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Evaluating the Regional Expansion of Brazil's Federal System of Vocational and Technological Education

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ABSTRACT

This present study investigates whether some of the Brazilian government's proposals have been accomplished, and especially the impact of creating federal institutes (FIs) on a set of migration and human capital variables. The expansion of the Brazilian Federal System of Professional and Technological Education between 2000 and 2010 created more than 150 new federal institutes offering high school, vocational and higher education. A new FI affected the proportion of new immigrants in the municipality of its location. More precisely, there was an increase of 1.98% in the proportion of new immigrants in the municipalities with new FIs. This means there were increases in the ratio of people who migrated and lived less than five years in the municipalities with a new FI, strengthening the role of FIs as an attractor of immigrants. Moreover, Brazil achieved the interiorization of education due to the expansion of federal institutes.

KEYWORDS

College education, Vocational education, Public policy, Human capital, Migration

Avaliação da Expansão Regional do Sistema Federal de Educação Profissional e Tecnológica do Brasil

RESUMO

O presente estudo investigou se algumas das propostas do governo foram cumpridas e, principalmente, o impacto da criação de um Instituto Federal (IF) em nosso conjunto de variáveis de migração e capital humano. A expansão do Sistema Federal Brasileiro de Educação Profissional e Tecnologia, entre 2000 e 2010, criou mais de 150 novos Institutos Federais de ensino médio, profissionalizante e superior. Assim, um novo IF impacta a proporção de novos imigrantes nesses municípios; mais precisamente, houve um aumento de 1,98% na proporção de novos imigrantes nos municípios com um novo IF. Isso significa que houve aumentos na proporção de pessoas que migraram e que vivem menos de cinco anos nos municípios que possuíam um novo IF, reforçando o papel dos IFs como atratores de novos imigrantes. Além disso, o Brasil alcançou a interiorização da educação com a expansão dos Institutos Federais.

PALAVRAS-CHAVE

Ensino superior, Educação profissional, Políticas públicas, Capital humano, Migração

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1. Introduction

Schooling is particularly important in Brazil. According to the Brazilian Institute of Geography and Statistics (IBGE, 2010),[1] in 2011 the Brazilian literacy rate of people over 15 years of age was 91.4%, meaning that 12.9 million (8.6% of the population) people were still illiterate in the country, and functional illiteracy reached 21.6%. The country's high level of personal and regional income inequality is mainly due to an inadequate educational distribution (Menezes-Filho, 2001; Barros, 2016; Oliveira and Raul da Mota, 2016). Data from the Organization for Economic Cooperation and Development indicate that Brazilian workers face one of the greatest differences in earnings according to education levels (Valle et al., 2015).

Notably, the situation also has a regional dimension, since state and municipal governments rather than the federal government are responsible for providing basic education (until high school). In this sense, the regional imbalance of schooling levels is becoming more important for understanding Brazil's very high regional income inequality. Oliveira and Raul da Mota (2016) showed that while the productive regional structure played a vital role in explaining the very high regional income disparities in Brazil until 1991, local human capital levels are essential for understanding regional income inequality.

This situation has motivated the federal government to expand schooling around the country. It undertook actions to increase high school, vocational training, and higher education in the nation through a plan called *Plano de Expansão da Rede Federal de Educação Tecnológica* (Plan to Expand the Federal System of Vocational and Technological Education (MEC, 2010)). The first stage of the plan, 2003 to 2007, included building 64 new teaching units to add to the 140 already in operation. Soon afterward, the second stage, from 2008 through 2010, establishing 214 new schools, increasing this teaching modality by more than 250%. Thus, between 2003 and 2010, more than 200 new federal institutes (FIs)[2] were created, especially expanding their presence in Brazil's interior (MEC, 2010). In 2018, it reached 659 units across the country, of which 643 are already in operation.

The Brazilian actions appear to be inspired by a key set of evidence and experiences worldwide. Studies of regional economies have linked higher human capital levels to increases in population and employment, wages, income and innovation (Glaeser et al., 1995; Florida et al., 2008; Adda et al., 2016), and low regional inequality (Ghose, 2020). Moreover, more rapid long-run economic growth is associated with more qualified local human capital (Glaeser et al., 1995; Glaeser and Saiz, 2004). Besides increasing individual-level productivity and idea generation (Becker, 1964), the concentration of human capital within a region can also facilitate knowledge spillovers (Valero and Reenen, 2019), enhance regional productivity, fuel innovation,

[1] For more information, see the 2011 PNAD (Pesquisa Nacional por Amostra de Domicílios).

[2] It is crucial not to confuse federal institutions with federal institutes. Federal institutions include federal universities in addition to federal institutes.

and promote economic growth (Lucas, 1988; Romer, 1990; Moretti, 2004). The available evidence about the influence of policies to expand higher education includes both measuring the association of the actions with their economic variables (Drucker and Goldstein, 2007; Ciriaci and Muscio, 2010; Monsalvez et al., 2015) and effective evaluation of the impact of these policies on economic and social variables (Armstrong, 1993; Breschi and Lissoni, 2003; Power and Lundmark, 2004; Faggian et al., 2007; Faggian and McCann, 2009). However, some researchers have also focused on quantifying outputs rather than translating them into economic variables (Adams, 1993; Azzone and Maccarrone, 1997; Jones-Evans et al., 1999; Candell and Jaffe, 1999; Rip, 2002; Walshok et al., 2002; Fischer et al., 2018; Choudhry and Ponzio, 2020) and regional input-output modeling, estimating Keynesian multipliers (Felsenstein, 1996; Harris, 1997; Thanki, 1999; Glasson, 2003; Kureski and Rolim, 2009).

