INSTITUTIONS, INNOVATION AND ECONOMIC GROWTH

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This article contributes to the growth literature by developing a formal growth model that provides the basis for studying institutions and technological innovation and examining how human capital and institutional constraints affect the *transitional* and *steady state* growth rates of output. The model developed in this article shows that the reason that growth models à la Romer (1990) generate endogenous growth is the use of a set of restrictive and unrealistic assumptions regarding the role of institutions in the economy. The *baseline model* developed in this article shows that the long-run growth of the economy is intrinsically linked to institutions and suggests that an economy with institutions that retard or prevent the utilization of newly invented inputs will experience low levels and low growth rates of output. The model also predicts that countries with institutional barriers that prevent or restrict the adoption of newly invented technologies will allocate a relative small share of human capital in the R&D sector. Moreover, both the baseline and the extended version of the model suggest that sustainable growth in human capital, not an increase in the stock of human capital, generates a *growth effect*.

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1.   INTRODUCTION

Economists recognize that the quality of institutional arrangements play a key role in explaining long-run economic performance (North and Thomas (1973), Engerman and Sokoloff (1997, 2005), Hall and Jones (1999), Rodrik (2000, 2003), Sala-i-Martin (2002), Easterly and Levine (2003), Gradstein (2004), Glaeser *et al.* (2004), Acemoglu *et al.* (2001, 2005)). Despite the growing recognition of the importance of institutions,[1]

[1] There is a large and growing empirical literature on the impacts of institutions on economic performance (e.g., Gastil (1979), Kormendi and Meguire (1985), Knack and Keefer (1995), Mauro (1995), Hall and Jones

difficulties in introducing institutions into standard economic growth models have inhibited the development of a formal growth framework capable of explaining the dynamic linkages between institutions and long-run economic performance. Fundamentally, growth economists are still struggling to model the linkages between institutional quality and innovation and to incorporate institutions into the standard theoretical framework of economic growth (Sala-i-Martin (2002), Huang and Xu (1999)). "We are still in the early stages when it comes to incorporating institutions into our growth theories" (Sala-i-Martin (2002, p. 18)).

Solovian models and endogenous growth models are built from the premise that income levels and income growth are determined by resource endowments (physical capital and human capital) and factor productivity [technology] (e.g., Solow (1956), Romer (1986, 1990), Lucas (1998) Grossman and Helpman (2001 [1991]), Aghion and Howitt (1992), Jones (1995), Young (1998), Segerstrom (1998)). Models in this tradition do not specify the role of institutions in the determination of income. Only a few studies have successfully incorporated institutions into the formal framework currently used to evaluate economic growth (e.g., Huang and Xu (1999), and Gradstein (2002, 2004)). While useful, these models focus the analysis on particular kinds of institutions and examine very specific issues. Thus, the dynamic association among institutions, innovation and income are not evaluated within a general framework that can answer basic questions such as: do institutions have growth or level effects on *per capita* income and does human capital interact with institutions? A model of growth that ignores the role of institutions may oversimplify the analysis and put out of sight important linkages in the dynamics of economic growth. Therefore, it seems that there is still a great deal of work with modeling the association between institutions and economic performance.

This article contributes to the growth literature by developing a formal growth model that provides the basis for studying institutions and technological innovation. It examines how institutional constraints affect the *transitional* and *steady state* growth rates of output and models the interactions between institutions and human capital. In particular, it studies how the quality of institution affects the allocation of human capital to the R&D industry and the impacts of human capital on R&D and income growth in economies with poor institutions. The model also provides testable implications and the basis for specifying an empirical model for studying innovation and institutions.

The rest of the article is organized as follows. Section 2 discusses the conceptual framework used to model the links between institutions, innovation and the adoption of new technologies in the productive process and then develops a baseline theoretical model. Section 3 discusses the baseline model's implication. Section 4 focuses on the links between human capital and institutions and presents an extension of the baseline model. Section 5 summarizes the article's findings.

(1999), Barro (1999), La Porta *et al.* (1999), Acemoglu *et al.* (2001, 2005), Easterly and Levine (2003)).

2. CONCEPTUAL FRAMEWORK

A major difficulty in dealing with institutions is their conceptualization.[2] For instance, Engerman and Sokoloff (1997) argue that institutions should be "interpreted broadly to encompass not only formal political and legal structures but culture as well" (p. 261). North (1990) proposes examining institutions in terms of formal and informal rules and enforcement of procedures. The New Institutional Economic school considers institutions as the "application and extension of concepts such as transaction costs, property rights, public choice, and ideology" (Furubotn and Richter (2005, p. 37)). Overall, this conceptualization is very general and provides little aid in building a workable framework for the measurement and modeling of institutional arrangements. Sala-i-Martin (2002) suggests a pragmatic conceptualization of institutions in terms of a set of elements related to the ways that a society and its economy works in modern capitalism. He argues that *institutions* (or institutional arrangements) should account for the enforcement of contracts, protection of property rights, perceptions that the judiciary system is predictable and effective, transparency of the public administration, control of corruption, and pro-market regulations.

In any event, from a theoretical standpoint, it would be intractable to incorporate every single nuance related to the concept of *institutions*. Therefore, in this article the quality of institutions (T) is treated as an aggregative index that measures attributes such as enforcement of contracts and property rights, perceptions that the judiciary system is predictable and effective, transparency of the public administration, control of corruption, and pro-market regulations.[3] Moreover, this aggregate variable, T, is assumed to be continuous, increasing with the quality of institutions, and grow at a constant rate, g_T. This specification relies heavily on the idea that institutions change slowly and smoothly over time (Matthews (1986), Atkinson (1998)).[4] More precisely,

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[2] An *institution* is related to a "significant and persistent element (as a practice, a relationship, an organization) in the life of a culture that centers on a fundamental human need, activity, or value, occupies an enduring and cardinal position within a society and is usually maintained and stabilized through social regulatory agencies" (Merrian-Webster (1993, p. 1171)).

[3] Empirical analyses on institutions have been conducted using *objective* and *subjective* measures of institutional quality. Objective measures quantify institutional aspects that are observable cross-countries, such as the number of political assassinations, number of revolutions and coups and policy volatility. The subjective measures of institutions are mainly assembled by private companies (e.g., Transparency International) and based on an assessment of *perception*. These companies conduct perception surveys of "economic agents who make growth-relevant decisions" (Grogan and Moers (2001, p. 326)) about factors such as corruption, contract enforcement, protection of property rights, political instability, etc.

[4] It could be argued that institutional change takes place as a discrete process (or shocks) rather than as a continuous and smooth process. However, treating institutional changes as a discrete process would create additional modeling difficulties and we think that this issue should be addressed in further research.

once institutions are built, economic, social, and political mechanisms generated as a byproduct of those institutions are expected to set constraints on future institutional changes, so that those early institutional arrangements tend to persist over time (Engerman and Sokoloff (1997, 2005), La Porta *et al.* (1999), Acemoglu *et al.* (2001)).

It is also important to acknowledge that institutional change (or growth of institutions) results from endogenous forces that are set in place by the quality and flexibility of the institution itself. For instance, institutional arrangements that allow for flexibility will allow the economic, political, and social forces to make changes to institutions so that private and/or public agents can "take advantage of new opportunities that arise as technology or the environment changes" (Engerman and Sokoloff (2005, p. 12)).[5] Therefore, the model developed in this article considers that *institutional growth* consists of changes in the legal system, regulations, enforcement of laws and culture aimed at improving the quality of the institutional structure of a country. Thus, *institutional growth* is expected to facilitate the decision-making process and increase the efficiency of resource allocation.

