Paper to be presented at the 51st European Congress of the Regional Science Association International (ERSA2011), to be held at Barcelona, Spain, from August 30th to September 3rd, 2011

The Non-linearity of the Relationship between Human Capital and Exports in Brazil – evidences of regional differences

Gilberto Joaquim Fraga[1]
Carlos José Caetano Bacha[2]

Abstract:
The study of Brazilian export determinants is a very important issue to policy-markers, principally when the export determinants are different among the Brazilian states or regions. Human capital (measured by the average level of employee formal schooling) has been one of these determinants and this paper, basing on Dixit and Woodland (1982) model, aims to evaluate the role played by human capital in the evolution of Brazilian states exports from 1995 to 2006, highlighting the differences among Brazilian states and/or regions. The empirical analysis is implemented by running regression of the data organized into a panel and considering the fixed effects (i.e., the amenities) among the 27 Brazilian states. The findings are consistent with the selected theoretical model and suggest that human capital has a non-linear effect on exports. The latter suggests the continuous improvement in the worker skill should not be neglected by public policies aimed at increasing the foreign trade of Brazilian states, but the unique characteristics of these states must be taken into account.

Key words: Brazilian states, exports, schooling, fixed effects.

1. Introduction

The increased openness of Brazil to the international trade in the last two decades and the consequent growth in trade flows[3] have attracted the attention of researchers, with a view to identifying the determinant of international competitiveness and the determinants of trade, both in developing and developed countries. In this context, there are different suggestions for increasing international competitiveness of economies for the purpose of increasing their exports, even though researchers focus their attention on analyzing the importance of specific factors such as human capital. Arbache and De Negri (2002) argue that, since capital and worth are mutually complementary, the level of human capital in the workforce may serve as a way of gauging the technological level of the firm. Thus, when analyzing the impact of human capital level on exports, someone may also indirectly be

[1] Ph.D. student at “Luiz de Queiroz” College of Agriculture, University of Sao Paulo – Brazil, E-mail: gjfraga@esalq.usp.br.
[2] Professor at “Luiz de Queiroz” College of Agriculture, University of Sao Paulo – Brazil. E-mail: cjcbacha@esalq.usp.br
[3] In 2006, the volume of exports added to Brazilian imports (in thousands of dollars) was 2.8 times higher than the value of the same variable in 1995 (according to information collected from IPEADATA).

measuring whether the technology level of the firm is a determinant of the exports of Brazilian states.

Using this reasoning, several studies have shown a positive relationship between human capital and the external competitiveness of countries. Stern and Maskus (1981), Courakis (1991), Corvers and Grip (1997), Chuang (2000) and Contractor and Mudambi (2008) highlight the importance of workers' schooling (a proxy for qualification) as determinants of the export competitiveness in developed countries. Chuang (2000) analyzes the relationship between human capital and exports in Taiwan between 1952 and 1995. According to this author's results, there is a positive and stable long-term relationship between the two variables throughout the period under study.

Contractor and Mudambi (2008) examine two groups of countries (Asian countries and developed countries) to determine the importance of human capital when it comes to explaining the evolution of exports between 1989 and 2003. The results confirm a positive relationship between the variables for both groups of countries, although the authors do point out that this relationship is not linear, suggesting an inflection point on the curve relating human capital and exports. The authors also point out that human capital impacts the evolution and size of exports of the regions (or countries) differently, depending on how developed the region or country is.

To explain the different impacts of variations on the production factors concerning exports, some models based on the assumption of intensity use of the factors, such as the traditional models like Rybczynski, can provide the theoretical foundation for this paper.

In 2009, Brazil was the eighth largest economy in the world, and the country is makes up of 27 states with different geographical dimensions and populations. The value of its exports grew at 9.75% per year from 1995 to 2006, but this growth was not evenly spread among all the states. For instance, exports in State of Pernambuco rose by 0.39% a year, while those of from the State of Mato Grosso grew by 17.15% per annum. These states held 1.55% and 0.36% respectively of the country's capital in 1995. Pernambuco had 4.51% of the Brazilian workforce while Mato Grosso had 1.54% in 1995, whereas the average level of human capital in the same year was 4.41 and 5.38 years of study, respectively.

In this scenario, the aim of this study is to analyze the impact of human capital on the evolution of exports from Brazilian states between 1995 and 2006, observing the differences among Brazilian states and/or regions. For this purpose, a generalization of the Dixit and Woodland (1982)'s model is used. The innovation of the model is that human capital has been inserted specifically, measured by the average level of schooling, of the part of the workforce employed during each period *t*. This aspect is relevant because it helps prepare policies to increase exports. For example, when verifying the maximum level of average schooling in employed workforce, trade policies, seeking to increase their competitiveness, could focus on in an improvement in worker qualifications, but with a different focus for each state or region.

This article estimates an exportable surplus equation starting from a production function in which human capital is added as an explanatory variable. The differences in the endowment of natural resources (including land), which plays an important role in Brazilian exports, will be considered by the econometric procedure that estimates the equation with dataset organized into panels, considering the fixed effects among the states.

The econometric methodology employed is the panel data regression in order to consider the potential fixed effects. The question of missing variables should always be considered because part of the differences among states has to do with fixed aspects such as natural resources, geography and culture, which are not captured in the estimates through standard procedure.

