching people's rights in constitutions in conjunction with *local knowledge*. In other words, these rules should not be contrary to the values of a group of people. Democratic behavior can facilitate processing and aggregating local knowledge in forming the best possible combination of institutions for a society.

2.2 Growth

Growth models are structured in two main strands: i) neoclassical models, whose foundations stem from Solow (1956), and ii) endogenous growth models, triggered

[10] He uses Barro-Lee (1993) human capital data whereas we use Barro-Lee (2000), which involves some important differences in the calculation. Additionally, he uses Gwartney *et al.* (1996) economic freedom measure, whereas we use the Gwartney *et al.* (2003), which is much more improved version of 1996 version in terms of the relevance of the variables.

[11] Another study that realizes the country-specific effects is by Wu and Davis (1999), but they do not take into account the channel effects, nor do they use human capital in their specifications. They use Arellano-Bond's (1991) GMM estimation to take care of individual effects and endogeneity.

by Romer (1989). Because of the relative ease in finding data and its cross-country implications such as convergence, researchers traditionally focused on the empirical analysis of the former. Neoclassical growth models assume constant returns to scale to reproducible factors of production and diminishing returns to capital. This implies that in the long-run, countries reach their steady-states based on their exogenous steady-state determining variables such as savings and population growth. At the steady-state, growth of capital accumulation ceases, and countries grow only at the rate of technology and population growth. There are several variants of neoclassical growth model, in which saving decisions are endogeneized (Cass 1965, Koopmans 1965), open and closed economy assumptions are played with, and the notion 'capital' is treated differently.[12]

In this paper, we use the version of the neoclassical growth model that was estimated and augmented by Mankiw *et al.* (1992). There are three reasons for adhering to this version of the model. First, the empirical performance of the models with endogeneized savings or various other growth determinants such as openness, government size *etc.* is similar. Second, we are interested in the institutions-growth relationship in the simplest possible framework without using variables other than the inputs in the production function. In this sense, we are not interested in the 'fit' of the regressions that could be increased by other variables such as openness and government size, but the functionality of the production function in the presence of institutions. This is driven by the concern that we want to look at the full effects of institutions on factor accumulation and factor productivity, tied together. Third, the use of human capital has been an issue in recent works related to growth. Mankiw *et al.* (1992) find that adding human capital results in more reasonable factor shares and convergence rates, while Islam (1995) finds that human capital does not have an explanatory power after controlling for country-specific effects. Because human capital is one of the channels through which institutions can act on growth, we would like to include it in our estimations.

2.3 Institutions and Growth

All arguments that link institutions to economic growth work through individualistic incentives to engage in productive activities, such as safety and security in investment or property rights. It is argued that poor institutions and policies result in lack of confidence as to the enforceability of contracts, protection of rightfully-acquired private property, rule of law and independent judiciary. Similarly, high tax rates limit individuals to access the fruits for their labour. High and volatile inflation rates distort prices, erode the value of the monetary assets, alter the fundamental terms of long-term contracts and make it virtually impossible for individuals and businesses to plan sensibly for the future. These lower the fruits for productive economic activi-

[12] For example, Barro and Sala-i Martin (1995) use male and female schooling, life expectancy and mortality variables separately to approximate for human capital.

ties, which will in turn hamper the incentives for investment (Gwartney *et al.*, 2003). Additionally, high amounts of government consumption or state-owned production decrease the scope for productive individual activities. Restrictions to free trade and controls on capital flows reduce the gains from exchange, and result in deadweight costs. Regulation of credit, labour and product markets, conscription, and heavy bureaucracy are all growth-inhibiting. All these equivalently signify the factor accumulation and factor productivity aspects of the institutions-growth relationship.

3 Data

In our data set, we have 119 countries for which we were able to match political and economic freedom data of Freedom House and Fraser Institute, respectively, and human capital data of Barro and Lee (2000). We denote this sample as our BIG sample. Then, following Mankiw *et al.*, we drop transition countries. The reason is that at some point in our data set, these countries had centrally-planned economies, and hence, they may not fit in the predictions of the neoclassical growth model. This is our non-transition (NT) sample, and has 105 countries. Also, again a la Mankiw *et al.*, we drop small countries, because they may have idiosyncratic factors in the determination of real income.[13] This sample is denoted as non-transition and non-small (NT/NS) sample, and consists of 87 countries. Further, we remove oil producing countries, because these countries mainly rely on natural resources for production, and a considerable portion of their GDPs do not represent value added. Hence they may not be ideal for the test of Solow model. This non-transition, non-small and non-oil (NT/NS/NO) sample has 82 countries. Due to relative absence of adverse concerns, we denote this sample as the "good" sample. Our final sample consists of 22 OECD countries.

We measure institutions with Freedom House's (Gastil) political rights and civil liberties indices, and economic freedom with Fraser Institute's measures. Gastil's democracy measures run from 1 to 7, with the lowest value representing the most democratic regimes. The economic freedom measure is scaled from 1 to 10, and the highest value represents the most economically-free countries. We obtain the political rights and civil liberties data from Freedom House web site. The economic freedom data are from Gwartney *et al.* (2003), and are available on the web site of the Fraser Institute. All other data are from World Development Indicators CD-ROM (2003).

Our data set spans the period 1970-1999, and is structured in 5-year intervals, such as 1970-74, 1975-79 and so on. This has become a common practice in the literature in order to eliminate business cycles effects on the relevant variables. Therefore each country has potentially six data points in the data set (depending on data availability). Growth is measured as the logarithmic change in real output per worker

[13] Small country here is defined as the one whose population is less than 1,000,000 in 1970-1974 period.

from the first year of the interval to its last year.[14] All other continuous variables are measured with the five-year averages of the respective data, except the human capital and economic freedom measures which are available for the initial years of the intervals, such as 1970, 1975 etc. There are various measures on human capital, the most renown of which have been provided by Barro and Lee (2000). We use the share of population with complete secondary schooling as a proxy for human capital.[15] Physical capital investment is the share of gross capital formation in GDP. World Bank (2003) defines gross capital formation as: "outlays on additions to the fixed assets of the economy plus net changes in the level of inventories".

A note is also due on the economic freedom measure. This is a composite index that comprises 50 variables in itself, and represents a variety of attributes of economic policies consistent with economic freedom. In particular, it is categorized in five major areas: (1) size of government: expenditure, taxes and enterprises; (2) legal structure and security of property rights; (3) access to sound money; (4) freedom to exchange with foreigners; and (5) regulation, credit, and business. We use a summary measure that takes the simple averages of each category. This note is important in that some explanatory variables commonly used in growth regressions such as government consumption, openness *etc.* are included in this index already, and therefore one should refrain from utilizing the same variable twice when the growth equation is augmented with economic freedom.

4 The Solow Model Without Institutions

We commence our study with the basic Solow model without institutions. In this way, we will address the econometric problems mentioned above via certain tests in a simpler framework, and prepare the background for a comparative analysis of the cases with and without institutions.

4.1 Textbook Solow Model

The textbook Solow model is defined as follows:

$$\ln(y_{it}) - \ln(y_{i,t-1}) = \phi_0 + \phi_1 \ln(s_{k_{it}}) + \phi_2 \ln(n_{it} + g_{it} + \delta_{it}) + \phi_3 \ln(y_{i,t-1}) + \epsilon_{it} \quad (1)$$

where y is output per worker, s_k is investment in physical capital, n is the labor force growth, g and δ are the exogenous technological change and depreciation, respectively

[14] In general, researchers use the labor force participation rate multiplied with the population between the ages 15-64 to calculate the labor force. We use the labor force figures given by International Labor Organization (ILO) as reported in WDI CD-ROM.

[15] Barro and Lee provide shares of population with incomplete and complete primary, secondary and tertiary education, decomposed for age groups (i.e., 15+ and 25+) and for gender differences. However, secondary schooling rates have commonly been used to approximate human capital in growth studies.

(capped to 0.05 together in the literature), ϵ is the random error, i is the subscript for countries, and t is the subscript for time.