2.1. The Baseline Model

Figure 1 synthesizes the structure of the model we develop and shows a schematic representation of a hypothetical economy where human capital, technical innovation and intermediate inputs are the proximal-causal factors of income (levels and growth). Institutions are considered the fundamental determinants of income because they have a direct effect on income generation through affects on factor productivity as well as an impact on human capital accumulation and on technical innovation, which are the direct and proximal-causal determinants of income.

For simplicity, the model is developed assuming that population and human capital are exogenously determined and constant. The baseline model overlooks the effects from human capital accumulation on institutions. This hypothesis is relaxed later in the *extended model*, which examines how the results of the baseline model change when we allow for human capital to impact the quality of institutions. It is worth noticing that the model developed in this article is not intended to provide a comprehensive and complete analysis of institutions and economic performance, but rather it is aimed at providing the formal basis for studying how institutions and economic performance are inter-related. The model helps to examine the channels by which institutions affect technical innovation and consequently economic growth.

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[5] "Perhaps the most important elements of institutional structures are those that ensure an ability to adapt to different conditions and to adjust to new circumstances as seems necessary" (Engerman and Sokoloff (2005, p. 13)).
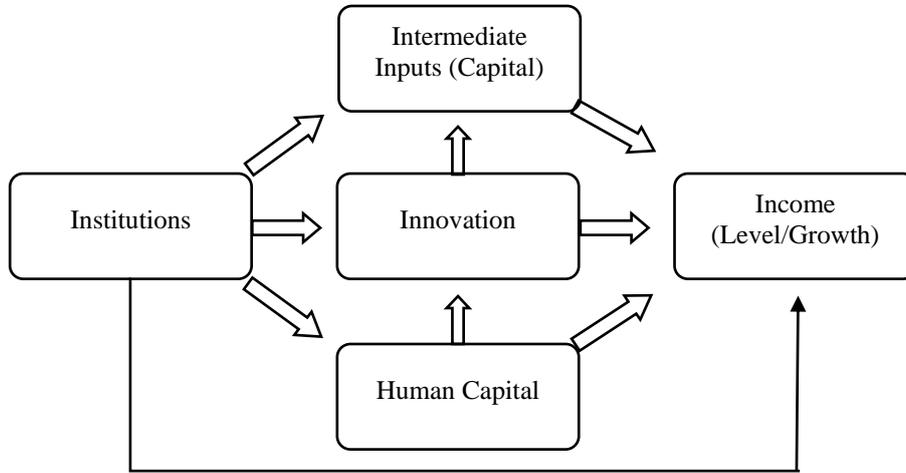
Figure 1. A Schematic Model Economy

The model economy has the structure used by Romer (1990). The economy has three sectors. One sector produces a final good using human capital and a weighted aggregate measure of intermediate inputs. A second sector produces intermediate inputs using forgone consumption and the projects (knowledge) are developed in the third sector, which conducts research and development (R&D). The complete specification of each of these sectors is discussed below.

2.1.1. Final Good Sector

The representative firm that produces the final good utilizes a constant-returns-to-scale (CRS) technology and operates in a market characterized by perfect competition. Output is produced using the following production function:

$$Y = H_Y^\beta \int_0^{f(A,T)} x(i)^\alpha \, di \,, \tag{1}$$

where H_Y is human capital employed in the final good sector, $x(i)$ denotes intermediate inputs, A denotes knowledge,[6] T measures the quality of institutions and is assumed to be increasing with the quality of the institutional structure, i indexes the

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[6] A is measured by the number of intermediate inputs already invented and available for use at any time with $x(i) = 0$ for all $i > A$. Moreover, A only increases if a newly invented intermediate input is superior in productivity compared to the existing intermediate inputs.

variety of intermediate inputs, $0 < \alpha < 1$, $0 < \beta < 1$, and $\alpha + \beta = 1$.[7]

Equation (1) is a modified version of the production function found in Romer (1990). Romer's model hypothesizes that all newly invented technologies can be instantaneously used in the production process. Instead, the specification here models potential institutional barriers to the adoption of new technologies into the production process. In a competitive market, firms are willing to use all intermediate inputs already invented and available if the cost of buying that input is less than or is equal to its marginal product. However, firms may have trouble in their decision to adopt newly productivity-increasing technologies due to institutional-related constraints, such as labor market imperfections (e.g., restrictive labor contracts or a union's bargaining power) and government regulations. These constraints may hold back the introduction of newly invented technologies in the production process (Baldwin and Lin (2002), Haucap and Wey (2004)). We use a particular and perhaps restrictive f function to express these ideas mathematically.[8]

$$Y = H_Y^\beta \int_0^{\min(\psi T, A)} x(i)^\alpha \, di \quad , \tag{2}$$

where $\psi (0 < \psi \leq 1)$ is a scale adjusting parameter that accounts for the influence of institutions on the adoption of new technologies and can be interpreted as a measure of the importance of institutional arrangements for the adoption of new technologies.

Equation (2), therefore, assumes that either technological improvements (A) or Institutions (T), but not both, have marginal effects on output. The logic behind this formulation is that an economy may face institutional constraints to the adoption of new technologies in the productive process. In this case, only improvements in institutions (T) will allow the economy to incorporate newly invented inputs in the production process. This specification implies that "institutions need continual adaptation in face of a changing environment of technology" (Matthews (1986, p. 908)). Without changes in current institutions, the economy cannot fully exploit the efficiency gains from current innovation and so "institutional change is a necessary part of economic growth" (Matthews (1986, p. 908)).[9] We also assume that in the long run, the rate of innovation is at most equal to the rate in which institutions change, that is, an economy cannot innovate indefinitely without adapting its institutions to the new technologies (Atkinson (1998), Engerman and Sokoloff (2005)). Under these assumptions, an economy may not be able to utilize available new technologies due to institutional barriers. Mathematically,

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[7] Notice that the argument time (t) is suppressed in all equations.

[8] Although restrictive, this specification generates a workable model and allows us to examine the impacts of institutions on the adoption of new technology. Other general functional specifications have caused difficulties in solving the model.

[9] See also Engerman and Sokoloff (2005).

we represent this case by setting $A > \psi T$, so the production function becomes:

$$Y = H_Y^{\beta} \int_0^{\psi T} x(i)^{\alpha} \, di \; .$$ (3)

This specification is consistent with case studies that examine how institutional-related constraints affect the adoption of new technologies.[10]

2.1.2.   The Intermediate Sector

A key feature of endogenous growth models is that they allow for imperfect competition in the intermediate sector, which makes the market structure relatively complex and constrains the researcher to model this sector in terms of a representative firm. In this study, it is assumed that there is a distinct producer for each input i, who must buy the patent (design) of that input from an R&D producer.[11] The model considers that there is only one producer of input $i,$ which implies that there is only one seller of input i who will face a downward sloping demand curve. However, because institutions may bind the adoption of new technologies, newly invented inputs might not be used for a while, so their marginal product and price would be driven to zero over the period of time for which institutions bind the adoption of the newly invented inputs. Therefore, at a point in time, the inverse demand function for input i — which can be derived from the profit optimality conditions of the producer of the final good — is given by:

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[10] For instance, one can make the case that government regulations prevent the use, production and commercialization of genetically modified crops; a productivity-increasing technology. There is a noticeable concentration of the production of transgenic crops in a few countries (James (2004)) while transgenic seeds have been widely available for commercialization since 1996 (James and Krattigger (1996)). Institutional arrangements explain much of this. First, innovating countries may be afraid of delivering new technologies to countries with a poor system of property rights protection (Krattiger (1997)). In this case, institutionally backward countries are not able to learn and adapt the new technologies because they have no access to the technology needed to manipulate the genetically altered seeds. This may lessen the benefits of using transgenic seeds in institutionally backward countries. However, these countries would still be able to buy transgenic seeds from the leading innovating countries. Second, biosafety regulatory laws impose strong constraints on the implementation of the production and commercialization of genetically altered seeds in many countries around the world (Krattiger (1997), James (2004)).

