Institutions-augmented solow model and income clubs

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ABSTRACT

Growth economists still face major challenges and limitations to incorporate institutions into the standard growth framework. This article develops a simple institutions-augmented Solow growth model --that can be used in the classroom and for policy discussions --that accounts for the interactions between institutions and factor-productivity and examine the impacts of the quality of institutions on *levels* and *growth rates* of output. The institutions-augmented growth model shows that differences in the quality of institutions preclude income convergence and determine both the *level* and the *growth rate* of output per worker. The model also shows that poor institutions induce poverty traps. Furthermore, the income gap between rich and poor countries will not disappear if poor countries' institutions do not improve relative to their rich counterpart.

Keywords: Solow Model, Institutions, Clubs, Poverty Traps.

1 INTRODUCTION

Recent work in the growth literature has placed institutions as one of the engines of long-run economic growth (Chong and Calderón, 2000; Acemoglu et al. 2001; Rodrik et al., 2004; Tebaldi and Elmslie, 2009). However, growth economists still face enormous challenges and limitations in terms of modeling institutions into the standard theoretical framework of economic growth. According to Sala-i-Martin (2002), "[w]e are still in the early stages when it comes to incorporating institutions into our growth theories" (p. 18). Important theoretical contributions in terms of modeling institutions within the realm of long-run economic growth include Huang and Xu (1999), Fedderke (2001), Gradstein (2002 and 2004), and Tebaldi and Elmslie (2008).

However, recent theoretical models incorporating institutions are, in general, mathematically complex, which limit their use in introductory macroeconomics and economic growth classes. This article develops a simple institutions-augmented Solow model that accounts for the impacts of the quality of institutions on levels and growth rates of output. In particular, we modify the production function and the capital accumulation equation found in the traditional Solow model, allowing for interactions between institutions and factor-productivity. Despite the simplicity of the model, it theorizes a formal link for specifying an empirical model for studying the impacts of institutions on economic performance. The institutions-augmented Solow model also allows analyzing the role of institutions in creating income *clubs* and poverty traps. The model is designed to be used in intermediate macroeconomics and economic growth courses and for policy discussions.

2 THE MODEL

The model economy is a modified version of the Solow (1956) model. Final goods are produced using a constant return to scale (CRS) technology in a market characterized by perfect competition. Institutions are assumed to play a central role in determining factors' productivity and technology adoption, so output (Y) is produced according to the following production function:

$$Y = f\big(A(T,t), K(T,t), L(T,t)\big) \tag{1}$$

where L denotes labor, $A \geq 1$ is an index denoting the level of state-of-art technology, K is capital, T is an index denoting the quality of institutions, and t is time.

We assume that the representative economy is small and has access to a pool of technology generated exogenously that grows at a constant rate of g. In addition, the growth rate of the labor force and the labor force participation rate are constant over time, which implies that $\frac{\dot{L}}{L} = n$, where n is the population growth rate. Moreover, T is assumed to be increasing with the quality of

institutions and, for simplicity, normalized to range between zero and one ($0 < T \leq 1$). Therefore, T is equal to one for an economy with the best relative institutions.[1]

Equation 1 poses a major question: how do institutions affect the adoption of available technologies and the productivity of physical capital?[2] It can be argued that poor institutions prevent the use of available technologies (Tebaldi and Elmslie, 2008) and limit the efficiency gains from current innovation (Matthews, 1986). Therefore, good (bad) institutions increase (decrease) the efficacy of technology and augment both labor and capital productivity. With respect to capital, it has been shown that poor institutional arrangements (translated into corruption and poor enforcement of laws and contracts) decrease the returns to investments and reduce capital accumulation (Mauro, 1995; Brunetti, Kisunko and Weder, 1997; Lambsdorff, 1999; Wei, 2000). We consider these ideas by developing two alternative specifications. First, we ignore the impacts of institutions on technology adoption and focus the analysis on the influences of institution on physical capital productivity. Then we develop a more general model that accounts for the impacts of institutions on technology adoption and capital productivity.[3] In both specifications we also examine the case of institutions-driven income clubs and poverty traps.