4.1.1 Are there country-specific effects in the textbook Solow Model?

One of the arguments foregoing in the literature is the individual heterogeneity in the cross-country production functions. The source of this heterogeneity is said to be differences in technology, institutions, climate *etc.*, which in turn affect the production process. In a panel framework, these effects can be correlated with initial income, and if not taken into account, may lead to omitted variable bias in the regression. For instance, Islam (1995) and Caselli *et al.* (1996) base their papers on this argument. They find that the omitted variable bias associated with this situation leads to overestimation of the coefficient of the initial income variable, which in turn underestimates the convergence, due to the inverse link between these two. In particular, the following model is argued to characterize the "true" relationship in cross-country growth analyses:

$$\ln(y_{it}) - \ln(y_{i,t-1}) = \phi_0 + \phi_1 \ln(s_{k_{it}}) + \phi_2 \ln(n_{it} + g_{it} + \delta_{it}) + \phi_3 \ln(y_{i,t-1}) + \mu_i + \epsilon_{it} \quad (2)$$

where, as different than above, μ_i denotes the individual effects for each country. In the majority of studies, however, this heterogeneity is imposed *a priori* on the production function, and has been rarely tested in an estimation framework. Before proceeding in our discussion, we first test the existence of these effects. This test is a simple Chow test that compares the restricted residual sum of squares residuals (RRSS) that come from an Ordinary Least Squares (OLS) estimation of the textbook Solow specification using a pooled data set across countries, and the unrestricted residual sum of squares (URSS) that come from Within estimation of the same specification. In other words, this is a test to determine whether equation (1) or (2) represents the "true" growth specification across countries (holding other limitations constant). The test statistic is:

$$F = \frac{(RRSS - URSS)/(N-1)}{(URSS/(NT - N - K)} \approx F_{N-1,N(T-1)-K}$$

where N is the number of countries, T is the number of time periods and K is the number of regressors in the estimation. The null hypothesis tested is:

$$H_0 = \mu_1 = \mu_2 = ... = \mu_N = 0$$

that is, all individual effects are jointly equal to zero.[16]

Within transformation takes the following form: Consider the following one-way error component model $Y_{it} = \phi_0 + \phi_1 X_{it} + \mu_i + v_{it}$ with conventional notations for

[16] See Baltagi (2001, p.14) for details of this test.

variables and parameters. Averaging the observations for each country over time gives $\bar{Y}_{i.} = \phi_0 + \phi_1 \bar{X}_{i.} + \mu_i + \bar{v}_{i.}$, where the accent "–" denotes time averages for each individual. Then substracting the second equation from the first gives the Within transformation as $Y_{it} - \bar{Y}_{i.} = \phi_1(X_{it} - \bar{X}_{i.}) + (v_{it} - \bar{v}_{i.})$. As can be noted, this transformation wipes out any country-specific effects μ_i including the constant term that are present in the specifications.[17]

Given these motivations, we estimate equation (1) with OLS and Within-estimation methods. These results are reported in Tables 1a and 1b. As these tables depict, we estimate the coefficient vector of the textbook Solow model $\hat{\boldsymbol{\phi}}$ significantly with the expected signs, for both OLS and Within estimations. In other words, physical capital investment variables have positive and significant signs, while $n+g+\delta$ and initial income variables have negative and significant signs. We also confirm a convergence with the negative sign of initial income, which is in line with the literature's findings. In the bottom of the table, the F statistics of the Chow tests are reported. In each case we reject the null hypothesis H_0 at high significance levels, giving credibility to equation (2).[18] These test results suggest that the treatment of individual heterogeneity is in order.

4.1.2 Is there any endogeneity in the textbook Solow Model?

Simultaneous determination of variables in behavioral equations such as consumption, production and investment has attracted a great deal of attention in the economics literature. We run Hausman (1978) tests to formalize this argument in the growth context. The existence of endogeneity would thus justify the use of a simultaneous equations framework for our analysis. Recall that our purpose is to treat the endogeneity in a systems framework that contains several equations, with which indirect effects of institutions on growth will be treated explicitly. This cannot be done with single-equation instrumental variables.

Hausman tests are conducted in two steps. In the first step, the suspected endogenous variables are regressed on certain exogenous variables in an auxiliary regression, then in the second step the residuals from this regression are inserted into the original model. The significance of the residuals in this model would indicate the existence of endogeneity. Because in our case we have several suspected endogenous variables, we look at the joint significance of these residuals in the original model via an F-test.

[17] One computational warning, however, should be issued. A typical computer package obtains the variance of the regression s^2 by dividing the residual sum of squares by $NT - K$. Because the intercept and dummies are dropped in Within estimation, the correct denominator should be $N(T-1)-K$. Therefore one should multiply the variance-covariance matrix by $[NT - K] / [N(T-1) - K]$ to obtain the correct variances.

[18] Interestingly, the test statistics decline each time as we carry out the estimations for countries that are similar in nature (or productive environment). This implies that, when we treat countries which have different productive characteristics as being similar, individual heterogeneity proves to be a stronger problem than, for instance, the case in which we only use OECD countries, where the problem is less pronounced. This is quite intuitive.

The test results in Table 2 show that the residuals from both investment and labor force growth regressions are jointly different than zero in the original model, implying that these variables are jointly endogenous to growth.

4.2 Human Capital-Augmented Solow Model

We next augment the textbook Solow model with human capital (as given by Mankiw *et al.*):

$$\ln(y_{it})-\ln(y_{i,t-1}) = \theta_0+\theta_1\ln(s_{k_{it}})+\theta_2\ln(s_{h_{it}})+\theta_3\ln(n_{it}+g_{it}+\delta_{it})+\theta_4\ln(y_{i,t-1})+\mu_i+\epsilon_{it} \quad (3)$$

where s_h is a measure on human capital.

It is generally accepted that human capital accumulation is an important channel through which the political and economic freedom act on growth, especially in the long-run. For our purposes, it is important to observe the changes in the role of human capital in growth equations when we include the institutions into the system framework. However, before delving into this process, it will be useful to issue some caveats. When the temporal dimension is introduced to the use of human capital variable, the measures generally provide insignificant estimates or unexpected signs (Islam, 1995). The reasons given were twofold: first, the proxies on human capital did not represent what the original theory proposes in the production function, that is, enrolment rates are only partial representatives of human capital accumulation. Secondly, the way human capital is specified in regressions is generally poor. For instance, Benhabib and Spiegel (1994) suggested with a flavor of endogenous growth model that human capital variable should be interacted with A and g. Additionally, the gap between the individual country and the leader country should be considered.

Keeping these issues in mind, we run our regressions with OLS first. The results are presented in Table 3. In this version of the Solow model too, we obtain highly significant results with expected signs. For instance, in the NT/NS and "good" samples, all coefficient estimates are significant. In the other samples, all coefficients are significantly estimated, except those of human capital.

However, the same concerns exist on country-specific effects and endogeneity in this version of the model as well, and therefore we test them through the same procedure above. The results show that these effects exist fairly significantly in these equations. The test results are presented in the bottom portion of Table 3.

4.3 Structural Equations for Factor Inputs

Having shown that there is a joint determination of growth and the factor inputs in equation (3), we next proceed with explicitly specifying the physical capital investment, human capital investment and labor force growth equations. In proceeding, we first estimate the structural equations for these variables individually with OLS to show that our results are qualitatively similar to those that are established in the literature. In the following sections, we will combine these equations and estimate them together in a system of simultaneous equations.

Let the following equations represent the individual factor input equations:

$$\ln(s_{k_{it}}) = k(\theta_k; 1,\ y^*_{it},\ \mathbf{X}_{it}) + u_{it} \tag{4}$$

$$\ln(s_{h_{it}}) = l(\theta_l; 1,\ y^*_{it},\ \mathbf{Y}_{it}) + \upsilon_{it} \tag{5}$$

$$\ln(n_{it}) = m(\theta_m; 1,\ y^*_{it},\ \mathbf{Z}_{it}) + \omega_{it} \tag{6}$$

where k, l and m are the functions that describe the relationships between the left-hand side variables and $y^*_{it} = \ln(y_{it}) - \ln(y_{i,t-1})$ along with vectors $\mathbf{X}$, $\mathbf{Y}$ and $\mathbf{Z}$ of dimension $(1 \times K_r)$, which include the explanatory variables for each equation $r = 4, 5, 6$, respectively. $\theta_{k,l,m}$ are the vector of structural parameters for each equation, 1 is the vector of ones, and u, υ and ω are the additive errors.

