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An analysis of human capital on the Brazilian States income level: MRW versus Mincer

Uma análise do capital humano no nível de renda dos estados brasileiros: MRW *versus* Mincer

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ABSTRACT
Human capital, productivity and physical capital are considered the main factors in the economies' GDP *per capita* determination. According to the neoclassical approach, human capital accumulation explains about a third of the variation in *per capita* income across countries. However, there is no consensus on the ways in which human capital influences GDP *per capita*. The present study's goal is to compare two production functions functional forms for the Brazilian States: the one developed by SOLOW (1956) and the one developed by MINCER (1974). The marginal return of education also has been estimated and we have analyzed the relevance of human capital on GDP *per capita* determination through a variety of estimation methods, for the 1980-2002 period. The empirical results rejected the neoclassical specification with human capital in favor of the mincerian's specification. The estimated marginal return of education is 15% and the empirical findings support the theory that states that human capital is one of the main factors affecting income level.

Key Words: Human Capital; Economic Growth; Mincerian Production Function; Return of Education

RESUMO

O capital humano, a produtividade e o capital físico são considerados os principais fatores na determinação do PIB *per capita* das economias. Conforme a abordagem neoclássica, a acumulação de capital humano explica praticamente um terço da variação do rendimento *per capita* entre os países. No entanto, ainda persistem discussões sobre as formas em que esse fator afeta o PIB *per capita*. O objetivo do presente estudo é comparar duas formas funcionais da função de produção para os estados brasileiros: as propostas por SOLOW (1956) e por MINCER (1974). Também foram feitas estimações do retorno marginal da educação, além da realização de uma análise da importância do capital humano na determinação do PIB *per capita* utilizando diferentes métodos de estimação, no.período de 1980-2002. Os resultados rejeitaram a especificação neoclássica com inclusão do capital humano em favor da minceriana. Adicionalmente, o retorno marginal estimado da educação foi de 15% e os resultados empíricos sustentam a teoria de que o capital humano é um dos principais fatores na determinação do nível de renda.

Palavras Chave: Capital Humano; Crescimento Econômico; Função de Produção Minceriana; Retorno da Educação.

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1 INTRODUCTION

Human capital is a production factor that gains more importance through time in the explanation of the income differential among countries, either in theoretical or empirical literature.

Theoretically, human capital is important directly and indirectly to income determination (NAKABASHI and FIGUEIRDO, 2008). The direct effects of human capital are those that affect income through the marginal productivity of labor improvement, keeping all other factors constant (labor, capital and technology), i.e. the improvement in the workers' ability for their respective tasks accomplishment. It is represented by the introduction of the human capital explicitly in the production function. This effect was emphasized, initially, by SCHULTZ (1962) and incorporated in economic models as in MANKIW, ROMER and WEIL (1992).

The indirect effects are those that affect the amount of technology available to be used in the production process. Thus, they are the elements that influence technology creation and diffusion. The importance of human capital in technology creation is emphasized by LUCAS (1988), ROMER (1990a), and AGHION and HOWITT (1992). With reference to the diffusion process, the seminal study is due to NELSON and PHELPS (1966). Extensions and empirical applications of this model were carried out by BENHABIB and SPIEGEL (1994, 2002).

Despite the fact that theory provides support to the idea that human capital is relevant to economic growth, some macroeconomic studies fail to find a relationship between human capital and income level and/or economic growth, such as PRITCHETT (2001) and ROMER (1990b). There are several reasons for these results, and three of them are the most relevant ones.

The first one is the use of an incorrect functional form to measure the relationship among the variables (TEMPLE, 1999). The second one is the inadequacy of the proxy used to measure human capital. ISLAM (1995) suggests that, in time series studies, the human capital proxies' low quality turns the positive relation between human capital and income level into no correlation between them.

Finally, in many empirical studies the appropriate method to estimate the theoretical model is not employed. A typical case is when researchers disregard the relationship of bi-causality or reverse causality between human capital and income level, as emphasized by BONELLI (2002), making the least squares estimation biased and inconsistent [see CRAVO (2006, p. 47)]. Thus, in empirical analyses, the endogeneity of the variable must be tested.

The present study focuses on the first and third above mentioned problems. Because the object of analysis is only one country (Brazil), it is expected that human quality difference among the Brazilian States is lower than in international comparison studies. Additionally, as emphasized by ISLAM (1995) and SACHS and WARNER (1997), when the human capital quality aspect is not considered, there is a decrease in the correlation between this variable and income level. Because we have found out a positive correlation between the above mentioned variables in the empirical analysis, the consideration of a human capital quality proxy would make the results even more evident.

Following FERREIRA, ISSLER and PESSÔA (2004), the model specification selection is made by means of a comparison between MANKIW, ROMER and WEIL (1992) and MINCER (1974)'s production function specifications. Thus, in the present study we develop an analysis of the human capital direct impacts on the Brazilian States income by the use of the two above mentioned specifications. The empirical analysis results support the mincerian approach, as in FERREIRA, ISSLER and PESSOA (2004).

In addition to this introduction, this paper is organized as follows: in section 2 we provide in brief some empirical studies for the Brazilian case; in the next section, we lay out the theoretical models, that are the basis for the empirical study; in section 4 there is a brief discussion of the methodology and data sources; in the last section, the empirical results are interpreted and commented.

2 EMPIRICAL STUDIES OF HUMAN CAPITAL FOR BRAZIL

The empirical economic analyses of the Brazilian States by and large focus in the income distribution and convergence debate. The level of inequality between regions in Brazil is a good reason to explain this tendency. Some of these studies use a human capital proxy as a control variable, but the analysis of that factor in explaining income level and rate of growth is far from the central concern.

In general, the empirical studies find evidences that give support to the per capita income absolute convergence hypothesis in the Brazilian States, as in Ferreira (1996) and AZZONI (2001). However, as stressed by AZZONI (2001), there are lots of variations in the income inequality evolution over time and regions in the convergence process.