2.1 BASELINE MODEL

This section presents a heuristic way to account for the impacts of institution on physical capital productivity. In particular, we assume that the elasticity of output with respect to capital is affected by institutions. More precisely, better institutions augment capital productivity and, therefore, influence the contribution of capital to output. Formally:

$$Y = K^{\alpha T}(AL)^{1-\alpha T} \tag{2}$$

where $0 < \alpha < 1$. Defining $y = \frac{Y}{AL}$ and $k = \frac{K}{AL}$ allows writing the production function as follows:

$$y = k^{\alpha T} \tag{3}$$

Combining equation (3) with a standard capital accumulation equation produces:

$$\dot{k} = sk^{\alpha T} - (\delta + n + g)k, \tag{4}$$

where s is the savings rate and δ is the capital depreciation rate. In a balanced-growth path $\frac{\dot{k}}{k} = 0$. This condition allows solving equation (4) for the steady state level of effective capital per worker:

$$k^* = \left[\frac{s}{(\delta + n + g)}\right]^{\frac{1}{1-\alpha T}} \tag{5}$$

where "*" denotes steady state values. Equation 5 implies that institutions impact positively the steady state level of effective capital worker[4] and, consequently, the steady state *level* of effective output per

[1] In this paper, *institutions* measure 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 (e.g., no price controls).

[2] Another relevant question is: how do institutions affect technology adoption and human capital accumulation? While important, this question is not the focus of this paper.

[3] Although restrictive, these specifications generate a workable model. Other general functional specifications have created difficulties in solving the model.

[4] $\frac{\partial k*}{\partial T} > 0$

worker. More specifically, better institutions (larger T) increases the return to capital accumulation, which boosts investments and leads to a higher steady-state level of effective capital per worker (k^*) and effective output per worker (y^*). Therefore, controlling for the savings rate (s), the depreciation rate (δ), population growth (n), and the rate of change in technology (g), the model suggests that countries are richer or poorer because of the quality of their institutions, that is, wealthier countries should have institutions better than that of poor countries. This result is consistent with Figure 1, which shows a strong correlation between alternative measures of institutions (control of corruption, regulatory quality, rule of law, and risk of nationalization) and the purchasing power parity (ppp) level of income per capita.

However, the model implies that the long-term growth rate of output per worker is still determined by the rate of technological progress. Defining $\bar{y} = \frac{Y}{L}$, using the fact that $\frac{\dot{k}^*}{k^*} = 0$, and log-differentiating equation 3 generates:

$$g_{\bar{y}} = \frac{\dot{\bar{y}}}{\bar{y}} = g \tag{6}$$

Equation 6 entails that there should be no effect of the quality of institutions in a country's long run growth rate of output per worker. Therefore, institutions have *level* effects but not *growth* effects. The lack of growth effects found in equation 6 is troubling (see details in Tebaldi and Elmslie, 2009) and is further examined below.

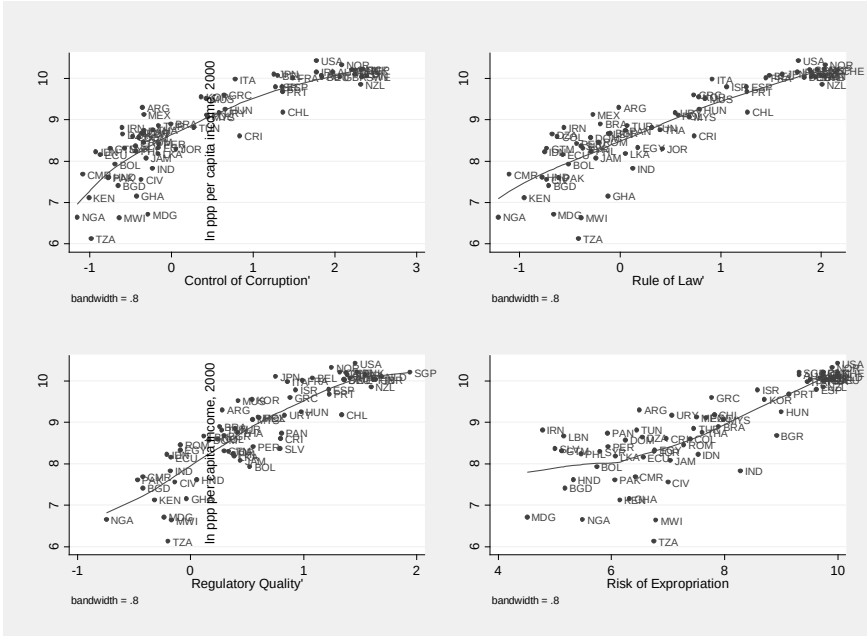

Figure 1. Institutions and Levels of Per Capita Income, 2000.

