Manager education and firm productivity in the Brazilian industry (1996-2017)*

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PRELIMINARY AND INCOMPLETE

Abstract

We merge two important Brazilian datasets (RAIS and PIA) to produce firm-level total factor productivity estimates that control for workers' human capital. Then we investigate the correlation between managers' education and firms' TFP considering different levels of industry disaggregation. We find a positive, albeit small correlation for the manufacturing sector as a whole, and much higher and more statistically significant correlations for some 2-digit industries. Also at the 2-digit level, we find that the positive correlation between firm TFP and manager schooling is higher for more R&D intensive industries, and lower for industries more dependent on external finance.

Keywords: firm TFP ; manager human capital ; industry characteristics

JEL codes: I25 ; L25 ; L60 ; O40

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1 Introduction

The role of education in economic development is usually assessed in terms of workers' human capital and labor productivity. Less attention is given to how managers' and entrepreneurs' education impacts firms' productivity. As has been argued theoretically by Nelson and Phelps (1966) and Bloom et al. (2012), this is likely an important channel because managers are directly responsible for production technique, organizational and strategic decisions at the firm level.

Recent literature has documented empirical facts about entrepreneurs' education such as its composition, wage premium, and its importance for inequality and productivity. Michelacci and Schivardi (2020) document that, over the last 30 years, the education premium for US entrepreneurs has increased. Our study is closely related to Queiro (2018), who finds that entrepreneur schooling is positively correlated with output, employment and productivity using Portuguese administrative data. Using the same dataset, Black (2019) examines the CEO quality and firm productivity. Castro and Ševčík (2017) examine how financial frictions impact entrepreneurial schooling decisions and productivity.

In this paper, we use Brazilian employer-employee microdata to estimate the impact of managers' education on firms' total factor productivity (TFP), considering extractive and manufacturing sectors. Different from other studies on Brazilian firms that estimate the TFP using only the physical capital and the number of workers as inputs[1], here we control for workers' human capital. Omitting this variable would produce a spurious correlation between CEO human capital and firm TFP when (as seems reasonable) there exists a cross-firm positive correlation between workers' and managers' human capital.

For the manufacturing sector as a whole, we find that the firm's TFP increases 1.15% per additional year of manager's schooling - considerably less than the 5% Portuguese corresponding figure in Queiro (2018). Also, at the 2-digit sector aggregation level, we find that the positive correlation between firm TFP and manager schooling is higher for more R&D intensive industries, and lower for industries more dependent on external finance.

[1] See, for example, Rocha et al. (2019)

2 Data and empirical strategy

2.1 Data and productivity measurement

We rely on two Brazilian datasets, *Relação Anual de Informações Sociais (RAIS)* and *Pesquisa Industrial Anual (PIA)*. RAIS is an employer-employee administrative dataset that covers the Brazilian formal labor market, including information on employee education level, age, tenure and occupation.[2] PIA provides information on firms' value-added, physical capital, and labor employment in the extractive and manufacturing sectors. It covers all firms with 30 or more employees, and it randomly selects firms with 5 to 29 employees. Our sample comprises over 92,000 firms appearing in both RAIS and PIA[3], and in at least one year between 1996 and 2017.

We assume a Cobb Douglas production function $Y_{jt} = A_{jt}K_{jt}^{\alpha}H_{jt}^{\beta}$ where $0 < \alpha + \beta < 1$. The subscripts j and t indicate firm and time, respectively. Y_{jt} represents value-added, K_{jt} physical capital and H_{jt} human capital for each firm from 1996 to 2017. Total human capital is defined as $H_{jt} = h_{jt}L_{jt}$ where h_{jt} is the firm's average human capital and L_{jt} the number of employees. We restrict the sample to 'active' employees in December.