As for the production factors that are included in the model and differentiate the evolutions of exports by the states, the following relationships are assumed: i) the industrial consumption of electricity (proxy for the capital variable) is expected to have a positive relationship with the evolution of exports, although the focus of this variable is the control variable with no highlighted role in the analysis of the dynamic of the states; ii) the workforce, represented here by the economically active population, should have a positive relationship with exports and with greater power to explain the latter variable than the other factors if exports are labor intensive; iii) the regression coefficient concerning the average level of schooling is expected to be positive and non-linear. Through this variable, it will be possible to determine whether exports involve high or low qualification levels of labor intensity, depending on the behavior of the estimated parameters.

The main contribution of this article is to ascertaining the importance of human capital to exports at the state level of a country such as Brazil. Another contribution is to verify the intensity of exports in terms of skilled labor of the states, considering their specific features and characteristics (such as geographical endowment) and the structural changes[4] that the Brazilian economy has undergone in the past two decades.

This article is organized as follows: Section 1, Introduction; Section 2, presentation of the theoretical model; Section 3, the econometric data and procedure; Section 4 presents

[4] Silva and Hidalgo (2009) present the recent changes in the structure of the Brazilian export sector.

the estimated equations and a discussion of the results. The final considerations are given in Section 5.

2. Theoretical Model

The economic model presented in this section is based on Dixit and Woodland (1982)'s model, which structures a relationship between the endowment of factors and the foreign trade of a nation. Initially, the model makes the following assumptions: 1) there is identical production technology among the countries (or regions) and with constant returns; 2) aggregate preferences are homothetic and identical; 3) there are *n* factors and *m* products; and 4) the productive sectors of the countries are assumed to have a set of possibilities for production represented by *Y*(*v*), where $v = (v_1,..., v_n)$ is the vector for the endowment of factors and *Y*(*v*) is the set of all the technically possible production vectors. Then, $Y = \sum_{i=1}^{m} y_i$. The production sector maximizes the national product and is represented by:

$$G(p,v) = \max_{y}\{p.y \mid y \in Y(v)\}, \qquad p \geq 0, v \geq 0. \qquad (01)$$

where *G*(*p, v*) is the production function of the economy and being:

$$G(p,v) \geq 0$$

where $p = (p_1,..., p_m)$ is the price vector of the *m* products, which is additionally taken for granted for a small open price-taking economy. The function $G(p,v)$ is concave, linearly homogenous and continuous in *v* for fixed *p*. Beginning with the assumption that *G* is differentiable and has constant returns to scale, then, $w_i(p,v) = \partial G(p,v) / \partial v_i$.

On the side of the consumers, there is:

$$E(p,u) = \underset{c}{mim}\{p.c \mid U(c) \geq u\}, \qquad p \geq 0, c \geq 0. \qquad (02)$$

With *E*(*p, u*) representing demand and $E_u > 0$.

The demand side can be described in terms of expenditure, given a minimum level of utility in accordance with equation (02), with *U* being the direct utility function and *c* is the aggregate consumption, with $c = \sum_{i=1}^{m} c_i$. The expenditure function is concave, linearly homogenous and continuous in *p* for fixed *u*. By assuming the non-satiation principle and that all income will be spent, the indirect utility can be obtained from the solution of the following equation:

$$S(p,v,u) \equiv G(p,v) - E(p,u) = 0. \tag{03}$$

where S is the indirect utility function.

Solution to equation (03) generates the maximum possible utility for a given country with and endowment of factor *v*, considering a price level *p* that results from the very organization of the production system and a high standard of trade. Thus, the maximum utility can be expressed as:

$$u = J(p,v) \tag{04}$$

Exports $x = y - c$ (i.e., exports are the surplus of production over domestic consumption) can be explained as a function of a given price (*p*) and the endowment of factors vector (*v*) of the country in question. Thus, equations (03) and (04) have the following indirect utility function[5] of trade:

$$x(p,v) = S[p,v,J(p,v]. \tag{05}$$

Consider two nations where endowments of factors differ to some extent. Country *A* initially has endowment *v* and the endowment of Country *B* is $v^* = kv$, where k is a positive scalar. This difference in endowment of factors allows, in the view of Hecksher-Ohlin-Samuelson (HOS), the impact of endowments on trade to be a relative function of relative intensity of factors in the production of goods. With a determined price (p^0 that is given), the variations in the exports of Country *A* can be written as:

$$dx^s = x_v dv \tag{06}$$

Therefore, the above equation establishes that the relationship between the endowment of factors and the international trade of goods is determined by the dependence of dx^s in relation to dv. Thus, the oversupply (*x*) of any good *j* will be intensive in the use of factor *i* when $\partial x_j / \partial v_i$ is positive. This effect follows the theorem of Rybczynski that focuses on the side of production[6].

2.1. Specification of the Model with Endowments of Specific Factors in Brazilian States

From the above theoretical exposition, it can be concluded that the differences in specific endowments of countries have implications for flow of their international trade. The empirical specification proposes a general model for the flow of exports from Brazilian states that includes, in addition to the traditional factors considered by Dixit and Woodland (1982) -

---

[5] See Woodland (1980) for a complete presentation of the derivations of the direct and indirect utility functions of trade.