Source: Authors calculation using data from the Penn World Table and Kaufmann, Kraay and Mastruzzi, M. (2007). Control or corruption, Rule of law and Regulatory Quality range from -2.5 to 2.5, with higher scores indicating better institutional arrangements. This study utilizes an average index through the time periods of 1996, 1998, 2000, 2002, 2004, and 2005. Expropriation Risk, is calculated as the average value for each country over the period 1985-1995 and ranges between 0 and 10. Higher scores representing better institutions, thus lower risk of confiscation or forced nationalization. This variable is originally obtained from Political Risk Services, and taken as reported in McArthur and Sachs (2001).

This modified-Solow model also formalizes the idea that poor institutions might induce poverty traps and income clubs.[5] Equation 4, simply depicted in Figure 2, implies that the quality of institutions generates different steady states. Consider two economies with identical δ, *n*, *g*, *s*, technology (*A*), and initial stock of capital (k_0), but economy *P* is endowed with poor institutions (T_p) relatively to economy *R*, so that $T_R > T_p$. The model implies that the differences in the quality of institutions will produce different steady states indicated by k_P^* and k_R^*. Country P will growth until reaching k_P^* and stuck at that point. On the other hand, country R, which has identical initial conditions, but is endowed with better institutions (T_R), will grow steadily reaching a higher steady state k_R^*. The lower steady state k_P^* can be interpreted as a poverty trap for a country that is endowed with poor institutions. Therefore, the model suggests that poor institutions might create poverty traps and the only way to escape it is through improvements in the quality of institutions. This result is consistent with North (1990), who questioned the ability of societies to eradicate an eventual inferior institutional framework that prevents poor countries to close the income gap with rich countries.

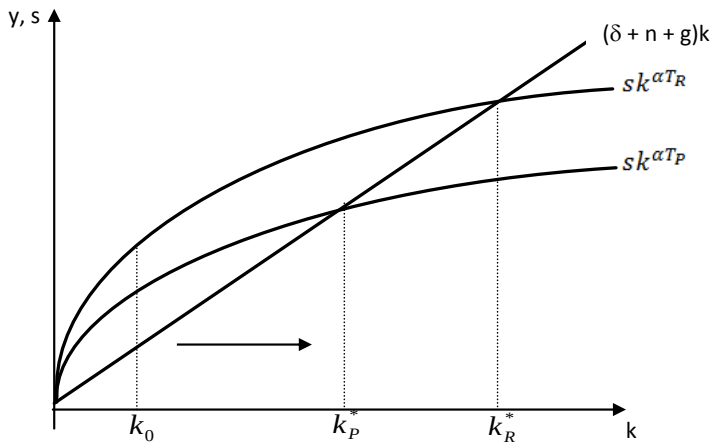

Figure 2. Institutions and Income levels.

2.2 EXTENDED MODEL

The literature suggests that institutions might create difficulties (e.g. labor market imperfections - restrictive labor contracts, or union's bargaining power, and/or government regulation) to utilize available technologies (Tebaldi and Elmslie, 2008; Baldwin and Lin, 2002, Haucap and Wey, 2004). It has also been argued that better institutional arrangements enable economic agents "to cooperate with one another more efficiently" (Matthews, 1986: 908) which ultimately boost factors' productivity. We account for these ideas by formally extending the baseline model. In particular, we re-specify the production function as follows:

$$Y = A^{(T-1)}K^{\alpha T}(AL)^{1-\alpha T} \quad (7)$$

Equation 7 incorporates the impacts of institutions on output in a traditional Solow production function. Since *T* is a normalized measure of institutional quality ranging from zero to one, an economy with the *relative* best institutions (*T=1*) would have a production function identical to the one used in

[5] The literature also shows that non-constant savings (Galor and Ryder, 1989), learning-by-doing and spillover effects (Barro and Sala-I-Martin, 1995) might generate poverty traps.