To the best of our knowledge, there is no study of the impact of expanding the Brazilian Federal System of Vocational and Technological Education (from now on Federal Education System or just FES) regarding immigration and human capital. This is the objective of the current investigation. Specifically, we combine propensity score matching (PSM) with a difference-in-differences specification to estimate the causal impact of the expansion of the FES – creating 150 new federal institutions – on the set of dependent variables of human capital and immigration. This set of variables includes seven human capital and immigration variables that can be affected by the expansion of the FES, specifically high school and higher education students and the proportion of people who completed high school and higher education. Regarding immigration, we check the impact on new immigrants and new immigrants' studying at the secondary and higher education levels.

In addition to this introduction, this paper is organized as follows: section 2 provides the institutional background; section 3 describes the identification strategy and methodological aspects; section 4 presents the descriptive statistics; section 5 presents the results; section 6 shows the falsification and robustness tests; section 7 presents the discussion and final considerations; and the last section is an appendix.

2. Institutional background and the Brazilian FES expansion

According to the Brazilian Ministry of Education (MEC), the Federal System of Vocational and Technological Education began in 1909, with the creation of 19 apprentice craftsmen schools (*escolas de aprendizes artífices*). These schools were more focused on the social inclusion of disadvantaged youths than a skilled workforce (MEC, 2016). In the 1930s and 1940s, technical education strategies for developing the economy were implemented. The apprentice craftsmen schools became industrial lyceums– secondary education establishments – and later became federal technical schools (MEC, 2016). These federal technical schools operated with pedagogical and administrative

autonomy.

The CEFETs (federal centers of technological education) were created in 1978 to replace Brazil's federal technical schools and federal agro-technical schools. The CEFET became a reference in technological education and became the standard unit of the FES, intending to train engineers and technical specialists, absorbing the technical and federal agro-technical schools (MEC, 2016). Vocational education institutions sought to diversify programs and courses to meet the labor market's new demands and diversified productive structure (MEC, 2016).

In the 2000s, the federal government promulgated new legislation to regulate vocational education. According to the (MEC, 2010), the political-pedagogical proposal of the federal institutes is to mainly to offer secondary education courses integrated with technical professional education; technical education in general; higher technology courses, bachelor's degrees in areas in which science and technology are vital components, in particular engineering, as well as *lato sensu* and *stricto sensu* postgraduate programs, while ensuring workers' initial and continuing education. The goal was to expand the vocational and higher education distribution throughout Brazilian non-metropolitan areas [3] The expansion process in the 2000s (Figure 2b) sought to interiorize the Federal Education System. Unlike the previous figure, the new map of the Federal Education System shows expansion particularly in the hinterlands. (MEC, 2016).

Starting in 2003, the Brazilian government took actions to increase vocational and higher education in the Plan to Expand the Federal System of Vocational and Technological Education (MEC, 2016). In this sense, the government attempted to increment the FES to bring quality vocational and college education to areas with low education levels. Between 2003 and 2010, more than 200 new federal institutes (FIs) were created (MEC, 2016). Figure 1 shows an increase of over 250% in the number of federal institutes, with a concomitant increase in openings. This expansion process continued in the following decade by increasing the number of federal institutes to 562, covering all the country's micro-regions (MEC, 2016). The new institutes were intended to have strong insertion in research and extension, aiming to stimulate technical and technological solutions and extend benefits to the community (MEC, 2016).

Figure 2a shows the distribution of the Federal Education System in 2000. There was little national coverage; most of the FIs were established in coastal areas. There were also a few schools in rural inland areas, mainly in the North and Midwest regions.

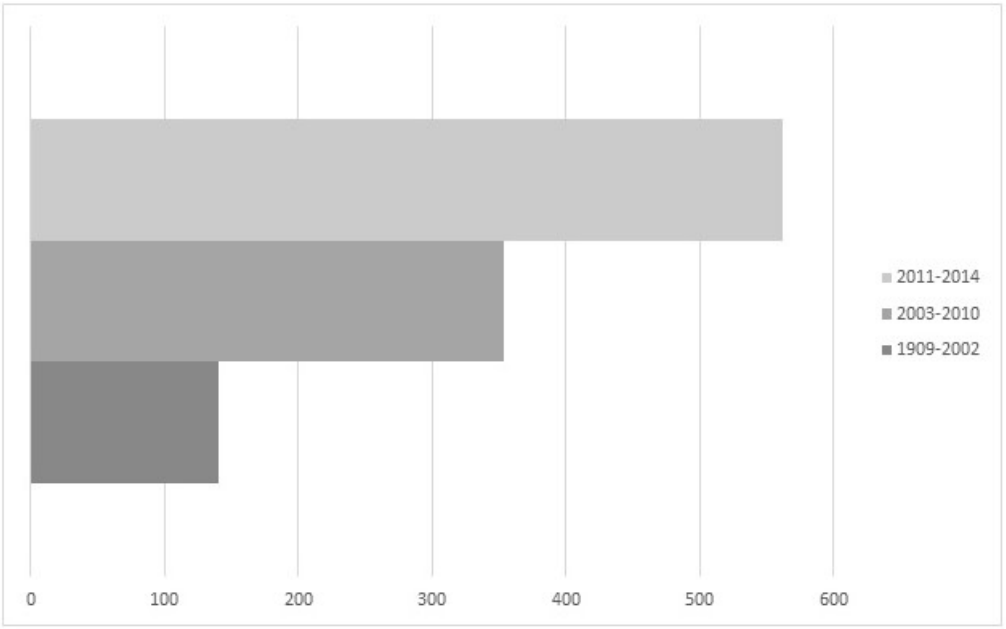
Between 2011 and 2014, the MEC invested approximately US$ 1.5 billion [4] to expand professional education, with 208 new units (MEC, 2016). In 2018, the number of federal institutes reached 562. There are currently 38 federal institutes in all states,

[3] Brazil has five official macro-regions: South, Southeast, Midwest, Northeast and North.