When some other variable is included as control it increase the speed of conditional convergence. Moreover, when a human capital proxy is included into the empirical analysis, its coefficient is positive and significant. The results found by AZZONI et all (1999) show that the Brazilian States' per capita income level is positively correlated with their human capital level. Other empirical studies for the Brazilian States that examine the human capital effect on per capita income growth level and/or growth rate are LAU et all (1993), FERREIRA (2000), and ANDRADE (1997). LAU et all (1993)'s results indicate that, on average, an additional year of schooling has a positive impact of approximately 20% on income. ANDRADE (1997) estimate a larger impact of human capital on income level: an additional working age population's year of schooling increases the GDP by 32%. The main concern of Ferreira (2000) was to measure the convergence speed among the Brazilian States. However, their results show that human capital is an important factor in explaining the Brazilian States income rate of growth.

NAKABASHI and SALVATO (2007) incorporate in the empirical analysis a proxy for human capital quality. The results indicate that although the impact of human capital on income level in the Brazilian States rate of growth are smaller than in the estimations that use only a quantitative proxy, its significance increases.

3 HUMAN CAPITAL ON INCOME DETERMINATION MODELS

3.1 Specification of MANKIW, ROMER and WEIL (1992)

MANKIW, ROMER and WEIL (1992)[1] argue that leaving out human capital in the empirical analysis, i.e. following the original growth model of SOLOW (1956) and SWAN (1956), increases influence of savings and population growth on per capita income because of

[1] MRW

the correlation between them and the former variable. Therefore, the augmented SOLOW-SWAN model takes into consideration the human capital factor:

$$(1) \qquad Y_t = K_t^{\alpha} H_t^{\beta} (A_t L_t)^{1-\alpha-\beta}$$

where Y is output, K is the stock of physical capital, L the is the amount of Labor, A is a technology index, and H is the stock of human capital. L and A are assumed to growth exogenously at rates n and g:

$$(2) \qquad L_t = L(0)e^{nt}$$

$$(3) \qquad A_t = A(0)e^{gt}$$

Setting output and the stocks of physical and human capitals in effective units of labor, we have: $\hat{y} = \dfrac{Y}{AL}$; $\hat{k} = \dfrac{K}{AL}$; e $\hat{h} = \dfrac{H}{AL}$. Additionally, considering that both physical and human capital depreciate at the same rate (δ), we have the equations that define the evolution of k and h:

$$(4a) \qquad \dot{\hat{k}}_t = s_k \hat{y}_t - (n + g + \delta)\hat{k}_t$$

$$(4b) \qquad \dot{\hat{h}}_t = s_h \hat{y}_t - (n + g + \delta)\hat{h}_t$$

where s_k is the income fraction invested in physical capital, s_h is the income fraction invested in human capital.

In the steady state, the equations (4a) and (4b) are equal to zero, forming a system of two equations and two endogenous variables: the amount of human and physical capital per effective units of labor. Solving for these variables, we have:

$$(5a) \qquad \hat{k}^* = \left(\frac{s_k^{1-\beta} s_h^{\beta}}{n + g + \delta} \right)^{1/(1-\alpha-\beta)}$$

$$(5b) \qquad \hat{h}^* = \left(\frac{s_k^{\alpha} s_h^{1-\alpha}}{n + g + \delta} \right)^{1/(1-\alpha-\beta)}$$

where subscribed * denotes the steady state value of the variable. Substituting equations (5a) and (5b) into the production function expressed in effective units of labor ($\hat{y} = \hat{k}^{\alpha} \hat{h}^{\beta}$) and taking logs, we find the steady-state income level of output per worker:

$$(6) \qquad \ln y^* = \ln A(0) + gt - \frac{\alpha + \beta}{1 - \alpha - \beta} \ln(n + g + \delta) + \frac{\alpha}{1 - \alpha - \beta} \ln(s_k) + \frac{\beta}{1 - \alpha - \beta} \ln(s_h)$$

In this equation, the gt term represents the rate of technological progress. The term A (0), in turn, reflects factors endowments such as institutions, degree of political stability, respect for individual freedoms, among others. Therefore, this term may vary between regions. MRW consider that:

$$(7) \qquad \ln A_t = a + \varepsilon$$

where a is a constant and ε represents the peculiarities of each region. Replacing (7) at (6):

$$(8) \qquad \ln(y^*) = a + gt + \left(\frac{\alpha}{1-\alpha-\beta}\right)\ln(s_k) + \left(\frac{\beta}{1-\alpha-\beta}\right)\ln(s_h) - \left(\frac{\alpha+\beta}{1-\alpha-\beta}\right)\ln(n+g+\delta) + \varepsilon$$

Equation (8) represents per capita income in the steady state and it will be used to estimate the influence of the right hand-variables on income per worker across the Brazilian States.

Estimating equation (8), the authors' results suggest that the right-hand variables explain approximately eighty percent of the per capita income variation among countries. Additionally, they found evidences that human capital is a factor of great importance to explain the differences in income levels and growth rate across countries.

3.2 MINCERIAN SPECIFICATION (1974)

Other authors, however, tested the mincerian specification for the production function. These two specifications for the production function were confronted by FERREIRA, ISSLER and PESSÔA (2004). Their results support the mincerian formulation of schooling-returns to skills.

Originally, the mincerian equation was developed to carry out analyses using microeconomic data such as the studies of BILS and KLENOW (2000), HALL and JONES (1999), and KLENOW and RODRIGUEZ-CLARE (1997). Alternatively, FERREIRA, ISSLER and PESSÔA (2004) showed that the specification is also appropriate in macroeconomic analysis.

In this specification, human capital is introduced in the production function exponentially:

$$(9) \qquad Y = AK^{\alpha}\left(\exp(\phi h) L \exp(g \cdot t)\right)^{\beta}$$

The parameter ϕ stands for the impact of an additional year of schooling on the percentage of income increase. The other variables and parameters have been defined previously.

As highlighted by FERREIRA, ISSLER and PESSÔA (2004), "it is assumed that the skill level of a worker with h years of schooling is exp(øh) greater than that of a worker with no education at all".

