GROWTH AND STRUCTURAL INEQUALITY: INTERPRETING THE EMPIRICAL FINDINGS THROUGH A THEORETICAL MODEL

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Abstract

The objective of this paper is to develop a theoretical model that addresses the question about policies that promote growth and helps minimize inequality. We will use this model to interpret recent empirical findings on growth and inequality. The model innovation are as follow: i) physical capital production depends upon human capital; and ii) Physical capital owner invest over the long run in R&D innovation to make physical capital more productive, not in quantity as in the traditional models. As primary result the model predicts very well different set of the empirical findings. It also shed some light on the empirical problem that arises from structural changes. As a final result the model predicts that higher growth and equality are reached by long run human capital accumulation, R&D innovation and policies that make the government more efficient, institutional reforms.

Keywords: growth economic, human capital and inequality

Resumo

O objetivo deste artigo é o de desenvolver um modelo teórico que permite analisar a questão das políticas que promovem o crescimento econômico e minimiza a desigualdade de renda. O modelo é então utilizado para interpretar recentes resultados empírico sobre crescimento e distribuição de renda. As inovações do modelo são: i) a produção de capital físico depende de capital humano; ii) os proprietários de capital físico investem em P&D visando tornar capital físico mais produtivos e não na quantidade como no modelo tradicional. Como resultados o modelo prediz muito bem alguns resultados empíricos demonstrando o porquê destes resultados em termos teóricos. O modelo ainda prediz que maior crescimento econômico e igualdade de renda no longo prazo está associado a acumulação de capital humano, P&D e políticas que tornem o governo mais eficiente, reformas institucionais.

Palavras chaves: Crescimento econômico, capital humano e desigualdade de renda

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1. Introduction

The objective of this paper is to present a model that shed some light on the different findings of the relationship between growth and structural inequality overtime. By structural income inequality I mean the division of the income between physical capital owner and human capital owner. The first receive rental of physical capital and the second wages. The objective of the model is to verify if there is a consensus policy that would promote growth and/or reduce inequality over the long run that is compatible with findings in the empirical literature.

The empirical literature on this subject is extensive and each contribution shows just the importance of element being analyzed. In this way, this literature misses a model that combines the findings in a single model.

The importance of a model that captures the consolidated contributions is that it enables us to see the relationship between the variables in a more broad way. Therefore, it allows us to see the complexity of the issues regarding growth and inequality. More interestingly it enables us to envision the relationship between the policies and the effects on growth and inequality over the long run.

The literature on growth and inequality has produced a set of different results. The different results found are regarded as either data problem – quality or lack of it - and or different stages of development of countries in the sample – sample mixture - or yet some technical problems - non-linearity, simultaneity, etc, in the regression model.¹

In this paper I plan to select for a theoretical analysis those empirical findings that are regarded by the literature as the most important for promoting growth and/or curbing down inequality. Hence, the model to be developed has as objective to show the implications of these findings in a theoretical way.

As an example of the research literature consider the Kuznets² U inverted relationship. This relationship between growth and inequality tells that in the first phase growth generates inequality and the second phase growth lowers income inequality. Which economies are in the rising inequality? Which economies are in the phase of lowering inequality? These are the basic question answered by this literature.

Although important, the studies on the relationship above do not answer anything about the policies that promote growth and equality. It assumes that this relationship is given and nothing else can be done. Contrary to this way of viewing growth and inequality in this paper the analysis will focus on policies that promote growth and help to minimize inequality.

In the review of the literature the goal is to sort the most important results that can be used by the theoretical analysis. However, most important of all we are searching for the answer to the following question: are there any consensus policies that promote growth and reduce income inequality? In other words, are there policies that might mitigate inequality and help improve growth at the same time?