[6] See Feenstra (2004).

physical capital (*K*) and the workforce (*L*) - the level of accumulated human capital (*H*). From equation (06), with $v=(K,H,L)$, given that the level of production will always be maximized, the result is:

$$dX = x_v d(K,H,L) \quad (07)$$

where $x_v = \frac{\partial x}{\partial v_i}\frac{v_i}{x}$.

From equation (07), changes in exports originate from the changes in the endowment of factors, in accordance with equation (08):

$$dX = x_k dK + x_h dH + x_L dL \quad (08)$$

Rewriting equation (08), the country's flow of exports may be written thus:

$$X_{it} = \alpha + \beta K_{it} + \varphi H_{it} + \phi L_{it} + u_{it} \quad (09)$$

$$u = \mu_i + \eta_{it}$$

Where X_{it} is the vector of exports from a certain state (or region) at a certain time *t*; K represents physical capital; H is human capital (measured by the average schooling of employees); L is the workforce; β, φ and ϕ are parameters to be estimated; μ_i are the unobservable fixed effects; and η_{it} are the dynamic shocks in time. In accordance with the empirical specification of equation (09), minor changes in the endowments of factors are reflected on the volume of exports. Thus, from this relationship, the parameters of interest that will be presented and discussed in section four can be estimated. Furthermore, there will be a non-linear estimation of equation (8), which is a variation of equation (09).

3. Econometric Data and Procedures

3.1. Data

Data utilized to estimate equation (9) were obtained from the Ministry of Development, Industry and Foreign Trade (MDIC in Portuguese), from Institute for Applied Economic Research (IPEADATA in Portuguese), from the Ministry of Mining and Energy (MME) and from Brazilian Institute of Geography and Statistics (IBGE).

The panel data was composed of 27 federal units (26 states plus the Distrito Federal) over a period of 12 years (from 1995 to 2006). Therefore, there is a matrix N x T: 27 x 12 for each variable in equation (09). It is worth pointing out that the panel is balanced, i.e., the dimension of time (t) is not a variable among Brazilian states. The variables that are utilized are:

1) Exports (X), defined as the total value of exports for each Brazilian state measured in thousands of reais (R$) deflated by the wholesale price index (IPA-OG);
2) Capital (K), for which the industrial consumption of electricity is used[7] (in megawatts per hour) as a proxy because Brazil does not have information on the stock of physical capital (or investment) for each state in the country;
3) Human capital (H) defined as the average schooling of the employed share of economically active population;
4) Human capital squared (H^2), which is the squared value of the former variable;
5) Workforce (L) – amount of the Economically Active Population (in thousands of persons).

Table 1 shows the growth rates of exports (X), capital (K) and the workforce (L) and the change in level of human capital (H) of Brazilian states. The data reflect the performance of these variables from 1995 to 2006 and can be viewed as a mirror of the regional disparities in Brazil. The first variable is the growth rate of the value of exports, which averaged 9.7% a year in Brazil during the period under study. On the other hand, there are cases of huge discrepancies that characterize the possible outliers. For example, the state of Tocantins[8] registered a growth rate in its exports of 54.2% per year, while the state of Piauí registered a negative growth in exports of -5.1% a year. Tocantins was also the state that registered the highest growth of capital (K), 9.8% p.a., followed by state of Rondônia, with 9.7%, highlighting that both states are part of the North region. Amapá was the state with the lowest growth rate of K, at -6.5% a year. Also in the North, the states of Pará and Roraima registered the highest growth rates of the workforce, with 8.1% and 7.9%, respectively. In contrast, states of Rio Grande do Sul and Maranhão States had the lowest growth rates of this variable (workforce). As for human capital, while Tocantins saw a rise of approximately 2.5 years in the level of average schooling of workers, while the state of Acre saw this variable remaining practically stagnant during the period under study.

[7] It is worth pointing out that there is a strong positive correlation between investment (gross formation of physical capital) and the industrial consumption of electricity, which justifies using it as a proxy.
[8] Tocantins is a relatively new state, having been created in 1988, which partly accounts for this performance in exports, since the state is rapidly expanding, especially in farming and livestock.

Table 1 – Evolution of exports, capital, labor and human capital in Brazilian states from 1995-2006.

State	Variables				State	Variables			
	X^a	K^a	L^a	H^b		X^a	K^a	L^a	H^b
AC	8.85	5.24	7.35	0.04	RN	10.71	5.49	1.85	1.93
AM	17.87	7.39	5.51	1.36	SE	8.31	5.06	2.47	1.89
AP	3.37	-6.49	5.90	1.69	DF	16.80	5.90	3.35	1.77
PA	7.18	3.71	8.13	0.85	GO	15.58	5.79	2.49	2.25
RO	15.33	9.73	6.15	0.13	MS	7.76	6.27	2.21	1.98
RR	8.88	5.06	7.86	1.06	MT	17.15	9.01	2.35	1.81
TO	54.21	9.84	2.89	2.49	ES	5.28	3.63	2.32	2.05
AL	1.09	0.46	1.72	1.37	MG	6.01	1.84	2.24	1.98
BA	8.33	3.62	1.51	2.30	RJ	12.15	-0.21	1.85	1.50
CE	6.20	3.35	2.16	2.45	SP	6.67	2.51	2.20	1.97
PI	-5.11	7.74	1.76	1.85	PR	6.43	4.87	1.85	2.14
PB	5.23	6.49	1.59	1.56	RS	4.68	5.08	1.21	1.52
PE	0.39	2.51	1.73	2.00	SC	4.60	4.76	2.11	2.13
MA	5.63	2.08	1.29	2.14					