Transforming equation (9) into per worker terms and using logs in both sides of it, we have:

(10) $$\ln y^{*} = \ln A + \alpha \ln k + \beta\phi h + (\alpha + \beta - 1)\ln L + \beta g t + \varepsilon$$

As suggested FERREIRA, ISSLER and PESSÔA (2004), the basic difference between equations (8) and (10) is whether human capital enters the production function in levels or in logs.

If human capital enters in logs – (8), there is a fixed human-capital elasticity in production for all countries. If it enters in levels – (10), human-capital elasticity in production will change across countries (and across time as well).

4 METHODOLOGY

4.1 Considerations about the estimations

Before defining the best method to be estimated and the best formulation for the production function, we have run econometric tests in order to identify possible problems that could result in biased and inconsistent estimations of parameters.

Tests have been carried out to detect problems of multicollinearity, heteroskedasticity and autocorrelation. To test for multicollinearity, we made use of the Variance Inflation Factor (VIF). The null-hypothesis of homoscedasticity was tested by means of the Breusch-Pagan test. For autocorrelation detection, the test used was proposed by Arellano and Bond, under the Null-hypothese that there is no first order autocorrelation in the panel.

Problems of autocorrelation and heteroskedasticity were correct the Prais-Winsten transformation. As observed by GREENE (2000), the Prais-Winsten transformation removes the autocorrelation and heteroskedasticity present in the data.

Other six methods of estimation have been applied to estimate the regressions' parameters. The first one is "pooled regression" that uses Ordinaries Least Squares (OLS) to estimate the data. This method has some limitations: the possible correlation between the error term and at least one of the independent variables.

The second method is panel data, which have two different approaches: fixed effects - Least Square Dummy Variable – LSDV; and random effects. In the first method, the differences among individuals are captured by a dummy variable. The second method is appropriate when individual specific constant terms is randomly distributed across cross-sectional units (GREENE, 2000).

The next step was to test variables endogeneity. DAVIDSON and MACKINNON (1993) recommend the Durbin-Wu-Hausman test for the detection of endogeneity. If this problem is detected, HAUSMAN (1983) suggests the use of lagged right hand side variables or instrumental variables. Hall and Jones (1999) suggest the use of the countries latitude as instruments. BARRO and LEE (1993), BARRO and SALA-I-MARTIN (1995), and FERREIRA, ISSLER and PESSÔA (2004) make use of instrumental variables to overcome the endogeneity problem.

Other alternatives to correct for endogeneity of variables are the Two Stage Least Squares Method (2SLS) and the Generalized Method of Moments (GMM), as emphasized by DURLAUF ET ALL (2004).

In the present study, the following instruments were used: the lagged values of the physical and human capital and the absolute value of the Brazilian States' latitude measured in degrees and divided by 90[2]. The regressions were also estimated by means of the 2SLS

[2] This procedure is similar to the one used by HALL and JONES (1999). The division by 90 is to constrain the latitude on a scale from 0 to 1.

method.

The fourth estimation method is the Fixed Effects one with the inclusion of instrumental variables. The fifth estimation refers to the Random Effects method using instrumental variables (Two-Stages Generalized Least Squares - 2SGLS).

The next step was to test the validity of the instruments used in structural models. FERREIRA, ISSLER and PESSÔA (2004) recommend the use of Sargan test. While this procedure is useful to test the "orthogonality" of each equation of the system, it is also useful to test the correct specification of the model[3].

To test the hypothesis that the human capital should go into the production function in level or log, the BOX-COX test was used, as suggested by AGUIRRE (1997).

Consider the general regression equation, using the transformation BOX-COX, we have:

$$y_t = \left(\frac{x_t^{\theta} - 1}{\theta} \right) \beta + \varepsilon_t \tag{11}$$

$$\lim_{\theta \to 0} \left(\frac{x_t^{\theta} - 1}{\theta} \right) = \ln \left(x_t \right) \tag{12}$$

$$\lim_{\theta \to 1} \left(\frac{x_t^{\theta} - 1}{\theta} \right) = x_t - 1 \tag{13}$$

If the θ = 0 hypothesis is not rejected, it supports the human capital variable logarithmic transformation; on the other hand, if θ = 1 can not be reject, we should assume that the human capital variable is more appropriate in level. These two hypotheses are tested through the WALD test, using the BOX-COX transformation to the human capital proxy.

4.2 DATABASE

The database is composed by 25 of the 27 Brazilian States[4] for the 1980-2002 period. The variables are: 1) Gross Domestic Product (GDP) per capita at constant prices - R$ 2000, deflated by the Gross Domestic Product Implicit Price Deflator; 2) domestic resident population to measure the variation in working age population (n); 3) electric power industry consumption in mega-watt-hours as a proxy for physical capital; and 4) years of schooling of the population over 25 years as a proxy for human capital. The first three variables are from IBGE (Instituto Brasileiro de Geografia e Estatística), the Brazilian Census Bureau, and the last one is from IPEA (Instituto de Pesquisa Aplicada).

5. EMPIRIC ANALYSIS

5.1 PRELIMINARY DATA ANALYSIS

Table 1 data show that differences in the per capita income (GDP) level in the Brazilian States are notable, as in AZZONI (2001).

[3] The rejection of the null hypothesis indicates that the instruments used are not valid.

[4] Goiás and Tocantins States were left out of the sample because the first one was divided into two (Goiás and Tocantins) in 1988.

The differences in per capita income level are astonishing. For example, Piauí's per capita income was only 10% of Distrito Federal's per capita income in 1980. After 22 years, the scenario has not change considerably: in 2002 it rose to 13%. Some states have managed to reduce the income gap considerably, as Paraiba, Ceará, Rio Grande do Norte, and Sergipe. However, the income per capita gap remains very high.