the standard Solow model.[6] However, not all countries will have the *relative best* institutions. Therefore, the Solow model is a particular case when institutions play no role in affecting the production process.[7] Moreover, the term $A^{(T-1)}$ accounts for the external effect of institutions on technology adoption and on total factor productivity. It implies that a country with poor institutions will be unable to fully benefit from the productivity gains generated by available technologies. The model is solved by defining $y = \frac{Y}{A^T L}$ and $k = \frac{K}{A^T L}$, which allows us to write the production in terms of effective labor: [8]

$$y = k^{\alpha T} \tag{8}$$

The effective capital accumulation equation is given by:

$$\frac{\dot{k}}{k} = sk^{\alpha T - 1} - (\delta + n + Tg) \tag{9}$$

This model has a well-behaved steady state solution in which $\frac{\dot{k}}{k} = 0$. Thus:

$$k^* = \left[\frac{s}{(\delta + n + Tg)}\right]^{\frac{1}{1-\alpha T}} \tag{10}$$

The extended model implies that institutions impact the long-run *level* and *growth* rate of output per worker. Defining $\bar{y} = \frac{Y}{L}$, using the fact that $\frac{\dot{k}^*}{k^*} = 0$, and log-differentiating equation 7 generates:

$$g_{\bar{y}} = \frac{\dot{\bar{y}}}{\bar{y}} = Tg \tag{11}$$

Therefore, the model implies that the growth rate of the output per worker is determined by technological change, but the quality of institutions also plays a major role in the growth rate of output per worker. More precisely, an economy may have access to state-of-art technology and experience fast growth in technology, but its poor institutions may hinder the adoption of available technologies and diminish the productivity of factors of production, which hampers economic growth.

Figure 3 provides mix evidence that institutions and the growth rate of per capita GDP (gross domestic product) are positively related. More precisely, the plot shows that there is a positive relationship between the growth rate of GDP per capita and the quality of institutions for countries with *relative poor* institutions. However, this relationship vanishes for countries with *relative good* institutions. Figure 3 suggest that there is a *quality threshold* for institutions; that is, countries with quality of institutions below this hypothetical threshold will experience significant increases in their growth rates of GDP per capita when their institutions improve. However, countries with relative good institutions and that have already crossed this *hypothetical* threshold might not experience any increase in their growth rate of GDP per capita when their institutional further improve.[9]

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[6] $\lim_{T\to 1} A^{(1-\alpha)T} K^{\alpha T} L^{1-\alpha T} = K^{\alpha}(AL)^{1-\alpha}$

[7] Equation 6 also satisfies the Constant Return to Scale (CRS) assumption, that is, if c is a nonnegative constant, then: $cY = A^{(1-\alpha)T}(cK)^{\alpha T}(cL)^{1-\alpha T} = c\left(A^{(1-\alpha)T}K^{\alpha T}L^{1-\alpha T}\right)$.

[8] It is worth noticing that our definition of "effective labor" accounts not only for the state-of-art technology but also for the quality of institutions.

[9] This study does not intend to provide empirical evidence on the model's predictions, so further study and empirical analysis are needed to investigate the relationship between the institutional-quality threshold and growth. Figure 3 is only displayed for didactical purposes.