We use RAIS to compute the average human capital by firm as

$$h_{jt} = \frac{\sum_{i \in j} h_{ijt}}{L_{jt}} \tag{1}$$

where $h_{ijt} = e^{\psi u_{ijt}}$ indicates the human capital of individual i in firm j at time t. u_{ijt} represents the number of schooling years which ranges from 0 to 23. We set ψ to 0.13 according to the Brazilian literature on returns to education. L_{jt} is the number of employees in firm j at time t. We compute the value-added and physical capital using PIA data.

Next, for each industry s, we consider the following specification to estimate the TFPs:

$$\ln Y_{jst} = \gamma_{0s} + \gamma_{1s} \ln K_{jst} + \gamma_{2s} \ln H_{jst} + \gamma_{3st} + \gamma_{4sj} + \varepsilon_{jst} \tag{2}$$

[2]RAIS follows the *Brazilian Classification of Occupations (Classificação Brasileira de Ocupações - CBO 02)*. The information on employee occupation is particularly important for separating managers from other workers. In terms of the *International Standard Classification of Occupations - ISCO 08*, here we consider not only "Managing Directors and Chief Executives" but all "Corporate Managers" at the 2-digit level.

[3]The merging of the two databases is possible because they share a common firm identifier, the *National Registry of Legal Entities (Cadastro Nacional de Pessoa Jurídica - CNPJ)*. The match between databases (measured as the number of firms in both RAIS and PIA divided by the number of firms in PIA) is 98%.

where γ_{3st} is a time fixed-effect and γ_{4sj} is a firm fixed-effect. The TFP is thus given by

$$\ln TFP_{jst} = \ln Y_{jst} - \hat{\gamma}_{1s} \ln K_{jst} - \hat{\gamma}_{2s}(\ln h_{jst} + \ln L_{jst}) \tag{3}$$

Table 1 reports value-added and input factors for the five largest 2-digit industries in the extractive and manufacturing sectors.[4]. Averages between 1996 and 2017 appear on the left panel. In this panel, value-added and capital are in millions of 2017 Reais (the Brazilian currency), and labor (measured in thousands) corresponds to the total number of employees. Growth rates (between 1996 and 2017) of the variables appear on the right panel.

Table 1: Value-added and inputs, industry level

	Average 1996-2017				Growth (%) 1996-2017			
Industry	Value-Added	Capital	Human Capital	Labor	Value-Added	Capital	Human Capital	Labor
Extractive								
Mining of metal ores	557.11	922.61	3.49	614.77	154.97	252.54	44.48	116.82
Extrac. of crude petroleum and natural gas	445.39	1381.68	6.18	93.12	839.20	2576.47	21.61	109.50
Mining support service activities	100.40	76.37	4.67	358.06	199.81	76.18	52.10	37.31
Mining of coal and lignite	38.36	49.86	3.28	277.62	38.94	62.88	92.70	17.73
Other mining and quarrying	7.14	15.27	2.84	65.91	53.36	52.63	56.34	1.70
Manufacturing								
Coke and refined petroleum products	757.94	1757.69	3.27	704.50	56.19	372.14	60.83	10.33
Tobacco products	170.37	158.07	3.33	418.37	-45.36	-14.04	57.27	-48.38
Basic metals	87.63	226.89	3.29	256.32	-22.70	15.62	47.22	-15.28
Basic pharmac. products	81.08	78.54	4.44	286.25	38.88	130.63	39.87	67.37
Beverages	73.96	93.11	3.40	259.37	-7.15	68.30	45.09	-5.22

The evolution of aggregate industrial value-added, physical capital and human capital are shown below.