[11] Models in the Romer (1990) tradition assume that the intermediate inputs can be produced using the same technology utilized to produce the final good, where consumption is forgone (in the form of capital) in order to produce the intermediate inputs. For simplicity, it is assumed here that each unit of consumption forgone can generate one unit of capital that can be used in the production of intermediate inputs.

$$p_i = \begin{cases} \alpha H_Y^{\beta} x_i^{\alpha-1} & if \quad \psi T \geq A, \\ 0 & if \quad \psi T < A. \end{cases} \tag{4}$$

Because we assume that institutions are continuously changing at a positive rate, eventually all newly invented inputs can be used to produce final goods. This, however, affects the intertemporal profitability of the producer of intermediate goods. We consider this issue below when modeling the value of innovation. For now, assume that the producer of intermediate inputs faces an opportunity cost of capital equal to the interest rate (r) and that the cost of buying a patent is fixed, so it can be omitted from the profit function:

$$\pi(i) = p(i)x(i) - rx(i). \tag{5}$$

Substituting Equation (4) into Equation (5) and taking the first-order conditions generates:

$$x(i) = \left(\frac{\alpha^2 H_Y^{\beta}}{r} \right)^{\frac{1}{1-\alpha}}. \tag{6}$$

Manipulating Equations (5) and (6) gives:

$$\pi = \pi(i) = \left(\frac{1-\alpha}{\alpha} \right) rx(i). \tag{7}$$

Substituting Equation (6) into Equation (4) generates $p(i) = p = \dfrac{r}{\alpha}$, that is, the price of the intermediate inputs are identical for all i. This result implies that the producer of the final good will demand an identical amount of each intermediate input i, that is, $x(i) = x$.

A potential new producer of an intermediate input decides to enter the market by comparing the discounted stream of profit generated by producing that input and the price that must be paid for the patent. If the price of a patent (new design) is determined in a perfectly competitive market then its price (P_A) will be equal to the present discounted stream of profit that the producer of intermediate inputs could make producing the intermediate input i. However, institutions bind the adoption of newly invented inputs until the time τ, when ψT is large enough. Assuming that the value of τ is identical for each innovation, then the market value of innovation is given by:

$$P_A = \int_\tau^\infty \pi e^{-rt} dt \,.$$ (8)

Equation (8) can be solved and its solution written as $P_A = \dfrac{\pi}{re^{r\tau}} = \dfrac{\pi}{r\kappa}$, where

$\kappa = e^{r\tau} \geq 1$. This shows that the discounted value of innovation depends on the time framework for which institutions bind the adoption of newly invented technologies. More precisely, the smaller is τ, the greater the value of new discoveries.[12] The case in which institutions do not bind the adoption of new technologies is easily obtained by setting $\tau = 0$.

2.1.3. The R&D Sector

The new growth theory à la Romer assumes that innovation results from ordinary economic activities aimed at generating profit. New growth theory also suggests that innovation depends primarily on personnel engaged in R&D and the existing knowledge (Romer (1990), Aghion and Howitt (1992), Grossman and Helpman (2001 [1991]), and Jones (1995)). Models developed in this tradition ignore the role of institutions in the innovation process. Despite the fact that institutions are not explicitly present in growth models, economists in this field readily accept the idea that institutions greatly impact innovation. For instance, Sala-i-Martin (2002) affirms that "it is hard to come up with new and better technologies if an economy does not have the right institutions" (p. 18).

Freeman (1987) shows that the quality of institutions is a key component in the process of creating and diffusing new technologies. Specifically, when firms are left on their own, they engage in *myopic* innovative processes that will lead to profit maximization in the short-run, but would not maximize long-run profits. In other words, one could argue that some institutions create incentives for firms to focus only on the short-run. Therefore, suitable macro-institutions may provide proper incentives for innovation by changing firms' myopic behavior in the short-run, leading firms to engage in innovative processes that would ensure long-term profitability.

Lundvall (1992) states that innovation is not a deterministic process and "together the economic structure and the institutional set-up form the framework for and strongly affect, processes of interactive learning, sometimes resulting in innovations" (Lundvall (1992, p. 12)). In agreement with this argument, Matthews (1986) points out that better institutional arrangements enable economic agents "to cooperate with one another more

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[12] For simplicity, τ is treated as a constant. In a more general framework, however, τ should be modeled as a function of both the quality of institutions and the state-of-technology, that is, $\tau = g(A,T)$. A workable functional form could take the form: $\tau = Max\left\{ \dfrac{A}{\psi T} - 1, \ 0 \right\}$.

efficiently" (p. 908) thus stimulating innovation. Furthermore, a complete model of innovation needs to recognize that "institutions need continual adaptation in face of a changing environment of technology" (Matthews (1986, p. 908)), that is, improvements in technology make existing institutions relatively obsolete.

These ideas are incorporated into the standard growth framework of innovation by explicitly modeling institutions as part of the innovation process. More precisely, we assume that the quality of institutions directly affects the innovation process by including a variable that accounts for the quality of institutions (T) directly into the production function of new ideas, but not as a choice variable. Therefore, R&D firms determine their demand for human capital taking institutions for granted. Consider the equation:

$$\dot{A} = \delta A H_A q(T(A)) , \tag{9}$$

where A measures technical knowledge, H_A is human capital engaged in R&D, q denotes the quality of institutions controlling for the state-of-art technology, and $\delta > 0$ is a productivity parameter. It is assumed that q increases with improvements in institutions (T), that is, $\left(\dfrac{\partial q}{\partial T} > 0 \right)$. The logic behind this formulation is that institutions affect the production of new R&D projects. Good institutions contribute to facilitate the process of registering new patents, to disseminate ideas and promote cooperation across researchers, to speed up diffusion of scientific knowledge, to improve enforcement of property rights and to reduce the uncertainty of new projects; all factors that stimulate R&D activities. Furthermore, we also need to consider the impacts of technology on the quality of institutions and, in particular, account for the needed adaptation of institutions in face of changes of technology (Matthews (1986), Engerman and Sokoloff (2005)). Institutional obsolescence due to technological change can be accounted for by assuming that $\left(\dfrac{\partial q}{\partial A} \right) < 0$. We propose a tractable specification of the q function by defining $q = (\psi T / A)^a$, where $0 \le a \le 1$. Accordingly, the production function of new technologies is:

$$\dot{A} = \delta A^{1-a} H_A (\psi T)^a . \tag{10}$$

It is worth noticing that this model of innovation departs greatly from Romer (1990). More precisely, Romer's R&D production function represents a special case where $a = 0$. Under the assumptions that $a = 0$ and institutions do not bind the adoption of new technologies, the model implies that doubling the number of workers devoted to R&D will double the growth rate of knowledge. In the steady state, the growth rate of

output *per capita* is equal to the growth rate of knowledge and the scale effect from the R&D sector extends to output *per capita*, i.e., doubling the number of workers devoted to R&D doubles the growth rate of *per capita* output. Jones (1995) shows that this result is not consistent with the empirical record and can be easily falsified. He suggests an alternative specification in which the discovery of new ideas becomes more difficult as the stock of knowledge increases.

The model developed here does not generate scale effects (see discussion in the next section), so Jones' critique is not an issue. Moreover, the model also expands on Jones's specification because it provides a rationale for how the discovery of new ideas becomes more difficult when the stock of knowledge increases. Additionally, it accounts for the direct effect of institutions on technical innovation. This development allows one to evaluate the channels through which institutions affect technical innovation.