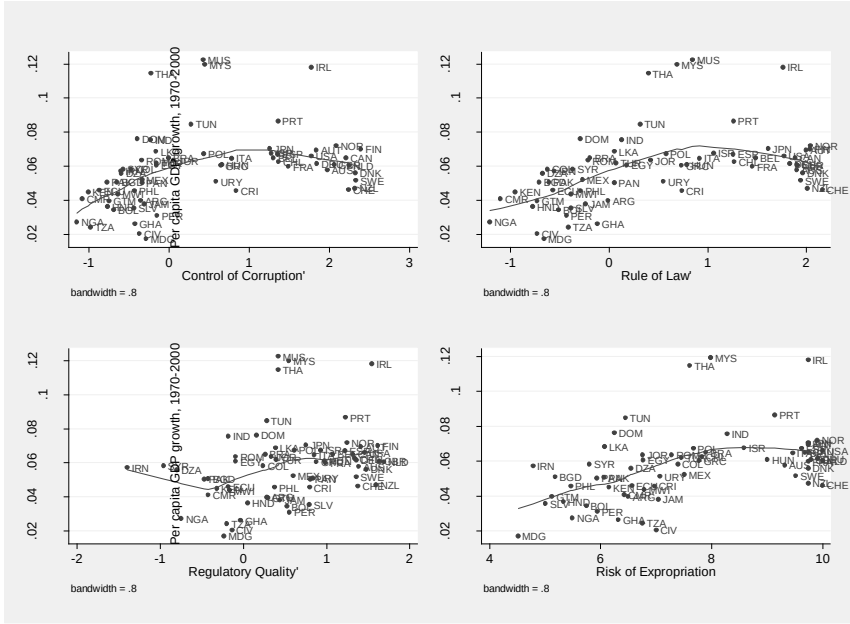

Figure 3. Per capita GDP growth and Institutions, 1970-2000.
Source: Authors calculation using data from the Penn World Table and Kaufmann, Kraay and Mastruzzi, M. (2007). Control or corruption, Rule of law and Regulatory Quality range from -2.5 to 2.5, with higher scores indicating better institutional arrangements. This study utilizes an average index through the time periods of 1996, 1998, 2000, 2002, 2004, and 2005. Expropriation Risk, is calculated as the average value for each country over the period 1985-1995 and ranges between 0 and 10. Higher scores representing better institutions, thus lower risk of confiscation or forced nationalization. This variable is originally obtained from Political Risk Services, and taken as reported in McArthur and Sachs (2001).

Institutions also affect the levels of output per worker, as displayed in Figures 1 and 2. However, the extended model suggests that the effect of institutions on output levels is stronger than that showed in Figure 2. Figure 4 depicts the case in which an economy is growing at the rate $T_1 g$ and subsequently, at time t_k, an exogenous shock improves the quality of institutions from T_1 to T_2 ($T_2 > T_1$). Here the improvement in the quality of institutions causes a once-for-all change in the *trajectory* of the level of output per worker, compared to a single jump in the model discussed in the previous section.

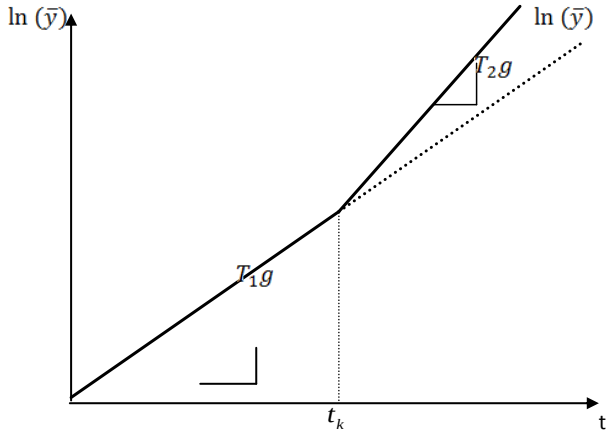

Figure 4. Institutional Quality and Time Path of GDP per worker.

The influence of institutions on output per worker originates not only from impacts on transitional and steady state technological efficiency, but also from impacts on capital accumulation. Institutions affect the marginal product of capital and therefore impact investments and capital accumulation. In particular, given that the ratio $\frac{y}{k}$ is constant around the steady state, deriving equation 8 with respect to *k* and evaluating its derivative around the steady state produces:

$$MP_k = \frac{\partial y^*}{\partial k^*} = \alpha T k^{\alpha T - 1} = \alpha T \frac{y^*}{k^*} > 0 \qquad (12)$$

This implies that improvement in the quality of institutions has a proportional impact on the steady state marginal product of capital. In other words, good institutions increase the returns to investments, which ultimately boost capital accumulation, leading to high level of output per worker. This result is consistent with empirical studies that find that capital accumulation is adversely affected by poor institutions (Mauro, 1995; Brunetti, Kisunko and Weder, 1997; Wei, 2000). For didactical purposes, Figure 5 shows that the investments share is positively related to the quality of institutions.