[4] Between 2011 and 2014, the Brazilian currency, the Real (R$), fluctuated between 1.674 and 2.639 (R$/US$), with an average of R$2.157/US$. Thus, the investment in the FES of R$ 3.3 billion was approximately US$ 1.5 billion.

offering qualification courses, high school integration, vocational classes, higher education, and postgraduate programs (MEC, 2016).

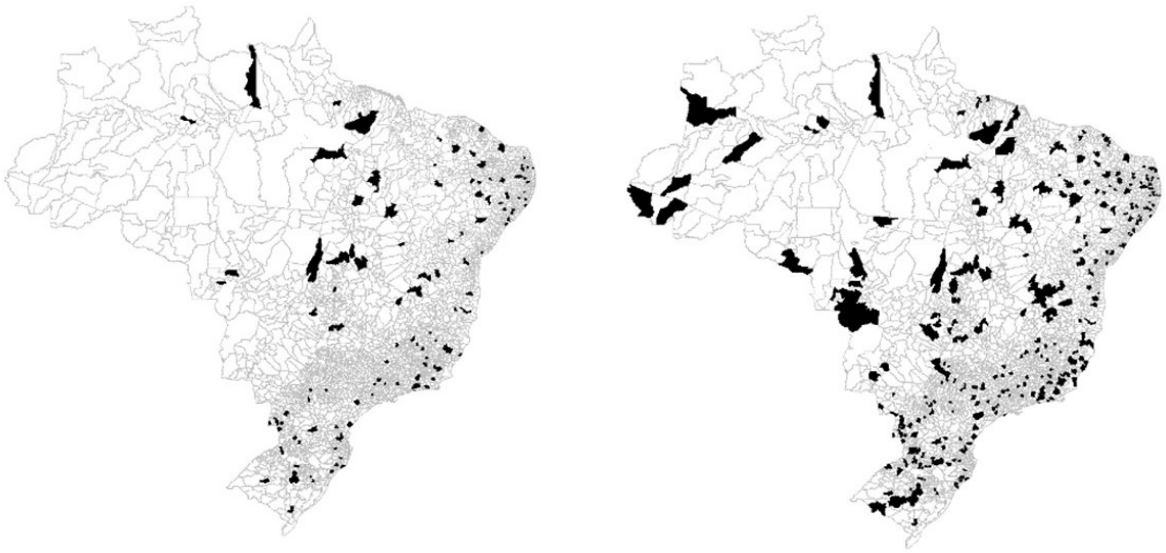
Figure 1. Evolution of the Federal System of Vocational and Technological Education (1909-2015)



Notes: Data are from the Ministry of Education and the federal institutes.

Figure 2. Expansion of the Federal System of Vocational and Technological Education in the Brazilian Municipalities

(a) 2000 **(b)** 2010



Data are from the Ministry of Education and the federal institutes.

3. Empirical strategy

Since the choice of municipalities for the FES expansion was not random, we use a quasi-experimental approach based on the difference-in-differences estimator (DiD) and on a propensity score matching strategy. The estimator compares the change in the treated group (municipalities that received a new federal institute) before and after the intervention with the difference in the control group (municipalities that did not receive a new federal institute between 2000 and 2010).[5] The information from the 1991 census is used in the falsification test to check for possible false expansion.

Using a DiD specification with two periods and two groups constrained our dataset: the variables are available only every ten years.[6] This poses an apparent disadvantage of not allowing direct testing the hypothesis of common pre-trends in the outcome variables. On the other hand, Beatty and Shimshack (2011) highlight that this model provides a more transparent econometric analysis. Different from a panel with varying treatment periods, it constantly compares treated and untreated units. Furthermore, since equation 1 is a saturated model, it is unnecessary to impose any linearity hypothesis (Angrist and Pischke, 2008). In any case, using only two periods requires additional precautions about the influence of unobservable factors, so we implement a significant number of different robustness checks.

Formally, we consider the following DiD specification with two periods and two groups:

$$Y_{it} = \alpha + \lambda d_t + \beta FES_i d_t + \gamma x_{it} + \theta_i + \epsilon_{it} \tag{1}$$

where Y_{it} is the variable of interest (local human capital or immigration variables), α is the intercept, FES_i is a dummy variable that assumes "1" if municipality "i" received a new federal institute, and "0" otherwise, θ_i is the municipal fixed effect, d_t is a time dummy that assumes "1" in the post-intervention period and" 0" in beforehand, x_{it} is a vector of time-varying controls and ϵ_{it} is the error term. The parameter λ measures the impact of time on the untreated group of municipalities, and β it is the parameter of interest, which measures the ATT, the average effect on the treated sample.

We are interested in measuring the impact of expanding the Federal Education System on human capital and immigration variables, since the federal institutes (FIs) offer high school, vocational training,[7] and higher education (undergraduate and postgraduate degrees). Thus, we only consider FIs that provided secondary and higher education together in the sample. As we mentioned, note that the local human capital may be affected by a new FI because of its direct effects on human capital formation and on the economic environment (Liu, 2015). Furthermore, both influences can also

[5] We choose these specific years due data availability. A large part of the variables are only available in census years (every ten years).

[6] The municipal data available come from the ten-year censuses. Thus, we used the 2000 and 2010 censuses to obtain the estimates. The 1991 census is used for a falsification test.

[7] The census makes no distinction between high school and vocational education. Thus, it is not possible to separate the effect among these two learning modalities.

attract non-native students and skilled laborers.

