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Human Capital and Income Concentration in Brazil

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Abstract

High income concentration and poverty in Brazil have been intensively studied by many researchers, suggesting that an obvious factor influencing unequal earnings in the country is the heterogeneous level of education in the labor force; for education can be understood as a mean to attain improvements in labor productivity and consequently in family income. The present study aims to construct a recursive general equilibrium model where agents differ in their education levels and therefore face different employment opportunities. This dynamics is captured by a stochastic process characterized by a two stage Markov chain. The associated transition probability matrixes reflect both the fact that more educated agents face a higher probability of remaining employed if they are currently employed and, that they also have a higher probability of being employed next period if they are currently unemployed. The long run analysis of the model economy calibrated for the Brazilian economy shows that it can generate a high income concentration as observed in the empirical evidence.

1 Introduction

High income concentration and poverty in Brazil have been intensively studied by Paes de Barro, Henriques and Mendonça (2000 a and b). In their words, "...Brazil is not a poor country, but a country with too much poor people...". Their careful research clearly shows that high poverty rates are due mainly to the high concentration of income and to the "unequal opportunities for social and economic inclusion". Although international comparisons show that between 1978 and 1998 almost 70% of the countries have a per capita income below Brazil's,10% of the richest families in the country have access to 50% of the aggregate family income whereas 50% of the poorest households have a participation of only 10% over the same aggregate income.

An obvious factor influencing unequal earnings is the heterogeneous level of education among the labor force, for education can be understood as a mean to attain improvements in labor productivity, consequently in family income.

This line of argument, based on the theory of human capital first developed by Becker (1964), Uzawa (1964), Lucas (1988) and Schultz (1978) among others, regards formal education as a mean to invest for better future earnings through the improvement in labor productivity it could bring about, with a positive impact in the economy's growth rate. On the other side, many empirical studies were conducted to link the unequal distribution of schooling as the factor most contributing to the high income concentration. Fishlow (1972) conducted a study analyzing the main factors contributing to the high Brazilian income concentration during the 60s. Based on the Brazilian Demographic Census the author showed that the control variable that most explained the high income concentration of the sample was the educational difference, which accounted as much as 20% of the total income concentration. Other control variables as economic activity, regional distribution and age groups were not contributing as much to explain the empirically observed income concentration. Langoni (1973) also showed that education was the factor most contributing for the high and increasing Brazilian income concentration during the 70s. Reis and Barros (1990) based on PNAD[2] data studied the Brazilian regional distribution of earnings for the period 1976-1986. Among different Brazilian regions prevailed a quite different pattern

[2]Pesquisa Nacional de Amostra Domiciliar, IBGE.

of distribution of education and, this factor alone, explained almost 50% of the earning differences observed in the country´s different regions. Lam and Levinson (1991) used different PNADs data to study the evolution of schooling and earning distributions in Brazil during the 70s and 80s, finding that the younger the analyzed group the better the improvement in the distribution of education as well as the distribution of earnings. Barros and Ramos (1992) also analyzing PNADs data found that for Brazil the return for a year of schooling is higher than for other countries, increasing with the level of schooling and decreasing with the level of regional development. Although there are many other factors affecting the income distribution of a given country[3], those factors act as complements in explaining the high Brazilian income concentration due to the unequal distribution of schooling in the population of the country as suggested by Cacciamali and Freitas (1992), Bonelli and Ramos (1993) in their static decomposition analysis and Franco (2001).

Based on the above evidence, the present study aims to construct a recursive general equilibrium model where a high income concentration can be generated due to differences in the human capital stock available to different types of agents. The agents of the model economy are heterogeneous for they differ in the level of education, and according to this differential they face different employment opportunities which evolves according to a stochastic process described by a two state Markov chain. The associated transition probability matrices reflect the fact that more educated agents face a higher probability to remain employed next period if they are currently employed and, if they are actually unemployed they also have a higher probability of been employed next period than for less educated agents. The steady state analysis shows that this model economy can generate a high concentration of income as suggested by the Brazilian empirical evidence.