In the estimation of these structural equations, we in general obtain the coefficients $\hat{\theta}_{k,l,m}$ with expected signs and significance, that are in line with literature. In Table 4a, we present a series of physical investment regressions (for the "good" sample). The selection of the explanatory variables follows Barro and Sala-i Martin (1995, ch. 12). Their regressions include the log of GDP, male and female secondary schooling, log of life expectancy, the share of government consumption in GDP, log of 1+black market premium, political instability, and growth rate of terms of trade as right-hand side variables. Some authors such as Barro (1991), Dawson (1998) and Tavares and Wacziarg (2001) use initial income instead of log of GDP, (or openness instead of terms of trade growth), but these variables essentially represent the same thing. That is, apart from some "auxiliary" regressors, the regressions should include the variables that capture and/or represent the fundamental characteristics of the economies. In our case, it is shown that there is contemporanous correlation between investment and growth, and therefore, we include the growth rate into the RHS in place of log GDP. We use all other explanatory variables in our regressions.[19] As noted above, the economic freedom measure comprises the values of the share of government consumption in GDP, black market premium and openness in its construction, and so we leave some specifications in such a way that they will be reasonably interpreted when these equations are augmented with economic freedom variable. Additionally, as will become clear in the following sections, we will be Within-transforming the whole system of equations to eliminate the individual-specific effects. This specific way of solving the problem, then, imposes another restriction on our specifications, that is, not using dummy variables in the regressions. The particular specification which will be used in forming a system is therefore Model 4, which is presented in the

[19] One exception is political instability, which results in a relatively high loss of observations, and hence we opt to drop it.

last column of Table 4a. Following from this, in Table 4b we present the estimation results for this model using the other samples.

In Table 5a, we present the estimations of the human capital equation (for the "good" sample again). Tavares and Wacziarg include log of initial income, income gini coefficient, openness, government consumption, ethnolinguistic fractionalization, and colonization and certain religion dummies as regressors for the estimation of this equation. We replace the initial income with the growth rate due to the established endogeneity, and use the other variables as regressors.[20] We also add urbanization and the growth of urbanization into this equation as explanatory variables in order to capture the impact of changing societies on human capital accumulation. In Model 4, we present the results of the specification without government consumption, openness and other dummies. Table 5b presents the estimations of Model 4 for the other samples.

The labor force equation is constructed in reference to the endogenous fertility literature. For instance, Barro and Sala-i Martin use male and female primary schooling, and male and female secondary and higher schooling, government consumption and regional dummies in their regressions, so we use them as explanatory variables. We also add the growth of output per worker due to the endogeneity. The estimation results are presented in Table 6a and 6b following the same course above.

4.3.1 Heterogeneity in Factor Input Equations

If there is individual heterogeneity in cross-country production functions as shown by the F tests above, there is no reason to believe that the functions of other RHS variables, especially that of investment, do not suffer from the same problem. After all, these are behavioral equations, and their dynamics can vary across countries. Therefore, we conduct the same F tests above for all structural equations of the RHS variables of the Solow model. All the results show that cross-country functions of both physical and human capital accumulation and labor force growth contain significant country-specific effects. The results of these tests are presented in bottom portions of the Tables 4a, 5a and 6a for the "good" sample, and 4b, 5b and 6b for the other samples for Model 4.

5 Simultaneous Equations Framework

In a simultaneous equations framework, identification of the system precedes the estimation. In particular, the inclusion of the RHS variables to each vector $\mathbf{X}$, $\mathbf{Y}$ and $\mathbf{Z}$ should be such that at least one variable for each equation should be distinct in order to meet the rank and order conditions. This is necessary to retrieve the estimable parameters meaningfully from the "observationally equivalent" data. Therefore, we

[20] Again exceptions are etholinguistic fractionalization and income gini that result in heavy loss of observations.

make sure that each equation has its own distinct explanatory variable in the estimations.

The next important issue is the methodology to be used in the estimation of the system. Remember that simultaneity and the individual heterogeneity are the problems to address. The simultaneity will be coped with in the systems of equations. The main reason for this is to better evaluate the indirect effects, as this will bring along an efficiency in the parameter estimates, in which case the significance of indirect effects and the information that spills over the equations can be tested more reliably.

There are several techniques used in the convergence literature to tackle the country-specific effects. For example, Least Square Dummy Variables (LSDV) or Minimum Distance Estimation (due to Chamberlain, 1982) are the techniques used by Islam (1995) with the assumption that these effects are "fixed" across countries. However, the former methodology would claim an enormous loss of degrees of freedom in our case where N=119, while the latter requires strictly exogenous independent variables (see Caselli *et al.*), a requirement not easy to meet in growth regressions.

In the presence of simultaneity and individual heterogeneity, the Arellano-Bond (1991) technique suggests itself as a possible methodology. Caselli *et al.* (1996), among others, use this technique. The technique requires first that the equation is first-differenced to eliminate the heterogeneity in production function, then an instrumental variable method (typically GMM) is applied on the differenced model. However, this method is more relevant when there is a lagged dependent variable in the regression, which would make the model a dynamic panel data model. Our approach is slightly different than this; although there is seemingly a lagged dependent variable in our case, this variable does not contain the observation on output per worker of the previous period. Rather, it is for the countries' initial income in the data interval (i.e., the observation of 1970 in 1970-74 growth interval). In this way, we are, in a sense, adopting the multiple-equation methodology of Barro (1996).[21] Additionally, there is no study that we are aware of that used this methodology in a simultaneous equations system. Going back to the first-differencing, there are problems with first-differencing of the variables, especially those of a production function. Importantly, the long-run relationship between inputs and the output is destroyed, the very thing that is attempted to be captured (Munnel, 1992). It is also reported that most studies found insignificant results in production functions when the data used is first-differenced (Holtz-Eakin, 1994).

Given these problems, our preferred methodology is the error components instrumental variables methods. These are Error Components Three-Stages Least Squares (EC3SLS) due to Baltagi (1981) and Error Components Generalized Method of Moments (ECGMM). These are the most straight-forward techniques for estimating a simultaneous equations system with error components.

Let the following equations describe our system of simultaneous equations (drop-

[21] Barro's system, however, is a cross-country data set pooled over three periods.

ping the usual subscripts):

$$y^* = j(\theta_{j;}\ 1, s_k, s_h, n + g + \delta, y_{-i}) + \epsilon$$

$$s_k = k(\theta_{k;}\ 1,\ y^*, \mathbf{X}) + u$$

$$s_h = l(\theta_{l;}\ 1,\ y^*, \mathbf{Y}) + v \tag{SYS1}$$

$$n = m(\theta_{m;}\ 1,\ y^*, \mathbf{Z}) + \omega$$

where j define the relationship between y^* and the steady-state determining variables, and y_{-i} is the initial income. The EC3SLS and ECGMM methodologies first require the Within- and Between-transformation of each equation, and stack them together as shown below:

$$\tilde{y}^* = \tilde{j}(\theta_{j;}\ s_k, s_h, n + g + \delta, y_{-i}) + \tilde{\epsilon}$$

$$\bar{y}^* = \bar{j}(\theta_{j;}\ s_k, s_h, n + g + \delta, y_{-i}) + \bar{\epsilon}$$

$$\tilde{s}_k = \tilde{k}(\theta_{k;}\ y^*, \mathbf{X}) + \tilde{u}$$

$$\bar{s}_k = \bar{k}(\theta_{k;}\ y^*, \mathbf{X}) + \bar{u}$$

$$\tilde{s}_h = \tilde{l}(\theta_{l;}\ y^*, \mathbf{Y}) + \tilde{v} \tag{SYS1-EC}$$

$$\bar{s}_h = \bar{l}(\theta_{l;}\, y^*, \mathbf{Y}) + \bar{v}$$

$$\tilde{n} = \tilde{m}(\theta_m;\ y^*, \mathbf{Z}) + \tilde{\omega}$$

$$\bar{n} = \bar{m}(\theta_m;\ y^*, \mathbf{Z}) + \bar{\omega}$$

where the accent "~" represents the Within transformation of the logarithms or levels of variables (where necessary), and "–" represents the Between transformation of the same variables.[22] Before estimation, each equation is pre-multiplied by the Within-