We consider the plan's effects on students and the labor force regarding the local human capital indicators. For the students, our outcome variables are the proportion of students enrolled in high school and college degrees programs in their respective expected school age (15 to 18 years old and 18 to 25 years old).[8] As for the local labor force, our outcomes correspond to the proportion of people with high school and college degrees in the local population. While the first two variables capture more direct effects of a new FI, the last two also may involve spillover effects (Liu, 2015).

As for immigration outcomes, we consider different proportions of immigrants living less than five years in a given municipality, defined as new immigrants. The short time since the expansion of the education system explained the five-year limit: most immigrants potentially affected by a federal institute have lived less than five years in the municipality and the data availability in the census is only every ten years. Thus, we consider especially three variables. The first one is the ratio between these new immigrants and recent immigrants already living in the municipality. The other two are the proportions of recent immigrant students enrolled in high school and college education. In the first case, we divide the new immigrants attending secondary school programs by individuals aged 15 to 18 years old; in the second, we divide the new immigrants attending college programs by the sum of individuals aged 18 to 25.

A common concern in DiD analysis is the possible existence of time-varying, confounding factors, here meaning variables that simultaneously explain the process of expansion of the Federal System Education and the trajectory of our dependent variables. The endogeneity problem comes into play in such a case, and the coefficients cannot be interpreted causally (Angrist and Pischke, 2008, 2014). We deal with these concerns using different expedients. First, we combine the DiD strategy with PSM; second, as expressed in equation 1, we consider several time-varying controls; finally, we implement a significant number of robustness checks.

Concerned about the possibility that municipalities with better infrastructure or higher economic development levels can attract more qualified labor, we also build a panel with several controls that can influence this choice. For example, it is possible that municipalities with a higher per capita income or higher urbanization rate have a greater capacity to attract and retain qualified labor, and consequently attract greater immigration to the municipality. Hence, we use the following traditional socioeconomic controls: per capita income; Gini coefficient; economically active population; metropolitan area; urbanization rate; manufacturing workers; and households with waste collection, electric power, and water and indoor bathroom facilities.

We must also be mindful of the municipality's demographic characteristics. For example, there is a possibility that a municipality with a higher number of unemployed

[8]For example, there are 20,000 people enrolled in high school and 40,000 people of school age, so, the variable is 20,000 divided by 40,000 or 0.5. It aims to measure the fluctuations in the human capital in the municipalities that had a new FI.

may not attract as many immigrants, and, also more people with higher education can represent a hub with a greater human capital level. Therefore, we add in equation 1 a series of controls related to demographics: people with age 25 years or more and higher education; population density; immigrant, unemployment; elderly population; male, Afro-descent, foreigner, and young people.

According to the MEC (2016), there are only two clear criteria for implementing a new federal institute. The first criterion is interiorization, aiming to reach all Brazilian micro-regions (MEC, 2010), a process that has been achieved (see Figure 2). The second point is the local economy (MEC, 2016). For example, if the municipality is part of an industrial automotive center, the courses should offer education geared to the automotive area. Thus, FIs have total autonomy to decide which courses they will offer to better meet each region's local demands (MEC, 2010). Note that since these criteria are too general, the choice to create a new FI tends to be more political than technical, and this may reverberate in our results.

Brazil is a country of continental proportions, and the municipalities have significant variability both within states and regions (Barros, 2016). Thus, we begin by trying to eliminate or attenuate bias using a propensity score matching strategy with DiD estimation and selected municipalities based on the three nearest neighbors, as proposed, for example, by Ho et al. (2011); Bock and Ontiveros (2013); Fang et al. (2020).[9] Thus, we use the following control variables to perform the matching between the three nearest neighbors: per capita income; Gini coefficient; economically active population; metropolitan area; urbanization rate; manufacturing workers; households with waste collection, electric power, and water and indoor bathroom facilities; people with age 25 years or more; and higher education; population density; immigrant, unemployment; elderly population; male; Afro-descent; foreigner; and young people.

Note that in the 1990s, Brazil underwent a series of municipal secessions, so several municipalities were divided, creating new municipalities (Reis et al., 2005; Lima and Neto, 2016), causing inaccurate direct time comparisons of some current municipalities. Although we use the 2000 and 2010 censuses in the benchmark equation, we use the 1991 census to perform the falsification test. Thus, like Lima and Neto (2016), we use MCAs (minimum comparable areas) instead of current municipalities. Proposed by Reis et al. (2005) and generally used (Resende, 2011; Resende et al., 2016; Lima and Neto, 2016), MCAs correspond to spatially compatible municipalities. Therefore, instead of the 5,655 municipalities in 2010, we use 4,267 MCAs, the number in 1991, which allows comparisons of 1991, 2000, and 2010. Henceforth, when referring to municipalities, we mean MCAs.

Thus, in our initial database, we have 4,267 municipalities, including all current municipalities in Brazil. Municipalities with a FI before 2000 or with a new federal university after 2000 (as will be seen shortly, there was a significant expansion of

[9]Subsequently, we performed tests with 1, 5, and 10 nearest neighbors, available in the appendix.

federal universities in the same period) are dropped from the sample to eliminate possible contamination from former federal institutes. These two restrictions dropped 220 municipalities from the sample before running the propensity score matching. In the robustness tests, we consider other possibilities concerning federal universities, removing them from the sample or adding dummies for higher education institutions.