The paper is organized as follows. Section 1 presents the model economy as well as the definition of the recursive equilibrium which is numerically computed. Section 2 describes the parameters and the data sources used for calibrating the model. Section 3 analyses the steady state distribution of income generated by the model. The conclusion presents the main findings and the extensions that could be incorporated in the study.

[3]See for instance the theory of efficiency wages and the theory of labor market segmentation.

2 The Model Economy

The model economy extends Aiyagari's (1994) formulation to include a large number of ex ante heterogeneous agents trading in incomplete markets. Agents are identical in their preferences but differ in their level of education: type 1 agents represent the labor force with 12 or more years of education and type 2 includes all agents with less than 12 years of education[4]. These differentiated levels of education determine, in turn, the differentiated Markov process governing the agent's employment opportunities, hence, the type 1 (type 2) agent's labor income at time t, s_t^1 (s_t^2), evolves according to a 2 state Markov chain with transition probability matrix $\mathbf{P}^1$ ($\mathbf{P}^2$), such that the respective elements $[P_{ij}], i, j = e(employed), u(unemployed)$ denotes the probability of type 1 (type2) agent being at state j next period given that currently is facing state i.[5] If the realization of the process at t is $s_t^1 = e$ ($s_t^2 = e$), the agent of type 1 (type 2) is employed and receives a labor income $w^1 s_t^1 = w^1$ ($w^2 s_t^2 = w^2$), where $w^1 > w^2$, for the productivity of type 1 labor exceeds the productivity of type 2 labor. Otherwise, if $s_t^1 = u$ ($s_t^2 = u$), the agent of type 1 (type 2) is unemployed. Notice that, for each agent of the same type, the histories of employment opportunities they have had can differ, differing consequently the capital, k_t^i, $i = 1, 2$, she/he had accumulated. The agents are constrained to hold a single asset, capital, among a grid of positive values $\kappa = [0 < k_1 < \ldots < k_n]$, hence they are not able to borrow/lend in any period. Moreover, if any type of agent is unemployed in any period t, she/he can finance her/his current expenditure in consumption, c_t^i, and/or investment, x_t^i, with a resource given by θw_t^i which could be understood as resources obtained from home production , equivalent to a fraction θ of the income if she/he were employed, w_t^i, as well as the return from capital services, $r_t k_t^i$, of accumulated capital in the past. Then, for each type of agent $i = 1, 2$, the maximum problem can be summarized as follows:

$$\max_{k_{t+1}^i} E_0 \left\{ \sum_{t=0}^{\infty} \beta^t \left[(1/(1-\sigma))(c_t^i)^{1-\sigma} \right] \right\} \tag{1}$$

such that,

$$c_t^i + x_t^i \leq w_t^i s_t^i + r_t k_t^i, \quad \text{for } t \in [0, \infty), \quad \text{if } s_t^i = e$$

[4] For justification of this cut line, please refer to section 3 below.

[5] *Please see below for detailed description of the transition probability matrix* $P^1(P^2)$.

$$c_t^i + x_t^i \leq \theta w_t^i + r_t k_t^i, \quad \text{for } t \in [0, \infty), \quad \text{if } s_t^i = u$$
$$c_t^i \geq o$$
$$k_{t+1}^i \in \kappa$$

given (k_0^i, s_0^i) and the law of motion for capital formation $k_{t+1}^i = (1-\delta)k_t^i + x_t$, where β is a discount factor, δ a depreciation rate of capital and, σ a risk aversion parameter.

The Bellman equation for each type of agent, $i = 1, 2$, each employment state $s \in m/m = \{e, u\}$ and each possible capital value $k_j \in \kappa$ is given by the expression below.

$$v^i(k_j^i, s_m^i) = \max_{k_{t+1}^i \in \kappa} \{(\frac{1}{1-\sigma})[(1-\delta-r_t)k_t^i + w_t^i s_{mt}^i - k_{t+1}^i] + \beta \sum_{m=1}^{2} P_{i,m} v(k^{i'}, s_m^{i'})\} \quad (2)$$

