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Human capital demand in Brazil: The effects of adjustment cost, economic growth, exports and imports☆

Joilson Dias *

Departamento de Economia, Universidade Estadual de Maringá, Brazil

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Abstract

The objective of this paper is to learn about the effects of the adjustment costs, economic growth, imports and exports on human capital labor demand. The dynamic model proposed by Sargent (1978) was adjusted to consider three types of human capital: (a) one with fundamental education (1–8 years of schooling); (b) one with secondary education level (9–11 years of education); (c) and one with tertiary education level (12 years or more of schooling). Using state level panel data, the dynamic econometrics estimates showed the following results: (i) the labor market adjustment costs are very higher; (ii) the adjustment cost for the human capital with intermediary education level is the highest one compared to the others; (iii) the states' economic growth favor those with superior education; (iv) the imports seems to favor the demand for those with intermediate education levels; (v) the degree of openness does show some weak effect on the demand for human capitals with intermediate education. In sum, the growing demand for human capital with some superior education seems to be more associated to its lower adjustment cost and economic growth; the non-significance of real wage elasticity and high adjustment cost seems to indicate that the human capital with intermediate knowledge is in short supply; hence, economic education policy that increases supply of such human capital are in need.

JEL classification: J21; J23; J24

Keywords: Human capital; Adjustment cost; Economic growth; Imports; Exports; Dynamic estimates; State panel data; Intertemporal elasticity

Resumo

O objetivo do artigo é o de avaliar os efeitos dos custos de ajustamento, do crescimento econômico, das importações e das exportações dos estados brasileiros sobre a evolução do mercado de trabalho. O modelo dinâmico proposto por Sargent (1978) foi ajustado para contemplar o mercado de capital humano: a) com conhecimento fundamental (1 a 8 anos de estudos); b) com conhecimento intermediário (9 a 11 anos de estudos); c) e com conhecimento em nível superior (12 anos ou mais de estudos). As estimativas econométricas dinâmicas demonstraram os seguintes resultados: i) que os custos de ajustamento (contratação) em geral são elevados nos estados brasileiros; ii) que os custos de ajustamento do capital com educação em nível intermediáro é superior

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* Correspondence to: State University of Maringa, Brazil.
E-mail address: dr.jdias@phdrisk.com.br

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aos demais; iii) que o crescimento econômico dos estados favorece a demanda for capital humano com educação superior; iv) que as importações contribuem ainda que fracamente para com a demanda do capital humano com educação interemdiária; v) que o grau de abertura econômica dos estados apresenta efeito muito fraco e instável sobre a demanda por capital humano com educação intermediária. Em suma, o crescente aumento relativo do capital humano qualificado com educação em nível superior parece estar mais associado ao seu menor custo de ajustamento (contratação); o custo de ajustamento e a insignificância da elasticidade do salário real do capital humano intermediário parecem indicar uma possível restrição de oferta do mesmo; considerando que, aumentos da demanda de capital humano intermediário favorem a demanda pelos demais capitais humanos, portanto, políticas de formação de pessoas com educação intermediária devem ser incentivadas.

Palavras-chave: Capital humano; custos de ajustamento; crescimento econômico; exportação e importação; estimativas dinâmicas; painel de dados dos estados; elasticidade intertemporal

1. Introduction

The labor market in Brazil during the period of 1997–2009 has changed quite substantially regarding the human capital distribution per level of education. For instance, individuals with schooling years between 1 and 8 years of education (fundamental education) lost participation in the market from 57.8% in 1997 to 41.3% in 2009. At the same time individuals with schooling between 9 and 11 years of education (secondary education) saw their participation to grow from 19.5% to 33.3%. The same happened for individuals with education above 12 years of schooling (some degree of tertiary education), their market participation jump from 8.7% to 15.9% in the same period.[1]

The labor market change can be credited in part to the supply growth of more educated labor. However, it is an equilibrium market and requires that demand responds in the same way as the growth in supply in order to have more educated individuals working in the labor market. Hence, this paper focuses on the demand side of the labor market equilibrium.

More specifically, this paper looks to three aspects of demand using state level dataset which are: (i) the adjustment costs; (ii) the economic growth; (iii) the import; and (iv) the exports. The objective is to understand the importance of these variables in the demand shift towards more educated workers. Another important aspect related to the demand shift is regarding the relative wages. Does it signal complementarity or substitutability between the groups of education levels in the labor market?

The reviewed literatures in this paper show that the relative growth of human capital with 12 years of schooling or more started during the 80s and 90s. In this period they observed three important economic aspects in their researches. First, economic policies at that time created incentive to physical capital imports, thereafter demanding more qualified works to operate them. Second, education policies fostered the growth of individuals with 11 years of schooling; their higher productivity, compared to the others, made them more attractive. Third, early estimates of hiring costs at industry level showed to be higher for individuals with lower fundamental education compared to the other groups.

One important finding in the reviewed literature is that the structural change made by the adoption of a new constitution in 1988 had no effect in the labor market dynamics. This is quite important since the labor cost changed very substantially with the new constitution of 1988.

As one may notice this paper complements the literature by looking to the role of new economic variables related to the development occurred at state level. More specifically, Brazilian states economies have been growing at different levels and the observed level of opening up are not the same. Therefore, they might influence labor market dynamics in a different way. At the same time education policy towards tertiary education are quite different among the states. Some depend heavily upon federal investments while others states like Sao Paulo and Parana have made this an important educational policy. By using panel data we expect to capture long run dynamics effects associated to economic and educational policies made at state level.

Also this paper will estimate the adjustment cost per group of education – fundamental, secondary and tertiary – and compare them using state level panel data. Is the adjustment cost one of the explaining factors behind the relative

[1] The data is from IBGE available at www.ibge.ov.br.

changes in the labor market? Are the opening up policies also responsible for the relative labor market change at state level?

To answer the above questions, this paper makes use of the theoretical model developed by Sargent (1978). The model version used here split the human capitals in three groups. Those with education between 1 and 8 schooling years were labelled as human capital with fundamental education as the first group. The second group considers human capital with intermediary education level, those with schooling years between 9 and 11. Finally in the third one are the human capitals with superior education, those with education levels above 12 years of schooling.

These three groups would be competing for jobs in the market. Thus, we look if their relative participation is due to economic growth, the opening up of the state economies or the adjustment costs. The results will give us a better view of what kind of educational or economic policy to pursue over the long run. For instance, if economic growth is more related to the relative growth of human capital with superior education, then more of them are needed in order keep positive growth over the long run. The same can be said about the cost adjustment when it is superior for a specific group of human capital.

Besides the above objectives this paper also addresses econometric issues like states fixed effects, omitted variables and causality. This is accomplished by using states data panel for the period 1997–2009 and the Arellano and Bond (1991) technique.

2. Literature review

The literature on labor market can be broken into two strands. The first one focuses on micro aspects of labor substitution. In this literature the main objective is to find the degree of substitution between works of different degrees of education. The second group looks at the degree of labor substitution, but gives some emphasis on economic policies that might have influenced the adjustment cost and the demand elasticities. Therefore, the models in the second group were more dynamic in their conception.

2.1. Labor market transformation of 1980s and 1990s

The studies made by the first group authors were very much concerned with the opening up policies of the 80s and 90s. A good example is Fernandes and Menezes-Filho (2002). They were the first authors to test the hypothesis of substitution between qualified workers and less qualified workers at industry level due to the opening up policies of 80s and 90s. They classified workers according to their levels of education. The first group considered those with education level between 0 and 4 years of schooling, the non-qualified ones; the second group included those with 5–11 years of schooling or the intermediate qualified workers; and the third group, those with education above 12 years of schooling, the qualified ones. They used data from PNAD – National Program of Domestic Sampling of IBGE – Brazilian Institute of Geography and Economics.[2] By using a Cobb-Douglas CES (Constant elasticity of substitution) they found that opening up policies indeed helped increase the participation of workers with intermediate education levels vis-à-vis the others in the labor market.