[22] Between transformation is just taking the time averages of each individual country in the form of $\bar{y}_{i.} = \phi_0 + \bar{X}'_{i.}\phi_1 + \bar{v}_{i.}$ where $i = 1, ..., N$. This average is replicated for each row observation of that country in the panel data set.

or Between-transformed vectors of exogenous variables (i.e, y_{-i}, $\mathbf{X}$, $\mathbf{Y}$ and $\mathbf{Z}$, respectively) in conjunction with the transformation type of the equations. In other words, Within-transformed equations are pre-multiplied with $\tilde{y}_{-i}$, $\tilde{\mathbf{X}}$, $\tilde{\mathbf{Y}}$ and $\tilde{\mathbf{Z}}$ respectively for the equations of each endogenous variable, and Between-transformed equations are pre-multiplied with $\bar{y}_{-i}$, $\bar{\mathbf{X}}$, $\bar{\mathbf{Y}}$ and $\bar{\mathbf{Z}}$ in the same manner. Note that the vector of ones 1 is dropped from each equation due to these transformations. Also, for the equations of each endogenous variable, the same structural parameters $\theta_{j,k,l,m}$ are estimated for both Within- and Between-transformed versions. Naturally, these parameters differ across equations.

The simple intuition behind this technique is as follows: Within transformation wipes off the individual-specific effects. However, at the same time, it eliminates the Between type variation across individual countries. For this reason, Within-transformed equations are supplemented with Between-transformed version of the same equation. Note that these transformations *per se* do not solve the inconsistency problem that arises from the simultaneous equations bias. Therefore the stacked system is estimated with instrumental variables.

An additional issue is which instruments to use in the estimation. We use the lagged values of the endogenous variables and the exogenous variables of each equation as instruments. We also experiment with the lagged values of these exogenous variables. However, in carrying out the estimation above, the instruments should also be transformed first. In particular, our instruments are $\tilde{y}_{-1,}$ $\bar{y}_{-1,}$ $\tilde{s}_{k,-1,}$ $\bar{s}_{k,-1,}$ $\tilde{s}_{h,-1,}$ $\bar{s}_{h,-1,}$ $\tilde{\vartheta}_{-1}$, $\bar{\vartheta}_{-1}$, $\tilde{y}_{-i,}$ $\bar{y}_{-i,}$ for the equation of $\ln(y) - \ln(y_{-i})$, $\tilde{\mathbf{X}}$ and $\bar{\mathbf{X}}$ for the equation of $\ln(s_k)$, $\tilde{\mathbf{Y}}$ and $\bar{\mathbf{Y}}$ for the equation of $\ln(s_h)$, and $\tilde{\mathbf{Z}}$ and $\bar{\mathbf{Z}}$ for the equation of $\ln(n)$, where the subscript "–1" denotes the lagged value, and $\vartheta = n + g + \delta$. The beauty of panel data is that it facilitates the use of different instruments from within the same data set. Following all these transformations, 3SLS and GMM are applied to the system.

Another issue worth discussing is that EC3SLS and ECGMM treat the country-specific effects μ_i as being random, rather than fixed. Islam (1995), by using LSDV and Minimum-Distance Estimation, treats these effects as fixed, while Tavares and Wacziarg treat them as random. Our choice of treating μ_i as random is due to both technical and intuitive reasons. Technically, this is imposed by a high number of countries N relative to our number of observations NT (which rules out LSDV), and the endogeneity of the RHS variables in the growth equation (which rules out modeling μ_i as is done in Minimum-Distance estimation). The intuition behind random effects is in line with Nerlove and Balestra (1996) and Baltagi (2001): the population consists not only of the infinity of individuals, but also of the infinity of decisions and opportunities. Certainly the choice of decisions, and opportunities used have differed across countries historically and as of today, and therefore they ended up or dealing with different technologies, geographies, and institutions. This is more relevant when the focus is on "long-run" growth.

In Table 7, we present the results of ECGMM estimations. EC3SLS results are qualitatively similar, so we do not present those.[23] For comparison purposes, we also present the GMM estimation of the un-transformed model in SYS1. Because the NT/NS/NO sample is our "good" sample, we focus on those results. With the ECGMM estimation, we obtain the estimates of the structural coefficients of the growth equation $\hat{\theta}_j$ with expected signs. Physical and human capital investment variables have positive signs, while labor force growth and initial income variables have negative signs. With the negative sign on initial income, we confirm a convergence of output per worker across countries in a system framework.

Additionally, the coefficients of the growth variables in other equations are intuitive. While growth positively adds to physical and human capital accumulation, it negatively effects the labor force growth. We invite the reader to judge the signs of other variables in the regressions from this table.

6 Institutions-Augmented Solow System

We can now augment the system in SYS1 with institutional variables. Let the following system describe our estimations:

$$
\begin{aligned}
y^* &= j_I(\theta_{j,I}; 1, s_k, s_h, n+g+\delta, y_{-i}, I) + \epsilon_I \\
s_k &= k_I(\theta_{k,I}\,; 1,\ y^*, \mathbf{X},\ I) + u_I \\
s_h &= l_I(\theta_{l,I}; 1,\ y^*, \mathbf{Y},\ I) + \upsilon_I \\
n &= m_I(\theta_{m,I}; 1,\ y^*, \mathbf{Z},\ I) + \omega_I
\end{aligned}
\tag{SYS2}
$$

where the variable I represents the institutional measures, and as a subscript, converts functional relationships and structural coefficients into institutions-augmented ones. In particular, we will incorporate political rights, civil liberties, political freedom (the average of political rights and civil liberties), and economic freedom into every equation of the system in a linear form individually. We will also add political and economic freedom together into the regressions, and observe the changes in the whole system when all institutions (that can possibly be quantified) are taken into account. We follow the same methodology as above when Within- and Between-transforming the whole system.[24]

[23] The results are available from the authors upon request.

[24] In the single-equation institutions-augmented estimations, we repeat the F-tests above, and we do find that the individual heterogeneity exists in each equation, implying that the institutions-augmented system should also be transformed.

The results are reported in Tables 8a, 8b and 8c. We present the results with "good" sample. First, take a look at Table 8a. It is shown that the coefficients of factor inputs in the growth equation are tightly estimated with expected signs. Also, the coefficients of growth rate as an explanatory variable in the factor input equations are significantly estimated with anticipated signs.

The effects of political rights and civil liberties (whose effects are similar) on the system are interesting. Higher levels of democracy (as shown by a decrease in the democracy score) have a positive effect on the total factor productivity and human capital, and this effect is significant. However, democracy affects physical capital accumulation and labor force growth negatively and significantly. The same result is replicated when we combine these two measures to denote political freedom (which is presented in the first two results column of Table 8b).

In the last two columns of Table 8b, one can see the effects of economic freedom on the system. The inclusion of economic freedom individually as an explanatory variable results in the loss of significance of the labor force growth and initial income variables in the growth equation. However, their signs remain negative, as expected. Physical and human capital accumulation have also expected positive and significant signs. Additionally, the growth rate as an explanatory variable has significant and expected signs in the factor inputs equations. Looking at the economic freedom variable in this equation, an increase in economic freedom (as shown by an increase in the score) affects total factor productivity positively and significantly (holding the inputs and initial income constant). In factor input equations, its effects on labor force growth are also positive and significant. Its effects on physical and human capital accumulation are estimated to be positive, but weakly significant at 18% and 11% levels, respectively.