TABLE 1 – INCOME DISPARITY: 1980-2002

Federal Unit	y_i (1980) [a]	y_i (2002) [a]	y_i/y_{DF} (1980) [b]	y_i/y_{DF} (2002) [b]	Ranking 80/2002 [c]	ΔR [d]	Annual growth (%) [e]
Distrito Federal	11,91	13,82	1,00	1,00	1/1	0	0,68
São Paulo	10,57	9,59	0,89	0,69	2/3	-1	-0,44
Rio de Janeiro	8,52	9,68	0,72	0,70	3/2	1	0,58
Rio Grande do Sul	7,15	8,41	0,60	0,61	4/4	0	0,74
Santa Catarina	6,36	7,83	0,53	0,57	5/5	0	0,95
Mato Grosso do Sul	5,59	5,99	0,47	0,43	6/9	-3	0,31
Amazonas	5,47	7,07	0,46	0,51	7/6	1	1,17
Paraná	5,28	6,96	0,44	0,50	8/7	1	1,25
Espirito Santo	5,09	6,45	0,43	0,47	9/8	1	1,07
Minas Gerais	4,93	5,72	0,41	0,41	10/10	0	0,67
Rondônia	3,92	4,09	0,33	0,30	11/14	-3	0,20
Mato Grosso	3,76	5,72	0,32	0,41	12/11	1	1,91
Roraima	3,76	3,52	0,32	0,25	13/17	-4	-0,30
Amapá	3,27	4,42	0,28	0,32	14/12	2	1,36
Bahia	3,21	3,91	0,27	0,28	15/15	0	0,89
Para	3,21	3,28	0,27	0,24	16/19	-3	0,11
Pernambuco	2,89	3,79	0,24	0,27	17/16	1	1,24
Acre	2,71	3,24	0,23	0,23	18/20	-2	0,81
Sergipe	2,39	4,29	0,20	0,31	19/13	6	2,65
Alagoas	2,34	2,54	0,20	0,18	20/23	-3	0,37
Rio Grande do Norte	2,34	3,41	0,20	0,25	21/18	3	1,71
Ceara	2,04	2,64	0,17	0,19	22/22	0	1,18
Paraíba	1,65	2,80	0,14	0,20	23/21	2	2,39
Maranhão	1,48	1,65	0,12	0,12	24/25	-1	0,48
Piauí	1,23	1,79	0,10	0,13	25/24	1	1,69

Notes: The states of Tocantins and Goias were excluded. [a] Gross Domestic Product (GDP) per capita. [b] Per capita income (or GDP) relative to Distrito Federal's income per capita, y_i/y_{DF}. [c] Ranking of per capita GDP in 1980 and 2002. [d] Change of position in per capita income ranking from 1980 to 2002. [e] Average income per capita growth rate in the 1980 – 2002 period.

São Paulo, the richest state in 1980, experienced a negative rate of per capita income growth. As a result, the gap in per capita GDP in relation to Distrito Federal has increased in 20%, and São Paulo's per capita income was still exceeded by Rio de Janeiro's per capita income in 2002. Another state that fell behind was Roraima, which lost four positions in the period of analysis.

Table 2's data shows a high educational inequality level among the Brazilian States. For example, Piauí's years of schooling of the population over 25 years was less than 30% in comparison to Distrito Federal's ones at the beginning of the period.

TABLE 2 – YEARS OF SCHOOLING DISPARITY: 1981 – 2002

Federal Unit	H (1981)[a]	H (2002)[a]	H_i/H_{DF} (1981)[b]	H_i/H_{DF} (2002)[b]	Ranking 81/2002 [c]	ΔR [d]	Annual growth (%) [e]
Distrito Federal	6.28	8.54	1.00	1.00	1/1	0	1.46
Rio de Janeiro	5.40	7.36	0.86	0.86	2/2	0	1.47
Amazonas	4.81	6.84	0.77	0.80	¾	-1	1.68
Roraima	4.76	5.54	0.76	0.65	4/16	-12	0.72
São Paulo	4.67	7.15	0.74	0.84	5/3	2	2.03
Pará	4.49	6.02	0.71	0.70	6/12	-6	1.40
Rio Grande do Sul	4.31	6.50	0.69	0.76	7/7	0	1.96
Amapá	4.16	6.68	0.66	0.78	8/5	3	2.26
Espírito Santo	3.95	6.03	0.63	0.71	9/11	-2	2.01
Santa Catarina	3.94	6.56	0.63	0.77	10/6	4	2.43
Acre	3.80	6.19	0.61	0.72	11/9	2	2.32
Mato Grosso do Sul	3.65	6.16	0.58	0.72	12/10	2	2.49
Minas Gerais	3.58	5.80	0.57	0.68	13/15	-2	2.30
Paraná	3.44	6.33	0.55	0.74	14/8	6	2.90
Mato Grosso	3.41	5.96	0.54	0.70	15/13	2	2.66
Rondônia	3.41	5.83	0.54	0.68	16/14	1	2.55
Pernambuco	2.86	5.14	0.46	0.60	17/19	-2	2.79
Rio Grande do Norte	2.79	5.20	0.44	0.61	18/18	0	2.96
Paraíba	2.63	4.44	0.42	0.52	19/22	-3	2.49
Bahia	2.55	4.53	0.41	0.53	20/21	-1	2.74
Sergipe	2.47	5.25	0.39	0.61	21/17	4	3.59
Ceará	2.27	4.62	0.36	0.54	22/20	2	3.38
Alagoas	2.12	3.98	0.34	0.47	23/25	-2	3.00
Maranhão	1.96	4.14	0.31	0.48	24/23	1	3.56
Piauí	1.79	4.04	0.29	0.47	25/24	1	3.88

Notes: Tocantins and Goiás states were excluded. [a] Years of schooling of population over 25 years old. [b] Years of schooling of population over 25 years old in relation to the Distrito Federal's years of schooling of population over 25, H_i/H_{DF}. [c] Ranking of years of schooling of the population over 25 years old in 1980 and 2002, respectively. [d] Change of position in years of schooling of the population over 25 ranking from 1980 to 2002. [e] Average years of schooling of the population over 25 growth rate in the 1980 – 2002 period.

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By the results of both tables we are able to arrive at motivating conclusions. Firstly, the educational gap between Roraima and the Distrito Federal has increased in the period. The former has lost four positions in per capita income ranking. Additionally, Sergipe had the highest per capita income growth rate in the period and almost doubled the population over 25 years of schooling. Paraná State had a substantial increase in average years of schooling and came up from 14º to 8º in the income per capita ranking.