A short version of worker qualification was adopted by Menezes-Filho and Rodrigues (2003). For them workers were considered qualified if years of schooling were above 11 years; the remaining ones were considered less qualified. They also used the same dataset and Cobb-Douglas-CES as the previous authors. However, they computed the technical progress in the transformation industry to verify the effect of it on labor substitution. According to them the technical progress brought about by physical capital imports helped increase qualified workers participation in the labor market in the 80s and 90s.

The opening up policies effects on the Brazilian economy also continued to be the focus in the paper by Arbache and Corseuil (2004). They look at industry level to see if the opening up altered the work structure and real wages. They use industry panel data to estimate dynamic models regarding wage occupation in the 80s and 90s. Concerned with potential endogeneity of the opening up policy of the period, they were careful in using instruments for the economic policies of the period. Their basic conclusions were that the opening up of the Brazilian economy did not alter in any significant way job creation or real wages for the matter.

[2] More details in www.ibge.com.br.

The above result was somewhat different from Giovanetti and Menezes-Filho (2006) when considering industries just for the state of Sao Paulo. By using RAIS – Labor Annual Social Information and PIA – Labor Annual Industrial Information from IBGE-Brazilian Institute of Geography and Economics[3] the authors confirmed that the opening up policies influenced the labor market structure in Sao Paulo at the industry level.

If the opening up policies had any influence in the labor market it must also show in the rate of unemployment of different groups. Reis (2006) did look at the rate of unemployment of the groups proposed by Fernandes and Menezes-Filho (2002). The non-qualified workers (0–4 years of schooling) productivity felt between 20% and 33% in the 90s compared to the others; the intermediate qualified workers (5–11 years of schooling) decreased their productivity by 4–6%; while the most qualified ones (above 11 years of schooling) increased their productivity by as much as 11%. As consequence the rate of unemployment of less qualified workers increased by as much as 77% and the intermediate ones by somewhat between 53% and 67%.

Given such predicted labor market transformation Ribeiro and Jacinto (2008) gathered more data in order to look at more details at micro level. The RAIS and PIA datasets were combined with the PINTEC – Information on Technology Industries to form a unique dataset.[4] By using a Cobb-Douglas – CES the authors verified that the demand for intermediate qualified workers were superior to the less qualified workers during the 1996–2003. The cross elasticities of wage and employment between the two groups were −0.478 and 0.094. An increase in real wages of less qualified workers by 10.0% would decrease their demand by 4.8% and increase the demand of intermediate qualified workers by 0.94%. The causality for this continuous changes in the labor market during the period analysed were credited to the opening up policies that brought the need for more qualified workers. Also in this period they observed the supply increase of intermediate qualified workers as one the factors to cause relative wage changes.

In sum, the labor market change in the 80s and 90s according to the literature was mostly due to the opening up policies and to supply increase. Would these change also influenced by the adjustment cost? The answer is in the coming section.

2.2. The more recent labor market changes

The literature studies in this group were adjusted to capture dynamic aspects. The models were no longer the traditional Cobb-Douglas type and moved towards dynamic models that take into account adjustment costs. They follow the proposed Eisner-Strotz-Prost (1962) model with changes made by Hamermesh (1989). According to the last author, the generalized adjustment cost function $C(H)$ assume the following form:

$$C(H) = b\dot{H}^2 + \begin{bmatrix} k\, se \left|\dot{H}\right| > 0 \\ 0\, se \dot{H} = 0 \end{bmatrix} \tag{1}$$

where b and k are constants, H is the quantity of human capital (labor) being hired and $\dot{H}$ is the changes in quantity overtime. If the cost of hiring new labor is fixed then the adjustment cost tends to remain constant over the period. However, if such cost was increasing then we should observe a quadratic cost structure in the estimative. The increasing cost may be due to specific policies or to external factors occurring in a specific period of time. So, specific economic policies related to labor market may lead to adjustment costs increases that would reflect directly in the labor market dynamics.

The adjustment cost is related to the parameter λ in the dynamic equation $H(t) = \lambda H(t-1)$ as shown by Sargent (1978). The importance of understanding adjustment cost was revealed by Hamermesh (1989) and Hamermesh and Pfann (1996). In their literature review they reported that (1) adjustment cost is very high and could be equivalent to an entire year of wages in some industries; (2) adjustment cost follows the level of qualification of the workers; (3) the cost of hiring is inferior to the promoting one. They pointed out the following reasons for the high adjustment cost in the literature or why the estimated parameter λ is close to one:[5]

[3] The datasets are available at www.ibge.gov.br.

[4] The PINTEC dataset have their origins in IBGE industries specific information research: http://www.pintec.ibge.gov.br.

[5] Hamermesh e Pfann (1996, p.1282).

Table 1
Gonzaga and Corseuil (2001) main results.

Period	Adjustment cost coefficients, $\lambda = \lambda_1 + \lambda_2$	Short run output elasticity, γ	Short run real wage elasticity, ω
1985–1999	0.968	0.037	−0.021
		Long run output elasticity, $\theta = \gamma/(1-\lambda)$	Long run real wage elasticity, $\delta = \omega/(1-\lambda)$
		1.13	−0.66

(I) First it might due to the lag between wage payment and the effective productivity contribution to the firm from the worker just hired;
(II) Second it is not possible to clearly identify the adjustment cost as being fixed, quadratic or somewhat between them in the overall labor market;
(III) Third the objective function of the representative firm may be more complex than the one supposed in these studies therefore not being able to capture the overall labor market behavior.

The Brazilian literature followed the proposed model by Hamermesh (1989) by setting up models that are more related to the Brazilian labor market. The first authors to study the Brazilian adjustment cost were Gonzaga and Corseuil (2001). Between 1989 and 1999 the Brazilian economy had undergone several economic policies regarding the stabilization process, being the most famous one the 1994 "Real Plan". So, after 1994 the inflation stabilization brought about real wages stabilization to workers compared to the previous period. The matter then becomes to learn if such economic policy might have any effect on the labor market adjustment cost or on the hiring cost. The model proposed by latter authors resulted in the following demand function: $N_t = F(N_{t-1}, N_{t-2}, Y_t, W_t)$. Where N_t represents the level of employment in period t that depends dynamically on the two previous periods N_{t-1} and N_{t-2}. The actual level of employment also depends on the industrial output Y_t and the prevailing real wage W_t. In this model the coefficient λ would be the sum of the coefficients of the two variables N_{t-1} and N_{t-2} in the dynamic log model. The industrial output coefficient is the elasticity regarding employment (γ); and wage elasticity would be the coefficient for the wage (ω) in the estimated dynamic equation. The long run elasticities would be defined by the equations: $\gamma = \theta/(1-\lambda)$ and $\omega = \delta/(1-\lambda)$.

The authors used VECM – Vector Error Correction Mechanism to estimate the dynamic model. The dataset between January of 1985 and August of 1999 was the monthly industrial labor information known as PIM from IBGE. The major results are in Table 1.

The main result of their findings was an adjustment cost very high or close to one. This result indicated that the actual demand follows a steady short run path related to the previous levels of employment. Short run changes coming from variables like real wage and output have little effect in the dynamic path. In simple words, the demand changes only in the very long run with either a fall on real wage or positive output growth.