¹ Temple (1999).
² Kuznet (1955).
The paper is conceived in the following way: Section One is the introduction; Section Two deals with the model and its relationship with the existing literature; Section Three is our conclusion.
2. The Model

2.1 Introduction

When developing a model, the most important aspect is about the engine of growth. The engines of growth can be physical capital which was introduced by Solow (1956), human capital that was considered by Lucas (1988) or yet R&D-Research and Development proposed by Romer (1990). In the model to be developed here the idea is to interpret the combination all these elements in a new way. Physical capital will be regarded as way of helping human capital to be more productive.\textsuperscript{3} In this view physical capital owners will be worried with the productiveness of their investment and not so much with the quantity of it provided by new investment. In this case physical capital accumulation is regarded as productivity improvement; so, it is more related to R&D-Research and Development model.

Moreover, the above aspects will be considered in a small open economy where on the real side the interest rate or the productivity of physical must equate around the world. I believe with these characteristics the model gain more flexibility in the analysis of the empirical findings. This last assumption as it will be shown is equivalent to say that the physical capital is a function of human capital. Either assumption will give us similar results at the aggregate level.

2.2 The Model Specification

The economy is comprised of N identical firms where profit maximization is the dominant objective. The output of any firm is given by the following Cobb-Douglas equation:

\begin{equation}
y = A k^{\alpha} (\mu h)^{1-\alpha}.\end{equation}

Where \( y \) is the output; \( A \) is the exogenous parameter that represents a set of government policies that affect the efficiency of the economy; \( k \) is the physical capital; \( \mu \) is an endogenous technological parameter; \( h \) stands for the human capital;\textsuperscript{4} and \( \alpha \) is the production parameter of the economy.

The profit maximization function is as follow:

\begin{equation}
\pi = A k^{\alpha} (\mu h)^{1-\alpha} - w \mu h - rk.
\end{equation}

Where \( w \) is the real wage in terms of final good and \( r \) is the international rate of return of physical capital. We assume it to be a small open economy in such way that \( r=r^* \).

The profit maximization condition leads us to the following two equations of real return to physical capital and wage:

\begin{align*}
3) & \quad \alpha A k^{\alpha-1} (\mu h)^{1-\alpha} = r = r^* \\
4) & \quad (1-\alpha) A k^{\alpha} (\mu h)^{\alpha} = w
\end{align*}

\textsuperscript{3} It can be interpreted as physical capital being a function of human capital.
\textsuperscript{4} For a model with heterogeneous human capital see Benabou (1996). This author also provides a very extensive review of literate on model of growth and inequality.
For example, making use of the assumption of small open economy, the ratio \( \mu h/k = \nu \) in equation (3) is constant. Any physical capital investment that makes the ratio increase would be equivalent to \( r > r^* \). This would bring more investments to the domestic economy from abroad. Thus, \( r = r^* \) would equate and so the ratio \( \mu h/k = \nu \).

By plugging \( \nu \) back to equations (3) and (4), the following two important equations arise.

5) \[ \alpha A \nu^{1-\alpha} = r = r^* \]
6) \[ (1-\alpha)A \nu^{-\alpha} = w \]

Let us open a parenthesis here for a policy analysis based on the two above equations. Let us keep in mind that \( A \) represents the efficiency index that converts input into output. So, it captures policies and other endogenous influences on the overall entrepreneurial activities in the economy.

Now, suppose an education policy that improves human capital, \( h \). This increases \( \nu \) to \( \nu'' \), so domestic interest rate will overshoot the international one for a short period, \( r > r^* \). The investment rise followed that (increase in physical capital) makes \( \nu \) returns to the equilibrium value. Hence, the domestic interest become equivalent to the international one, \( r = r^* \). Thus, real wage decrease would be temporary. Would that improve income inequality and/or growth? Unfortunately, nothing can be said without looking to the long run effect.

As a last example we look at an economic policy that decreases the exogenous factor \( A \) to \( A' \). This would generate a disincentive for investment, since \( r < r^* \). Capital outflow would put \( \nu \) back to its equilibrium. However, as a result real wages will be lower. This would lower the incentive for human capital accumulation. So, bad policies can make the incentive for further knowledge accumulation simply disappear hurting long run growth.