Moreover, the correlation index (SPEARMAN) between human capital and economic growth were high in both periods. In 1980 the correlation was 0.81. In 2002 it rose to 0.87.

5.2 ECONOMETRIC RESULTS

5.2.1 MRW SPECIFICATION

Table 3's results indicate problems of heteroskedasticity and first order autocorrelation. Multicollinearity is not as a severe problem. Consequently, the heteroskedasticity and first order autocorrelation must be considered in the estimations.

TABLE 3 Tests of multicollinearity, heteroskedasticity and autocorrelation in the data panel

Specification	Multicollinearity(*)	Heteroscedasticity (**)		Autocorrelation(***)	
	VIF	Breusch – Pagan	Prob > χ^2	Arellano-Bond AR(1)	Prob > z
MRW	1.76	48.281	0.00	-8.37	0.00
Mincer	1.76	65.314	0.00	-8.37	0.00

(*) As rule of thumb, multicollinearity is considered a serious problem if VIF > 10.
(**) Null-hypothesis: the disturbances are homoscedastic.
(***) Null-hypothesis: inexistence of first order autocorrelation.

To test the best estimation method: Ordinary Least Squares; Fixed Effects; or Random Effects; we employed the F and HAUSMAN (1978) tests. The F test compares the Fixed Effects method and the Ordinary Least Squares method. It tests the hypothesis that all dummies are zero at the same time. The F test's results showed that supports the Fixed Effects for the Brazilian states in the period of 1980-2002 (Table 4). HAUSMAN (1978) test compares the Fixed Effects an Random Effects methods (Table 4).

The DURBIN-WU-HAUSMAN (DWH) test verifies the presence of explanatory variables endogeneity. The results of the DWH test (Table 4) point to the presence of endogeneity in physical and human capital proxies. Therefore, instrumental variables are needed to estimate de regression equations.

The next step is to estimate the model using Two Stage Least Squares regression (2SLS), fixed effects with the inclusion of instrumental variables and Two Stages Generalized Least Squares (2SGLS). The F and HAUSMAN tests are then used to identify the best estimation method. The results support the use of the Fixed Effects method with the inclusion of instrumental variables (Table 4).

Finally, Sargan test was carried out to validate the use of the instrumental variables considered in the present study. Sargan test does not reject the hypothesis that the instruments are valid.

The regressions results in Table 4 correspond to equation (8) specification. The considered level of significance is 5%.

In column (1) are the pooled regression's results. In column (2) are the Fixed Effects' results corrected for heteroskedasticity. The results of estimation via Random Effects are shown in column (3). In column (4) are the 2SLS's results. The results via the best method of estimation - Fixed Effects with the inclusion of Instrumental Variables - are in column (5). The results of regression by 2SGLS are presented in column (6) to compare to the previous column's results. Finally, in column (7), are the results correct for heteroskedasticity and first order autocorrelation (PRAIS-WINSTEN).

TABLE 4 MRW equation for the Brazilian states (1980-2002)

Variables	dependent variable: per capita income (ln)						
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
lnk_{it}	0.111	0.070	0.091	0.114	0.153	0.157	0.083
	(16.31)***	(4.64)***	(6.95)***	(16.45)***	(4.47)***	(7.88)***	(7.66)***
lnh_{it}	1.752	0.244	0.477	1.786	0.396	0.691	1.225
	(33.25)***	(3.33)***	(6.61)***	(33.31)***	(4.19)***	(7.86)***	(14.20)***
lnn_{it}	0.017	0.158	0.175	0.017	0.183	0.206	0.053
	(0.48)	(6.00)***	(6.36)***	(0.50)	(6.38)***	(7.02)***	(1.74)*
T	-0.036	0.003	-0.002	-0.037	-0.003	-0.009	-0.021
	(-12.46)***	(1.53)	(-1.03)	(-12.67)***	(-0.96)	(-3.45)***	(-5.68)***
C	68.702	-6.359	3.796	70.306	4.263	15.445	40.579
	(12.02)***	(-1.57)	(0.92)	(12.22)	(0.80)	(3.22)***	(5.52)***
N	450	450	450	450	450	450	450
R^2 (adjusted)	0.79	-	-	0.79	-	-	0.66
R^2 (between)	-	0.59	0.69	-	0.44	0.61	-
R^2 (overall)	-	0.55	0.65	-	0.43	0.58	-
F [a]	-	87.63	-	-	74.53	-	-
Prob > F	-	0.00	-	-	0.00	-	-
Hausman [b]	-	226.33	-	-	89.04	-	-
Prob > χ^2	-	0.00	-	-	0.00	-	-
h_{it} [c] endogeneity	-	19.77	-	-	-	-	-
Prob > F	-	0.00	-	-	-	-	-
k_{it} [c] endogeneity	-	11.56	-	-	-	-	-
Prob > F	-	0.00	-	-	-	-	-
Sargan test [d]	-	-	-	-	3.92	-	-
Prob > χ^2	-	-	-	-	0.42	-	-

Notes: (1) Ordinary Least Squares (OLS). (2) Least Squares Variable Dummy (LSDV). (3) Generalized Least Squares (GLS). (4) Two Stages Least Squares (2SLS). (5) Fixed effects with instrumental variables. (6) Two Stages Generalized Least Squares (2S GLS). (7) Generalized Least Squares - Prais-Winsten.
lnk is the natural logarithm of electric power industry consumption, lnh is years of schooling natural logarithm of population over 25, lnn is population growth rate natural logarithm, t is the year and C is the constant.
*** Significant at 1%; ** Significant at 5%; * Significant at 10%
[a] The F test null hypothesis is that all dummies variables coefficients are zero. [b] Test for Fixed Effects versus Random Effects: the null hypothesis is that Random Effects panel data is the most efficient estimation method. Ho rejection implies that Fixed Effects method is the most efficient one. [c] Durbin-Wu-Hausman test for endogeneity: under Ho, the explanatory variables are note endogenous. [d] under Ho, the instruments are valid.