Lastly, we include both types of freedoms into the whole system. Regarding the factor inputs in the growth equation and growth variables in the factor input equations, all estimates have the expected signs which are significant at conventional levels. One exception is the growth rate in labor force growth equation which is now insignificant. Therefore, these results provide us with a fairly strong basis to evaluate the effects of two freedoms on the system. Holding the factor inputs, initial income and economic freedom constant in the growth equation, political freedom have positive effects on total factor productivity. Holding the other variables constant in this equation, economic freedom has also a positive and significant effect on total factor productivity. Holding economic freedom and other relevant independent variables constant in the factor input equations, political freedom has a negative and significant effect on physical capital accumulation, positive and significant effect on human capital accumulation, and negative and significant effect on labor force growth. Holding political freedom and other relevant independent variables constant in those equations, economic freedom has a positive and significant effects on factor accumulation variables, which are physical and human capital accumulation, and labor force growth.

The final issue is to find the total effect of institutions on growth. To do this, one can multiply the coefficient of freedom variables in the factor input equations with the coefficients of the factor inputs in the growth equation, respectively for each input. Then, adding this product to the coefficients of the freedom variables in the growth equation (total factor productivity) will give the total effect of each freedom on growth. Back-of-the-envelope calculations show that the total effect of political freedom on growth is 0.13, while the total effect of economic freedom on growth is 0.14. This implies that both types of institutions have positive effects on growth, and they are equally important for long-run development.

7 Conclusion and Extensions

In an encompassing framework, we analyzed the institutions-growth relationship. In the largest set of analysis, we find that the effects of political freedom on total factor productivity and human capital accumulation are positive and significant, but they are negative and significant on physical capital accumulation and labor force growth. Economic freedom, on the other hand, has positive and significant effects on total factor productivity, physical and human capital accumulation, and labor force growth.

Before drawing firm conclusions from these results, it is vital to carry out some sensitivity analyses. Our preliminary tests show that these results are fairly robust. However the tests should be expanded further, especially with respect to the choice of instruments. Recall that the ECGMM technique facilitates the use of several instruments, and one needs to see how the results change when the composition of the instrument list changes. Hence, our next step will be to analyze the "distribution" of partial correlations of important variables with respect to changes in the instruments lists, as far as the Sargan overidentification tests permit. Looking at the distribution of partial correlations instead of point estimates has been suggested by Sala-i Martin (1997). However, this has rarely been applied in the growth context. For our analysis, we think that it is relevant.

One can argue that including both political and economic freedom into a regression captures their nonorthogonal effects on growth, which can be limiting to see their full effects. While this argument may be correct, a quick look at the tables with single and double freedoms shows that their signs are stable across estimations. However, it is true that our approach so far assumes that institutions are exogenous to the system. There are strong theoretical and empirical arguments that institutions are endogenous (Helliwell 1994). Therefore, our further step is to endogeneize both political and economic freedoms, and augment the four-equation system estimated in this version of the paper to a six-equation system. In specifying the political freedom equation, Barro (1999) can be helpful where he investigates the determinants of democracy. Regarding the economic freedom equation, causality tests of Dawson (2003) can be our guide in specifying the determinants of economic freedom.

An additional and important issue is the exogeneity of the RHS variables. Apart from the modeled endogenous variables, we treat other variables as exogenous. This is partly because we adopt these variables from some well-known studies such as Tavares and Wacziarg (2001), who do the same treatment. However, in a more specific growth context like ours, this problem may need a more detailed approach. Failure of the exogeneity of one of the RHS variables can propagate a bias across the system, and thereby may lead to imprecise results. Hence, one of our next steps will be to check whether this bias exists or not, and if it does, to find out its extent. The way to address this issue is Monte Carlo simulations.

Our framework also makes possible the analysis of convergence rates across countries. While we confirm in most cases that there is convergence in output per worker across countries, the rate of convergence has been the main focus of Mankiw *et al.* (1992), Islam (1995) and Caselli *et al.* (1996). Because we eliminate econometric problems and test the neoclassical growth model by augmenting it with institutions, it will be implicative to see how the convergence rate changes through the analysis.

References

[1] Alesina, A. And Perotti, R. (1994). "The Political Economy of Growth: A critical survey of the recent literature", *The World Bank Economic Review*, 8: 351-71

[2] Arellano, M. and S. Bond (1991), "Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations", *Review of Economic Studies*, 58: 277-97.

[3] Aron J. (2000), "Growth and institutions: A review of the evidence", *World Bank Research Observer*, 15 (1): 99-135.

[4] Baltagi, B. (1981), "Simultaneous Equations with Error Components", *Journal of Econometrics*, 17: 189-200.

[5] Baltagi, B. (2001), "*Econometric Analysis of Panel Data*", John Wiley Sons and Ltd.

[6] Barro, R.J., (1991), "Economic Growth in a cross-section of countries", *Quarterly Journal of Economics*, 106:407-43.

[7] Barro, Robert J. (1996), "Democracy and Growth", *Journal of Economic Growth*, 1:1-27.

[8] Barro, R. (1999), "Determinants of Democracy," *Journal of Political Economy*, 107: S158-S183.

[9] Barro, R. and J. Lee (1993), "International Comparisons of Educational Attainment," *Journal of Monetary Economics*, 32: 363-94.

[10] Barro, R. and J. Lee (2000), "International Comparisons of Educational Attainment: Some Updates and Implications", *Oxford Economic Papers.*

[11] Barro, R. and X. Sala-i Martin (1995), "*Economic Growth*", McGraw Hill.

[12] Benhabib, J. And M. Spiegel (1994), "The Role of Human Capital in Economic Development: Evidence From Aggregate Cross Country Data", *Journal of Monetary Economics* 34, 143-79.

[13] Brunetti, A. and B. Weder, (1995), "Political Sources of Growth: A Critical Note on Measurement", *Public Choice*.

[14] Cass, D. (1965), "Optimum Growth in an Aggregative Model of Capital Accumulation", *Review of Economic Studies*, 32: 233-40.

[15] Chamberlain, G. (1982), "Multivariate Regression Models for panel data", *Review of Economic Studies*, 18, 5-46.

[16] Dawson, J.W. (1998). "Institutions, Investment and Growth: new cross-country and panel data evidence", *Economic Inquiry*, 36, pp. 603-19.

[17] Dawson, J.W. (2003). "Causality in the freedom-growth relationship", *European Journal of Political Economy*, 19, 479-95.

[18] De haan, J., (2003), "Economic Freedom: editor's introduction", *European Journal of Political Economy*, 19, 395-403.

[19] De Haan, Jakob and Siermann C. (1995), "A Sensitivity Analysis of the Impact of Democracy on Economic Growth", *Empirical Economics.*

[20] Caselli, F., G. Esquivel and F. Lefort. (1996), "Reopening the convergence debate: a new look at cross-country growth empirics." *Journal of Economic Growth*, 1, 363-390.

[21] Gwartney, J. and R. Lawson (2003), "*Economic Freedom of the World Annual Report*" , The Fraser Institute, Vancouver.

[22] Hall, R.E. and Jones, C.I. (1999). "Why Do Some Countries Produce So Much More Output Per Worker than Others?" *Quarterly Jorunal of Economics*, February, 83-116.

[23] Hausman, J. (1978), "Specification Tests in Econometrics", *Econometrica*, 46, 1251-71.

[24] Helliwell, John, (1994), "Empirical Linkages Between Democracy and Economic Growth", *British Journal of Political Science.*

[25] Holtz-Eakin, D. (1994), "Public sector capital and the productivity puzzle", *Review of Economics and Statistics*, 76, 12-21b

[26] Islam, N., (1995), "Growth Empirics: A Panel Data Approach", *Quarterly Journal of Economics*, November, pp. 1127-70.

[27] Koopmans, T.C. (1995), "On the Concept of optimal Economic Growth", in *The Economic Approach to Development Plannin*g, Pontifical Academy of Sciences.

[28] Levine, R. And Renelt, D. (1992), "A Sensitivity Analysis of Cross-Country Growth Regressions", *American Economic Review*, 82:942-963.

[29] Lin, J. and and J. Nugent (1995), "Institutions and Economic Development' in *Handbook of Economic Development*, vol. 3, eds. J. Behrman and T. Srinivasan, North Holland.

[30] Mankiw, N.G., D. Romer and D. Weil (1992), "A Contribution to the Empirics of Economic Growth", *Quaterly Journal of Economics*, May, pp. 407-37.