As we may see from the above paragraphs the complex relationship between the two variables and the effect of the policies need more attention. The forthcoming section will bring the dynamics of this relationship and help us clarify some of the results found in the literature.

2.2 The Dynamics

In this economy there are two types of consumers and only one type of knowledge. The first consumer is in charge of accumulating human capital and the second one is the owner of the physical capital good. The economic policies here are understood as simply an exogenous parameter change.

The consumers have the traditional welfare function, where the consumption is represented by \( c_j \), the intertemporal elasticity of consumption is given by the parameter \( \xi \). The overtime discount rate is assumed to be constant and equal to \( \rho \). More specifically, we have

7) \[ W = \int_0^\infty \left( \frac{c_j}{1-\xi} - 1 \right) e^{-\rho t} dt \quad \text{for} \quad \xi = 1, \text{ and} \]

\[ W = \int_0^\infty \ln (c_j) e^{-\rho t} dt \quad \text{for} \quad \xi = 1. \]

Where \( j = h, k \) represents the owners of human and physical capital, respectively.
Now recall our hypothesis that the production of physical capital objective is a function of human capital. It is similar to our hypothesis of small economy for $v^1 = \phi$, where $\phi$ is the technological improvement in physical capital. Remember, this equality is an especial condition not the general case. The physical capital production is equivalent to the following:

8) \[ k = \phi^{1/\alpha} \mu h \]

This production function presents increasing returns to physical capital technological improvement. By replacing the definition of physical capital by (8) and considering that the representative of the human capital owner only gets $(1-\alpha)$ of the total income, equation (4), we have the following result:

9) \[ y = (1-\alpha)A\phi \mu h = B\phi h, \quad \text{where } B = (1-\alpha)A \mu \]

For the consumer owner of $h$, the variables $A$, $\mu$ and $\phi$ are given at any point in time. The Hamiltonian for this problem led us to the following solution:

10) \[ G(h) = (1/\xi)[B\phi - \rho] \]

This is the growth rate of the human capital owner income, which is also the growth rate of human capital. Human capital owners would benefit from an economy where investment in physical capital productivity ($\phi$) are higher.

Now, suppose an exogenous shock in $\phi$, increasing physical capital productivity. This would lead to a human capital accumulation rise fostering their growth rate. As we shall see this human capital improvement will further push up the growth rate of the physical capital accumulation.\(^5\) Hence, it will generate a positive cycle.

Now, let us move our attention to the consumer owner and producer of the physical capital. The consumer objective overtime is to increase $\phi$ or the physical capital productivity. Thus, we are moving way from the traditional physical capital quantity accumulation literature. This consumer receives $(1-\alpha)$ of the overall income, equation (3); therefore, equation (9) equivalent form is the following:

11) \[ y = (1-\alpha)A\mu h\phi = Dh\phi, \quad \text{where } D = (1-\alpha)A \mu. \]

The Hamiltonian for this problem gives us the following solution:

12) \[ G(\phi) = (1/\xi) [Dh - \rho]. \]

Remember that $A$, $\mu$ and $h$ are given. Here, the main difference is that the stock of $h$ is an important element in the growth rate of the physical capital owner income. In this way, physical owners will benefit from educational policies that improve $h$ (stock), because it make their income grows fast in the long run.

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\(^5\) In terms of international labor force mobility, human capital owners would immigrate to economies where physical capital productivity is rising overtime.
The overall growth rate of the economy is the sum of the equations (10) and (12). Now, let us make $h$ and $\phi$ to represent the average of a distribution function of human and physical capital owners. Therefore, the income distribution of any country is the combination of these two distributions. So, growth and inequality studies in order to be accurate must dealt with that by using an index that represents these distributions independently and not just the overall income distribution.

The potential for conflicting policies that affect wage and capital rental receivers as well as growth can lead us to a number of substantial combinations. If we add to these combinations, the cross-country differences then results becomes even more unpredictable. The coming section illustrates some of the conflicts of the empirical findings in the literature.