Unlike NAKABASHI and SALVATO (2007)'s results for the Brazilian states, the effective capital depreciation rate – population growth rate as a proxy – has a pos0itive impact on per capita GDP in all estimations. Additionally, the only effective capital depreciation coefficients that are not statistically different from zero are the ones in columns (1) and (4). FIGUEIRÊDO and GARCIA (2003), in a study for the period 1960-1990, assert that this result may be due to the fact that per capita income is the main determinant of migration. As a result, states with superior per capita income were those with the highest migration rate and labor force growth.

One of the most important results is that both physical and human capital have a positive and statistically significant impact on product per capita level in all regressions. Thus, we can conclude that these results are robust.

In column (1), the pooled regression's results indicate that all variables are statistically significant, except the growth population rate. The results support the idea that human capital has a greater impact on per capita income level than physical capital. A 1% increase in physical capital stock elevates per capita income in 0.11%. On the other hand, a 1% increase in human capital stock has a positive raises per capita income in 1.75%.

There is a large reduction in the human capital coefficient for the Fixed Effects estimation method's results (column (2)). As suggested by NAKABASHI and SALVATO (2007), a possible explanation for this result is that human capital is positively correlated to each state's technology level. Thus, the estimated coefficient in the first regression captures the direct and indirect impacts of human capital on the level of per capita income. Therefore, when the particularities of each state are controlled by the introduction of dummies variables, the magnitude of the human capital coefficient is reduced.

The Random Effects estimation' results, which also control by Brazilian States differences, are in column (3). Both methods have similar results.

To solve the endogeneity problem of physical and human capital proxies, the regression equation (8) was estimated using instrumental variables and the results are in column (4). The 2SLS regressions' results are quite similar to the ones shown in column (1). This suggests that, despite its existence, the endogeneity problem is not serious.

In column (5) we find the most appropriate method's results by the statistical tests. Thus, it is appropriate to provide more attention to them. All variables are significant, except the time variable and the constant. As in the other regressions, the human capital proxy effects are very small when controlled for the states characteristics. A 1% increase in this variable expands income per capita GDP in 0.4%. Anyhow, its impact is considerably greater than the physical capital ones.

The average years of schooling in the period of analysis (4.7 years), so one year of schooling corresponds to 21.3% of the total years of schooling. Thus, one additional year of schooling increases per capita income in 8.5%. NAKABASHI (2005, p.68) estimated that the return of an additional year of schooling is 9.3%; very close to the one found in the present study.

Compared to LAU ET ALL (1993) and ANDRADE (1997)'s results, the human capital's effect on income level in the present study is considerable smaller. This is because in those studies each Brazilian State characteristics were not controlled for.

The 2SGLS regression's results are shown in column (6). In this estimation method the possibility of correlation among the residuals from different equations is taken into account. Compared to the results of equation (4), there are relevant changes such as the human capital variable lost of importance and the fact that the effective capital depreciation coefficient turns out to be significant, as well as the increase of its magnitude. These results indicate that the correlation among the residuals from different equations is a relevant matter.

Finally, in column (7), the PRAIS-WINSTEN method's results support the idea that human capital has a greater impact on income per capita than physical capital. The results are similar to those in the OLS method's results possibly because PRAIS-WINSTEN method does not take into account each state characteristics. The difference is that all variables are statistically significant at 10% level of significance.

The main conclusion from Table 4 analysis is that the human capital impacts on income per capita level are positive and significant in all cases. In addition, its effects are greater than the physical capital ones, even when it is controlled for each Brazilian State characteristics.

5.2 MINCERIAN SPECIFICATION

Table 5's results are equivalent to Table 4's results. The difference is that the production function is the one proposed by MINCER (1974). The regressions' results presented in this table are from equation (10) specification.

The same procedure adopted previously to determine the best method of estimation was used in this case. The F test favors the Fixed Effects method. Hausman test supports that Fixed Effects is more appropriate than Random Effects. The DURBIN-WU-HAUSMAN test points to physical and human capital proxies' endogeneity. Therefore, it is necessary to include instrumental variables in the model estimations.

Selection model tests' results indicate that Fixed Effects with instrumental variables is the most consistent and efficient method of estimation. Additionally, there are problems of heteroskedasticity and first order autocorrelation in the panel.

TABLE 5 - Equation of MINCER (1974) for the Brazilian states (1980-2002)

Variables	dependent variable: ln the per capita income						
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
lnk_{it}	0.113	0.072	0.091	0.116	0.199	0.174	0.092
	(16.93)***	(4.73)***	(6.94)***	(17.07)***	(5.43)***	(8.52)***	(8.58)***
h_{it}	0.384	0.071	0.130	0.394	0.154	0.235	0.285
	(33.98)***	(3.74)***	(7.17)***	(34.11)***	(4.64)***	(8.92)***	(15.48)***
lnn_{it}	0.004	0.146	0.150	0.001	0.170	0.170	0.054
	(0.12)	(5.56)***	(5.53)***	(0.04)	(5.74)***	(5.65)***	(1.71)*
t	-0.035	0.001	-0.005	-0.036	-0.011	-0.018	-0.023
	(-12.50)***	(0.51)	(-2.20)**	(-12.82)***	(-2.72)***	(-5.67)***	(-6.23)***
C	68.278	-2.343	9.769	70.593	20.547	34.099	44.057
	(12.17)***	(-0.50)	(2.15)**	(12.48)***	(2.61)***	(5.52)***	(6.10)***
N	450	450	450	450	450	450	450
R^2 (adj.)	0.79	-	-	0.79	-	-	0.68
R^2 (between)	-	0.66	0.75	-	0.51	0.71	-
R^2 (overall)	-	0.62	0.71	-	0.49	0.68	-
F [a]	-	85.10	-	-	64.81	-	-
Prob > F	-	0.00	-	-	0.00	-	-
Hausman [b]	-	89.56	-	-	26.92	-	-
Prob > χ^2	-	0.00	-	-	0.00	-	-
BOX-COX $\theta = 0$ [c]	14.41	5.22	-	-	-	-	-
Prob > χ^2	0.00	0.02	-	-	-	-	-
BOX-COX $\theta = 1$ [c]	1.24	0.01	-	-	-	-	-
Prob > χ^2	0.26	0.93	-	-	-	-	-
Endogeneidade h_{it} [d]	-	28.57	-	-	-	-	-
Prob > F	-	0.00	-	-	-	-	-
Endogeneidade k_{it} [d]	-	13.27	-	-	-	-	-
Prob > F	-	0.00	-	-	-	-	-
Teste de Sargan [e]	-	-	-	-	8.99	-	-
Prob > χ^2	-	-	-	-	0.06	-	-