We complement our baseline results by considering different robustness checks. First, note that there was an expansion of higher education in Brazil in 2000-2010. The Prouni Program grants full and partial scholarships to undergraduates in private higher education institutions. According to the MEC (2010, 2016), the federal government also created other programs, such as FIES (Student Financing Fund), enabling the grant of partial scholarships not covered by other programs. Prouni added to FIES the Unified Selection System (SISU), the Open University of Brazil (UAB), and the Support Program for the Restructuring and Expansion of Federal Universities (REUNI). Together these expanded the supply of higher education in Brazil. For example, the number municipalities with a federal university campuses increased from 114 in 2003 to 237 at the end of the decade (MEC, 2015).

Indeed, Prouni and other programs can generate selection biases. With this point in mind, we obtained additional estimates considering this possible effect. First, we identified municipalities that received a Prouni grant and dropped them from the benchmark equation 1 for the first robustness check. In the same line, it may happen that federal universities, even the oldest ones, not dropped from the sample, might affect our dependent variables. Hence, we considered alternative results by dropping all municipalities with federal universities.

The next test aims to eliminate any effect other college institutions might have on our human capital and immigration variables. Thus, we identified municipalities with college institutions, private or public, in 2000 and 2010 and considered additional estimates including a dummy for each municipality with a college institution in 2000 and 2010. Then, we added the two dummies in the benchmark equation and checked the combined effect of having both college institutions in 2000 and 2010.

The third set of robustness tests considers the possibility of spatial influence or spillovers influencing the results. Initially, notice that a federal university outside the municipality may affect its micro-region's human capital and immigration variables. Thus, to test this possibility, we obtained an additional estimate by adding a dummy, which equals one if a certain micro-region, has a federal university and zero otherwise. Second, remember that we are working with MCAs, so a municipality that forms an MCA may have a new FI, and the other municipalities may not. We dropped all MCAs in which all the municipalities did not have a new federal institute. Besides this, we carried out another test in which we dropped all municipalities divided in the last decades. Third, to deal with concerns about spatial spillovers, we identified all untreated municipalities that are neighbors of treated municipalities and dropped them from the sample to obtain a new set of results.

If there is an influence of unobservable variables on the results, it may appear more clearly in the complete sample composition. Thus, in the last robustness test, we analyzed the entire sample of MCAs, 4,267 municipalities, without dropping any variables or applying the PSM strategy. Finally, we implemented a falsification test by obtaining new results assuming a false launch of federal institutes in 2000 instead of 2010. To obtain these additional results, we used 1991 as the pre-treatment period. Hence, we estimate the false launch in 2000 only with the data from 1991 and 2000.

4. Data and descriptive statistics

To analyze the effect of the Federal Education System's expansion on our set of human capital and immigration variables, we built panel data containing the pre-expansion period (2000) and the post-expansion period (2010). As previously stated, first we used the PSM strategy to match treated municipalities with three nearest neighbors using information from 4,047 municipalities.[10] Thus, 150 municipalities had received a new FI, and after the PSM strategy, another 317 municipalities were in the control group, not treated. As argued by Ho et al. (2011), when done correctly, the matching before the estimation can reduce model dependence and variance, lower the mean square error, and generate less potential bias. This number also results from the requirement of common support of the PSM.[11]

We constructed a set of variables using data from the Brazilian demographic censuses of 2000 and 2010, obtained from the IBGE. The dependent variables were log-transformed to facilitate interpretation; the control variables are the proportion in each municipality. Table 1 presents descriptive statistics for treated and untreated subsamples in the pre-intervention period, post-intervention period, and additionally the mean difference statistics.

Since we use the PSM strategy, treated and untreated municipalities, both before and after treatment, have very similar characteristics, indicating that the balancing, in fact, was done well. We highlight the growth of people over 25 years old and with higher education, the aging population, and the decrease in young people's proportion. There was also a decrease in the Gini Index. Indeed, the dependent variables present the main differences. There was an increase in the number of high school students in the control and treated groups and a significant increase in higher education between 2000 and 2010 (students more than doubling). There were also slight increases in people who completed high school. The complete college ratio also grew substantially in the same period. The new immigrants decreased in the treatment group from 0.2814 in 2000 to 0.2305 in 2010. However, students who migrated to attend high school remained almost unchanged. The college immigrant students increased in the municipalities with new FIs between 2000 and 2010 from 0.0118 to

[10]Note that before the matching, we already dropped from the sample 220 municipalities with new federal universities after 2000 or federal institutes before 2000.

[11]The estimate of the logit model and details of the propensity score estimative are available upon request.