[31] Mauro, Paolo. (1995). "Corruption and Growth". *Quarterly Journal of Economics*. 681-712

[32] Minier, Jenny A. (1996), "Democracy and Growth: Alternative Approaches", *Journal of Economic Growth*

[33] Munnel, A. (1992), "Infrastucture Investment and Economic Growth", *Journal of Economic Perspectives*, 6:4, pp. 189-98.

[34] Nerlove and Balestra (1996), Formulation and estimation of econometric models for panel data, Chapter 1 in *The Econometrics of Panel Data: A Handbook of the Theory With Applications*, eds, L. Matyas and P. Sevestre, Kluwer Academic Publishers, pp. 3-22.

[35] North, D. (1990), "*Institutions, institutional change, and economic performance*", Cambridge University Press.

[36] Przeworski, A. and Limongi, F. 1993. "Political Regimes and Economic Growth", *Journal of Economic Perspectives*, 7:51-69.

[37] Rodrik, Dani (2000), "Institutions for High-Quality Growth: What They are How to Acquire Them," *Studies in International Comparative Development*, Fall 2000. vol. 35:3

[38] Sala-i-Martin, X. (1997), "I just ran two million regressions", *American Economic Review*, 87. pp.178-83.

[39] Sirowy, L and Inkeles, A. (1990), "The Effects of Democracy on Economic Growth and Inequality: a review", *Studies in Comparative International Development*, 25:126-57

[40] Solow, R. (1956), "A contribution to the Theory of Economic Growth", *Quarterly Journal of Economics*, 70: 65-94.

[41] Sturm JE, De Haan J. (2001), "How robust is the relationship between economic freedom and economic growth?" *Applied Economics*, 33 (7): 839-844

[42] Tavares, Jose and Wacziarg R. (2001), "How Democracy affects Growth", *European Economic Review*, 45:1341:78.

[43] Temple, J. (1999), "The new growth evidence", *Journal of Economic Literature*, March 1999, 37(1), 112-156

[44] World Bank (2003), World Development Indicators, CD ROM.

[45] Wu, W.B and Davis OA, 1999, "The two freedoms, economic growth and development: An empirical study", *Public Choice,* 100 (1-2): 39-64, July.

8 Appendix

Notes to the Tables

1. F-statistic$^{!}$ is the Chow test statistic that tests the null hypothesis that all country-specific effects are jointly equal to zero (Within estimation is reported only for Table 1).

2. F-statistic$^{!!}$ is the Wald test statistic that tests the joint significance of the residuals of suspected endogenous variables (factor inputs) in being jointly equal to zero. (The testing procedure is reported only for the textbook Solow Model).

3. * denotes significance level at 10%, ** denotes significance level at 5%, and *** denotes significance level at 1%.

4. In parantheses are the t-statistics, except the ones in Summary Statistics table which are the standard deviations of the means.

5. Political rights and civil liberties data represent political freedom in a descending order, i.e, as the score increases, the level of political freedom declines.

6. Economic freedom measure represents freedom in an ascending order.

Summary Statistics – Means and Std. Deviations

	BIG	NT	NT/NS	GOOD	OECD
$\ln(y_{it}) - \ln(y_{i,t-1})$	0.046	0.049	0.048	0.051	0.086
	(0.162)	(0.156)	(0.141)	(0.138)	(0.069)
s_k	0.225	0.221	0.216	0.213	0.236
	(0.080)	(0.070)	(0.068)	(0.066)	(0.042)
s_h	0.091	0.090	0.088	0.090	0.185
	(0.087)	(0.088)	(0.091)	(0.093)	(0.111)
$n + g + \delta$	0.072	0.074	0.073	0.073	0.061
	(0.016)	(0.015)	(0.010)	(0.010)	(0.007)
Political Freedom	3.681	3.645	3.751	3.675	1.413
	(1.950)	(1.938)	(1.931)	(1.922)	(0.848)
Economic Freedom	5.591	5.629	5.587	5.636	6.560
	(1.157)	(1.160)	(1.161)	(1.151)	(0.909)

Note: See the notes at the beginning of the Appendix.

Table 1a. Textbook Solow Model – OLS Estimation

	BIG	NT	NT/NS	GOOD	OECD
Constant	-0.644***	-1.065***	-0.967***	-0.867***	-0.360*
	(-6.429)	(-9.784)	(-7.841)	(-7.020)	(-1.909)
$\ln(s_k)$	0.158***	0.188***	0.186***	0.193 ***	0.053*
	(8.269)	(10.342)	(9.904)	(10.087)	(1.649)
$\ln(n+g+\delta)$	-0.104***	-0.254***	-0.215***	-0.166***	-0.232***
	(-3.090)	(-6.780)	(-4.814)	(-3.657)	(-4.339)
$\ln(y_{t-1})$	-0.008*	-0.015***	-0.014***	-0.012***	-0.035***
	(-1.874)	(-3.615)	(-3.045)	(-2.598)	(-3.378)
No. of Obs.	638	597	506	477	131
Adjusted R^2	0.11	0.19	0.18	0.20	0.13
Res. sum of Sq.	15.05	11.63	8.23	7.46	0.52

Table 1b. Textbook Solow Model – Within Estimation

	BIG	NT	NT/NS	GOOD	OECD
$\ln(s_k)$	0.127***	0.122***	0.140***	0.129	-0.005
	(5.626)	5.511	(6.083)	(5.494)	(-0.097)
$\ln(n+g+\delta)$	-0.135***	-0.166***	-0.198***	-0.169	-0.228***
	(-2.563)	-2.982	(-3.092)	(-2.609)	(-3.203)
$\ln(y_{t-1})$	-0.274***	-0.237***	-0.222***	-0.202	-0.097***
	(-11.890)	-10.513	(-8.754)	(-7.809)	(-2.588)
No. of Obs.	638	597	506	477	131
Adjusted R^2	0.21	0.18	0.17	0.14	0.11
Res. sum of Sq.	8.47	7.15	5.41	5.04	0.38
F-statistic!	3.40***	2.95***	2.52***	2.32***	1.86**

Note: See the notes at the beginning of the Appendix.

Table 2. Hausman Tests for Textbook Solow Model

	BIG	NT	NT/NS	GOOD	OECD
Constant	-0.320	-0.952***	-1.472***	-1.446***	-1.471***
	(-1.477)	(-4.012)	(-5.961)	(5.794)	(-2.579)
$\ln(s_k)$	0.205***	0.247***	0.294***	0.311***	0.096
	(3.985)	(5.140)	(7.332)	(7.771)	(1.406)
$\ln(n+g+\delta)$	0.101	-0.133*	-0.317***	-0.292***	-0.670***
	(1.590)	(-1.862)	(-3.851)	(-3.478)	(-3.698)
$\ln(y_{t-1})$	0.000	-0.012**	-0.025***	-0.025***	-0.058***
	(0.042)	(-1.946)	(-3.717)	(-3.654)	(-4.331)
Res_$\ln(s_k)$	-0.002	-0.002	-0.005***	-0.006***	-0.000
	(-0.630)	(-0.917)	(-2.593)	(-2.821)	(-0.019)
Res_$\ln(n+g+\delta)$	-3.632***	-2.015**	1.808	2.271*	7.250**
	(-3.686)	(-2.050)	(1.327)	(1.644)	(2.545)
F-statistic!!	8.52***	3.82**	3.44**	4.18**	3.64**

Note: See the notes at the beginning of the Appendix.

Table 3. Human Capital-Augmented Solow Model

	BIG	NT	NT/NS	GOOD	OECD
Constant	-0.950***	-1.093***	-0.942***	-0.851***	-0.371*
	(-8.233)	(-8.875)	(-7.223)	(-6.534)	(-1.888)
$\ln(s_k)$	0.207***	0.214***	0.195***	0.204***	0.053
	(10.447)	(10.639)	(9.396)	(9.587)	(1.564)
$\ln(s_h)$	0.005	0.010	0.015**	0.014**	-0.000
	(0.665)	(1.340)	(2.116)	(1.965)	(-0.005)
$\ln(n+g+\delta)$	-0.208***	-0.273***	-0.230***	-0.179***	-0.234***
	(-5.600)	(-6.655)	(-5.154)	(-3.970)	(-4.135)
$\ln(y_{t-1})$	-0.022***	-0.028***	-0.027***	-0.024***	-0.035**
	(-3.737)	(-4.661)	(-4.399)	(-3.940)	(-2.228)
Adjusted R^2	0.21	0.22	0.20	0.21	0.13
F-statistic!	2.51***	2.61***	2.32***	2.09***	1.71**
F-statistic!!	2.36*	1.74	1.87	2.69**	3.44**

Note: See the notes at the beginning of the Appendix.