The above equation is solved for a value function $v^i(k, s)$ and an associated policy function $k^{i'} = g^i(k^i, s^i)$ mapping this period (k^i, s^i) pair into an optimal choice of capital to carry into next period, $k^{i'}$. The solution of the above problem, for each type of agent, induces a stationary distribution $\lambda^i(k, s)$: starting with a particular distribution $\lambda_0^i(k, s)$ at t=0, the distribution of agents of the same type over individual state variables, (ki, s), remains constant over time even while the employment status of the individual agent of the corresponding type is itself a stochastic process. Thus, the average level of capital across agents of the same type i, $i = 1, 2$, is given by:

$$K^i = \sum_{k^i, s^i} \lambda^i(k^i, s^i) g(k^i, s^i) \quad (3)$$

and, the average level of capital across agents of the economy by:

$$K = qK^1 + (1-q)K^2 \quad (4)$$

where q represents the proportion of agents of type 1 in the unitary mass of workers.

The average level of employment for each type of agents is:

$$L^i = \sum_{k^i} \lambda^i(k^i, s^i = e) \quad (5)$$

so that the average level of employment for the economy is given by the expression below.

$$L = qL^1 + (1-q)L^2 \tag{6}$$

The Markov process governing the employment opportunities differ according to the type of agent, hence, the associated transition probability matrices are given by:

$$\mathbf{P}^1 = \begin{bmatrix} a_{ee} & a_{eu} \\ a_{ue} & a_{uu} \end{bmatrix} \qquad \mathbf{P}^2 = \begin{bmatrix} b_{ee} & b_{eu} \\ b_{ue} & b_{uu} \end{bmatrix}$$

where,

$$\begin{cases} a_{ee} & > & a_{eu} \\ a_{ue} & < & a_{uu} \end{cases} \qquad \begin{cases} b_{ee} & > & b_{eu} \\ b_{ue} & < & b_{uu} \end{cases} \qquad \text{and,} \qquad \begin{cases} a_{ee} & > & b_{ee} \\ a_{eu} & < & b_{eu} \\ a_{ue} & > & b_{ue} \\ a_{uu} & < & b_{uu} \end{cases}$$

The elements of the above matrices reflect the fact that the more educated the agent, the higher is also his/her probability of remain employed next period if he/she is already employed and, the higher also his/her probability to be employed next period if currently unemployed.

The competitive firms of the model economy produce according to a technology described by a Cobb-Douglas production function of the following form:

$$Y_t = AK_t^{\alpha_1} L_t^{1,\alpha_2} L_t^{2,(1-\alpha_1-\alpha_2)} \tag{7}$$

The factor's markets are competitive, hence, their real returns are given by their respective marginal physical products, according to the first order conditions of the firm's profit maximization problem. They are given by:

$$w_t^1 = A\alpha_2 K_t^{\alpha_1} L_t^{1,\alpha_2-1} L_t^{2,(1-\alpha_1-\alpha_2)} \tag{8}$$

$$w_t^2 = A(1-\alpha_1-\alpha_2) K_t^{\alpha_1} L_t^{1,\alpha_2} L_t^{2,(-\alpha_1-\alpha_2)} \tag{9}$$

$$r_t = A\alpha_1 K_t^{\alpha_1 - 1} L_t^{1,\alpha_2} L_t^{2,(1-\alpha_1-\alpha_2)} \tag{10}$$

where factor share parameters are assumed to be $\alpha_1 \in (0,1)$, $\alpha_2 \in (0,1)$ such that $(\alpha_1 + \alpha_2) < 1$. Therefore, if in the economy type 2 (less educated) labor is more abundant than type 1, i.e. $L_t^2 > L_t^1, \forall t \geq 0$, the real return of the latter will be necessarily higher than of the former, i.e. $w_t^1 > w_t^2, \forall t \geq 0$.