Notes: (1) Ordinary Least Squares (OLS). (2) Least Squares Variable Dummy (LSDV). (3) Generalized Least Squares (GLS). (4) Two Stages Least Squares (2SLS). (5) Fixed effects with instrumental variables. (6) Two Stages Generalized Least Squares (2S GLS). (7) Generalized Least Squares - Prais-Winsten.

lnk is the natural logarithm of electric power industry consumption, lnh is years of schooling natural logarithm of population over 25, lnn is population growth rate natural logarithm, t is the year and C is the constant.

*** Significant at 1%; ** Significant at 5%; * Significant at 10%

[a] The F test null hypothesis is that all dummies variables coefficients are zero. [b] Test for Fixed Effects versus Random Effects: the null hypothesis is that Random Effects panel data is the most efficient estimation method. Ho rejection implies that Fixed Effects method is the most efficient one. [c] test to find out the best production function specification. When the null hypothesis Ho: $\theta = 0$ is not rejected, it favors the MRW specification. When the null hypothesis Ho: $\theta = 1$ is not rejected, it favors the mincerian specification. [d] Durbin-Wu-Hausman test for endogeneity: under Ho, the explanatory variables are note endogenous. [e] under Ho, the instruments are valid.

Judged against Table 4's results, in first column's result we can verify that the magnitude and significance of physical capital and capital effective depreciation proxy's coefficients are virtually the same in both specifications. Additionally, physical capital's coefficients are positive and significant in all cases.

There are not major changes in the time variable coefficients' magnitude, but there are increases in their significance. All time variable's coefficients are negative and become statistically different from zero, except for the results in column (2). This variable should capture technology effects on the evolution of per capita income. Thus, the negative coefficients signal reflects Brazilian States weak economic performance in the period of analysis.

By column (5)'s results, we observe that all variables are statistically significant at the 1% level. In the mincerian production function specification, there is a particular interest in the human capital coefficient, i.e., in ø parameter of equation (10). It can be interpreted as the percentage of income increase caused by an additional year of schooling. The results indicate that, for the Brazilian States, one more year of schooling raises the income per capita by approximately 15%.

For a cross country study, MINCER (1974) estimated that a 10% return of an additional year of schooling. Using MRW's country sample, FERREIRA, ISSLER and PESSÔA (2004) estimated a 8% return of an additional year of schooling. Considering the Brazilian States low education level, it would be expect a higher education return rate for them.

Anyhow, it is interesting to note the disparity in the return of an additional year of schooling for the different specifications. The lowest return is in the Fixed Effects estimation (7.1%). Through 2SLS method, the estimated return is nearly 0.40% (column (4)). As already mentioned, this is due to the fact that the 2SLS method does not take into account each state specificity. The opposite is valid for the Fixed Effects method.

Compared to Table 4's results, the impact of human capital on income level is higher in all mincerian specification estimations. There is also an increase in the coefficient of determination in the Panel Data estimations.

In addition, the BOX-COX test supports the mincerian specification as a substitute to MRW's specification[5] (Table (5)). This result is crucial because the Brazilian States educational return depends on the specification used. Therefore, the present study support the view that mincerian specification is more appropriate than the MRW's one, as in FERREIRA, ISSLER and PESSÔA (2004).

[5] In the BOX-COX test for the Brazilian States the time variable is not considered. When this variable is included in the test, it rejects both specifications Ho: $\theta = 0$, and Ho: $\theta = 1$

6. CONCLUSION

The importance of human capital as an economic growth strategic factor has been extensively studied since the 1990 decade. However, the debate on the channels in which human capital influences income per capita level and growth remains.

The present study's objective was to confront the mincerian and MRW production function specifications for the Brazilian States in the1980-2002 period. The BOX-COX test was used with this purpose. Another goal was to test the importance of human capital on income level determination taking into consideration many problems that plague empirical studies as explanatory variables endogeneity and econometric techniques misuse.

The results suggest that the mincerian specification is more appropriate than that one proposed by MANKIW, ROMER and WEIL (1992). In addition, the impact of human capital on income level determination was positive and significant in all regressions. The impact of this factor on per capita income level is greater than the physical capital impact even when each state's specificities are controlled for.

The return of an additional year of schooling by the mincerian specification is about 15%. Therefore, the impact of human capital on per capita income level in the Brazilian States are bigger than in cross country studies as in MINCER (1974) (10%) and FERREIRA, ISSLER and PESSÔA (2004) (8.0%). This result is not surprising due to the low level of human capital in relation to physical capital in the Brazilian States.

Another central result is that human and physical capital factors have a positive and statistically significant impact on income per capita level in all the different estimation methods and specifications. This is true even when the estimations are controlled for the endogeneity problem and for each state's specificities.

The human capital effect reduction on income per capita level when each state's specificities are controlled for is evidence that this factor is correlated with the Brazilian States technology level. As a result, further analyses of the relationship between these two variables are crucial to understand the real importance of this factor on per capita income level and growth.

REFERENCES

AGHION, P., HOWITT, P. A model of growth through creative destruction. *Econometrica*, v.60, n.2, p.323-351, 1992.

AGUIRRE, A. Uma nota sobre a transformação BOX-COX. *Working Paper UFMG/Cedeplar*. n. 116, 18p, 1997.

ANDRADE, M. V. Educação e crescimento econômico no Brasil: evidências para os estados brasileiros: 1970/1995. In: *Encontro Nacional de Economia,* 25, 1997, Recife - PE, p.1529-1548, 1997.

AZZONI, C. R. Economic growth and regional income inequality in Brazil. *The Annals of Regional Science*, 35(1), p.133-152, 2001.