Give the dynamic nature of this model, Barros and Corseuil (2004) used it to investigate the impact of the new 1988 Brazilian Constitution. The new constitution has made significant changes to laws related to the labor market. It gave more freedom for labor organizations to negotiate wages and other rights directly with the employees. For instance, the constitution increased the extra hour payment from 20.0% to 50.0% above the normal wage. On top of that maternity leave changed to 4 months instead of the traditional 3 months. Plus, workers were entitled to receive an extra 1/3 of the wage when undergoing vacation. The authors expected that such extra costs would change the dynamics of the labor market by influencing directly the adjustment cost. The solution of their proposed model can be represented by the following two equations:

$$H_i(t) = \alpha(t) + \beta_i^* + \lambda H_i(t-1) + H_i(*), \quad (2)$$

where

$$H_i(*) = \sum_{s=1}^{m} \varphi_s^*(t) I_{is} - \delta(t) w_i + U_i^*(t) \quad (3)$$

In Eq. (2), $H_i(t)$ is the actual level of employed workers; $H_i(t-1)$ is the previous period level of employed workers; and $H_i(*)$ is the converging optimum long run level of employed workers. The parameters $\alpha(t)$ and β_i^* represent the trend and the fixed effects of each industry, respectively. In Eq. (3), the parameters φ_s^* and $\alpha(t)$ are the elasticities of

Table 2
Barros and Corseuil (2004) main results.

Period	Adjustment cost coefficient, λ	Short run output elasticity, γ	Short run real wage elasticity, ω
1985–1997	0.5	Not reported	−0.2
		Log run output elasticity, $\theta = \gamma/(1-\lambda)$	Long run real wage elasticity, $\omega = \delta/(1-\lambda)$
		Not reported	−0.40

sector output and real wage; lastly, U_i^* represents the technological levels of each sector. By using monthly data from IBGE for the period June 1986–December 1997, the equation estimated by the authors produced the following results (Table 2).

The adjustment coefficient for the period $\lambda = 0.5$ was very low which indicates that the adjustment cost was lower than the one estimated by previous authors. So the level of employment was less persistent over time compared to the previous period, with only 50.0% of actual level linked to the previous period.

The authors made several estimates of the function over the entire period using OLS estimates to see if parameters would have undergone any significant change after the 1988 Constitution. The results were that the new constitution with new labor laws had no influence whatsoever on the adjustment cost of the Brazilian labor market.

Hamermesh (2004) reviews the previous studies including the one made by Fajnzylber and Maloney (2005) for Latin America. Besides econometric problems, Hamermesh found that these studies did not bring theory close enough to reality.

By taking these aspects into consideration, Dias and Dias (2011) observed that some of the demand changes might be related to changes in social structure, mainly social classes' changes. In order to do so, the authors combined several datasets from IBGE to form a dynamic panel for the Brazilian sates during the period of 1998–2003. They selected the Hamermesh (1989) model; however the human capital definition embraced a broader definition compared to the two previous models. Instead of level, they used the ratio between individuals with 11 or more schooling years and those with education level below 11. They estimated three models using Arellano and Bond (1991) technique, which produced the following results.

According to Table 3, λ represents the relative adjustment cost. Individuals with 11 or more years of schooling had an adjustment cost between 25.8% and 59.7% lower than those with less than 11 years of schooling. In this case the adjustment cost of the less qualified human capital (less than 11 years of schooling) was higher than the more qualified ones. So, according to the authors' view, this might explain some of the dynamic change in the labor market.

The relative real wage elasticity (a_w) was not significant; thus real wage changes were not enough to explain overtime substitution. On the other hand, the relative output elasticity of the service sector (a_s) was positive and significant. Nonetheless, the relative output elasticity of the commerce sector (a_c) was negative and the industrial sector output elasticity (a_i) was not significant. These results clearly indicate that the service sector favors more educated human capital, and the commerce sector less educated human capital over short and long run.

The relative elasticity related to social class was very high. Any improvement in the average social class by 1%, would increase the demand somewhat between in 4.23% and 5.29% towards more educated labor (11 years or more of schooling). Hence, social class improvement brings about more demand for qualified workers, particularly those attending tertiary education.

Resuming, the adjustment cost literature did show that the structural changes occurred in the Brazilian economy did not affect the labor market dynamics. It seems, however, that the major changes are accruing from the adjustment cost differences between less qualified and more qualified human capitals. The relative real wage change does not seem

Table 3
Dias and Dias (2011) main results.

Models	λ^*	a_w	a_s^*	a_c^*	a_i	a_m^*
λ_1	−0.258	0.009	0.413	−0.369	0.177	4.233
$\lambda_1 + \lambda_2$	−0.582	0.015	0.380	−0.631	0.089	5.290
$\lambda_1 + \lambda_2 + \lambda_3$	−0.597	0.100	0.368	−0.167	0.090	4.479

Note: The * means the variable is significant at 5%.

to have made any influence on the labor market, since it is not significant in the estimates. Hence, the labor market shift toward more educated human capital is being led by the service sector and the social class improvement. The commerce sector is somewhat holding up the importance of less educated labor with its positive demand. In the next section, the investigation goes a step further by looking to other macroeconomic events at state level.

3. The model

One very important aspect of the adjustment cost literature is regarding the theoretical model to be used. The starting point in the adjustment cost literature was done by Lucas (1967). In the referred paper the adjustment cost showed to have influences on the long run labor supply function. The author's model was further developed by Sargent (1978) by adding the representative firm and its decision between hiring new workers and/or paying extra hours to the already hired ones. By solving the model, the author noticed that the adjustment cost was the most important element in this decision. Thus, dynamic estimates to obtain the adjustment cost coefficient would show us which decision would bring more advantage to the representative firm. Specifically, the model proved that the coefficient λ follows the increase of labor cost.

The Sargent (1978) model can then be easily adapted to solve our proposed problem. Our problem requires that the representative firm decides on hiring competing human capitals with different sets of schooling years. A simplified version of the model requires that the representative firm makes a choice between hiring any two human capitals that are different in qualification or years of schooling.

$$y_t = \int_0^1 y(t+\tau)d\tau = \psi_1\left[(f_0 + a_{1t})H_{1t} - \left(\frac{f_1}{2}\right)H_{1t}^2\right] + \psi_2\left[(f_0 + a_{2t})H_{2t} - \left(\frac{f_1}{2}\right)H_{2t}^2\right] \tag{5}$$

where y_t is the output; ψ_1 and ψ_2 are parameters; H_{1t} human capital qualified with higher schooling years; H_{2t} less qualified human capital (lower schooling years);); f_0, f_1 represents their average productivity parameters; a_{1t} and a_{2t} are exogenous stochastic processes that might affect the average productivity aleatory. The overtime changes in a_{1t} and a_{2t} obeys a stochastic process with $E(a_{1t}) = 0$ and $E(H_{2t}) = 0$. Thus, the human capitals hiring costs obeys the following quadratic function.