Table 1. Summary Statistics for Pre-treatment and Post-treatment Period

Variable	Pre-treatment Period (2000)			Post-treatment Period (2010)		
	Not Treated	Treated	Mean Diff.	Not Treated	Treated	Mean Diff.
Log of High School Students	0.3618	0.3693	-0.0075	0.4609	0.4717	-0.0108
Log of College Students	0.0643	0.0750	-0.0107**	0.1482	0.1699	-0.0217***
Log of High School Graduates	0.4613	0.4729	-0.0116	0.5109	0.5300	-0.0191**
Log of College Graduates	0.0760	0.0900	-0.0140**	0.1891	0.2187	-0.0296***
Log of New Immigrants	0.2877	0.2814	-0.0063	0.2196	0.2305	-0.0109
Log of High School Immigrants	0.0036	0.0343	-0.0039***	0.0284	0.0348	-0.0064***
Log of College Immigrants	0.0091	0.0118	-0.0027***	0.0175	0.0277	-0.0102***
Immigrants	0.3456	0.3691	-0.0235	0.3651	0.3789	-0.0138
Metropolitan Region (0 or 1)	0.1703	0.1133	0.0570	0.2271	0.1933	0.0338
Waste Collection	0.8390	0.8470	-0.0080	0.9456	0.9529	-0.0073
Gini Coefficient	0.5641	0.5715	-0.0074	0.5009	0.5230	-0.0221***
Industrial Workers	0.0764	0.0784	-0.0020	0.0920	0.0911	0.0009
Foreigners	0.0015	0.0017	-0.0002	0.0013	0.0017	-0.0004
Afro-Descent	0.0595	0.0589	0.0006	0.0716	0.0711	0.0005
Electric Power	0.8991	0.9046	-0.0055	0.9770	0.9790	-0.002
Water and Bathroom Facilities	0.6809	0.6953	-0.0144	0.8262	0.8351	-0.0089
Pop. more than 25 Years old and Higher Education	0.0340	0.0394	-0.0054*	0.0687	0.0812	-0.0125***
Population Density (Population/Area)	0.1178	0.1196	-0.0018	0.1117	0.0962	0.0155
Monthly Per Capita Income (R$)	406.00	438.27	-32.27	550.99	612.36	-61.37***
Male	0.4993	0.4992	0.0001	0.4971	0.4964	0.0007
Elderly Population	0.0580	0.0557	0.0023	0.0752	0.0712	0.004*
Economically Active Population	0.3982	0.4039	-0.0057	0.4437	0.4550	-0.0113
Young People	0.1355	0.1371	-0.0016	0.1242	0.1263	-0.0021*
Unemployment	0.1328	0.1322	0.0006	0.0765	0.0725	0.004
Urbanization	0.7427	0.7638	-0.0211	0.7785	0.7991	-0.0206
Observations	317	150		317	150	

Note: *** p<0.01, ** p <0.05, * p <0.1. The first six variables (about education level) are in log. The dependent variables were log-transformed to facilitate interpretation, using the following formula: $DV_{rate} = log(DV_{Proportion} + 1)$. Thus, we can interpret the result in proportional terms. Some municipalities do not have higher education institutions and therefore do not have higher education students. Thus, the addition of 1 in the log eliminates this problem. The control variables are the proportion in each municipality. Brazil's

0.0277.

Overall, as Table 1 clarifies, Brazil has evolved considerably in many aspects during the 2000s. The numbers indicate that Brazil became a more prosperous country, with an older population, more industrial workers, and lower unemployment and inequality (Ferraro, 2011; Neto, 2015; Albuquerque et al., 2017). Notably, there were also improvements in the proportion of people attending higher education and people with a college education.

5. Results

5.1 Human capital variables

This first subsection presents the estimate for a new FI's impact on the proportions of individuals attending secondary and college programs. Note that the variables capture the possible direct consequence of the expansion of the FES, since new federal institutes offer both instruction modalities (MEC, 2016). All dependent variables were log-transformed for a better interpretation of the results. Table 2 presents the results.

Table 2. Effects of the Expansion of the FES: High School and College Students

	High School Students			College Students		
	(1)	(2)	(3)	(4)	(5)	(6)
Federal System * Year	0.0204***	0.0051	0.0056	0.0151***	0.0083**	0.0026
	(0.0055)	(0.0056)	(0.0070)	(0.0035)	(0.0036)	(0.0034)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	No	Yes	Yes	No	Yes	Yes
Municipal Fixed Effects	No	No	Yes	No	No	Yes
Adjusted R^2	0.6736	0.6995	0.7659	0.8291	0.8401	0.8814
Observations	934	934	934	934	934	934

Note: ***p <0.01, ** p <0.05, * p <0.1. We used robust standard errors clustered at the municipal level. The t-values are in parentheses. Columns (1) to (3) show the FES expansion effect on the proportion of high school students. Columns (4) to (6) show the FES expansion effect on the proportion of college students. Municipal controls was a relevant set of time-varying controls: socioeconomics variables of the municipalities such as per capita income, Gini coefficient, economically active population, metropolitan area, urbanization rate, and industrial workers; and demographics variables: people with age 25 years or more and higher education, population density, immigrant, unemployment, elderly population, males, Afro-descent, foreigners, young population, households with waste collection, electric power, and water and indoor bathroom facilities. The dependent variables are log-transformed to facilitate interpretation of the parameters.

As shown in Table 2, column (1), when we considered only municipal controls, the numbers indicated an impact of 2.04% on the proportion of people attending high school due to the FES expansion, which means a significant effect of almost 20% in

this proportion, considering the difference of 0.1024 (0.4717 - 0.3693, according to Table 1) between the municipalities before (2000) and after a new FI (2010). Nevertheless, when we added the time fixed effect, column (2), and the municipal fixed effect, column (3), the FES effect on the proportion of people attending high school was no longer statistically significant. That is an indication that the expansion of the FES did not impact high school attendance. Column (4) of Table 2 shows that the impact of the Federal Education System's increase on the proportion of people attending college programs was positive, around 1.51% and statistically significant at 1%, which represents an impact of approximately 16% on this modality of schooling between 2000 and 2010 in the treated group. When we added the time fixed effect, there was a decrease in the ATT measured, but it was still positive and statistically significant at 1%. However, the addition of the municipal fixed effect made this variable not statistically significant. Thus, the evidence in Table 2 suggests there was no impact on the proportion of people attending high school or college programs in municipalities with a new federal institute.

The following step focuses on the local accumulation of human capital. As we argued, if a certain percentage of the students stay in the region of origin after graduation, this would positively affect the local stock of human capital (Vidal, 1998; Beine et al., 2001). Table 3 displays the results.