2.1 Recursive Equilibrium

The recursive equilibrium for the above model economy consists of:

(i) a set of policy functions for each type of agent, $g^i(k^i, s^i)$,

(ii) a set of stationary probability measures $\lambda^i(k^i, s^i)$, $i = 1, 2$, describing the distribution of agents across the state variables (k, s), for each type of agent and,

(iii) a set of positive numbers $(K, r, w^1, w^2) \in R_+$,

such that,

1. prices satisfy $w_t^1 = \partial Y_t / \partial L_t^1$, given by (8); $w_t^2 = \partial Y_t / \partial L_t^2$, given by (9) and, $r_t = \partial Y_t / \partial K_t$, given by (10);
2. each policy function $g^i(k^i, s^i)$, $i = 1, 2$, is the solution to the respective agent's maximization problem (1);
3. each probability distribution $\lambda^i(k, s)$, $i = 1, 2$, is a stationary distribution associated with the policy functions $g^i(k^i, s^i)$, $i = 1, 2$ and the probability transition matrices $\mathbf{P}^i$, i.e.
$$\lambda^i(k, s) = \sum_{s^i} \sum_{k^i} \lambda^i(k^i, s^i) \mathbf{P}^i(s^i, s^{i'})$$
4. the aggregate capital stock of the economy is determined by the average behavior of the agents, i.e.
$$K = q\lambda^1(k^1, s^1) g(k^1, s^1) + (1-q)\lambda^2(k^2, s^2) g(k^2, s^2)$$
5. the average employment of the economy is given by the aggregate employment status for both types of agents.
$$L = q\lambda^1(k^1, s^1 = e) + (1-q)\lambda^2(k^2, s^2 = e)$$

3 Calibration

To obtain a numerical solution to the model and generate a steady-state income distribution, we need to choose particular values for the parameters of the model. The calibration of the model was made under the assumption that the model period is one week.

The parameter α_1 correspond to the capital's share in production. Following Araújo and Cavalcante Ferreira (1999) the value of this parameter is taken to be 0.49, being this value consistent with the National Account Tables data.[6]

The depreciation factor for capital stock, $1-\delta$, is set to 0.88 which implies an annual rate of depreciation, δ, of 12%. To fully describe the production function we still have to set the value of the parameter α_2, the educated labor's share in production.

From equations (8) and (9) one may conclude that:

$$\frac{w_1}{w_2} = \frac{\alpha_1}{1-\alpha_1-\alpha_2}\frac{L^2}{L^1} \tag{11}$$

Data from the Pesquisa Mensal de Empregos (PME)[7] covering the period from 1991 to 1997 shows that the wage of workers with 12 or more years of education is about 3.50 times the wage of workers with less than 12 years of education. The same data source shows that the participation of the less educated workers in the total labor force is 5.25 times the participation of the more educated workers. These informations and equation (11) above implies a value of α_2 of approximately 0.31.

The reason to choose 12 years of education as the threshold between educated and less educated worker comes from Table 1 and Table 2 below.

[6]This value for the capital's share based on the Brazilian National Accounts data is high compared to international evidences. Nonetheless, this parameterization is adopted because we are not dealing with a balanced growth model. For a detailed analysis of the long run implication of this data please refer to Gomes, V., Bugarin M and Ellery Jr, R. (2005).

[7]Monthly Emplyment Inquiry

Table 1: Unemployment rate by years of education (%)[8]

	0-4	5-8	9-11	≥12
average 1991	3.86	6.96	5.35	2.56
average 1992	4.67	8.72	6.65	2.63
average 1993	4.34	7.29	6.17	2.50
average 1994	3.93	6.94	5.87	2.39
average 1995	3.61	6.55	5.69	2.32
average 1996	4.18	7.23	6.63	2.79
average 1997*	4.42	7.85	7.37	2.69

*January to April

Table 2: Average income by years of education (R$ of Dec./1995)[9]

	0-4	5-8	9-11	≥12
average 1991	291.18	341.86	546.45	1,269.67
average 1992	241.19	281.97	457.39	1,036.24
average 1993	262.11	308.73	500.92	1,173.25
average 1994	263.14	315.05	525.61	1,286.70
average 1995	298.73	354.33	552.34	1,359.21
average 1996	315.51	362.69	569.12	1,396.33
average 1997*	317.81	362.44	542.07	1,336.71

*January to April

Table 1 displays two cuts, the first between 0-4 and 5-8 years of education the second, the second and clearest happens between 9-11 and 12 or more years of education. Table 2 displays only one clear cut and it is located between 9-11 and 12 or more years of education. Since the model allows for two types of agents the most appropriated classification is the one which separates individuals with more than 12 years of education from the others.