2.1.4.   Equilibrium in the Labor Market

The model assumes a competitive labor market with human capital perfectly mobile across the final good sector and the R&D sector. In equilibrium, wages are equalized across sectors so $W_Y = W_A$, where W_Y and W_A are the wages in the final good sector and R&D sector, respectively. Using the results from the previous section (in particular the fact that $x(i) = x$ and Equation (3)) we derive the marginal product of human capital in the final-good sector:

$$W_Y = \beta H_Y^{\beta-1} \psi T x^\alpha . \tag{11}$$

The wage in the R&D sector is obtained by considering that the R&D producer is willing to hire more workers as long as the wage rate is less than or equal to its marginal product. The optimizing conditions give:[13]

$$W_A = \frac{\pi}{r\kappa} \delta A^{1-a} (\psi T)^a . \tag{12}$$

Defining $Z = \dfrac{\psi T}{A}$ and using the equilibrium condition $W_A = W_Y$, Equation (6), Equation (7), and the identity $H_A = H - H_Y$ generates:

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[13] Consider the profit function: $Max \, \pi_A = P_A \overset{\bullet}{A} - W_A H_A = P_A \delta A^{1-a} H_A (\psi T)^a - W_A H_A$. From the first-order conditions, we obtain $W_A = P_A \delta A^{1-a} (\psi T)^a$. Substituting Equation (8) into this equation produces the result above.

$$H_A = H - \frac{\kappa}{\alpha\delta} Z^{1-a} r .$$ (13)

Equation (13) represents the inverse demand function for human capital in the R&D sector and summarizes both the labor market equilibrium and the supply side of the economy. The following section examines the demand side, so we can close the model and determine the general equilibrium conditions.

2.1.5.   Closing the Model

The demand side is modeled in terms of a representative agent. For simplicity, the population is normalized to 1 and the utility function is assumed to have a logarithmic form[14]. The solution of the consumer problem is well-known in the growth literature and produces the Euler equation, $\dot{C}/C = r - \rho$, where C is consumption, r is the interest rate and ρ is the intertemporal discount rate. To save space, the derivations are not shown here. The model generates a well-behaved steady state solution where output and consumption grow at the same rate $\frac{\dot{Y}}{Y} = \frac{\dot{C}}{C}$. Log-differentiating Equation (3) and using the Euler equation give:

$$\frac{\dot{Y}}{Y} = \frac{\dot{C}}{C} = g_T = r - \rho ,$$ (14)

where $g_T = \frac{\dot{T}}{T}$. Equation (14) represents the equilibrium condition for the demand side.

General equilibrium requires that both the demand and the supply side equilibrium-equations hold together and that the steady state growth rates of technology and output be constant. From Equation (10) we obtain:

$$g_A = \frac{\dot{A}}{A} = \delta H_A Z^a .$$ (15)

In the steady state $\frac{dg_A}{dt} = 0$, so Equation (15) implies that $g_A = g_T$. Combining this result with Equation (14) produces $g = g_T = g_A$. Because the growth rate of institutions is exogenous, this result implies that long-run economic growth is determined

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[14] $U(C) = \ln(C)$.

exogenously by the rate of change in institutions. The detailed implications of the model are discussed in the next section.

3. DISCUSSION AND IMPLICATIONS

Even though the model predicts that long-run growth is determined exogenously by the rate of change in institutions, the model allows examining how institutions affect the economic dynamics of relevant variables and how institutions influence the production and adoption of technologies. We can solve the model for the steady state values of relevant endogenous variables such as Z, H_A, and H_Y and then study how these variables are affected when we relax the assumptions regarding the role of institutions on production and adoption of technologies. We begin by finding the values of Z and H_A around the steady state and then examine how these variables and the growth rate of output respond to changes in the assumptions regarding the impacts of institutions on the production and adoption of technologies.

The *Baseline model* implies that in the steady state g is a constant and can be treated as a parameter. Therefore, Equations (13), (14), and (15) can be rearranged to form:

$$\frac{H_A}{H} + \frac{\kappa}{H\alpha\delta}(g+\rho)Z^{1-a} - 1 = 0,$$
$$H_A - \frac{g}{\delta}Z^{-a} = 0. \tag{16}$$

Equation (16) represents a non-linear system with no analytical solution. We simplify this problem by using a first-order Taylor approximation around the steady state. Let $\overline{H}_A = H_A - H_A^*$ and $\overline{Z} = Z - Z^*$, where H_A^* and Z^* denotes the steady state values of H_A and Z, respectively. In matrix form, a first-order linear approximation of Equation (16) can be written as follows:

$$\begin{bmatrix} \dfrac{1}{H} & \dfrac{(1-a)\kappa}{H\alpha\delta}(g+\rho)Z^{*-a} \\ 1 & \dfrac{ag}{\delta}Z^{*-a-1} \end{bmatrix} \begin{bmatrix} \overline{H}_A \\ \overline{Z} \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}. \tag{17}$$

A nontrivial solution for this system around the steady state will exist only if the coefficient matrix is singular, that is, the determinant of the coefficient matrix must be zero. Imposing this condition produces:

$$\frac{ag}{H\delta}Z^{*-a-1} - \frac{\kappa}{\alpha\delta H}(1-a)(g+\rho)Z^{*-a} = 0 \,. \tag{18}$$

Equation (18) can be solved for the steady state value of Z:

$$Z^* = \left[\frac{a}{(1-a)}\frac{g}{(g+\rho)}\frac{\alpha}{\kappa}\right]. \tag{19}$$

Z^* can be interpreted as the steady state quality of institutions adjusted for the state-of-art technology. In other words, the model suggests that there is an optimal mix of technology development (A) and institutional structure (T). Therefore, an economy will not be able to promote technological development without having an institutional structure appropriate for its level of technological development;

Proposition 1: There is an optimal mix of technology and institutional quality, so that technological change will only take place in an economy that has an institutional structure suitable to its level of technological development.

In line with the result above, institutions also affect the allocation of human capital in the R&D sector. Considering that perfect labor mobility guarantees that the labor market is in equilibrium at all points in time, we can combine Equations (13), (14), and (19) and obtain a solution for the steady state value of H_A:

$$H_A^* = H - \frac{1}{\delta}\left[\frac{a}{1-a}\right]^{1-a}\left[\frac{\kappa}{\alpha}\right]^a [g+\rho]^a g^{1-a} \,. \tag{20}$$

Equation (20) implies that poor institutions negatively influence the allocation of human capital in the R&D industry. This can be easily seen by considering the case in which institutions deteriorate causing the time required to adopt new technologies (τ) to increase once-for-all. Consequently, the value of the parameter κ increases. Using Equation (20) we find that the partial derivative $\dfrac{\partial H_A^*}{\partial \kappa}$ is negative,[15] which implies that the steady state employment (and share) of human capital in the R&D sector decreases. Therefore, controlling for all other determinants of innovation, a country with poor institutional arrangements and restrictions to adopt new technologies is expected to have a relatively small share of human capital employed in the R&D sector. This result is

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15   $\dfrac{\partial H_A^*}{\partial \kappa} = -\dfrac{a}{\delta\kappa}\left[\dfrac{a}{1-a}\right]^{1-a}\left[\dfrac{\kappa}{\alpha}\right]^a [g+\rho]^a g^{1-a} < 0.$

summarized in *Proposition 2*.