$$C(H_{1t}) = \left(\frac{d}{2}\right)(H_{1t} - H_{1t-1})^2 \tag{6}$$

$$C(H_{2t}) = \left(\frac{e}{2}\right)(H_{2t} - H_{2t-1})^2 \tag{7}$$

where d and e represent direct hiring costs of each human capital. The market wages are as follows: $w_t\psi_1 H_{1t}$ and $pw_t\psi_2 H_{2t}$, being $p < 1$, hence the wage of less qualified human capital is assumed to be lower compared to the more qualified one. Given Eqs. (1)–(7), the present value of the profit can be written as follows:

$$v_t = E_t\sum_{j=0}^{\infty} b^j\left[(f_0 + a_{1t+j} - w_{t+j})\psi_1 H_{1t+j} - \left(\frac{f_1}{2}\right)\psi_1 H_{1t+j}^2\right] - \left(\frac{d}{2}\right)(H_{1t+j} - H_{1t+j-1})^2$$
$$+ \left[(f_0 + a_{2t+j} - pw_{t+j})\psi_2 H_{2t+j} - \left(\frac{f_1}{2}\right)\psi_2 H_{2t+j}^2 - \left(\frac{e}{2}\right)(H_{2t+j} - H_{2t+j-1})^2\right] \tag{8}$$

where $0 < b < 1$ is the discount factor and $f_0, f_1, d, e > 0, p < 1$ are the productivity and cost parameters. The solutions to the Euler equation (8) that obeys the transversality conditions are given by the following functions:

$$H_{1t} = \lambda_1 H_{1t-1} - \left(\frac{\lambda_1\psi_1}{d}\right)H_1^* \tag{9}$$

$$H_{2t} = \mu_1 H_{2t-1} - \left(\frac{\mu_1\psi_1}{e}\right)H_2^* \tag{10}$$

The variables H_1^* and H_2^* represents the optimum long run level of employment of each human capital. They are the level to which the equation systems are expected to converge over the long run. Sargent (1978) assumed their representation as follows:

$$H_1^* = \sum_{t=0}^{\infty} \left(\frac{1}{\lambda_2}\right) E_t(w_{t+i} - a_{1t+1} - f_0) \tag{11}$$

$$H_2^* = \sum_{t=0}^{\infty} \left(\frac{1}{\mu_2}\right) E_t(pw_{t+i} - a_{2t+1} - f_1) \tag{12}$$

The above solutions implies that $(1/\lambda_2) = b\lambda_1$ and that λ_1 is a direct function of d. As the cost of human capital d increases it also increases the adjustment parameter λ_1. Similarly $(1/\mu_2) = b\mu_1$ and μ_1 increases with the value of e. Even though we do not observe d and e, their level can be obtained indirectly through the estimates of λ_1 and μ_1. By estimating them we learn about the adjustment cost of the labor market.

Sargent's empirical estimates of Eqs. (9)–(12) required additional assumptions about the behavior of the aleatory shocks and wages. The optimum level of human capital was set to be a function of the level of the lagged human capital and real wages: $H_1^* = F(H_{2t-1}, \gamma(L)w_{1t})$ and $H_2^* = F(H_{1t-1}, \gamma(L)w_{2t})$, where $\gamma(L)$ was the lag operator. The log functions of the Eqs. (9)–(11) took the following forms:

$$H_{1t} = \lambda_1 H_{1t-1} - \left(\frac{\lambda_1 \psi_1}{d}\right) F(H_{2t-1}, \gamma(L)w_{1t}) \tag{13}$$

$$H_{2t} = \mu_1 H_{2t-1} - \left(\frac{\mu_1 \psi_1}{e}\right) F(H_{1t-1}, \gamma(L)w_{2t}) \tag{14}$$

The author provided several empirical estimates; however the most important results showed that λ_1 was between 0.94 and 0.96, and μ_1 was between 0.74 and 0.76. The author reached the conclusion that the extra hours' hiring costs were lower than hiring new labor for the firm. The wage variance decomposition also showed the adjustment cost was responsible for 49% of the new hired human capital. The same wage variance decomposition of the adjustment cost related to the cost of extra working time explained only 16.0% of the new hirings. Moreover, long run payments of extra time may explain 29.0% of the new hired human capital. In simple words, as the firm starts hiring extra working time, the chances that it will create a new position increases from 16.0% to 29.0%.

3.1. The empirical model

Our empirical equations are based on (13) and (14); however, they account for three types of human capitals. The representative firm decides which to hire based on availability, productivity and long run labor market cost. Specifically in our case, the representative firm makes two decisions. First, it decides between hiring less qualified human capital with some or complete fundamental education level (1–8 years of schooling) and the intermediate qualified human capital with some or secondary education level (9–11 years of schooling). The second choice is between intermediate qualified human capital and superior qualified human capital with some or complete tertiary education level (12 years or more of schooling years). Thus, we assume that the decisions are made independently; but our empirical model does consider the supply interaction and cross-wages to learn about complementarity/substitutability among the human capitals.

The overall model solution results in the following three equations:

$$H_{1t} = \lambda_1 H_{1t-1} - \left(\frac{\lambda_1 \psi_1}{d}\right) \sum_{t=0}^{\infty} \left(\frac{1}{\lambda_2}\right) E_t(w_{1,t+i} - a_{1t+1} + w_{i,t+i} + y_t - m_t + x_t + H_{i,t}) \tag{15}$$

$$H_{2t} = \mu_1 H_{2t-1} - \left(\frac{\mu_1 \psi_1}{e}\right) \sum_{t=0}^{\infty} \left(\frac{1}{\lambda_2}\right) E_t(w_{2,t+i} - a_{2t+1} + w_{i,t+i} + y_t - m_t + x_t + H_{i,t}) \tag{16}$$

Table 4
Data statistics 1997–2009.

Variables	Mean	Standard deviation
$H_{fund,t}$	50.11%	7.12%
$H_{int,t}$	26.75%	7.00%
$H_{sup,t}$	11.28%	5.04%
$w_{fund,t}$	R$ 277.78	R$ 93.49
$w_{int,t}$	R$ 499.76	R$ 134.66
$w_{sup,t}$	R$ 1361.15	R$ 334.07
y_t	R$ 18.7 billions	R$ 3.81 billions
m_t	R$ 583.04 millions	R$ 11.85 millions
x_t	R$ 811.77 millions	R$ 11.12 millions

Source: PNAD-IBGE and IPEA.

$$H_{3t} = \delta_1 H_{2t-1} - \left(\frac{\delta_1 \psi_1}{k}\right) \sum_{t=0}^{\infty} \left(\frac{1}{\lambda_2}\right) E_t(w_{3,t+i} - a_{3t+1} + w_{i,t+i} + y_t - m_t + x_t + H_{i,t}) \tag{17}$$

where λ_1, μ_1 and δ_1 are the adjustment cost parameters; d, e and k the cost of hiring each human capital; $1/\lambda_2 = b\lambda_1$; $w_{1,t+i}$, $w_{2,t+i}$ and $w_{3,t+i}$ are the human capital real wages in each state; $w_{i,t+i}$ is the state level real wage of competing human capital; y_t is the state domestic production (total output less import and export); m_t is the state imports; x_t is the state exports; and $H_{i,t}$ is state supply of competing human capital. As one may remember, $E(a_{1t}) = 0$, $E(a_{2t}) = 0$ and $E(a_{3t}) = 0$ over the long run. The log versions of these equations are as follows:

$$lH_{fund,t} = \lambda_1 lH_{fund,t-1} + \omega_1 lw_{fund,t} + \omega_{2,1} lw_{\text{int},t} + \gamma_1 ly_t + \iota_1 lm_t + \chi_1 lx_t + \varphi_1 lH_{\text{int},t-i} + \varepsilon_{1,t} \tag{18}$$

$$lH_{\text{int},t} = \mu_1 lH_{\text{int},t-1} + \omega_2 lw_{\text{int},t} + \omega_{3,1} lw_{\text{sup},t} + \gamma_2 ly_t + \iota_2 lm_t + \chi_2 lx_t + \varphi_2 lH_{\text{sup},t-i} + \varepsilon_{2,t} \tag{19}$$

$$lH_{\text{sup},t} = \delta_1 lH_{\text{sup},t-1} + \omega_3 lw_{\text{sup},t} + \gamma_3 ly_t + \iota_3 lm_t + \chi_3 lx_t + \varphi_3 lH_{in,t-i} + \varepsilon_{3,t} \tag{20}$$

Here the *fund*, *int* and *sup* replace the subscripts 1, 2 and 3 in Eqs. (15)–(17) and they refer to fundamental, intermediary and superior (tertiary) education levels. The real wage elasticities are (ω_{fund}, ω_{int}, ω_{sup}); the cross-elasticity of real wages are ($\omega_{int,fund}$, $\omega_{fsup,int}$); the domestic output elasticities (γ_{fund}, γ_{int}, γ_{sup}); the import elasticities are (l_{fund}, l_{int}, l_{sup}; the export elasticities are (χ_{fund}, χ_{int}, χ_{sup}) and cross elasticities of human capitals are (φ_{fund}, φ_{int}, φ_{sup}). Also the degree of opening up (gab_t) replaced in some estimates imports and exports of each state.