The elements of the transition probability matrices computed based on the statistics computed by Curi, A.Z. and Menezes-Filho, N.A. (2006). This study shows that during the 90s the transition probability of an economically active formally employed agent of the Brazilian economy to be employed

[8] Source: Mercado de Trabalho: Conjuntura e Análise; Ministério do Trabalho e IPEA. (Table A.4.6).

[9] Source: Mercado de Trabalho: Conjuntura e Análise; Ministério do Trabalho e IPEA. (Table A.7.6).

next period is 77.24% and of an economically active unemployed worker to continue unemployed next period is 14,9%. They also compute the marginal impact of various factors on the transition path. Taken the mean value of the workers with less than 11 years of education and comparing it with the marginal value corresponding to workers with more than 11 years of education, we observed that the transition from state e to state u is 62% higher for less educated workers. On the other side, the marginal effect on the transition from state u to state e is 11.66% higher for more educated workers than for the less educated ones. Taking this numbers into consideration, the transition probability matrices can be calibrated as follows.[10]

The transition probabilities matrices are then given by:

$$P^1(s,s') = \begin{bmatrix} .77 & .23 \\ .94 & .06 \end{bmatrix} \quad \textit{and} \quad P^2(s,s') = \begin{bmatrix} .63 & .37 \\ .83 & .17 \end{bmatrix}$$

where s is the current state and s' is the next period state.

There exists a wide range of empirical estimation for the intertemporal elasticity of substitution[11], $1/\sigma$ and, there is also a large set of studies dealing with the estimation of the intertemporal elasticity of substitution for Brazil, most of them applying econometric approaches to estimate this parameter or to identify some facts related with the value of this parameter[12]. Although most of the empirical literature deals with credit restriction and may produce values consistent with our model, we have chosen to use the value proposed in Barreto and Schymura (1995), since, like us, they work with a calibrated dynamic general equilibrium model. So we set the value of σ at 1.43, which correspond to a intertemporal elasticity of substitution of 0.7.

The discount rate β was taken from Araújo and Cavalcante Ferreira(1999) and is set to an annual value of 0.96. Finally, the parameter θ, was set to 0.05 following Aiyagari (1994).

[10] The above study uses data from the monthly employment survey of the Brazilain main metropolitan regions (Pesquisa Mensal de Emprego) publisehd by the Instituto Brasiliero de Geografia e Estatística, IBGE.

[11] This seems also to be the case even for the U.S economy, see Imrohoroğlu, A., İmrohoroğlu, S. and Jones, D. (1998), among others.

[12] See Cavalcanti (1994), Issler and Rocha (1999) and Reis, Issler, Blanco and Carvalho (1998).

4 Steady State Analysis

Table 3 below presents the average level of the real variables of the model economy at the steady state for each type of agent and the prices of the three factors of production as well.

Table 3: Steady State Variables Values

Variables	type 1	type 2
Capital Stock	18.070	14.922
Employed Mass	0.8132	0.7071
Wage Type 1	2.9946	0.1406
Capital Rent	0.0740	0.0740

The exercise shows that capital stock corresponding to the type 1 agent is approximately 21% higher than the capital stock corresponding to the second type. This result seems to reflect the fact that the former have a labor income more than 20 times higher than the latter as well as a higher probability of being employed. Moreover, the model economy produces an employment mass of type 1 workers 15% higher than the corresponding mass for the type 2.

Table 4 below shows in turn the sensitivity analysis results adopting, (i) different values for the risk aversion parameter, σ, (inverse of the intertemporal elasticity of substitution) and alternatively (ii) a different value for the capital income share, α_1, noticing that the values in the third column correspond to the original calibration above.[13]

Table 4: Sensitivity Analysis (steady state values)

Variables	$\sigma = 1.2$	$\sigma = 1.43$	$\sigma = 1.6$	$\sigma = 2$	$\alpha_1 = 0.33$
Capital Stock type 1	18.169	18.070	17.923	17.613	7.2756
Capital Stock type 2	15.243	14.922	15.024	15.865	1.8665
Capital Rent	0.0734	0.0740	0.0740	0.0737	0.0600
Wage type 1	3.0209	2.9946	2.9970	3.0094	0.8435
Wage type 2	0.1418	0.1406	0.1407	0.1413	0.7118

[13] Since there is no changes in the calibration of the transition probability matrices, employed labor in the long run equilibrium for both types of agents are not reported in Table 4.