Proposition 2: *Poor institutions or institutional barriers that prevent or restrict the adoption of newly invented technologies decrease the share of human capital employed in the R&D sector, which hinders innovation.*

It can also be demonstrated that an increase in κ decreases the short-run (transitional) growth rate of output. It is worth noticing that it only makes sense to consider the impact (short-run) of a change in κ on g (output growth) around the neighborhood of the steady state solution for Z. The impact of changes in κ on transitional (or short-run) growth rate of output can be analyzed by utilizing Equations (13), (14), (15), and (20). Combining these equations generates:

$$g = \frac{\delta H Z^{*a} - \frac{\kappa\rho}{\alpha}Z^*}{1 + \frac{\kappa}{\alpha}Z^*} = \frac{\delta H Z^{*a-1} - \frac{\kappa\rho}{\alpha}}{Z^{*-1} + \frac{\kappa}{\alpha}} \ . \tag{21}$$

It can be shown that $\frac{\partial g}{\partial \kappa} < 0$ [16], which suggests that the short-run growth rate of output decreases when changes in institutions add more restrictions to the adoption of newly invented technologies. This implies that institutional arrangements that constrain the adoption of newly invented technologies hamper short-run output growth.

Proposition 3: *Institutional barriers to adopt newly invented technologies decrease the short-run growth rate of output.*

The model also precludes income convergence as predicted by Solovian-type models. For instance, consider two small countries,[17] S_1 and S_2, that face a world with perfect and instantaneous diffusion of knowledge, such that A is identical for both countries. In other words, these countries may potentially utilize all of the available technology in the world. Moreover, assume that the stock of human capital is identical in both countries and that country S_1 has relatively poor institutions that bind the adoption of new technologies $(\psi T < A)$ while country S_2 faces no institutional barriers to adopt new technologies $(\psi T \geq A)$. Under these conditions and using Equation (2) and the results

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[16] Because g is nonnegative the following condition must hold: $Z \geq \left(\frac{\alpha\delta}{\kappa\rho}H\right)^{\frac{1}{1-a}}$.

[17] A country is small in the sense that its knowledge production does not affect the world knowledge frontier.

from Section II, we obtain the ratio $\frac{Y_{S1}}{Y_{S2}} = \frac{\psi T}{A} = Z$. Because Z is less than one and constant in the steady state (see Equation (19)), the income gap will not disappear and income in the country with relative poor institutions (S_1) will never catch up to the levels of income in the country with relative better institutions. This result is summarized as follows:

Proposition 4: Controlling for diffusion of technology and human capital, a country with a lower level of income and relative poor institutional arrangements will not converge to the levels of income existing in countries with better institutions.

It is also worth noticing that relaxing the assumption that institutions prevent the use of newly invented technologies is neither sufficient to generate endogenous growth nor affect the steady state growth rate of output. The model can easily allow for instantaneous use of new technologies by setting $\kappa = 1$ and $Z \geq 1$ (or $\psi T \geq A$). Using Equation (2) and the results from Section v still generates $\frac{\dot{Y}}{Y} = \frac{\dot{A}}{A}$. From Equation (10) we find that $\frac{\dot{A}}{A} = \frac{\dot{T}}{T}$. Therefore, long-run economic growth is still determined by the rate of change in institutions, which is exogenous. Endogenous growth is only obtained by assuming that institutions neither bind the adoption of new technologies nor affect the production of new ideas. The model easily allows examining this scenario by considering that $Z, \kappa \to 1$ and $a \to 0$. Imposing these conditions produces:[18]

$$\overline{g} = \begin{cases} \lim g \\ Z, \kappa \to 1 \\ a \to 0 \end{cases} = \left[\frac{\alpha \delta H - \rho}{1 + \alpha} \right] > 0 . \tag{22}$$

To sum up, the model suggests that the reason that growth models à la Romer (1990) generate endogenous growth is the use of a set of restrictive and unrealistic assumptions regarding the role of institutions in the economy. Endogenous growth is precluded in a more general framework that allows institutions to play a role in the production and adoption of new technologies. The model developed in this paper actually shows that institutions affect technological innovation, long-run economic growth, and the allocation of human capital in the R&D sector. The next section further discusses the implications of the model and considers the impacts of human capital accumulation on

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[18] We can easily get these results by either solving the model again or by calculating the limit of Equation (21).

institutions and economic growth.

4.   INSTITUTIONS AND HUMAN CAPITAL

The results discussed in section III imply that an increase in the stock of human capital neither influences the steady state growth rate of technical progress nor affects the steady growth rate of output. More specifically, changes in *H* will affect the short-run growth rate of innovation and output, but will not affect the rates of technological change and output growth in the long-run. This result contradicts Romer (1990) and Jones (1995). Moreover, according to Equation 19, changes in *H* will not affect the optimal combination of technology development (*A*) and institutional structure (*T*). Therefore, the *Baseline Model* greatly diminishes the role of human capital in explaining long-term economic performance. In fact, the predominant role of human capital that is emphasized in the New Growth literature is replaced with the quality of institutions. However, this strong conclusion is a byproduct of the model economy that assumes that institutions and human capital are unrelated. In this section, we take a first step toward relaxing this working-assumption. In particular, given the fact that the growth literature emphasizes the importance of human capital accumulation for economic growth (e.g., Lucas (1988), Romer (1990), Glaeser *et al.* (2004)), we modify the model to allow for interactions between human capital and institutions. Specifically, we incorporate the idea that current institutions depend on human capital accumulation.[19] Consider the following equation:

$$T(t) = x \int_{-\infty}^{t} H(s)e^{\eta s} ds,$$ (23)

where $x > 0$ accounts for all determinants of institutions[20] other than human capital (*H*) and η weights the impact of human capital on current institutions.

The form of this equation has a long history in economic thought. Rosenberg (1963) explains Bernard Mandeville's (early 1700's) ideas on the development of good institutions as an evolutionary process dependent on generations of accumulated knowledge. "Human institutions are not to be regarded as the product of human ingenuity, much less the result of a single mind. They are, rather, the fruits of a long gradual growth process. The results of this evolution are not only contrivances beyond the ingenuity of individuals; once they have evolved, they multiply manyfold the

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[19] A more general framework should also model the impacts of institutions on human capital accumulation.

[20] To conform to the literature (e.g., La Porta *et al.* (1999), Acemoglu *et al.* (2001, 2005)), *x* can be specified as a function of geographically related variables and the colonial legacy (e.g., origin of the legal system, colonization type, etc).

otherwise crude and limited abilities of the individual human agent… [Institutions] are the product, not of inspiration (either human or divine) but of the collective experience of the human race" (Rosenberg (1963, pp.186-187)) or $T(t) = x \int_{-\infty}^{t} H(s)e^{\eta s} ds$.

Equation (23) implies that the current institutional arrangement is a function of current and past human capital stocks and of colonial legacy and geography (x). The motivation for including x in the model has been debated extensively by economists. For instance, Acemoglu *et al.* (2001, 2005) argue that early institutions were affected by geography because the colonization process endogenously responded to certain environmental conditions, creating institutions specific to the colony's geography. Specifically, colonies characterized by a heavy burden of infectious disease (e.g., malaria and yellow fever) discouraged the formation of European-type settlements. In these non-settler colonies "…colonial powers set up 'extractive states'… . These institutions did not introduce much protection for private property, nor did they provide checks and balances against government expropriation" (Acemoglu *et al.* (2001, p. 1370)). On the other hand, geographically advantaged settlement colonies were relatively free to engage in processes that replicated in some way European social arrangements, which ultimately helped to develop better institutions and generate a system that protected private property rights in these colonies (Denoon (1983), Acemoglu *et al.* (2001)). Engerman and Sokoloff (2005), Gallup *et al.* (1999), and Sachs (2000) also support the view that geography affects the development of growth-promoting institutions. In addition, Tebaldi and Elmslie (2008) show that stock of human capital is an important factor in explaining early institutions.