Notes: [a]) the annual percentage growth rates of X, K and L were obtained as follows: $X_{2006}=X_{1995}e^{rt}$, where r is the rate and t is the time; [b]) the values for human capital (H) represent the change of level of the average for this variable, i.e., $H=H_{2006}-H_{1995}$;

3.2. Regression with panel data

Estimations with data that combine time series with cross-section data have increasingly become frequent into the economic literature. Baltagi (2005) lists some advantages in using panel data, such as the possibility to control individual heterogeneity, more power of information from the data, greater variability, less co-linearity among variables, a higher degree of freedom and greater efficiency, better analysis of the dynamic of adjustment, a possibility to identify and measure effects that the temporal series data or pure cross-section do not capture.

The regression model for data organized into panels can be represented through the following equation:

$$X_{it} = \sum_{j=1}^{k} \beta Z_{it}^{j} + u_{it} \tag{10}$$

The equation of the error component could be written as:

$$u_{it} = \mu_i + \eta_{it} \tag{11}$$

In equation (11), it is assumed that η_{it} is not correlated with Z_{it} (a matrix *nxn* of explanatory variables). Meanwhile, the first term of decomposition (μ_i), called the individual effect, represents the so-called idiosyncrasies of the states that are fixed over time but are not disparate among the states, such as the amount of land available for the production of commodities (both agricultural and mineral) and whether the region lies on the coast. Concerning the term of error, we assume:

$$E[\mu_i \mid Z] = E[\eta_{it} \mid Z] = 0, \tag{12}$$

$$E[\mu_i \mu_j \mid Z] = 0, \qquad para \quad i \neq j, \tag{13}$$

$$E[\mu_i \eta_{jt} \mid Z] = 0, \tag{14}$$

$$E[\eta\eta' \mid Z] = \sigma_\eta^2, \tag{15}$$

$$E[\mu_i \mu_i \mid Z] = \sigma_\mu^2, \tag{16}$$

$$E[\eta_{it}\eta_{jt} \mid Z] = 0, \forall \quad i \neq j. \tag{17}$$

Equation (10) can be estimated through two procedures: the random effects and fixed effects. In the model of random effects, μ_i is not correlated with Z_{it}, in accordance with equation (12). Meanwhile, in the fixed effects model, μ_i is correlated with the independent variables Z_{it}, i.e., $E[\mu_i |Z_{it}] \neq 0$ and it is assumed that this correlation is constant in terms over time and individuals (in our cases, the Brazilian states). Normally, the two models should be estimated under the conditions of fixed and random effects so that statistical tests can define the most suitable procedure that can be used. The test proposed by Hausman (1978) verifies whether the fixed and random effect models are identical. If they are, given the condition of orthogonality between the random effects and the independent variables, the best specification is that of random effects. To corroborate the Hausman test, the Maximum Likelihood (ML) proposed by Breusch and Pagan (1980) can be estimated.

4. Results of the Regressions

Table 2 presents the estimated parameters of equation (09), both through the fixed effect and random effect procedures. Unlike the other explanatory variables, human capital was used at a level to enable a direct, easier interpretation. Despite employing neperian logarithm (ln), the statistical significance remains the same.

Table 2 – Fixed effect and random models: export dependent (lnx)

Variables and parameters[1] (1)	Fixed (fe) (2)	Random (re) (3)
LnK	0.29*	0.35*
	(0.09)	(0.09)
H	0.30*	0.30*
	(0.06)	(0.05)
lnL	1.45*	1.24*
	(0.22)	(0.17)
Constant	-14.00	-11.68
R^2 – within	0.42	0.41
- among	0.80	0.81
- total	0.77	0.78
corr (μ+η , X)	0,22	-
$\sigma_{u=\mu+\eta}$	1,09	0,93
σ_η	0,53	0,53
F[(26.294). u_i=0]=36.43	Prob(0.00)	-
N	324	324

Notes: (*) indicates level of significance of 1%; (**) indicates level of significance of 5% and (***) indicates level of significance of 10%. Values in brackets are standard deviations. 1) Estimations done using STATA 10.

The above results show that both fixed effect and random models show the parameters are statistically significant. Nevertheless, tests are required to verify whether the results are linked to heteroskedasticity and autocorrelation phenomena, which are common in regression using panel data. In principle, the most relevant information in the regressions below are: the F-statistic, which signals the fixed effects model as potentially adequate and the value of the correlation between (μ+η) and the independent variables (Z) – correlation (μ+η , Z) of 22%, which is another indication of the importance of the existing correlation with the fixed effects of the states.

It is worth pointing out the importance of the F-statistic (column 1), which shows whether the states have equal u_i = 0 long-term export dynamics. According to the results shown, each state does indeed have its own dynamic. In other words, the first results show that there are persistent and idiosyncratic differences among Brazilian states, which strengthens the indication that economic policies should differ from one state to another to stimulate exports. As for the standard deviation of the fixed effects (σ_μ=0.56), this was shown to be higher than the standard deviation of the components of imbalance, σ_η.