2.3) The Empirical Findings

The first parameter to be analyzed is $\alpha$. This parameter gives us the importance of the wage and/or rental receivers over the growth rate. The importance of this parameter emerged in the study done by Barro (1999). Considering that in developed economies wage participation in the overall GDP is above 0.5 or $\alpha > 0.5$ while in developing economies it stays below 0.5, thus any economic policy that causes changes in this parameter is equivalent to transfer income from one class to the other. However, the overall growth rate should not be affected according to our model.

Consider the aspect of that the wage equation represents not the overall economy, but sectors of the economy. Thus, it will be as many as wage equations as sectors. The wages will differ among the sector in the long run by the level of productivity of physical capital as predicted by equation (10). Hence, we expect that economies where human and physical capitals are more evenly distributed among sectors the income inequality would be lower. These results are compatible with the findings of Walde (2000). The author compared Germany, where workers have almost the same knowledge level, with US where knowledge is less evenly distributed in the sectors. Hence in US new technology requiring more skilled workers lead to more wage inequality.

Changes in $\mu$ is reflected in the result of the paper by Robinson (1976). He showed that this must be the case for explaining the findings of Adelman and Morris (1973) where inequality was not changing at all, but income was improving in average for wage and physical capital owners.

The change in $\phi$ overtime was investigated by Barro (1999). More specifically, he studied the role of the investment - physical capital accumulation - over growth. The result found by the author is that this policy would improve growth. According to our equation (10) if this policy increases only $\phi$, then the human capital owners (wage receivers) are the beneficiary ones in the first place. This result held even by annulling the high weight of wage receivers in rich economies; however income inequality would rise in the long run as found by the author. The question is would the high wages promote more human capital accumulation in the long run? This is a fact that remains to be explored.

The above results are also sensitive to data modifications. For example Banerjee and Duflo (2000) after exploiting the data sets used by Barro (1999) and Perotti (1996) found that changes in inequality, whichever direction, reduces economic growth. This preliminary result was accomplished by:
i) Collapsing both distributions (wage and rental owners) for each country into one, then having a unique distribution for the overall data set; and

ii) Eliminating all the cross-country policies effects and distribution parameters differences by using the variables in differences.

This showed that the mean of the growth rate of the samples from Barro (1999) and Perotti (1996) were positive while the mean of the Gini coefficients did not change overtime. Thus, Banerjee and Duflo (2000) showed that between 1960 - 1990 growth speeds was declining in average while the variance of the overall distribution was increasing. In other words, the non-linearity of the relationship growth and inequality had the shape of an inverted U distribution. More, this distribution has moved overtime at a decreasing speed while spreading out at the same time (opening the legs of U relationship). In simple words, rich countries became in average richer relative to poor ones in the samples. Can we say that just the movement affected the shape or the shape affected the speed of the movement? As answered by the authors the data has little to say about that.

The A role in the long run can be better seen as the efficiency of the government presence in the economy. It has as objective to collect taxes from consumers and give back in terms of services, transfers, infrastructures, etc. This job can be accomplished in terms of a production function where the net results for the overall society for the government is represented by the following three situations: Decreasing Returns to Scale – DRS; Constant Returns to Scale – CRS; and Increasing Returns to Scale – IRS.

The DRS government is the one that give a net negative return to the society or waste money, so A’ < A. The CRS is the one that give back to society no net results of its service or A=A’. The IRS would be the one that would give back to society a net increase in overall result or A’ > A. This would make the government grew in size relative to the private sector, so we will not consider this last case.

Simplifying the analysis in order to focus on the education issue investigated by some authors, we concentrated on the case where tax revenue is used to promote educational policies. In this case, we start by assuming a case of the government that tax the capital owners (τ) and give it back in the form of education (ξ). Equations (10) and (12) become the following ones:

13) \[ G(h) = (1/\xi)[(1-\tau)B - \rho]; \]

14) \[ G(\phi) = (1/\sigma)[(1-\tau)Dh' - \rho], \text{ where } D= (1-\alpha)A\mu. \]

Let us assume a DRS government (A’ < A) then increase in tax would lead to decrease in overall growth in the first moment, according to equation (14). Nonetheless, as \(h\) increases to \(h' = h(1+\xi)\) in the future growth will be positive, but below the previous pre-tax rate.