The ideas above are treated in a simplistic way by assuming that the stock of human capital is constant over time, that is, $H(t) = H$. Therefore, Equation (23) becomes:

$$T(t) = \left(\frac{x}{\eta} \right) H e^{\eta t}. \tag{24}$$

Notice that Equation (24) implies $T(0) = \frac{x}{\eta} H$. Thus it suggests that a country that started with a larger stock of human capital and were located in geographically -advantaged areas would be able to develop better *early* institutional arrangements, which ultimately reflects in the quality of current institutions because of the *persistence effect*. The *persistence effect* is the idea that once institutions are built, economic and political mechanisms generated as a byproduct of those institutions will set constraints on future institutional changes and those early institutional arrangements will persist over time (Engerman and Sokoloff (1997), La Porta *et al.* (1999), Acemoglu *et al.* (2001)). Equation (24) also implies that the initial conditions will not affect the rate in which institutions change over time, thus initial conditions have level but not growth effects on the quality of institutions. Log-differentiating Equation (24) produces:

$$g_T = \frac{\dot{T}}{T} = \eta \, . \tag{25}$$

Equation (25) implies that the growth rate of institutions depends on the weight (or persistence effect) that historical (or geographical) determinants (x) and previously accumulated human capital have in determining current institutions. Specifically, a larger η implies that the historical legacy (or initial human capital) is very persistent over time and once a society develops these early institutions, it is very hard to change them, so current institutions is very much the result of early institutional arrangements. For instance, a large η implies that a country's initial stock of human capital would have a significant role in shaping earlier institutions, which, through the persistence effect, would positively influence current institutions. Therefore, this model makes the case that the growth rate of current institutions depends on the weight (persistence effect) that historical determinants and accumulated human capital have on current institutions.

Even though this formulation is basic and ignores the feedback effect from institutional change on human capital accumulation, it allows for the evaluation of changes in human capital accumulation patterns on institutions, innovation and economic growth.[21]

We use the framework above to investigate the impacts of a once-for-all increase in H, at time t_k, on the time paths of $T, Z,$ and Y. Equation (24) and Figure 2 show that the quality of institutions responds to the rise in the stock of human capital. The level of $\ln(T)$ jumps up at t_k, the moment in which the stock of human capital increases, and then settles into a higher path parallel to the first trajectory. Therefore, an increase in the stock of human capital is expected to improve the quality of institutions (level effect), but does not affect the rate in which institutions change.

Using this result and the fact that A is constant at a point in time, an increase in T will cause Z to jump up from Z^* to Z^1, as shown in the lower panel of Figure 3. Equations (10) and (15) imply that improved institutions and the availability of more human capital will increase the short-run rate of innovation, causing A to increase over time (see upper panel in Figure 3). The latter effect causes Z to decrease and move towards its steady state value. Therefore, the economy returns to its long-run growth path, where A and T grow at the same rate (g) and Z is constant. The long-run rate of output growth is unaffected because output, innovation, and institutions grow at the same rate in the steady state.

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[21] Further research should consider the case in which institutions impacts human capital accumulation.
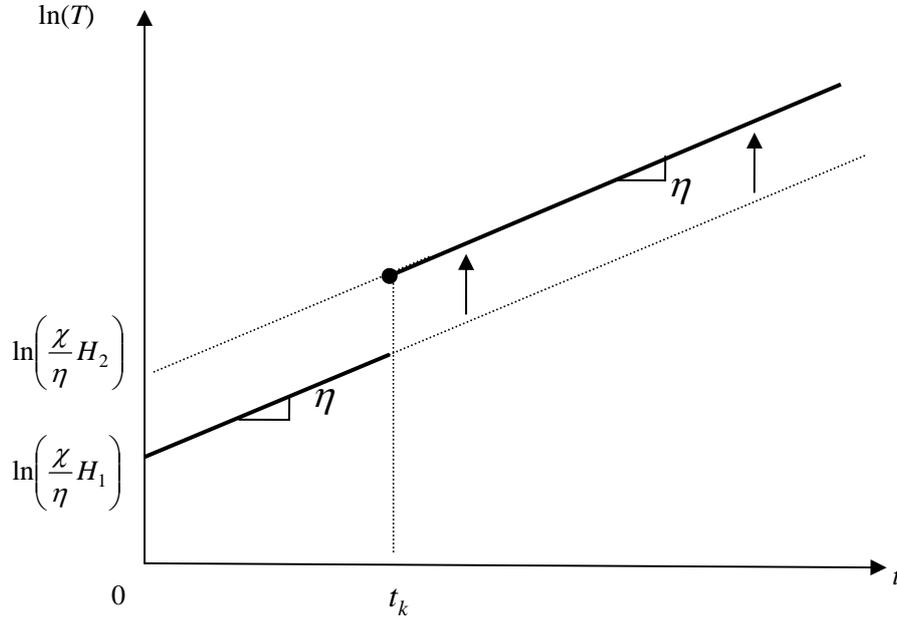
Figure 2.   Current Institutions and Initial Conditions

Proposition 5: A once-and-for-all increase in the stock of human capital will not affect the long-run growth rate of the economy. Only sustainable growth in human capital generates steady state growth effects.

However, because an increase in the stock of human capital affects the levels (quality) of institutions, it will also affect innovation and the growth rate of output in the short-run as well as the steady state levels of output. In particular, improvements in the quality of institutions will boost the adoption of new intermediate inputs (technologies) and increase output levels. More precisely, calculating the partial derivative of Equation (21) with respect to H, in the neighborhood of the steady, produces $\left.\dfrac{\partial g}{\partial H}\right|_{Z=Z^*} = \dfrac{\alpha\delta Z^{*\alpha-1}}{\kappa+\alpha Z^{*-1}} > 0$.

However, this effect is only temporary and output growth returns to its long-run path that is determined by the growth rate of institutions (see Figure 4). The rationale behind these results is as follows: an increase in human capital causes a jump in the quality of institutions and enhances innovation increasing the production of new technologies and the growth rate of output. However, this short-run effect will cease over time because new technologies will also change the production modes and increase the complexity of the social and economic relationships, making the existing institutional structure relatively obsolete. In turn, this slows down the innovation rate (g_A) and, consequently,

slows down the growth rate of output, which eventually returns to its long-run path. This result can be summarized as follows:
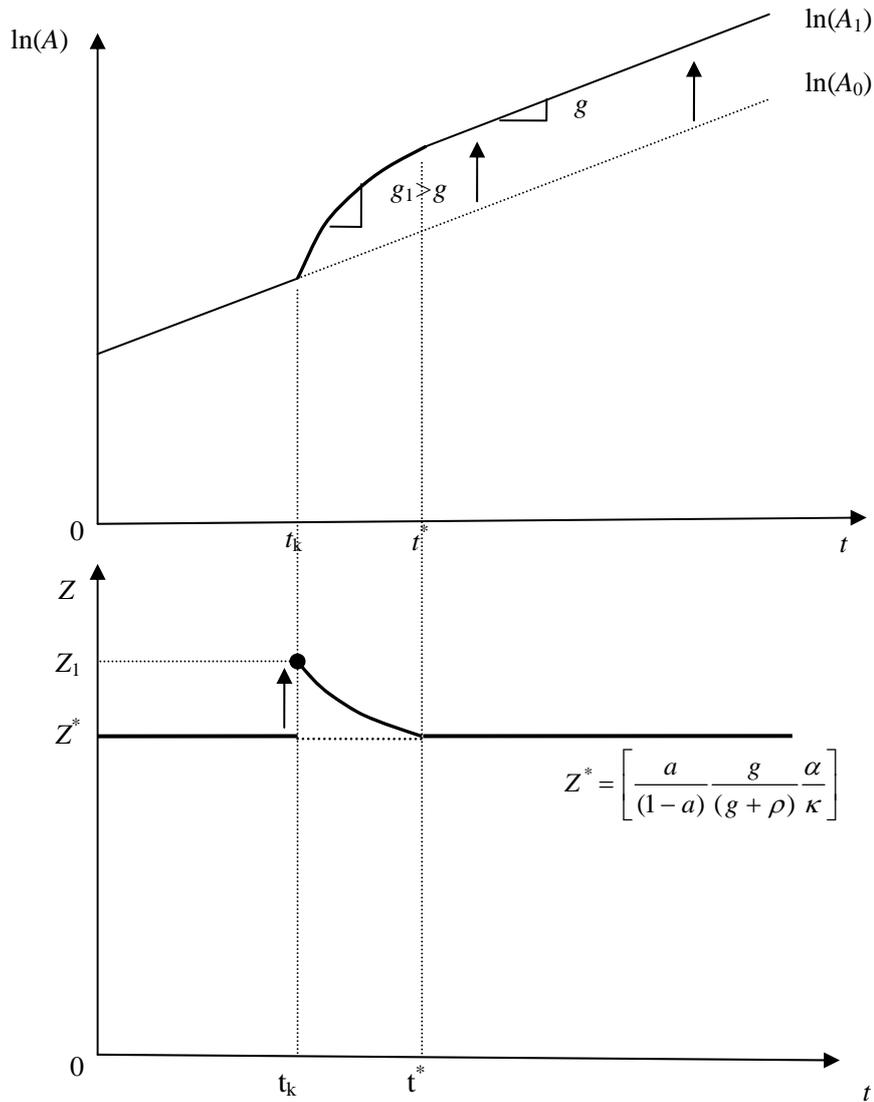