[4]The industry classification we use is the version 2.0 of the *National Classification of Economic Activities (Classificação Nacional de Atividades Econômicas - CNAE)*

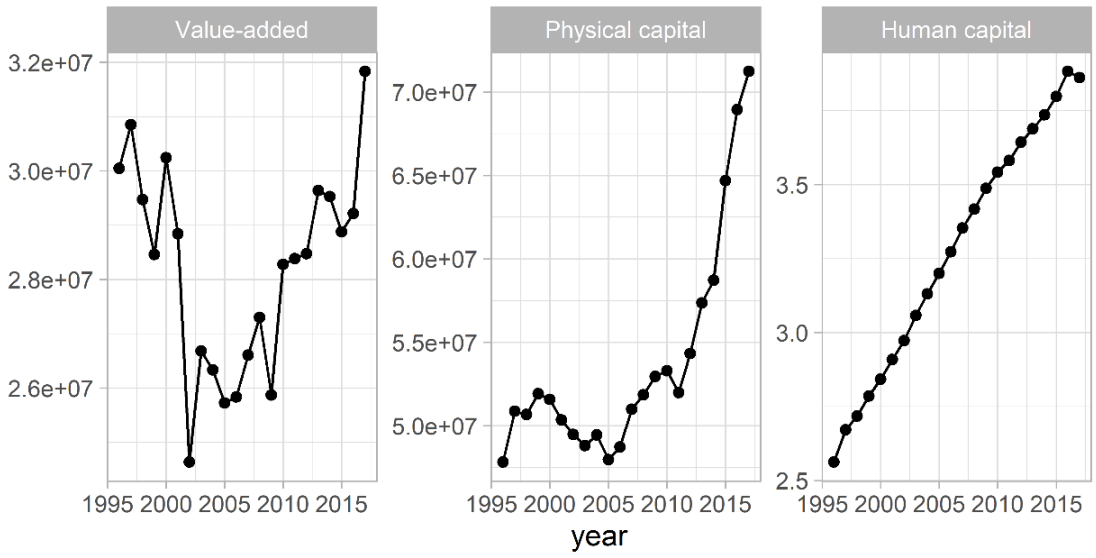

Figure 1: Output and factors

Also, we set the TFP in 1996 equal to one and depict its aggregate evolution until 2017 in the left figure and by quintile in the right figure below. Figure 2 shows that there is heterogeneity in TFP evolution, with the bottom quintiles displaying greater variation in the long run: Firms at the bottom of the TFP distribution *(p5)* are more volatile than firms at the top *(p95)*.

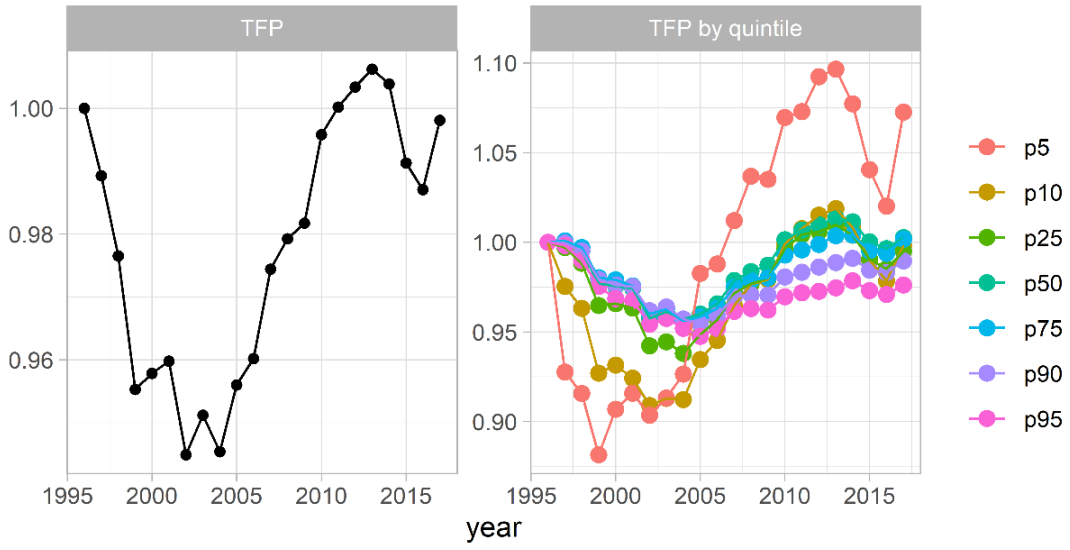

Figure 2: TFP

2.2 Empirical strategy

We regress firm productivity on manager's human capital considering several specifications. The baseline specification is given by,