3.2. Econometric results

To form the final dataset we combined micro data for each state from PNAD – IBGE – Brazilian Institute of Geography and Economics with the macro data from IPEA – The Economic Applied Research Institute.[6] The micro data for the variables $H_{funt,t}$, $H_{int,t}$ and $H_{sup,t}$ and their respective real wages $w_{fund,t}$, $w_{fint,t}$ and $w_{sup,t}$ were pondered by their group weights in each state. The groups are: (i) workers with education between 1 and 8 years of schooling, (ii) those with education between 9 and 11 years of schooling, and (iii) workers with 12 years or more of schooling. The remaining macro-data like domestic output, import and export are readily available from IPEA, thus there was no need for aggregation at state level.

According to Table 4, the average participation of workers with education between 1 and 8 years of schooling among the states was 50.11% with standard deviation of 7.12% for the period of 1997–2009. It is important to emphasize that the human capitals labor market participation has changed over the period in a very dynamic way. For instance, as mentioned in the introduction, human capital with superior education ($H_{sup,t}$) moved from 8.7% in 1997 to 15.9% in 2009.

The average domestic output was 18.7 billion of reals with standard deviation of 3.81 billion of reals. The other variables are easily interpreted, since they follow the same pattern as the described ones.

[6] The datasets can be easily obtained from their sites: www.ibge.gov.br and www.ipeadata.gov.br.

The econometric model specification tests are in Table A1 in the Appendix. There one can see that the Fixed Effect model (FE) is preferred to the Random Effects model (RE), according to the tests of Hausman (1978) and Baltagi and Li (1991,1995).

Also in the Appendix are the remaining estimates where each table considered a specific hypothesis. Tables A2–A5 are dynamic panel estimates that consider fixed effects of the states. Table A2 shows the results under the assumption of contemporaneous exogeneity. These estimates also consider the existence of AR(1) process. Tables A3–A5 present the estimates using the GMM-SYS method proposed by Arellano and Bond (1991), Arellano and Bover (1995) and Blundell and Bond (1998). These estimates use instrumental variables and also correct for AR(1) and AR(2) processes. Tables A6–A8 use the same techniques, but the variables import and export are replaced by the degree of opening up of the states.

Tables A4, A5 and A7 all present acceptable tests results. For instance AR(2) is not significant, thus the initial conditions are not influencing the actual labor market dynamics; the quality of the instruments, according to the Sargan and Hansen tests, is significant. However, Table A8 was not analyzed since it does not fully attend the instrument tests.

The coming section breaks the result analysis into two major topics: adjustment costs parameters and short and long run elasticities.

3.2.1. Adjustment cost results

Tables A2–A7 have as major result that the adjustment cost is higher for the intermediate human capital (9–11 years of schooling) compared with the other two. For instance, the average adjustment cost parameter of the human capitals were $\lambda_{fund} = 0.82$, $\lambda_{int} = 0.90$ and $\lambda_{sup} = 0.78$. In simple words, the cost of hiring workers with fundamental and tertiary education levels are lower compared to the ones with secondary education level. The increased participation of educated labor $H_{sup,t}$ (12 years or more of schooling) in the labor market can be largely influenced by this lower adjustment cost or hiring cost, according to this result. In general these adjustment costs are close to the ones obtained by Gonzaga and Corseuil (2001) and Dias and Dias (2011).

3.2.2. Short and long run elasticities results

Tables A4, A5 and A7 again are the ones used to obtain the average elasticities since the estimates there do show robustness in their results and consider omitted variables, endogeneity and states fixed effects. The real wage coefficient elasticities of the human capitals with fundamental (ω_{1fund}) and superior education (ω_{3fsup}) levels are all significant, but not the intermediate (ω_{int}) one.

The average short run elasticity of human capital with fundamental education level is $\omega_{1fund} = -0.392$ and the superior education level is $\omega_{3sup} = -0.576$. The long run elasticities are $\xi\omega_{fund} = \omega_{1fund}/(1 - \lambda_{fund}) = -0.392/(1 - 0.82) = -2.18$ and $\xi\omega_{sup} = \omega_{1sup}/(1 - \lambda_{sup}) = -0.576/(1 - 0.78) = -2.62$. The real wages are elastic in the long run. It means that any increase of real wages may lead to less demand for those human capitals.

Workers with intermediate education levels may not suffer from less demand from an increase in real wage, since ω_{int} was not significant. This means that they are in need by the firms hiring in the labor market. Education policies that do increase their supply were welcome ones.

The cross-elasticities ($\omega_{int,fund}$, $\omega_{sup,int}$) were not significant. These mean that firms hiring in the labor market do not perceive them as labor substitutes.

The domestic output elasticity was significant only for those with 12 or more years of schooling – superior education. The average elasticity of the estimates is $\gamma_{3sup} = 0.255$ $\xi\gamma_{sup} = 1.14$, short and long run respectively. Hence a 2.0% domestic output growth may lead as much 0.50% increase in the demand for this human capital in the short run and as much as 2.28% over the long run. In this case economic growth favors more educated labor in the Brazilian states.

The import elasticity showed to be significant only for human capital with intermediate education level. The short and long run elasticities are $\iota_{2int} = 0.024$ and $\xi\iota_{int} = 0.11$. The export sector elasticities were not significant. The average value of the elasticity of the degree of opening up was $\iota_{2int,gab} = 0.000432$. It was significant only for the human capital with intermediate education level. Given the size of the import sector and the degree of the opening up elasticities it is possible that the import seems to favor workers with education between 9 and 11 years of education, but having a very dismal impact.

The cross-elasticity supply between the human capitals showed to be significant for fundamental and intermediate education levels $\varphi_{1fund,int} = 0.308$ and intermediate and superior levels $\varphi_{3sup,int} = 0.355$. The positive sign of both cross-elasticities indicates that they are complementary to each other. Thus, the demand increase for any human capital level also triggers the demand for the other. The long run elasticities are $\xi\varphi_{fund,int} = 3.08$ and $\xi\varphi_{sup,int} = 1.61$. Hence, firms hiring workers with fundamental education would also hire those with intermediate education levels since they complement each other; the same applies for firms that are more dependable on human capital with superior education – these firms would also be hiring human capital with intermediate level of education. This result also indicates the need for specific education policies that incentives individuals to conclude their secondary education.

4. Conclusion

The theoretical model based on Sargent (1978) enabled us to learn about the labor market's adjustment cost role. According to our estimates the adjustment cost of human capital with degree of superior education (12 years or more of schooling) present the lowest cost compared to the others. In second place comes human capital with fundamental education level (1–8 years of schooling). The highest adjustment cost belongs to human capital with intermediate education level (9–11 years of schooling).

The adjustment cost seems to justify greatly the increasing market share of human capital with superior education level, but not the one with intermediate education level.

The loss of market share by the human capital with fundamental education is related to the real wage. Real wage increases lowers their demand and might favor human capital with intermediary education level.