Figure 3.   Impacts of an Increase in *H* on the Time Paths of *A* and *Z*

Proposition 6: A one-time increase in the stock of human capital enhances the quality of institutions and positively affects the level and the short-run growth rate of output.
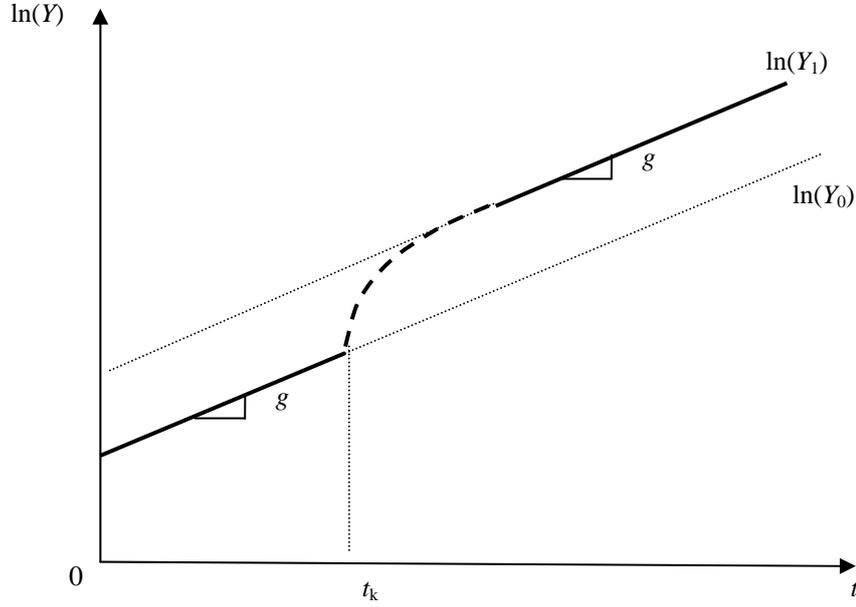
Figure 4. Impact on Levels of Output

Do the results above change if the assumption that institutions bind the adoption of new technologies is relaxed? To examine this case we assume that $A < \psi T$ and $\kappa = 1$. We solve the model again considering these assumptions, but to save space, only the key equilibrium conditions are reported below. More precisely, Equations (19) and (20) are now given by:

$$Z^* = \left(\frac{g(1+\alpha)+\rho}{\delta \alpha H} \right)^{\frac{1}{a}}, \tag{19A}$$

$$H_A^* = H\left[1 - \left(\frac{g+\rho}{g(1+\alpha)+\rho} \right) \right]. \tag{20A}$$

Under the assumptions stated above, it can be shown that long-run output growth is still determined by the rate of change in institutions. Therefore, a once-for-all change in the stock of human capital will not influence long-run output growth. However, the short-run dynamics of output and innovation and the optimal mix of technology development and institutions are affected. According to Equation (19A), a once-for-all increase in the stock of human capital will reduce the optimal mix of technology

development and institutions (*Z*), that is, $\dfrac{dZ^*}{dH} < 0$. This actually implies that human capital works, in some degree, as a substitute for institutions in the R&D industry, and so economies with a large stock of human capital will have a smaller requirement of institutions to technology (Z^*). This in turn means that human capital allows an economy to expand its knowledge frontier (*A*) relative to the quality of its institutions.

Proposition 7: Under the assumption that institutions do not bind the adoption of new technologies, a one-time increase in the stock of human capital allows an economy to expand its knowledge frontier (A) relatively to the quality of its institutions.

Moreover, Equation (20A) implies that $\dfrac{d\left(\dfrac{H_A^*}{H}\right)}{dH} = 0$. This result shows that a change in the stock of human capital will not affect the size of the optimal share of human capital allocated in the R&D industry. Other general results found in section III still holds. In particular, it is worth noticing that (as discussed in section III) an increase in *H* will cause a discontinuous jump in the levels of institutions in the short-run growth rate of the economy, *g*. However, the impact-change productivity gains in terms of innovation and adoption of technologies, which are then followed by a short-run expansion in output cannot be sustained in the long-term due to the incapacity of the society to change its institutional structure quick enough to the satisfy the new social, economic, and political organizational demands created by the new technologies. This decelerates the growth rate of innovation as well as the growth rate of output, bringing the economy back towards its steady state path, which is determined by institutional changes.

5.   CONCLUSION

The model developed in this article shows that growth models à la Romer (1990) generate endogenous growth by using a set of restrictive and unrealistic assumptions regarding the role of institutions in the economy. Endogenous growth is precluded in a more general framework that allows institutions to play a role in the production and adoption of new technologies. This article shows that the long-run growth of the economy is intrinsically linked to the growth rate of institutions and suggests that an economy with institutions that retard or prevent the utilization of newly invented inputs will experience low rates of technological change and output growth. In either case, whether institutions bind or whether institutions do not bind the adoption of technologies, the long-run growth of output is driven by the growth rate of innovation, which is ultimately determined by the growth rate of institutions. However, the short-run growth

rate of the economy and the *level* of output are lowered if institutional arrangements constrain the adoption of new technologies. In the short-run, an economy whose institutional arrangements are not changing at the rate needed to follow the path of technological change will experience a slowdown in its rate of innovation and consequently a slowdown in its growth rate of output. Therefore, institutional barriers to adopt newly invented technologies decrease the short-run growth rate of output.

The model also predicts that countries with institutional barriers that prevent or restrict the adoption of newly invented technologies will allocate a relatively small share of human capital to the R&D sector, which hinders innovation.

The model also supports the view that human capital is an important determinant of both institutions and output. In fact, it suggests that a one-time increase in the stock of human capital enhances the quality of institutions, allows an economy to expand its knowledge frontier relatively to the quality of its institutions, and positively affects the short-run growth rate of innovation and output and the level of output. However, it also implies that human capital has no growth effect, that is, an increase in the stock of human capital will not affect the long-run growth rate of the economy. Only sustainable growth in human capital generates growth effects in output. Therefore, differences in the stock of human capital are expected to explain income level differentials across countries, but not growth differentials across countries. This is broadly consistent with the predictions of the Uzawa (1965), Lucas (1988) and Jones (1995) theoretical models, which suggest that the growth rate of output is proportional to the growth rate of human capital. However, it contradicts the predictions of the Romer (1990) and Rebelo (1991) models, which suggest that the level of human capital is associated with the growth rate of the economy. To sum up, the model presented in this article lessens the role of human capital in explaining long-term economic performance while emphasizing the significance of institutions as the engine of long-term technological innovation and economic performance.