$$\ln TFP_{jt} = \beta_0 + \beta_1 \ln hceo_{jt} + \beta_{2j} + \beta_{3t} + \epsilon_{jt} \tag{4}$$

where TFP_{jt} is the TFP of firm j at period t estimated in (3). *hceo* indicates the average human capital of the managers in each *firm-period*, such that,

$$hceo_{jt} = \frac{\sum_{ij} m_{it} hceo_i}{\sum_{ij} m_{it}}, \text{ with } m_{it} = \frac{\text{number of months worked in year t}}{12} \tag{5}$$

and $hceo_i$ is the individual manager's human capital computed using the years of schooling as before.[5] β_{2j} and β_{3t} are firm and time fixed-effects, respectively.

While (4) is estimated pooling all industries together, in the next three specifications we let the coefficients associated to the managers' human capital and to other characteristics to vary by 2-digit industry s.

$$\ln TFP_{jt} = \beta_0 + \{\beta_{1s}\}_{s=1}^{27} \ln hceo_{jt} + \beta_{2j} + \beta_{3t} + \epsilon_{jt} \tag{6}$$

$$\ln TFP_{jt} = \beta_0 + \{\beta_{1s}\}_{s=1}^{27} \ln hceo_{jt} + \beta_{2j} + \beta_{3t} + \{\beta_{4s}\}_{s=1}^{27} \ln ten_{jt} + \epsilon_{jt} \tag{7}$$

$$\ln TFP_{jt} = \beta_0 + \{\beta_{1s}\}_{s=1}^{27} \ln hceo_{jt} + \beta_{2j} + \beta_{3t} + \{\beta_{4s}\}_{s=1}^{27} age_{ceo_{jt}} + \{\beta_{5s}\}_{s=1}^{27} + age^2_{ceo_{jt}} + \epsilon_{jt} \tag{8}$$

, where there are 27 2-digit industries. In (7) ten_{jt} corresponds to firm j managers' average tenure (with the accumulated number of months of each manager at the firm

[5]For the year 2017, we find that the correlation between h_j as defined in (1) and $hceo_j$ as defined in (5) is 0.52 for the whole sample, 0.44 for extractive industries and 0.54 for manufacturing industries. As we argue in the introduction, this positive cross-firm correlation between workers' and managers' human capital is an important reason to control for workers' human capital when we measure the firm's TFP.

weighted by the number of months he/she worked in year t), and in (8) age_{jt} accounts for firm j managers' average age.

We also consider specifications with a broader industry classification, where we let coefficients vary according to whether industries are manufacturing or extractive.

$$\ln TFP_{jt} = \beta_0 + \{\beta_{1s}\}_{s=1}^{2} \ln hceo_{jt} + \beta_{2j} + \beta_{3t} + \epsilon_{jt} \tag{9}$$

$$\ln TFP_{jt} = \beta_0 + \{\beta_{1s}\}_{s=1}^{2} \ln hceo_{jt} + \beta_{2j} + \beta_{3t} + \{\beta_{4s}\}_{s=1}^{2} \ln ten_{jt} + \epsilon_{jt} \tag{10}$$

$$\ln TFP_{jt} = \beta_0 + \{\beta_{1s}\}_{s=1}^{2} \ln hceo_{jt} + \{\beta_{4s}\}_{s=1}^{2} age_{ceo_{jt}} + \{\beta_{5s}\}_{s=1}^{2} age_{ceo_{jt}}^{2} + \beta_{2j} + \beta_{3t} + \epsilon_{jt} \tag{11}$$

Table 2 shows summary statistics for the variables appearing on regressions (4) to (11):