Another aspect that favors the demand for human capital with intermediate education level is the imports and opening up degree of the state's economies. Their short and long run elasticities are positive. Thus, these results at the aggregate level confirm the findings at industry level. In simple words, the open up economic policies incentive imports of goods that demand more human capital with intermediate education level compared to the others. Such effect may be weak for the period analyzed, but it helps to explain their relative participation increase in the labor market.

Combining the results of adjustment cost, short and long run real wage elasticities and cross-elasticities they all point out that market is in need of human capital with intermediate education level. Higher hiring cost, no real wage effect, no cross-substitution are the key elements favoring such conclusion.

Other interesting aspect is that the output growth favors the demand for human capital with superior education, which may well lead to the demand increase for human capital with intermediate education level. The reason is that their cross-elasticity is positive which indicates their complementarity in the production process.

In sum, human capital with intermediary education level is in need according to the results; plus they are also complementary to the other two human capitals in the production process. Hence, education policies that incentive human capital formation at secondary education level or equivalent training will be a welcome long run educational policy.

Appendix.

Table A1
Dynamic estimates: fixed effect model (EF) and random effect model (ER). *Dependent*: Log of human capital. *Hypothesis*: Variables are strictly exogenous.

$lH_{fund,t}$	(1) EF $lH_{fund,t}$	(2) ER $lH_{fund,t}$	$lH_{int,t}$	(3) EF $lH_{int,t}$	(4) ER $lH_{int,t}$	$lH_{sup,t}$	(5) EF $lH_{sup,t}$	(6) ER $lH_{sup,t}$
$lH_{fund,t-1}$	0.601***	0.909***	$lH_{int,t-1}$	0.665***	0.929***	$lH_{sup,t-1}$	0.606***	0.848***
	[14.71]	[44.43]		[17.03]	[39.58]		[13.16]	[36.51]
$lw_{fund,t}$	−0.447***	−0.148***	$lw_{int,t}$	−0.262***	−0.0898***	$lw_{sup,t}$	−0.203***	−0.219***
	[−7.35]	[−3.91]		[−5.80]	[−3.06]		[−2.96]	[−5.40]
$lw_{int,t}$	0.0343	0.109**	$lw_{sup,t}$	0.0316	0.0244			
	[0.55]	[2.02]		[0.83]	[0.77]			
ly_t	−0.0300	0.0221	ly_t	0.108***	0.0624***	ly_t	0.144**	0.186***
	[−0.63]	[0.95]		[2.76]	[2.85]		[1.98]	[6.46]

Table A1 (*Continued*)

$lH_{fund,t}$	(1) EF $lH_{fund,t}$	(2) ER $lH_{fund,t}$	$lH_{int,t}$	(3) EF $lH_{int,t}$	(4) ER $lH_{int,t}$	$lH_{sup,t}$	(5) EF $lH_{sup,t}$	(6) ER $lH_{sup,t}$
lm_t	−0.00837	−0.0128**	lm_t	0.00525	−0.00262	lm_t	−0.0271**	−0.0181***
	[−1.12]	[−2.52]		[0.88]	[−0.65]		[−2.32]	[−2.67]
lx_t	−0.0201	0.0188***	lx_t	−0.0148	0.00600	lx_t	−0.000514	−0.00717
	[−1.55]	[3.41]		[−1.43]	[1.44]		[−0.03]	[−1.05]
$lH_{int,t}$	0.118***	0.0491	$lH_{sup,t}$	0.136***	−0.0124			
	[2.94]	[1.47]		[4.58]	[−0.75]	Time dummies	Yes	Yes
Constant	7.242***	0.266	Constant	2.518***	0.401**	Constant	4.498***	0.851***
	[8.72]	[1.44]		[3.72]	[2.20]		[3.46]	[3.44]
# Obs	297	297	# Obs	297	297	# Obs	297	297
R^2	0.957	0.995	R^2	0.996	0.997	R^2	0.984	0.992
F-Test $\sigma_i^2=0$	P(0.00)		F-Test $\sigma_i^2=0$	P(0.00)		F-Test $\sigma_i^2=0$	P(0.00)	
Hausman test	P(0.00)		Hausman test	P(0.00)		Hausman test	P(0.00)	
LM test	P(0.00)		LM test	P(0.00)		LM test	P(0.22)	

Notes: (i) *t* statistics in parenthesis. P(0.00) tests probabilities.
(ii) The subscripts *fund*, *int* and *sup* represent the sequence of the regressions in each column: *fund* – fundamental, *int* – intermediate and *sup* – superior.
(iii) Example: $lw_{\text{int},t}$ in column (1) is the log of wages of intermediate education and $lw_{\text{sup},t}$ in column (2) is the log of wages of superior education.
* $p<0.10$.
** $p<0.05$.
*** $p<0.01$.

Table A2
Dynamic estimates: Models with autoregressive and heteroscedasticity corrections. *Dependent*: Log of human capital. *Hypothesis*: Variables are contemporaneously exogenous.

$lH_{fund,t}$	(1) $lH_{fund,t}$	$lH_{\text{int},t}$	(2) $lH_{\text{int},t}$	$lH_{\text{sup},t}$	(3) $lH_{\text{sup},t}$
$lH_{fund,t-1}$	0.853***	$lH_{\text{int},t-1}$	0.929***	$lH_{\text{sup},t-1}$	0.850***
	[32.34]		[36.25]		[32.08]
$lw_{fund,t}$	−0.110***	$lw_{\text{int},t}$	−0.0921***	$lw_{\text{sup},t}$	−0.175***
	[−3.06]		[−2.65]		[−3.45]
$lw_{\text{int},t}$	−0.00549	$lw_{\text{sup},t}$	−0.00423		
	[−0.09]		[−0.11]		
ly_t	0.0129	ly_t	0.0643**	ly_t	0.177***
	[0.60]		[2.56]		[5.28]
lm_t	−0.0169***	lm_t	−0.00275	lm_t	−0.0183***
	[−2.93]		[−0.61]		[−2.69]
lx_t	0.0205***	lx_t	0.00428	lx_t	−0.00374
	[4.23]		[1.00]		[−0.64]
$lH_{\text{int},t}$	0.125***	$lH_{\text{sup},t}$	−0.00917		
	[3.67]		[−0.55]		
Constant	0.630***	Constant	0.584**	Constant	0.627**
	[2.99]		[2.51]		[2.22]
Time dummies	Yes	Time dummies	Yes	Time dummies	Yes
# Obs	297	# Obs	297	# Obs	297
R^2	0.996	R^2	0.996	R^2	0.993

Notes: (i) *t* statistics in parenthesis. P(0.00) tests probabilities.
(ii) The subscripts *fund*, *int* and *sup* represent the sequence of the regressions in each column: *fund* – fundamental, *int* – intermediate and *sup* – superior.
(iii) Example: $lw_{\text{int},t}$ in column (1) is the log of wages of intermediate education and $lw_{\text{sup},t}$ in column (2) is the log of wages of superior education.
* $p<0.10$.
** $p<0.05$.
*** $p<0.01$.

Table A3
Dynamic estimates: Models with autoregressive and heteroscedasticity corrections. *Dependent*: Log of human capital. *Hypothesis*: Variables are predetermined.