The next step is to find which method is more suitable. For this purpose, the Hausman (1978) specification test is used, which verifies whether the fixed and random effect models are identical or whether they have systematic differences. The Hausman test obtained the following results: Chi square χ^2=12.52, making it possible to reject the hypothesis of equal coefficients, because its likelihood is 0.006. This probability confirms the fixed effects model as the most adequate for this study.

As for confirming the possible presence of autocorrelation, the specific test for autocorrelation in panel data suggested by Wooldridge (2002) is used. This test is presented by Drukker (2003), and the statistic F(1.26) = 10.957 indicates that, for a significance level of 1%, it is not possible to reject the hypothesis that there is a first-order autocorrelation among the regression residuals.

Another important test is that which checks for the possible presence of heteroskedasticity in the panel groups. Specifically, the test consists of verifying whether $E(u_{it}u_{jt}) \neq I\sigma^2$ for $i \neq j$, where I is the identity matrix. Therefore, it seeks to verify whether the variances of the groups are homoscedastic. This test[9] (which is based on the statistic distribution χ^2 (chi-square) for the panel data) is introduced by Greene (2003). The result shows a significance level of 1%, it is not possible to reject the hypothesis of heteroskedasticity for the panel group. Therefore, the data are heteroskedastic (Table 3). Considering the specifics of Brazilian states, the result of this test reflects the Brazilian reality.

Considering that the Hausman test may have been influenced by the presence of autocorrelation, new tests can be made to corroborate the results as the Maximum Likelihood (ML) proposed by Breusch and Pagan (1980) and Baltagi and Li (1995) for random effects, which considers the presence of autocorrelation, are shown in Table 3 below.

Table 3 – Tests for random effect and serial correlation

Tests (1)	Value (2)	Likelihood H_0 (3)
Random Effects		
ML: Var(u_i) =0	28.92	0.00
MVA: Var(u_i) =0	24.80	0.00
Serial correlation		
ML: ρ=0	237.04	0.00
MVA: ρ=0	15.46	0.00
Joint test		
ML: Var(u_i)=0 e ρ=0	851.87	0.00
Heteroskedasticity		
H_0: $\sigma_i^2 = \sigma^2 \ \forall \ i$	8003.9	0.00

In accordance with the random effects tests, both the maximum likelihood without correction for autocorrelation and that which considers correction for autocorrelation (MLA)

[9] Greene (2003) called this test the groupwise heteroskedasticity test.

show that the fixed effects model is what should be chosen given the zero likelihood of random effects. As for serial autocorrelation, the probability of ρ=0 is null. Therefore, the null hypothesis of non-autocorrelation is rejected, both in the ML and MLA version. The joint test, which checks for the presence of the random effect and the absence of autocorrelation, also showed no statistically significant result.

Considering the set of tests conducted, the results show that a fixed effects model should be applied, taking into consideration (and correcting) the presence of autocorrelation and heteroskedasticity. Therefore, the tests indicate that in the first estimates (Table 2) the parameters can be biased and the model of equation (09) may not be the most suitable, and new estimates are proposed based on equation (18).

$$X_{it} = \alpha + \beta K_{it} + \varphi H_{it} + \theta H_{it}^2 + \phi L_{it} + u_{it} \tag{18}$$

The above equation is an extension of equation (09), with the addition of the human capital squared. The non-linear inclusion of this variable specifically seeks to capture the impacts of the different levels of human capital accumulated by the workers over time and find a potential point of inflection.

Some dummies can be added to equation (18) in order to capture differences among the Brazilian regions. The 27 Brazilian states are grouped in five regions: North, Northeast, Central-West, Southeast and South. The most developed region is the Southeast, then four dummies variables can be added to equation (18) in order to express if the state belongs to North, Northeast, Central-West or South and to find out if the region can influence the performance of the state to export.

For this purpose, the Prais-Winsten (P-W) methods are used to estimate the model by Ordinary Least Squares (OLS), in addition to the Factor Generalized Least Square (FGLS)[10], both taking into account the problems of heteroskedasticity and autocorrelation. The estimates following these two methods are shown in Table 4.

The parameters obtained through both the P-W (models 2 and 3) the FGLS (models 4 and 5) are statistically significant and robust. Even when the procedure changed, from P-W to FGLS, and new variables were added (as H^2 and regional dummies), the parameters of the variables of interest remained with their expected signs and statistically significant levels of significant. Thus, the results shown in Table 4 are more consistent than the basic model shown in Table 2.

[10] According to Wooldridge (2002, p. 277-78), the FGLS procedure can be adapted for estimations through the serial correlation and heteroskedasticity.

The coefficient of lnK variable, which represents the industrial consumption of electricity (in megawatts per hour) and is a proxy for capital in the Brazilian states, had a positive and statistically significant signal. Although a positive relationship is expected, as found, the main function of this proxy is as a control variable in the specification of the empirical model.