AZZONI, C. R., MENEZES-FILHO, N., MENEZES, T., SILVEIRA NETO, R. Geography and regional convergence of income in Brazilian states: 1981-1996.*European Regional Science Association - ERSA Conference Papers*, 99, 23p,1999.

BARRO, R. and LEE, J. International Comparison of Educational Attainment, *NBER Working Paper*, 1993.

BARRO, R. and SALA-I-MARTIN, X. Economic Growth. McGraw-Hill, 1995.

BENHABIB, J., SPIEGEL, M. M. Human capital and technology diffusion. *Federal Reserve Bank of San Francisco Working Paper*, 2003-02, 2002.

BENHABIB, J., SPIEGEL, M. M. The role of human capital in economic development: evidence from aggregate cross-country data. *Journal of Monetary Economics*, 34(2), p.143-173, 1994.

BILS, M.; KLENOW, P.J. Does Schooling Cause Growth? *American Economic Review* 90(5), December, 2000, p. 1160-1183.

BONELLI, R. Crescimento, desigualdade e educação: notas para uma resenha com referência ao Brasil. *Economia Aplicada*, 6(4), p.819-873, 2002.

CRAVO, T. A. A Importância do Capital Humano e Inovação na Convergência Real entre Países e entre os Estados do Brasil. Dissertação (Mestrado em Economia) - Universidade de Coimbra, Portugal, 103p, 2006.

DAVIDSON, R.; MACKINNON, J. G. Estimation and Inference in Econometrics. New York: Oxford University Press, 1993.

DURLAUF, S. N.; JOHNSON, P. A.; TEMPLE, J. R. W. Growth Econometrics. *University of Winsconsin Working Paper*, n. 61, 2004.

FERREIRA, A. H. Convergence in Brazil: recent trends and long-run prospects. *Applied Economics*, 32(4), p.479-489, 2000.

FERREIRA, A. H. A distribuição interestadual da renda no Brasil, 1950-85. *Revista Brasileira de Economia*, 50(4), p.469-85, 1996.

FERREIRA, P. C.; ISSLER, J. V.; PESSÔA, S. A. Testing Production Functions Used in Empirical Growth Studies. *Economics Letters*, 88(1), 29-35, 2004.

FIGUEIRÊDO, L., GARCIA, R. A. Impactos de Diferentes Metodologias para o Cálculo da Taxa Líquida de Migração sobre o Estudo do Crescimento Econômico e da Distribuição da População dos Estados Brasileiros. In: Encontro Transdisciplinar Espaço e População - Abep/Nepo, Campinas-SP, 2003.

GREENE, W.H. Econometric Analysis. 4th ed. New Jersey: Prentice-Hall, 2000. 1075p.

HALL, R. E.; JONES, C. I. Why Do Some Countries Produce So Much More Output per Worker than Others? *The Quarterly Journal of Economics*, 114(1), p. 83-116, 1999.

HAUSMAN, J.A. Specification Tests in Econometrics. *Econometrica*, 46(6), p. 1251-1271, 1978.

______________. Specification and estimation of simultaneous equation models, in: Zvi GRILICHES AND M. D. INTRILIGATOR (eds), Handbook of Econometrics Vol. 1. Amsterdam: North Holland, 1983.

ISLAM, N. Growth empirics: a panel data approach. *The Quarterly Journal of Economics,* 110(4), p.1127-1170, 1995.

KLENOW, P.J.; RODRÍGUEZ-CLARE, A. The Neoclassical revival in growth economics: has it gone too far? In BERNANKE, B.S.; ROTEMBERG, J.J., eds. NBER macroeconomics annual 1997. Cambridge, MA; MIT press, p. 83-103, 1997.

LAU, L. J., JAMISON, D. T., LIU, S. C., RIVKIN, S. Education and economic growth: some cross-country evidence from Brazil. *Journal of Development Economics*, 41(1), p.45-70, 1993.

LUCAS, R. E. Jr. On the mechanics of economic development. *Journal of Monetary Economics*, 22(1), p.3-42, 1988.

MANKIW, N. G., ROMER, D., WEIL, D. A contribution to the empirics of economic growth. *The Quarterly Journal of Economics*, 107(2), p.407- 437, 1992.

MINCER, J. Schooling, experience, and earnings. New York: Columbia University Press, 1974.

NAKABASHI, L. Três ensaios sobre capital humano e renda por trabalhador. Tese de Doutorado, CEDEPLAR/UFMG, 145p, 2005.

NAKABASHI,L; FIGUEIREDO,L. Mensurando os impactos diretos e indiretos do capital humano sobre o crescimento. *Revista de Economia Aplicada*, 12(1), p.151-171, 2008.

NAKABASHI, L.; SALVATO, M. A. Human Capital Quality in the Brazilian States. *Economia – Revista da Anpec*, 8(2), p.211-229, 2007.

NELSON, R. R., PHELPS, E. S. Investment in humans, technological diffusion, and economic growth. *The American Economic Review*, 56(2), p.69-75, 1966.

PRITCHETT, L. Where has all the education gone? *The World Bank Economic Review*, 15(3), p.367-391, 2001.

ROMER, P. Endogenous technological change. *The Journal of Political Economy*, 98(5), p.71-102, 1990a.

ROMER, P. Human capital and growth: theory and evidence. *Carnegie-Rochester Conference Series on Public Policy*, 32, p.251-286, 1990b.

SACHS, J. D., WARNER, A. M. Fundamental sources of long-run growth. *The American Economic Review*, 87(2), p.184-188, 1997.

SCHULTZ, T. W. Reflections on investment in man. *The Journal of Political Economy*, 70(5), p.1-8, 1962.

SOLOW, R. M. A contribution to the theory of economic growth. *The Quarterly Journal of Economics*, 70(1), p.65-94, 1956.

SWAN, T. W. Economic Growth and Capital Accumulation. *The Economic Record*, p. 334-61, 1956.

TEMPLE, J. R. W. A positive effect of human capital on growth. *Economic Letters*, 65(1), p.131-134, 1999.