	(1) $lH_{fund,t}$	(2) $lH_{\text{int},t}$	(3) $lH_{\text{sup},t}$		(4) $lH_{fund,t}$	(5) $lH_{\text{int},t}$	(6) $lH_{\text{sup},t}$
$lH_{f,i,s,t-1}$	0.916***	0.983***	0.837***	$lH_{f,i,s,t-1}$	0.918***	0.983***	0.829***
	[35.27]	[44.75]	[29.23]		[30.68]	[47.74]	[27.20]
$lw_{f,i,s,t-2}$	−0.0590*	−0.0122	−0.0268	$lw_{f,i,s,t-2}$	−0.0163	−0.0178	0.00782
	[−1.78]	[−0.40]	[−0.42]		[−0.46]	[−0.62]	[0.12]
$lw_{i,s,i,t-2}$	0.0125	−0.0497	0.00767	$lw_{i,s,i,t-2}$	−0.0521	−0.0495	−0.00187
	[0.25]	[−1.41]	[0.14]		[−0.98]	[−1.44]	[−0.03]
ly_{t-1}	0.00569	0.0501**	0.0936**	ly_{t-2}	0.00239	0.0498**	0.0976**
	[0.28]	[2.20]	[2.48]		[0.11]	[2.23]	[2.57]
lm_{t-1}	−0.0112*	−0.00248	−0.00586	lm_{t-2}	−0.00402	0.000390	−0.0155**
	[−1.95]	[−0.60]	[−0.87]		[−0.65]	[0.09]	[−2.26]
lx_{t-1}	0.0144***	0.000626	−0.00616	lx_{t-2}	0.00912*	0.00133	0.00121
	[2.97]	[0.17]	[−1.08]		[1.71]	[0.35]	[0.21]
$lH_{i,s,i,t-1}$	0.0640**	−0.0390***	0.0804**	$lH_{i,s,i,t-2}$	0.0590	−0.0440***	0.0861**
	[2.00]	[−2.69]	[2.23]		[1.62]	[−3.10]	[2.25]
Constant	0.344*	0.367*	−0.152	Constant	0.563***	0.391**	−0.328
	[1.79]	[1.79]	[−0.44]		[2.69]	[1.96]	[−0.93]
Time dummies	Yes	Yes	Yes	Time dummies	Yes	Yes	Yes
# Obs	297	297	297	# Obs	297	297	297
R^2	0.997	0.998	0.993	R^2	0.997	0.998	0.993

Notes: (i) *t* statistics in parenthesis.
(ii) The subscripts *f*, *i*, *s* represents the sequence of the regressions in each column: *f* – fundamental, *i* – intermediate and *s* – superior.
(iii) Example: $lw_{i,s,i,t-2}$ in column (1) used the log of wages of intermediate education, in column (2) log of wages of superior education, in column (3) log of wages of intermediate education level.
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

Table A4
Dynamic estimates: Robust GMM-SYS. *Dependent*: Log of human capital. *Hypothesis*: Instrumented variables.

	(1) $lH_{fund,t}$		(2) $lH_{\text{int},t}$		(3) $lH_{\text{sup},t}$
$lH_{fund,t-1}$	0.565***	$lH_{\text{int},t-1}$	0.761***	$lH_{\text{sup},t-1}$	0.721***
	[4.26]		[6.39]		[10.20]
$lw_{fund,t}$	−0.352***	$lw_{\text{int},t}$	−0.156	$lw_{\text{sup},t}$	−0.470**
	[−2.85]		[−1.60]		[−2.21]
$lw_{\text{int},t}$	−0.0576	$lw_{\text{sup},t}$	0.00907		
	[−0.67]		[0.12]		
ly_t	0.0329	ly_t	0.0170	ly_t	0.271***
	[0.42]		[0.32]		[2.99]
lm_t	0.00722	lm_t	0.0212**	lm_t	−0.00729
	[1.06]		[2.05]		[−0.25]
lx_t	0.0227	lx_t	0.0241	lx_t	−0.00386
	[1.45]		[1.10]		[−0.17]
$lH_{\text{int},t}$	0.363***	$lH_{\text{sup},t}$	0.0745		
	[4.03]		[1.11]		
Constant	2.165**	Constant	1.931**	Constant	2.445*
	[2.41]		[2.00]		[1.79]

Table A4 (*Continued*)

	(1) $lH_{fund,t}$		(2) $lH_{\text{int},t}$		(3) $lH_{\text{sup},t}$
Time dummies	Yes	Time dummies	yes	Time dummies	yes
# Instruments	37	# Instruments	37	# Instruments	37
# Obs	297	# Obs	297	# Obs	297
AR(1)	0.000967	AR(1)	0.00122	AR(1)	0.0343
AR(2)	0.668	AR(2)	0.968	AR(2)	0.827
Hansen test	0.949	Hansen test	0.941	Hansen test	0.949

Notes: (i) *t* statistics in parenthesis. P(0.00) tests probabilities.
(ii) The subscripts *fund*, *int* and *sup* represent the sequence of the regressions in each column: *fund* – fundamental, *int* – intermediate and *sup* – superior.
(iii) Example: $lw_{\text{int},t}$ in column (1) is the log of wages of intermediate education and $lw_{\text{sup},t}$ in column (2) is the log of wages of superior education.
* $p<0.10$.
** $p<0.05$.
*** $p<0.01$.

Table A5
Dynamic Estimates: Robust GMM-SYS. Dependent: Log of human capital Hypothesis: Variables predetermined and instrumented.

	(1) $lH_{fund,t}$	(2) $lH_{\text{int},t}$	(3) $lH_{\text{sup},t}$		(4) $lH_{fund,t}$	(5) $lH_{\text{int},t}$	(6) $lH_{\text{sup},t}$
$lH_{f,i,s,t-1}$	0.970***	0.910***	0.679***	$lH_{f,i,s,t-1}$	0.714***	0.867***	0.659***
	[7.76]	[5.44]	[6.34]		[5.43]	[5.94]	[4.86]
$lw_{f,i,s,t-1}$	0.167	0.503***	−0.161	$lw_{f,i,s,t-2}$	−0.0727	0.0665	0.219
	[1.30]	[2.77]	[−1.05]		[−0.74]	[0.29]	[1.21]
$lw_{i,s,i,t-1}$	0.259*	−0.121	−0.313	$lw_{i,s,i,t-2}$	−0.0868	−0.00741	0.389
	[1.87]	[−0.96]	[−1.33]		[−0.94]	[−0.09]	[0.99]
ly_{t-1}	−0.0609	−0.0375	0.266**	ly_{t-2}	0.00782	0.0668	0.0959
	[−0.76]	[−0.30]	[2.46]		[0.10]	[0.75]	[0.83]
lm_{t-1}	−0.0116	0.00588	0.0296	lm_{t-2}	0.00475	0.0266*	−0.0244
	[−1.07]	[0.39]	[1.00]		[0.82]	[1.68]	[−0.99]
lx_{t-1}	0.0675***	−0.00972	−0.0129	lx_{t-2}	0.0231	0.0203	−0.0182
	[3.09]	[−0.54]	[−0.36]		[1.26]	[0.74]	[−0.50]
$lH_{i,s,i,t-1}$	−0.0288	0.150	0.000773	$lH_{i,s,i,t-2}$	0.224**	−0.0664	0.355**
	[−0.23]	[1.22]	[0.00]		[2.44]	[−0.55]	[2.21]
Constant	−1.879	−2.090***	2.213	Constant	1.123	0.176	−5.007
	[−1.58]	[−2.69]	[1.46]		[1.07]	[0.11]	[−1.46]
Time Dummies	Yes	Yes	Yes	Time Dummies	Yes	Yes	Yes
# Instruments	25	25	37	# Instruments	25	25	37
# Obs	297	297	297	# Obs	297	297	297
AR(1)	0.00770	0.00201	0.00353	AR(1)	0.00393	0.00569	0.0407
AR(2)	0.135	0.165	0.989	AR(2)	0.557	0.547	0.973
Hansen test	0.784	0.941	0.861	Hansen test	0.902	0.100	0.960

Notes: (i) *t* statistics in parenthesis.
(ii) The subscripts *f*, *i*, *s* represents the sequence of the regressions in each column: *f* – fundamental, *i* – intermediate and *s* – superior.
(iii) Example: $lw_{i,s,i,t-2}$ in column (1) used the log of wages of intermediate education, in column (2) log of wages of superior education, in column (3) log of wages of intermediate education level.
* $p<0.10$.
** $p<0.05$.
*** $p<0.01$.