Table 4a. $\ln(s_k)$ Regressions – Good Sample

	Model 1	Model 2	Model 3	Model 4
Constant	-2.884***	-2.083***	-2.031***	-2.039***
	(-5.886)	(-4.471)	(-4.389)	(-4.422)
$\ln(y_{it}) - \ln(y_{i,t-1})$		0.732***	0.748***	0.721***
		(7.781)	(8.077)	(7.953)
Log(GDP)	0.020**	0.010		
	(1.967)	(0.973)		
Female Sec. Sch.	-0.007***	-0.006***	-0.006***	-0.004***
	(-4.383)	(-3.735)	(-3.848)	(-2.933)
Male Sec.Sch.	0.003*	0.002	0.003*	0.002
	(1.861)	(1.480)	(1.813)	(1.098)
Log(Life Expec.)	1.346***	1.188***	1.229***	1.249***
	(10.068)	(9.438)	(10.360)	(10.557)
Govt. Cons.	0.004	0.006***	0.006*	
	(1.594)	(2.615)	(2.499)	
Log(1+BMP)	-0.012	-0.001	-0.002	
	(-1.383)	(-0.070)	(-0.186)	
Terms of Trade Gr.	-0.367	-0.373	-0.379	
	(-1.419)	(-1.388)	(-1.410)	
No. of Obs.	433	431	431	450
Adjusted R^2	0.36	0.44	0.44	0.43
F-statistic!	3.92***	3.29***	2.91***	3.23***

Note: See the notes at the beginning of the Appendix.

Table 4b. ln(s_k) Regressions – Other Samples (Model 4)

	BIG	NT	NT/NS	OECD
Constant	-0.481	-0.663	-1.744***	-4.023**
	(-1.120)	(-1.546)	(-3.824)	(-2.052)
$\ln(y_{it}) - \ln(y_{i,t-1})$	0.539***	0.670***	0.670***	0.362*
	(7.388)	(8.518)	(7.450)	(1.654)
Female Sec. Sch.	-0.004**	-0.004***	-0.006***	-0.004**
	(-2.428)	(-2.676)	(-4.362)	(-2.213)
Male Sec. Sch.	0.003*	0.002	0.004***	-0.001
	(1.785)	(1.583)	(2.906)	(-0.219)
Log (Life Expec.)	0.860***	0.910***	1.173***	1.757***
	(7.832)	(8.269)	(10.052)	(3.752)
No. of Obs.	598	560	479	126
Adjusted R^2	0.27	0.30	0.38	0.15
F-statistic!	4.22***	4.54***	3.93***	7.18***

Note: See the notes at the beginning of the Appendix.

Table 5a. ln(s_h) Regressions – Good Sample

	Model 1	Model 2	Model 3	Model 4
Constant	-4.098***	-3.492***	1.373***	1.435
	(-6.192)	(-5.176)	(6.438)	(7.231)
$\ln(y_{it}) - \ln(y_{i,t-1})$		0.429	1.209***	1.167
		(1.500)	(4.258)	(4.134)
log (GDP)	0.225***	0.202***		
	(8.867)	(7.550)		
Urbanization	0.013***	0.014***	0.022***	0.020
	(5.035)	(5.435)	(8.875)	(8.822)
Urbanization Gr.	-0.185***	-0.206***	-0.285**	-0.294
	(-6.115)	(-6.962)	(-9.631)	(-9.975)
Govt. Cons.	-0.012	-0.007	-0.007	
	(-1.556)	(-0.957)	(-0.917)	
Openness	0.005***	0.005***	0.001	
	(4.301)	(3.648)	(1.012)	
Protestant	0.359***			
	(2.747)			
Catholic	0.048			
	(0.511)			
Muslim	0.000			
	(0.002)			
No. of Obs.	424	422	422	430
Adjusted R^2	0.67	0.67	0.63	0.62
F-statistic!	18.30***	18.94***	20.05***	19.17***

Note: See the notes at the beginning of the Appendix.

Table 5b. ln(s_h) Regressions – Other Samples (Model 4)

	BIG	NT	NT/NS	OECD
Constant	1.184***	1.154***	1.376***	3.198**
	(7.984)	(7.558)	(7.204)	(8.527)
$\ln(y_{it}) - \ln(y_{i,t-1})$	0.696***	0.7474***	1.033***	-1.095
	(3.030)	(3.185)	(3.846)	(-1.429)
Urbanization	0.023***	0.023***	0.021***	-0.000
	(12.637)	(12.571)	(9.591)	(-0.075)
Urbanization Gr.	-0.235***	-0.2311***	-0.281***	-0.308***
	(-11.187)	(-10.625)	(-10.031)	(-5.609)
No. of Obs.	522	507	453	126
Adjusted R^2	0.59	0.59	0.61	0.27
F-statistic!	15.44***	17.29***	18.81***	22.44***

Note: See the notes at the beginning of the Appendix.

Table 6a. ln($n + g + \delta$) Regressions – Good Sample

	Model 1	Model 2	Model 3	Model 4
Constant	-1.858***	-1.902***	-3.615***	-3.731***
	(-3.536)	(-3.606)	(-21.311)	(-28.984)
$\ln(y_{it}) - \ln(y_{i,t-1})$		-0.285	-0.338*	-0.298
		(-1.385)	(-1.624)	(-1.550)
log (GDP)	-0.078***	-0.074***		
	(-3.619)	(-3.426)		
Female Pri. Sch.	0.014***	0.014***	0.012***	0.014***
	(4.803)	(4.759)	(4.069)	(5.035)
Male Pri. Sch.	-0.008***	-0.008**	-0.006**	-0.007
	(-2.594)	(-2.488)	(-1.992)	(-2.156)
Female Sec. Sch.	-0.018***	-0.017***	-0.017***	-0.015***
	(-4.516)	(-4.473)	(-4.387)	(-4.145)
Male Sec. Sch	0.004	0.004	0.001	-0.001
	(0.951)	(0.860)	(0.276)	(-0.293)
Govt. Cons.	-0.002	-0.003	0.001	
	(-0.296)	(-0.509)	(0.200)	
Sub-saharan Afr.	-0.212**	-0.244***	-0.138	
	(-2.342)	(-2.592)	(-1.536)	
Latin America	0.078	0.041	0.1230	
	(0.862)	(0.433)	(1.412)	
No. of Obs.	443	441	441	445
Adjusted R^2	0.43	0.43	0.42	0.41
F-statistic!	5.58***	5.77***	6.05***	6.17***

Note: See the notes at the beginning of the Appendix.

Table 6b. ln$(n+g+\delta)$ Regressions − Other Samples (Model 4)

	BIG	NT	NT/NS	OECD
Constant	-3.725***	-3.684***	-3.748***	-4.185**
	(-28.065)	(-31.757)	(-30.931)	(-3.637)
$\ln(y_{it}) - \ln(y_{i,t-1})$	-0.5725***	-0.705***	-0.391***	-2.894***
	(-3.285)	(-4.562)	(-2.175)	(-2.767)
Female Pri. Sch.	0.015***	0.014***	0.014***	0.0086
	(5.115)	(5.575)	(5.251)	(0.375)
Male Pri. Sch.	-0.007**	-0.007**	-0.007***	-0.002***
	(-2.162)	(-2.541)	(-2.168)	(-0.117)
Female Sec. Sch.	-0.019***	-0.016**	-0.016	-0.017**
	(-4.915)	(-4.854)	(-4.643)	(-1.952)
Male Sec. Sch.	0.002	0.001	-0.000	0.007
	(0.412)	(0.293)	(-0.058)	(0.679)
No. of Obs.	575	554	47	1256
Adjusted R^2	0.36	0.38	0.41	0.15
F-statistic[!]	7.55***	6.90***	6.40***	4.04***

Note: See the notes at the beginning of the Appendix.