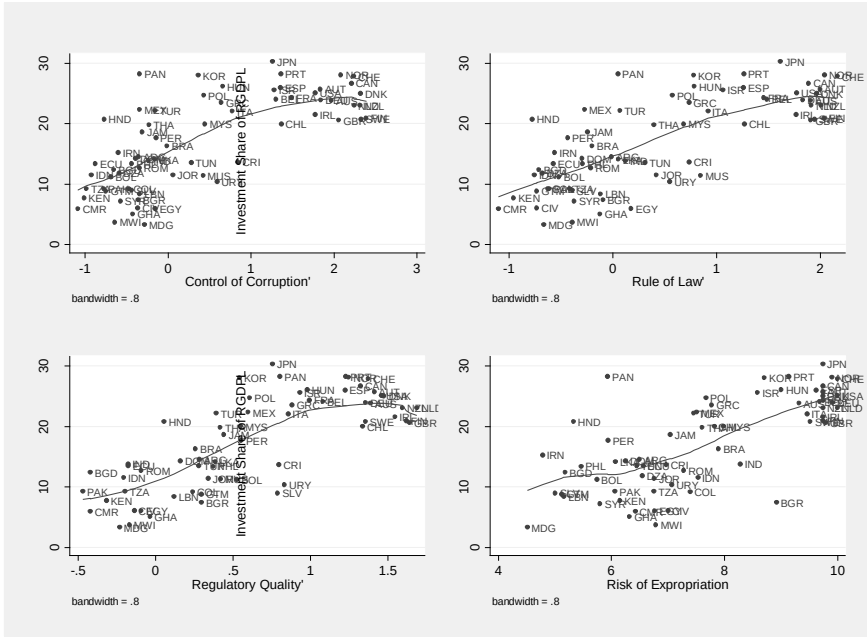

Figure 5. Institutions and the Investment Share of GDP, 2000.
Source: Authors calculation using data from the Penn World Table and Kaufmann, Kraay and Mastruzzi, M. (2007). Control or corruption, Rule of law and Regulatory Quality range from -2.5 to 2.5, with higher scores indicating better institutional arrangements. This study utilizes an average index through the time periods of 1996, 1998, 2000, 2002, 2004, and 2005. Expropriation Risk, is calculated as the average value for each country over the period 1985-1995 and ranges between 0 and 10. Higher scores representing better institutions, thus lower risk of confiscation or forced nationalization. This variable is originally obtained from Political Risk Services, and taken as reported in McArthur and Sachs (2001).

The extended modified-Solow model also predicts that poor institutions induce the creation of income clubs. As in the previous section, consider a case in which shows two economies (R and P) have identical δ, *n*, *g*, *s*, *A*, initial stock of capital per worker (k_0) and institutions, which implies that that income per worker in these economies are also equal $(\bar{y}_{0,R} = \bar{y}_{0,P})$. However, assume that at time t_k, economy R experiences an institutional shock that permanently improves the quality of its

institutions, so that $T_R > T_P$. Using the fact that the long-term trajectory of the output per worker is determined according to Equation 11, we can easily derive the trajectory of the relative output per capita $\left(\frac{\bar{y}_P}{\bar{y}_R}\right)$ of these two economies. Figure 6 shows that the differences in the quality of institutions will generate an income gap that persists over time. The income gap can be interpreted as an institutions-induced income club (or poverty trap), because economies with poor institutions will not be able to close the income gap.

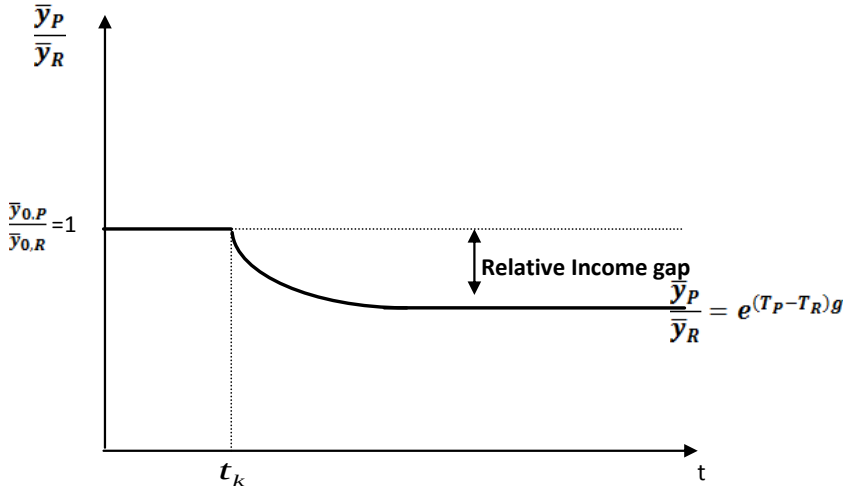

Figure 6. Institutions-induced Income Gap.

3 FINAL REMARKS

In this paper, we extend the traditional Solow model by modifying the production function and capital accumulation equations to allow for interactions between institutions and factor-productivity. The institutions-augmented Solow growth model shows that differences in the quality of institutions preclude income convergence and determine both the *level* and *growth rate* of output per worker. The model also shows that poor institutions induce poverty traps and the income gap between rich and poor countries will not disappear if poor countries' institutions do not improve relative to their rich counterparts.

RESUMO

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Palavras-chave: ?

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