Table A6
Dynamic estimates: Models with autoregressive and heteroscedasticity corrections. *Dependent*: Log of human capital. *Hypothesis*: Variables are predetermined – open up degree.

	(1) $lH_{fund,t}$		(2) $lH_{\text{int},t}$		(3) $lH_{\text{sup},t}$
$lH_{fund,t-1}$	0.894***	$lH_{\text{int},t-1}$	0.925***	$lH_{\text{sup},t-1}$	0.840***
	[38.47]		[36.55]		[28.99]
$lw_{fund,t}$	−0.0478	$lw_{\text{int},t}$	−0.0989***	$lw_{\text{sup},t}$	−0.156***
	[−1.48]		[−2.79]		[−3.92]
$lw_{\text{int},t}$	−0.0588	$lw_{\text{sup},t}$	−0.00209		
	[−0.96]		[−0.06]		
ly_t	−0.00667	ly_t	0.0579**	ly_t	0.155***
	[−0.31]		[2.38]		[5.36]
lxm_t	0.0000241	lxm_t	0.0000586	lxm_t	−0.000139**
	[0.61]		[1.52]		[−2.42]
$lH_{\text{int},t}$	0.105***	$lH_{\text{sup},t}$	0.000327		
	[2.96]		[0.02]		
Constant	0.724***	Constant	0.672***	Constant	0.562**
	[3.16]		[2.94]		[2.46]
Time dummies	Yes	Time dummies	Yes	Time dummies	Yes
# Obs	297	# Obs	297	# Obs	297
R^2	0.996	R^2	0.997	R^2	0.993

Notes: (i) *t* statistics in parenthesis. P(0.00) tests probabilities.
(ii) The subscripts *fund*, *int* and *sup* represent the sequence of the regressions in each column: *fund* – fundamental, *int* – intermediate and *sup* – superior.
(iii) Example: $lw_{\text{int},t}$ in column (1) is the log of wages of intermediate education and $lw_{\text{sup},t}$ in column (2) is the log of wages of superior education.
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

Table A7
Dynamic estimates: Robust GMM-SYS. *Dependent*: Log of human capital. *Hypothesis*: Instrumented variables – open up degree.

	(1) $lH_{fund,t}$		(2) $lH_{\text{int},t}$		(3) $lH_{\text{sup},t}$
$lH_{fund,t-1}$	0.513***	$lH_{\text{int},t-1}$	0.679***	$lH_{\text{sup},t-1}$	0.712***
	[4.29]		[3.79]		[10.76]
$lw_{fund,t}$	−0.431***	$lw_{\text{int},t}$	−0.248	$lw_{\text{sup},t}$	−0.682**
	[−3.18]		[−1.24]		[−2.27]
$lw_{\text{int},t}$	−0.151	$lw_{\text{sup},t}$	0.0255		
	[−1.38]		[0.33]		
ly_t	0.137	ly_t	0.132	ly_t	0.230**
	[1.34]		[1.11]		[2.30]
lxm_t	0.000229	lxm_t	0.000432**	lxm_t	0.000116
	[1.27]		[2.49]		[0.35]
$lH_{\text{int},t}$	0.339***	$lH_{\text{sup},t}$	0.0748		
	[3.39]		[1.05]		
Constant	3.010***	Constant	2.369	Constant	4.474***
	[2.74]		[1.64]		[3.39]

Table A7 (*Continued*)

	(1) $lH_{fund,t}$		(2) $lH_{\text{int},t}$		(3) $lH_{\text{sup},t}$
Time dummies	Yes	Time dummies	Yes	Time dummies	Yes
# Instruments	31	# Instruments	21	# Instruments	31
# Obs	297	# Obs	297	# Obs	297
AR(1)	0.00119	AR(1)	0.00173	AR(1)	0,0295
AR(2)	0.769	AR(2)	0.699	AR(2)	0.845
Hansen test	0.889	Hansen test	0.945	Hansen test	0.711

Notes: (i) *t* statistics in parenthesis. P(0.00) tests probabilities.
(ii) The subscripts *fund*, *int* and *sup* represent the sequence of the regressions in each column: *fund* – fundamental, *int* – intermediate and *sup* – superior.
(iii) Example: $lw_{\text{int},t}$ in column (1) is the log of wages of intermediate education and $lw_{\text{sup},t}$ in column (2) is the log of wages of superior education.
* $p<0.10$.
** $p<0.05$.
*** $p<0.01$.

Table A8
Dynamic estimates: Robust GMM-SYS. *Dependent*: Log of human capital. *Hypothesis*: Variables predetermined and instrumented – open up degree.

	(1) $lH_{fund,t}$	(2) $lH_{\text{int},t}$	(3) $lH_{\text{sup},t}$		(4) $lH_{fund,t}$	(5) $lH_{\text{int},t}$	(6) $lH_{\text{sup},t}$
$lH_{f,i,s,t-1}$	0.931***	1.499**	0.684***	$lH_{f,i,s,t-1}$	0.727***	0.735***	0.730***
	[6.15]	[1.99]	[4.77]		[5.47]	[4.94]	[4.56]
$lw_{f,i,s,t-1}$	−0.00104	0.339	−0.265*	$lw_{f,i,s,t-2}$	−0.0777	0.0951	0.313
	[−0.01]	[1.24]	[−1.83]		[−0.83]	[0.33]	[1.43]
$lw_{i,s,i,t-1}$	0.0746	−0.128	−0.228	$lw_{i,s,i,t-2}$	−0.158	−0.0667	0.514
	[0.63]	[−0.57]	[−0.78]		[−1.58]	[−0.85]	[1.31]
ly_{t-1}	0.119	−0.254	0.284**	ly_{t-2}	0.0489	0.194	0.0484
	[1.23]	[−0.55]	[2.33]		[0.47]	[1.52]	[0.38]
lxm_{t-1}	0.000445***	−0.000253	0.000261	lxm_{t-2}	−0.00000340	0.000194	−0.000467
	[4.04]	[−0.89]	[1.12]		[−0.02]	[0.40]	[−1.39]
$lH_{i,s,i,t-1}$	−0.128	−0.195	−0.0131	$lH_{i,s,i,t-2}$	0.212**	−0.0242	0.303
	[−0.85]	[−1.23]	[−0.05]		[2.54]	[−0.25]	[1.29]
Constant	0.0463	−0.908		Constant	1.458	0.446	−6.654*
	[0.05]	[−0.36]			[1.45]	[0.17]	[−1.68]
Time dummies	Yes	Yes	Yes	Time dummies	Yes	Yes	Yes
# Instruments	31	21	31	# Instruments	31	21	31
# obs	297	297	297	# Obs	297	297	297
AR(1)	0.0116	0.198	0.00782	AR(1)	0.00304	0.0677	0.0458
AR(2)	0.137	0.525	0.993	AR(2)	0.287	0.976	0.996
Hansen test	0.419	0.332	0.210	Hansen test	0.536	0.100	0.430

Notes: (i) *t* statistics in parenthesis.
(ii) The subscripts *f*, *i*, *s* represents the sequence of the regressions in each column: *f* – fundamental, *i* – intermediate and *s* – superior.
(iii) Example: $lw_{i,s,i,t-2}$ in column (1) used the log of wages of intermediate education, in column (2) log of wages of superior education, in column (3) log of wages of intermediate education level.
* $p<0.10$.
** $p<0.05$.
*** $p<0.01$.

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