Table 7. System Estimation (Based on Model 4) – Good Sample

		GMM		ECGMM	
Dependent Var.		Coeff.	t-stat.	Coeff.	t-stat
$\ln(y_{it}) - \ln(y_{i,t-1})$	Constant	-0.806***	-5.332		
	$ln(s_k)$	0.123***	4.008	0.089***	4.723
	$ln(s_h)$	0.022***	2.950	0.184***	8.055
	$\ln(n+g+\delta)$	-0.239***	-4.814	-0.194***	-4.759
	$\ln(y_{-i})$	-0.022***	-3.746	-0.119***	-7.754
$ln(s_k)$	Constant	0.036	0.052		
	$\ln(y_{it}) - \ln(y_{i,t-1})$	2.864***	8.665	1.534***	9.310
	Female Sec. Sch.	-0.001	-0.560	-0.003	-1.075
	Male Sec. Sch.	-0.001	-0.486	0.001	0.393
	Log(Life Expec.)	0.718***	4.084	0.740***	90.083
$ln(s_h)$	Constant	1.443***	6.773		
	$\ln(y_{it}) - \ln(y_{i,t-1})$	4.803***	7.837	2.317***	50.63
	Urbanization	0.017***	7.330	0.035***	39.216
	Urbanization Gr.	-0.297***	-9.370	-0.123***	9.112
$\ln(n+g+\delta)$	Constant	-3.773***	-42.879		
	$\ln(y_{it}) - \ln(y_{i,t-1})$	-0.357	-1.488	-2.189***	-3.445
	Female Pri. Sch.	0.017***	7.651	-0.003	-0.412
	Male Pri. Sch.	-0.009***	-3.133	-0.014**	-2.346
	Female Sec. Sch.	-0.016***	-4.319	0.051***	9.730
	Male Sec. Sch.	0.002	0.415	-0.031***	-21.849
No. of Obs.		395		389	
Total System Obs.		1456		2850	

Note: See the notes at the beginning of the Appendix.

Table 8a. Institutions-Augmented System (ECGMM) – Good Sample

		I : Political Rights		I : Civil Liberties	
DependentVar.		Coeff.	t-stat.	Coeff.	t-stat
$\ln(y_{it}) - \ln(y_{i,t-1})$	$ln(s_k)$	0.1943***	7.028	0.227***	8.203
	$ln(s_h)$	0.083***	3.961	0.046**	2.260
	$\ln(n+g+\delta)$	-0.136***	-4.517	-0.110***	-3.681
	$\ln(y_{-i})$	-0.101***	-12.138	-0.093***	-11.663
	I	-0.042***	-4.526	-0.054***	-6.156
$ln(s_k)$	$\ln(y_{it}) - \ln(y_{i,t-1})$	2.148***	7.090	1.926***	5.330
	Female Sec. Sch.	0.006	1.468	0.006	1.350
	Male Sec. Sch.	-0.007	-1.434	-0.004	-0.737
	Log(Life Expec.)	0.696***	24.576	0.632***	21.427
	I	0.029**	1.981	0.059***	4.406
$ln(s_h)$	$\ln(y_{it}) - \ln(y_{i,t-1})$	1.742***	4.340	2.658***	4.451
	Urbanization	0.037***	31.229	0.036***	27.659
	Urbanization Gr.	-0.101***	-4.646	-0.111***	2.619
	I	-0.023	-1.479	-0.026	-0.731
$\ln(n+g+\delta)$	$\ln(y_{it}) - \ln(y_{i,t-1})$	-4.237***	-2.746	-7.039***	-2.523
	Female Pri. Sch.	0.054***	2.985	0.065	2.841
	Male Pri. Sch.	-0.081***	-3.365	-0.107**	-3.188
	Female Sec. Sch.	-0.069***	-2.927	-0.066*	-1.887
	Male Sec. Sch.	0.051**	1.757	0.061	1.385
	I	0.150	1.135	0.472***	3.100
No. of Obs.		389		389	
Total System Obs.		2850		2850	

Note: See the notes at the beginning of the Appendix.

Table 8b. Institutions-Augmented System (ECGMM) – Good Sample

		I : Political Freedom		I : Economic Freedom	
Dependent Var.		Coeff.	t-stat.	Coeff.	t-stat
$\ln(y_{it}) - \ln(y_{i,t-1})$	$ln(s_k)$	0.166***	6.052	0.146***	2.992
	$ln(s_h)$	0.100***	4.667	0.097*	1.789
	$\ln(n+g+\delta)$	-0.103***	-2.912	-0.123	-1.253
	$\ln(y_{-i})$	-0.092***	-8.593	-0.018	-0.513
	I	-0.024***	-2.754	0.123***	4.047
$ln(s_k)$	$\ln(y_{it}) - \ln(y_{i,t-1})$	1.820***	5.392	1.341***	7.243
	Female Sec. Sch.	0.008*	1.933	-0.006*	-1.789
	Male Sec. Sch.	-0.006	-1.178	0.004	-0.737
	Log(Life Expec.)	0.626***	20.812	0.710***	34.762
	I	0.068***	4.682	0.023	1.314
$ln(s_h)$	$\ln(y_{it}) - \ln(y_{i,t-1})$	3.0562***	7.116	6.915***	7.518
	Urbanization	0.035***	27.247	0.048***	17.232
	Urbanization Gr.	-0.123***	-3.748	-0.014***	14.809
	I	-0.002	-0.060	0.046	1.590
$\ln(n+g+\delta)$	$\ln(y_{it}) - \ln(y_{i,t-1})$	-6.118***	-2.9346	5.512***	4.209
	Female Pri. Sch.	0.057***	3.210	0.074	3.338
	Male Pri. Sch.	-0.088***	-3.803	-0.120***	-5.582
	Female Sec. Sch.	-0.071**	-2.224	0.048**	2.316
	Male Sec. Sch.	0.058	1.526	-0.125***	-5.261
	I	0.242*	1.819	1.003***	5.829
No. of Obs.		389		389	
Total System Obs.		2850		2764	

Note: See the notes at the beginning of the Appendix.

Table 8c. Institutions-Augmented System (ECGMM) − Good Sample

		I : Institutions (Pol. + Econ. Free.)	
DependentVar.		Coeff.	t-stat.
$\ln(y_{it}) - \ln(y_{i,t-1})$	$ln(s_k)$	0.330***	5.140
	$ln(s_h)$	0.076*	1.861
	$\ln(n+g+\delta)$	-0.144**	-2.060
	$\ln(y_{-i})$	-0.040**	-1.971
	I_1 : Pol. Freedom	-0.038**	-2.161
	I_2 : Econ. Freedom	0.167***	7.275
$ln(s_k)$	$\ln(y_{it}) - \ln(y_{i,t-1})$	2.615***	7.579
	Female Sec. Sch.	0.014***	2.939
	Male Sec. Sch.	-0.016	-2.848
	Log(Life Expec.)	0.858***	11.389
	I_1 : Pol. Freedom	0.051***	2.563
	I_2 : Econ. Freedom	0.077***	2.539
$ln(s_h)$	$\ln(y_{it}) - \ln(y_{i,t-1})$	5.443***	4.084
	Urbanization	-0.005	-0.524
	Urbanization Gr.	0.179***	1.915
	I_1 : Pol. Freedom	-0.737***	-6.676
	I_2 : Econ. Freedom	0.672***	4.823
$\ln(n+g+\delta)$	$\ln(y_{it}) - \ln(y_{i,t-1})$	-1.416	-0.886
	Female Pri. Sch.	0.060***	4.316
	Male Pri. Sch.	-0.123***	-7.036
	Female Sec. Sch.	-0.021	-0.772
	Male Sec. Sch.	-0.014	-0.437
	I_1 : Pol. Freedom	0.390***	4.942
	I_2 : Econ. Freedom	0.695***	5.066
No. of Obs.		389	
Total System Obs.		2768	

Note: See the notes at the beginning of the Appendix.