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6 In reality the overall results are hard to interpret and were as these according to the authors “High levels of inequality are associated with higher subsequent growth in Latin America, while they are associated with lower subsequent growth in the rest of the sample”. Continuing…”The relationship is fairly linear (but of opposite sign) in both sub samples. Looking at rich and poor countries, outside Latin America, yields similar results” [Banerjee & Duflo (2000)]. It requires that the weight of the countries in the sample that decreased growth surpassed the Latin America (or rich countries in Barro paper) effect of increase in growth while at the same their decrease in inequality did not surpassed the Latin America increase in inequality (or the poor countries in Barro interpretation). If this is the case then authors’ data manipulation did not eliminated the α weight of our theoretical model, so the weight factor was still there.
however inequality would start to increase. The size of the growth impact and the inequality would be very different for each country based on the size of the parameter $\alpha$. This theoretical result is compatible with the findings of Alesina and Rodrik (1994) where “The Greater the income inequality of wealth and income, the higher rate of taxation, and the lower is growth.”

In the same line, Sylvester (2000) study “finds that a higher level of income inequality is associated with more spending for public education. Although these expenditures have a negative impact upon growth contemporaneous with these public education expenditures, the impact upon future growth is positive”. So, the benefit of the growth as predicted by the model is intertemporal.

Alesina and Perotti (1993) explain the same finding that high level of income inequality lowers subsequent growth because it introduces political instability. While Perotti (1994) found that these results is because it induces government to raise transfers.

Persson & Tabelini (1994) found that inequality is negatively correlated with subsequent growth. In their study they suggest that the transmission mechanism channel for their finding remains to be more extensively investigated. One should pay attention to the nature of the government policy intervention.

Whichever transmission mechanism is used to explain this intertemporal redistribution, it seems to be independent of government being democratic or dictatorial since samples used have both cases. According to our model, the only way to avoid or minimize this important and necessary intertemporal redistribution effect on growth is by making government overtime less DRS. In other words, this lead us to the fact that over the long run another common consensus policy to be pursued would be the one that makes government more efficient - institutional reforms. The study done by Williamsom (1997) for the period 1965-1990 seems to corroborate with that. According to the author, increase in human capital quality and quantity, together with better institutions, seems to be the explaining fact for positive growth in the period.

3. Conclusion

The growth and inequality relationship which are simultaneously determined in our model seems to have different impact from policies. This is compatible with over time and across countries empirical studies. One element that seems to influence this relationship is the structural parameter represented by the elasticity of output regarding physical capital. This parameter is different across countries and possibly over time as indicates the values found for developing economies in contrast to developed ones. Therefore, wages and capital rental are structurally different among countries.

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7 Similar results the author found in his Sylvester (2002) study.
8 Partridge (1997) applied the same study of Persson and Tabelini (1994) to a panel data for US states. Their results are as follows: states with more income inequality had experienced greater subsequent growth, but states in which the middle income quintile had a larger share of income had grown faster. This contradictory result shows how complex is the relationship of policies and mechanism of transmission that can be seen through equations (13) and (14) at state level. Nonetheless, when the authors analyze their result at variable level they find that an increase in expenditure in education that lead to improvement equivalent to a standard deviation results in positive growth far great then a simple income transference program that reduces income inequality. In our view, this is equivalent to make a government less DRS through educational policies.
9 Better human capital in terms of quality is captured by log of years of secondary schooling and the increase in the economic active population. Increase in the quantity and quality of the working force.
The growth and structural equality seems to benefit mostly from policies that promote human capital accumulation and R&D investment that makes physical capitals more productive rather than investment that promote their increase in quantity. Policies that make the economy as whole more efficient, especially the government, promotes long run higher growth rate and less income inequality. Hence, the model predicts that institutional reforms are welcome policies of growth and income structural equality.
References