Table 3. Effects of the Expansion of the FES: Local Human Capital

	High School Students			College Students		
	(1)	(2)	(3)	(4)	(5)	(6)
Federal System * Year	0.0151**	0.0127*	0.0134	0.0226***	0.0124***	0.0039
	(0.0067)	(0.0070)	(0.0082)	(0.0043)	(0.0044)	(0.0039)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	No	Yes	Yes	No	Yes	Yes
Municipal Fixed Effects	No	No	Yes	No	No	Yes
Adjusted R^2	0.6248	0.6254	0.6270	0.8500	0.8651	0.9082
Observations	934	934	934	934	934	934

Note: ***p <0.01, ** p <0.05, * p <0.1. We used robust standard errors clustered at the municipal level. The t-values are in parentheses. Columns (1) to (3) show the FES expansion effect on the proportion of people who completed high school. Columns (4) to (6) show the FES expansion effect on the proportion of people who completed college education. Municipal controls: see note to Table 2. The dependent variables are log-transformed to facilitate interpretation of the parameters.

Table 3 shows the impact on the proportion of people with a high school and a college degree. Initially, there was an impact of 1.5% on the proportion who completed secondary education due to the FES's expansion, which affected this teaching modality by approximately 26%. When we added the fixed time effect, the impact decreased to 1.27% and remained statistically significant. However, when adding the fixed municipal effect, we did not find any effect on this variable. Column (4) of Table

3 shows that the proportion of people with higher education is statistically significant with an impact of 2.26%; this has a substantial effect of more than 160% compared to the municipalities treated between 2000 and 2010 (see Table 1). In column (5), with a fixed time effect, the impact decreases, although it is still statistically significant. Finally, when adding the fixed municipal effect, column (6), we did not find any effect on the municipalities' proportion of people with complete higher education due to new FIs. To a certain extent, this specific set of results is not surprising since the FES's expansion happened in the late 2000s, so there was a small window to impact the human capital variables.

To sum up, none of the analyzed variables were statistically significant regarding the capital human variables when considering the fixed effects of municipalities. Interestingly, the absence of impact on human capital variables differs from those obtained for other developing countries. For example, Wang and Liu (2011); Xing (2016); Ibidunni et al. (2016); Andreev et al. (2019); Wu and Tang (2020) found positive impacts of the regional expansion of higher education on local human capital variables, respectively, for China, Nigeria, Russia, and Taiwan.

This initial set of results for Brazil does not necessarily indicate the inefficacy of the plan. Human capital variables take time to appear. Specifically, it takes time to verify the effect of the FES expansion, and it is possible that in the future a positive impact will appear, especially considering the variables in Table 2. However, it is impossible to rule out the policy's ineffectiveness concerning local human capital effects (Table 3). The plan may be inadequately designed, choosing unattractive locations. The presence of a FI is not sufficient to attract human capital for activities relying on the institute.

5.2 Immigration variables

The spread of the Federal Education System into Brazil's interior originated a new possibility of education in areas that lacked vocational training and higher education, possibly affecting the immigration to the municipalities with new federal institutes. For example, given the reduced costs and/or time of commuting, a student may decide to migrate to study in a school with better location (Ciriaci, 2014). Conversely, establishing a new FI may create a hub that attracts regional talents (MEC, 2010). Thus, implementing a new FI could impact the new immigrant proportion (new immigrants divided by total immigrants). Table 4 shows the results for the proportion of new immigrants.

While considering only the municipal controls, we found no impact of the plan on the proportion of new migrants, column (1) of Table 4. When adding the time fixed effect of state, the result indicates an increase of 1.07% in the proportion of new immigrants, statistically significant at 10%, column (2). Finally, considering the municipal fixed effect, a new FI's impact on new immigrants is 1.98% and statistically significant at 1%. As Table 1 shows, between 2000 and 2010, the proportion of new immigrants in the treated municipalities presented an average reduction of 18.1%

Table 4. Effects of the Expansion of the FES: New Immigrants

	New Immigrants		
	(1)	(2)	(3)
Federal System * Year	-0.0006	0.0107*	0.0198***
	(0.0056)	(0.0059)	(0.0070)
Controls	Yes	Yes	Yes
Time Fixed Effect	No	Yes	Yes
Municipal Fixed Effects	No	No	Yes
Adjusted R^2	0.3569	0.3899	0.5097
Observations	934	934	934

Note: ***p <0.01, ** p <0.05, * p <0.1. We used robust standard errors clustered at the municipal level. The t-values are in parentheses. Columns (1) to (3) show the FES expansion effect on the proportion of new immigrants. Municipal controls: see note to Table 2. The dependent variables are log-transformed to facilitate interpretation of the parameters.

(dropping from 0.2814 to 0.2305). Thus, the effect of 1.98% represented around 11% of this reduction. In other words, the implementation of the FIs notably contributed to reducing the decline mentioned above.

The following step is to understand if there was any change in the new immigrant student profile. Thus, we check if there was an impact on high school and college student immigration. Table 5 shows the effect of the FES expansion on new immigrant student variables. Columns (1) and (2) of Table 5 indicate a slight effect on new immigrant high school students, approximately 0.55%, even when considering the control and time fixed effect, respectively. However, as the number of column (3) of Table 5 indicates, the Federal Education System's expansion did not have a statistically significant impact on the proportion of new immigrant high school students when considering the municipal fixed effect.

As for the immigrant college student proportion, initially we found an impact of 0.65% associated with the FES expansion, column (1). The addition of the time fixed effect and municipal fixed effect reduced this effect by 0.61% and 0.44%, respectively, but they are still statistically significant at 1%. Bear in mind that Table 1 indicated a very substantial increase in immigrant college students' proportion in the treated municipalities between 2000 and 2010 (from 0.0118 to 0.0277, or a rise of 134.7%). Hence, the impact of 0.44% indicates a significantly reduced contribution of the plan.