Table 2: Summary statistics

Variable	Mean	Std. dev.	p5	p50	p95
TFP	7.08	1.48	4.81	7.14	7.16
Managers' human capital	6.33	1.49	3.44	7.03	7.03
Age	46.61	9.76	30	47	62
Tenure	94.90	86.97	7.09	68.90	274.25

3 Results

3.1 Education and TFP

In Table 3 we report the estimation results for specifications (4), (9), (10) and (11) above. The main result is the one for specification (10), in which we measure the effect of manager human capital on firm TFP by one-digit sector (extractive and manufacturing), controlling for the manager's tenure. As expected, the coefficient associated to *hceo* is positive and statistically significant for the manufacturing sector. In this case, we find a 0.0897 elasticity of firm TFP with respect to the manager human capital. Given the 0.13 value of the returns

to education parameter ψ in $h_{ijt} = e^{\psi u_{ijt}}$, this result is equivalent to saying that the firm's TFP increases 1.15% per additional year of manager's schooling.

Table 3: TFP Regressions

	(4) TFP	(9) TFP	(10) TFP	(11) TFP
Human capital$_{ceo}$	-0.0140			
Extractive * human capital$_{ceo}$		0.0703	-0.143	-0.212
Manufacturing * human capital$_{ceo}$		0.0704	0.0897*	0.0667
Extractive * tenure$_{ceo}$			0.134***	
Manufacturing * tenure$_{ceo}$			0.0139	
Extractive * age$_{ceo}$				0.0398**
Manufacturing * age$_{ceo}$				0.0330***
Extractive * age$^2_{ceo}$				-0.000221
Manufacturing * age$^2_{ceo}$				-0.000340***
Constant	7,506***	7.330***	7.245***	6.573***
Year fixed effect	Yes	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes	Yes
Observations	92,055	30,948	30,948	30,968
Number of firms	16,418	9,667	9,667	9,668
*** p0.01, ** p0.05, * p0.1				

Inspecting the columns for (10) and (11) in Table 3, we further find that the manager's tenure is positively correlated with the firm's TFP in the extractive sector. Also, the manager's age is positively correlated with the firm's TFP in both the extractive and the manufacturing sectors.

3.2 Industry heterogeneity and industry characteristics

Beneath the 0.0897 elasticity of firm TFP with respect to manager human capital we found for the manufacturing sector as a whole, there is considerable heterogeneity at the 2-digit industry level: when we estimate the specification in (7), we find a -1.323 elasticity for "computing equipment and electronic products", 1.253 for "miscellaneous products", 1.019 for "transport equipment", 0.703 for "printing and recording media" and 0.521 for "metallurgy" - all these at 1% of significance, and to report only the top 5 elasticities in absolute value.[6]

[6]Out of 24 manufacturing industries, we find 20 statistically significant elasticities, of which 12 are positive and 8 negative.

How does the elasticity of firm TFP with respect to manager human capital relate to industry characteristics? In Figure 3 we take the coefficient associated to *hceo* from (7) and plot it against: i) the 2-digit industry's Herfindahl-Hirschman index; ii) the industry's R&D intensity; and iii) the industry's dependence on external finance, as defined in Klapper et al. (2006) .[7]