REFERENCES

Acemoglu, D., S. Johnson, and J.A. Robinson (2001), "The Colonial Origins of Comparative Development: An Empirical investigation," *American Economic Review*, 91(5), 1367-1401.

_____ (2005), "Institutions as the Fundamental Cause of Long-Run Growth," in ed., Aghion, P., and S. Durlauf, *Handbook of Economic Growth*, Chapter 6, North Holland; Elsevier.

Aghion, P., and P. Howitt (1992), "A Model of Growth through Creative Destruction," *Econometrica*, 60(2), 323-351.

Atkinson, G. (1998), "The Evolutionary Theory of the Development of Property and the

State," in ed., W. Samuels, *The Foundation of Institutional Economics*, New York, Routledge.

Baldwin, J., and Z. Lin (2002), "Impediments to Advanced Technology Adoption for Canadian Manufacturers," *Research Policy*, 31(1), 1-18.

Barro, R. (1999), "Determinants of Democracy," *Journal of Political Economy*, 107(6), S158-S183.

Denoon, D. (1983), *Settler Capitalism: The Dynamics of Dependent Development in the Southern Hemisphere*, Oxford: Clarendon Press.

Easterly, W., and R. Levine (2003), "Tropics, Germs, and Crops; How Endowments Influence Economic Development," *Journal of Monetary Economics*, 50, 3-39.

Engerman, S.L., and K.L. Sokoloff (1997), "Factor Endowments, Institutions and Differential Paths of Growth Among New World Economies; A View from Economic Historians of the United States," in ed., S. Haber, *How Latin America Fell Behind*, Stanford.

_____ (2005), "Institutional and Non-Institutional Explanations of Economic Differences," *Handbook of New Institutional Economics*, Dordrecht and New York: Springer.

Freeman, C. (1987), *Technology Policy and Economic Performance: Lessons from Japan*, London: Pinter Publishers.

Furubotn, E.G., and R. Richter (2005), *Institutions and Economic Growth*, Ann Arbor: The University of Michigan Press, 2nd edition.

Gallup, J.L., and J.D. Sachs, with A.D. Mellinger (1999), "Geography and Economic Development," *International Regional Science Review*, 22(2), 179-232.

Gastil, R.D. (1979), *Freedom in the World: Political Rights and Civil Liberties*, New York: Freedom House.

Glaeser, E.L., R. La Porta, F. Lopes-de-Silanes, A. and Shleifer (2004), "Do Institutions Cause Growth?" *Journal of Economic Growth*, 9(1), 271-303.

Gradstein, M. (2002), "Rules, Stability and Growth," *Journal of Economic Development*, 67, 471-484.

_____ (2004), "Governance and Growth," *Journal of Development Economics*, 73, 505-518.

Grossman, G.M., and E. Helpman (2001, [1991]), *Innovation and Growth in the Global Economy*, Cambridge, MA: The MIT Press, Seventh printing. (First Printing 1991)

Hall, R.E., and C. Jones (1999), "Why Do Some Countries Produce So Much More Output Per Worker Than Others?" *Quarterly Journal of Economics*, 114(1), 83-116.

Haucap, J., and C. Wey (2004), "Unionisation Structures and Innovation Incentives," *Economic Journal*, 114(494), C149-165.

Huang, H., and C. Xu (1999), "Institutions, Innovations and Growth," *American Economic Review*, 89(2), 438-443.

James, C. (2004), "Global Status of Commercialized Biotech/GM Crops: 2004," ISAAA Briefs, 32, ISAAA: Ithaca, NY

James, C. and A.F. Krattiger (1996), "Global Review of the Field Testing and

Commercialization of Transgenic Plants, 1986 to 1995: The First Decade of Crop Biotechnology," ISAAA Briefs, 1, ISAAA: Ithaca, NY.

Jones, C. (1995), "R&D-Based Models of Economic Growth," *Journal of Political Economy*, 103(4), 759-784.

Knack, S., and P. Keefer (1995), "Institutions and Economic Performance; Cross-Country Tests Using Alternative Institutional Measures," *Economics and Politics*, 7(3), 207-227.

Kormendi, R.C., and P.G. Meguire (1985), "Macroeconomic Determinants of Growth," *Journal of Monetary Economics*, 16, 141-163.

Krattiger, A.F. (1997), "Insect Resistance in Crops: A Case Study of Bacillus Thuringiensis (Bt) and Its Transfer to Developing Countries," ISAAA Briefs 2, ISAAA: Ithaca, NY.

La Porta, R., F. Lopes-de-Silanes, A. Shleifer and R. Vishny (1999), "The Quality of Government," *Journal of Law, Economics, & Organization*, 15(1), 222-279.

Grogan, L. and L. Moers (2001), "Growth Empirics with Institutional Measures for Transition Countries," *Economic Systems*, 25(4), 323-344.

Lucas, R. (1988), "On the Mechanics of Economic Development," *Journal of Monetary Economics*, 22(1), 3-42.

Lundvall, Bengt-Ake (1992), *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*, London: Pinter Publishers.

Matthews, R.C.O. (1986), "The Economics of Institutions and the Sources of Growth," *Economic Journal*, 96, 903-918.

Mauro, P. (1995), "Corruption and Growth," *Quarterly Journal of Economics*, 110(3), 681-712.

North, D.C. (1990), *Institutions, Institutional Change and Economic Performance*, New York, Cambridge University Press.

North, D.C., and R.P. Thomas (1973), *The Rise of the Western World: A New Economic History*, Cambridge University Press.

Rebelo, S. (1991), "Long-Run Policy Analysis and Long-Run Growth," *Journal of Political Economy*, 99(3), 500-521.

Rodrik, D. (2000), "Institutions for High-Quality Growth: What They Are and How to Acquire Them," NBER Working Paper, 7540.

_____ (2003), *In Search of Prosperity. Analytic Narratives on Economic Growth*, New Jersey: Princeton University Press.

Romer, P. (1986), "Increasing Returns and Long-Run Growth," *Journal of Political Economy*, 94, 1002-1037.

_____ (1990), "Endogenous Technological Change," *Journal of Political Economy*, 98, S71-S102.

_____ (2002), "Preface," in ed., Jaffe Adam B., and Manuel Trajtenberg (2002), *Patents, Citations & Innovations*, Cambridge: The MIT Press.

Rosenberg, N. (1963), "Mandeville and Laissez-Faire," *Journal of the History of Ideas*, 24(2), 183-196.

Sachs, J.D. (2000), *Tropical Underdevelopment*, Center for International Development, Harvard University.

Sala-i-Martin, Xavier X. (2002), "15 Years of New Growth Economics: What Have We Learnt?" Central Bank of Chile Working Paper, 172, 22.

Segerstrom, P.S. (1998), "Endogenous Growth Without Scale Effects," *American Economic Review*, 88(5), 1290-1310.

Solow, R. (1956), "A Contribution to the Theory of Economic Growth," *Quarterly Journal of Economics*, 70, 65-94.

Tebaldi, E., and B. Elmslie (2008), "Do Institutions Impact Innovation?" MPRA Working Paper, 8757.

Uzawa, H. (1965), "Optimal Technical Change in an Aggregative Model of Economic Growth," *International Economic Review*, 6, 18-31.

Young, A. (1998), "Growth Without Scale Effects," *Journal of Political Economy*, 106(1), 41-63.

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