Table 4 – *P-W* and *FGLS* Models: dependent exports (lnX)

Variáveis	*P-W*		*FGLS*	
(1)	(2)	(3)	(4)	(5)
lnK	$0,54^{*}$	$0,53^{*}$	$0,43^{*}$	$0,46^{*}$
	(0,08)	(0,09)	(0,06)	(0,05)
H	$1,54^{*}$	$0,96^{*}$	$0,96^{*}$	$0,41^{***}$
	(0,40)	(0,37)	(0,24)	(0,23)
H^2	$-0,11^{*}$	$-0,07^{**}$	$-0,06^{*}$	$-0,03^{***}$
	(0,04)	(0,03)	(0,02)	(0,02)
lnL	$0,87^{*}$	$1,04^{*}$	$0,96^{*}$	$1,18^{*}$
	(0,13)	(0,19)	(0,09)	(0,11)
Central West	-	$-0,26^{ns}$	-	$0,16^{ns}$
		(0,38)		(0,29)
Northeast	-	$-0,02^{ns}$	-	$-0,20^{ns}$
		(0,45)		(0,22)
North	-	$1,01^{*}$	-	$1,19^{*}$
		(0,46)		(0,27)
South	-	$0,85^{*}$	-	$0,91^{*}$
		(0,29)		(0,19)
Constant	$-12,29^{*}$	$-13,12^{*}$	$-10,32^{*}$	$-12,18^{*}$
R^2	0,95	0,96	-	-
N		324		324

Notes: (*) indicates level of significance of 1%; (**) indicates level of significance of 5% and, (***) indicates level of significance of under 10%, (ns) non-significant.

The average schooling variable (H) level and its squared level (H^2) should be analyzed together. In accordance with the values of the parameters of equation (5) in Table 4, equal increases in the level of average schooling can lead to increased exports. Nevertheless, this growth is not linear because it is growing up to a certain point and from thereon it falls. The statistical significances of the coefficients associated with H and H^2 confirm the existence of a quadratic behavior that will be examined in more detail below.

Concerning the workforce (lnL), it is expected that the higher the value of this variable, the more positive the effect it will have on the volume of exports, i.e., it will increase. In this case, as can be seen in the estimated models in the above table, the results are in accordance with the initial assumptions concerning the signs; and the magnitudes of the parameters suggest that exports are intensive in labor.

Concerning the regional structure of the economy, represented by regional dummies, the sign of the coefficient is positive and statistically significant (Table 4). Exports increase differently and more in the South-Eastern region. This is also the case of the South and the North. However, the coefficients of the Central-West and North-East are not statistically significant. This suggests that the exports of these regions tend to grow in a similar manger to those of the South-East. Given this heterogeneity between Brazilian states (aggregate in five regions), the policies to stimulate exports should be differentiated, taking regional characteristics and features into account.

The statistical significance of the human capital variable demonstrates its direct influence on exports. This result is coherent with the assumptions of non-linearity of this influence, according to the traditional theory of international trade such as the Hecksher-Ohlin-Samuelson (HOS) style. Regressions (3) and (5) in Table 4 show that human capital has a positive effect on exports, even though this effect has a limit (maximum point). When the level of schooling in a determined state is low and grows, it leads to increased exports. However, when this level of schooling reach a certain point, improved schooling does not mean increased exports. In other words, exports are intensive at a low level of human capital. One can see that from a certain level the coefficient, although small, becomes negative and remains statistically significant. This result, in addition to showing the technological intensity of the Brazilian export basket, is in agreement with the theoretical assumptions of the function of indirect utility of exports (equations 3-5). The direct quadratic relationship between and the level of human capital may be expressed as: $X = \beta_1 H - \beta_2 H^2$.

Through the values estimated in regression (5) in Table 4, and calculated the partial derivative ($\partial X/\partial H$) and equaling to zero, the maximum point of the human capital (h^*) is 6.83 years of study[11]. Therefore, the aggregate exports of the Brazilian states are intensive in work with a skill less than seven years of average schooling. Thus, the states with schooling levels of under seven years should concentrate their public policies on education in order to improve the competitiveness and exports. For policies at the national level, it is worth moving to the right of this maximum point, i.e., making exports intensive with a higher level of education.

Arbache and De Negri (2002) estimated the impact of the average schooling of workers on export firms on the likelihood that they would indeed export. According to these authors, this likelihood grows monotonically up to the level of finishing high school and some further education. The point of inflection found by these authors is higher than the one found

[11] From equation 5 in Table 4: $\ln x = 0{,}41h - 0{,}03h^2$, which calculating the partial derivative and equating to zero:

$$\frac{\partial \ln x}{\partial h} = 0{,}41 - 0{,}06h = 0 \qquad \Rightarrow \qquad h^* = \frac{0{,}41}{0{,}06} = 6{,}83$$

in this paper, which can be briefly explained by two main reasons: the methodology used by the authors (qualitative model) that seeks to measure the probability and, secondly, the database that directly refers to the qualification of the workers employed in exporting firms.

This paper uses the general average schooling of the employed share of economically active population because skilled workers in sectors that do not export may contribute indirectly to exports. For instance, workers with a higher educational level in the public sector can streamline the exporting process for firms.

The results shown in Table 4 are in line with the findings of Contractor and Mudambi (2008). These authors estimated the importance of human capital to the export of goods and services, considering two groups of countries and, according to their results, this relationship is not linear, i.e., the positive correlation only exists up to a certain point.