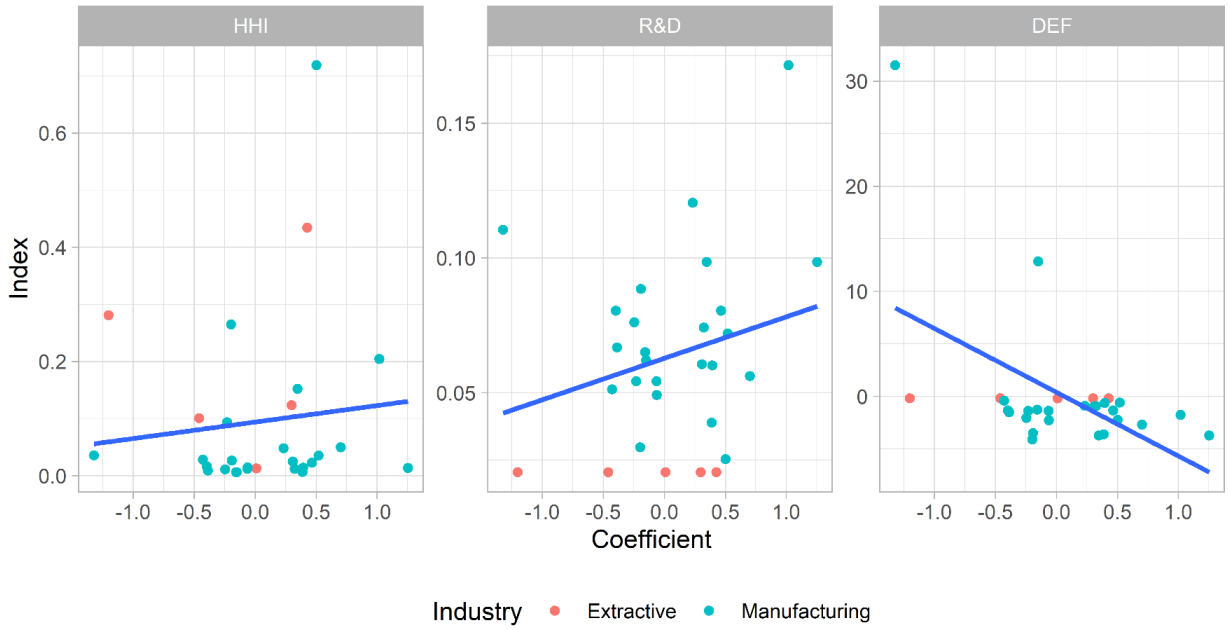

Figure 3: Correlations TFP-hceo coefficients X sector characteristics

The cross-industry correlation between the elasticity of firm TFP with respect to manager human capital and the Herfindahl-Hirschman index is only 0.10. However, for the industry R&D intensity we find a higher, 0.25 correlation. As Queiro (2018) finds for the Portuguese, for the Brazilian economy we find that the positive correlation between firm TFP and manager schooling is higher for more R&D intensive industries. This evidence is in accordance with the view that having more educated managers is important for firms' technology adoption.

Finally, the cross-industry correlation between the elasticity of firm TFP with respect to manager human capital and the dependence of external finance is -0.51. The interpretation we give to this result is: in more credit constrained sectors, the connection between the firm's TFP and the manager's schooling is weaker. This pattern is rationalized by Cas-

[7]We extract R&D intensities for the 2-digit industries from the Brazilian PINTEC, a survey on technology and innovation. Klapper et al. (2006) define dependence of external finance as the ratio total investment expenditure/free cash flow, which we calculate from the Brazilian PIA and PINTEC.

tro and Ševčík (2017), in whose model credit frictions cause schooling investments to get misallocated: entrepreneurs with the best productivity potential are the ones compelled to reduce schooling investments the most. To our knowledge, we are the first to empirically document this effect, as reflected on a weak connection between the firm's TFP and the manager's schooling in sectors with bigger external finance dependence.

4 Conclusion

In this paper, we investigated the correlation between firm TFP and manager education in the Brazilian industry. To do that, it was important to have a TFP measure that controls for workers' human capital, which we constructed merging the RAIS and PIA databases.

At the 2-digit industry level, we found considerable heterogeneity in the size and signal of the elasticity of firm TFP with respect to manager human capital. This elasticity is positively correlated with the industry R&D intensity and negatively with the dependence on external finance.

For the manufacturing sector as a whole, we found that the firm's TFP increases 1.15% per additional year of manager's schooling - considerably less than the 5% Portuguese corresponding figure in Queiro (2018). We conjecture that this has to do with certain characteristics of the Brazilian industry, like the relatively high participation of family and small firms. Thus, an interesting exercise to do in the future is re-estimating our regressions in subsamples with only large (or multiple managers) firms, expecting to find a stronger TFP-manager human capital relation.

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