The sensitivity results shows that the obtained long run equilibrium values are fairly robust to the adopted elasticity of substitution calibration. Whereas, the steady state equilibrium variable values changes drastically using the capital income share of 0.33 based on international evidence and keeping the elasticity of substitution parameter to 0.7 as the initial calibration In this case, we can observe that the capital stock decreases in absolute terms but the differential between the two types of agents increases drastically. Type 1 agents have 1.21 times more capital stock than type 2 using the initial calibration. On the other side, adopting the alternative capital share of 0.33, the capital stock pertaining to the type 1 appears to be approximately 3.89 times higher than the capital stock allocated to the second type in equilibrium.

4.1 Income Distribution Analysis

Using the model economy described in Section 2, calibrated with the parameters presented in Section 3, the stationary distribution of agents type 1 and 2 over the aggregate income level generated by the model economy is shown in Figure 1 below.

[FIGURE 1 HERE]

As the figure shows, this model generates a high concentration of income as expected. First the figure shows the high concentration of agents type 2 at lower levels of income and a relatively small mass of type 1 agents at high income levels, indicating a high concentration of income the model with heterogeneous human capital (schooling) can generate. Moreover, the maximum income level for type 1 agents is approximately 1.5 times higher than the maximum income for type 2 agents and, the difference between the minimum income for both types increases drastically such that type 1 minimum income can be as high as 15 times the minimum income for type 2.

Second, only a small mass of the agents of the model economy corresponding to the more educated type are located at the top level of income whereas a considerable mass of less educated workers attains the average income level of this type.

Finally, we can also observe the distribution of income within groups generated by the model economy. Income is more equally distributed within the agents of type 1, with more than 12 years of schooling. Whereas the income within the second type, with less than 12 years of schooling, is much more unequally distributed.

The above results are generated by the model, first, due to the fact that the marginal product of the more educated agents, reflected in their wage rate, is more than 21 times higher than the one corresponding to less educated agents and, as well as by the fact that the former faces a higher probability of being employed than the later independently of the state they are currently facing.

Empirically, the above findings could be sustained by various studies conducted by the IDB (1998). Their main result on the magnitude of inequalities among Latin American countries shows that the high unequal distribution of schooling is the factor most contributing to the high Gini coefficient of those countries. According to their data, this coefficient for Brazil which reaches almost 0.6 (the highest among Latin American countries) improves considerably, to 0.45 approximately, taking away the 10% richest of the economy and, on the other side, this group has 10 or more years of schooling, whereas the 30% poorest of the population have at most (only) 2 years of schooling, strongly suggesting a very important role for unequal human capital distribution in explaining the country's high income concentration.

5 Conclusion

The model economy constructed in this study aimed to capture an important feature to explain the high concentration of income in Brazil. Agents with 12 or more years of education represents only 15% of the labor force in the country, hence, qualified labor turns out to be the scarcest resource of the economy and, consequently, the corresponding productivity which dictates their income, becomes as much as 3.5 times the productivity of the less educated workers. Along this line of argument, the model economy introduces two types of agents differing in their years of schooling (human capital).

In addition, the model incorporates another relevant empirical fact: the more educated the workers the higher the probability of being employed. Therefore, the individual shocks of employment opportunities differ between the two types of agents.

The introduction of the above elements in the model generates a highly concentrated income distribution at the recursive equilibrium which is supported by the Brazilian empirical evidence. The artificial economy generates a very high concentration of less educated agents at low levels of income and a relatively small mass of agents around the highest level of income. Moreover, the simulations have shown a much more unequal income distribution among agents with less than 12 years of education than among the more educated ones. At the steady state distribution, the model also generates a maximum income 1.5 times higher for the more educated workers than for the less educated ones and, a minimum income 15 times higher for the former than for the latter.

Given the above results, an extension of this study to include a transfer mechanism between different types of agents seems to be in order as a topic for future research. This scheme could allow the less qualified, hence less productive agents to be able to accumulate more human capital, improving in turn the income distribution among the agents of the economy

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