Considering the point of inflection found in the present paper and the findings of Arbache and De Negri (2002) and Contractor and Mudambi (2008) papers, it can be said that the present work adds evidence that policies of qualification (through increased average schooling) of the economically active population should be a priority when thinking of improving Brazilian competitiveness on the international market.

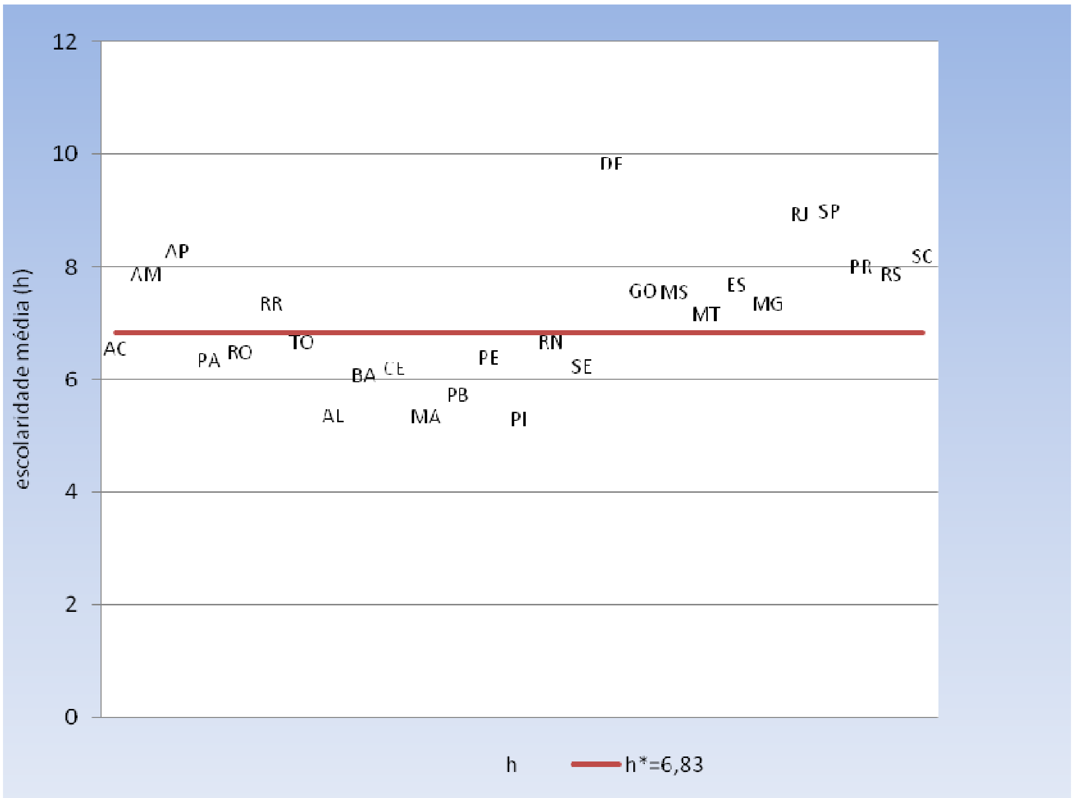
Considering the heterogeneity of the Brazilian states (or regions of Brazil), policies of regional stimulus concerning education for the workforce and improved competitiveness should vary from one region to another.

Graph 1 shows the average level of schooling of Brazilian states in comparison with the excellent (H^*) level.

As shown in the above graph, the average human capital level of around 50% of the Brazilian states is below the maximum point ($H^* = 6.83$ years). Therefore, improving the level of schooling in these states generates positive marginal returns. It is worth pointing out that these states are concentrated in the North and Northeast of Brazil. The North was where the level of education for workers progressed least during the period under study (1995-2006), with an increase of 1.12 years of study in the average level of schooling. Meanwhile, the Northeast saw an increase of 2.02 years. On the other hand, the growth rates[12] of exports for these two regions come in second and third place, respectively, in the period under study. The Central-West region (not including the Distrito Federal) deserves to be mentioned. Along

[12] The growth rates were calculated using the following procedure: $\ln Z = \alpha + \beta t + u$, where the growth rate (r%) of the variable Z (region *i*)is equal to: $r = (e^{\beta} - 1) \times 100$.

with the Northeast, the greatest rise in average schooling and, at the same time, the growth rate of exports, of the former were the highest among the Brazilian states.



Graph 1 – Average level of schooling in Brazilian states: 2006
Source: research data
Note: AC = state of Acre, AM = state of Amazonas, AP = state of Amapa, PA = state of Pará, RO = state of Rondônia, RR = state of Roraima, TO = state of Tocantins, AL = state of Alagoas, BA = state of Bahia, CE = state of Ceara, MA = state of Maranhão, PB = state of Paraíba, PE = state of Pernambuco, PI = state of Piauí, RN = state of Rio Grande do Norte, SE = state of Sergipe, DF = Distrito Federal, GO = state of Goais, MS = state of Mato Grosso do Sul, MT = state of Mato Grosso, ES = state of Espírito Santo, MG = state of Minas Gerais, RJ = state of Rio de Janeiro, SP = state of Sao Paulo, PR = state of Parana, RS = state of Rio Grande do Sul and SC = state of Santa Catarina.

5. Final Considerations

In this study, a model was applied to take into account the importance of the so-called fixed effects of the states on the growth of its exports. This model's main feature was that it examined the role of the average level of schooling of the employed workforce during each period concerning exports.

The regressions with panel data seeking to explain the exports of the states showed evidence of a pattern of exports at the state level based on the endowment of factors, as suggested by the theoretical model that was presented. However, the relationship between human capital and exports proved to be non-linear, suggesting an inverted U shape. For levels of average schooling of up to 6.83 years of study, the marginal effect of this variable on exports is positive. For levels of schooling above 6.83 years of study, the marginal effect of this variable on the exports of Brazilian states becomes negative. This probably has to do with the export basket being heavily based on commodities (farming, agro-industrial and mineral) that do not require as high a level of human capital as required for hi-tech industrial products.

Considering that the human capital of the workforce plays an important role, the general recommendation of this study is that policies to increase exports from the states should also focus on continuing the education of employed workers, even though the relationship is non-linear. This, however, will not keep Brazil from seeking comparative advantages in the export of hi-tech products, which can be partly achieved by improving the education of workers employed here.

6. References

ARBACHE, J. S.; DE NEGRI, J. A. 2002. Determinantes das exportações brasileiras: novas evidências. In: **XXX Encontro da ANPEC**, Nova Friburgo. Anais do XXX Encontro da ANPEC.

BALTAGI, B. H. 2005. **Econometric Analysis of Panel Data**. New York: Jhon Willey & Sons.

BALTAGI, B. H.; LI, Q. 1991. A Joint Test for Serial Correlation and Random Individual Effects. **Statistics and Probability Letters**, vol. 11(3): 277-280.

BALTAGI, B. H.; LI, Q. 1995. Testing AR(1) Against MA(1) Disturbances in an Error Component Model. **Journal of Econometrics**. vol. 68(1): 133-151.

BREUSCH, T. e PAGAN, A. 1980. The LM Test and its Applications to Model Specification in Econometrics. **Review of Economic Studies**, 47(1):239-254.

CHUANG, Y. 2000. Human Capital, Exports, and Economic Growth: A Causality Analysis for Taiwan, 1952-1995. **Review of International Economics,** vol. 8(4): 712-720.

CONTRACTOR, F. J.; MUDAMBI, S. 2008. The Influence of Human Capital Investment on the Exports of Services and Goods: An Analysis of the Top 25 Services Outsourcing Countries. **Management International Review,** vol. 48(4): 433-446.

CORVERS, F.; GRIP, A. 1997. Explaining Trade in Industrialized countries by country-specific Human Capital Endowments. **Economic Modelling,** vol. 14(3): 395-416.

COURAKIS, A.S. 1991. Labour Skills and Human Capital in the Explanation of Trade Patterns. **Oxford Economic Papers,** vol. 43(3): 443-462.

DIXIT, A.; WOODLAND, A. 1982. The Relationship Between Endowments and Commodity Trade. **Journal of International Economics,** vol. 13(3-4): 201-214.

DRUKKER, D. M. 2003. Testing for Serial Correlation in Linear Panel-data Models. **Stata Journal**, vol. 3(2):168-177.

FEENSTRA, R. C. 2003. **Advanced International Trade**: Theory and Evidence. Princeton: Princeton University Press.

GREENE, W. H. 2003. **Econometric Analysis**. New Jersey: Prentice Hall.

HAUSMAN, J. A. 1978. Specification Tests in Econometrics. **Econometrica**, 46(6):1251-1272.

INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA (IBGE). 2009. Pesquisa Nacional por Amostra de Domicílio (PNAD). Disponível em: < http://www.ibge.gov.br >.

INSTITUTO DE PESQUISA ECONÔMICA APLICADA – IPEA**.** 2009. **IPEADATA**. Disponível em: < http://www.ipeadata.gov.br.htm >.

MINISTÉRIO DO DESENVOLVIMENTO, INDÚSTRIA E COMÉRCIO EXTERIOR (MDIC). 2009. **Estatísticas de Comércio Exterior**. Disponível on line: < http://www.desenvolvimento.gov.br/sitio/interna/interna.php?area=5&menu=1078&refr=1076 >.

MINISTÉRIO DE MINAS E ENERGIA. 2009. **Boletins Anuais de Consolidação do Mercado de Energia Elétrica e da Economia.** Disponível on line: < **http://www.epe.gov.br/mercado/Paginas/Mercado_9.aspx?CategoriaID=** >.

SILVA, J. L. M.; HIDALGO, A. B. 2009. Composição e Diversificação do Setor Exportador Brasileiro: Uma analise do perfil das exportações. In: VII Encontro Nacional da Associação Brasileira de Estudos Regionais e Urbanos **– ENABER**. São Paulo: ABER.

STERN, R. M.; MASKUS, K. E. 1981. Determinants of the Structure of US Foreign Trade, 1958-76, **Journal of International Economics**, vol. 11 (2): 207-224.

WOOLDRIDGE, J. 2002. **Econometric Analysis of Cross Section and Panel Data**. Cambridge: MIT Press.

WOODLAND, A. 1980. Direct and Indirect Trade Utility Functions. **Review of Economics Studies**, vol. 47 (5): 907-926.