The results found are in line with research in other countries. For example, Rokita-Poskart (2016) demonstrated that educational migration related to higher education can influence the supply and demand of academic municipalities' regional labor markets in Poland. In turn, Huffman and Quigley (2002) showed evidence that the presence of universities had a key role in attracting human capital and also stimulated entrepreneurship in the Silicon Valley region. Faggian et al. (2007) also indicated a

Table 5. Effects of the Expansion of the FES: High School and College Immigrants

	High School Students			College Students		
	(1)	(2)	(3)	(4)	(5)	(6)
Federal System * Year	0.0055***	0.0054***	0.0028	0.0065***	0.0061***	0.0044***
	(0.0015)	(0.0015)	(0.0020)	(0.0015)	(0.0015)	(0.0016)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	No	Yes	Yes	No	Yes	Yes
Municipal Fixed Effects	No	No	Yes	No	No	Yes
Adjusted R^2	0.1016	0.1018	0.1995	0.4939	0.4947	0.4616
Observations	934	934	934	934	934	934

Note: ***p <0.01, ** p <0.05, * p <0.1. We used robust standard errors clustered at the municipal level. The t-values are in parentheses. Columns (1) to (3) show the FES expansion effect on the proportion of immigrants attending high school. Columns (4) to (6) show the FES expansion effect on the proportion of immigrants attending college. Municipal controls: see note to Table 2. The dependent variables are log-transformed to facilitate interpretation of the parameters.

strong attraction of immigration due to higher education in Scotland and Wales. Finally, the impact of our immigration variables is similar to that of Millett and Filippidis (2020) for the Philippines and Wu and Tang (2020) for Taiwan.

6. Robustness and falsification checks

This section presents the results of robustness checks and a falsification test to verify the reliability of our results. Due to space restrictions and a more revealing focus, we examine only the statistically significant variables of section five, i.e., new immigrants in general and new immigrant college students. The results for the other variables are available in the appendix and confirm their initial values and non- significance. Note that all estimations in this section included controls, time fixed effect, and municipal fixed effects, and all dependent variables were log-transformed.

In the first place, it is important to note that there were other government policies associated with schooling expansion in Brazil in the same period of the extension of the FES (FIES and Expansion of the federal universities, for example). Although we controlled for the influence of a great variety of time-varying municipal characteristics and dropped all municipalities with FIs before 2000 or new federal universities after 2000, we cannot rule out the possible influence of other public educational policies. Thus, concerned with the potential effects of different public policies proposed by the federal government, our initial set of robustness checks consisted of three tests.

First, we eliminated from the sample all MCAs with a federal university, regardless of when it was created. We also identified and dropped from the sample all municipalities that received a Prouni scholarship grant. Table 6 shows the results for these

two initial tests.

Table 6. Robustness Check: Dropping all Federal Universities and Municipalities with Prouni Scholarship Grants

	Without Federal Universities		Without Prouni Scholarship Grants	
	New Immigrants	College Immigrants	New Immigrants	College Immigrants
	(1)	(2)	(3)	(4)
Federal System * Year	0.0208***	0.0034**	0.0135***	0.0304
	(0.0072)	(0.0015)	(0.0038)	(0.0260)
Controls	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes
Municipal Fixed Effects	Yes	Yes	Yes	Yes
Adjusted R^2	0.5020	0.4797	0.7543	0.7954
Observations	892	892	499	499

Note: ***p <0.01, ** p <0.05, * p <0.1. We used robust standard errors clustered at the municipal level. The t-values are in parentheses. Columns (1) and (2) show the FES expansion effect by dropping all federal universities in the sample. Columns (3) and (4) show the FES expansion effect by dropping all the municipalities that received the Prouni scholarship grant. Municipal controls: see note to Table 2. The dependent variables are log-transformed to facilitate interpretation of the parameters.

Columns (1) and (2) of Table 6 show the impact of the FES expansion for a sample of MCAs without any federal university. These results are close to our benchmark ones and statistically significant. Columns (3) and (4) show the effect of a new FI dropping the municipalities that received a Prouni scholarship grant. While the estimated impact of new immigrants is smaller than our benchmark result, it is still statistically significant. Note, however, that there is no effect on the college immigrant variable due to the FES expansion.

We then extended the above exercises by adding to our initial specification of equation (1) dummies indicating presence of a higher education institution in the MCA in 2000 and 2010. We also used information from the Ministry of Education, the INEP Higher Education Census,[12] to identify municipalities with higher education institutions regardless of whether they were public or private in 2000 and 2010. Table 7 shows these added results.

The numbers of Table 7 indicate that even considering higher education institutions in 2000 and 2010, the estimated impacts are still close to our benchmark and statically significant. The most notable difference is found for new immigrants when considering universities' existence in 2000, with an impact of 1.69% for the new immigrants, although not very different from the value of 1.98% of our main estimation.

Our second set of robustness checks considers different samples of MCAs. It is

[12]For further information, see: http://portal.inep.gov.br/web/guest/educacao-superior.

Table 7. Robustness Check: College Institutions in 2000 and 2010

	College Institution in 2000		College Instituion in 2010		College Institution in 2000 or 2010	
	New Immigrants	College Immigrants	New Immigrants	College Immigrants	New Immigrants	College Immigrants
	(1)	(2)	(3)	(4)	(5)	(6)
Federal System * Year	0.0169**	0.0043***	0.0190***	0.0041***	0.0172**	0.0041**
	(0.0071)	(0.0016)	(0.0070)	(0.0016)	(0.0070)	(0.0016)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Municipal Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.5137	0.4619	0.5101	0.4630	0.5139	0.4630
Observations	934	934	934	934	934	934

Note: ***p <0.01, ** p <0.05, * p <0.1. We used robust standard errors clustered at the municipal level. The t-values are in parentheses. Columns (1) and (2) show the FES expansion effect considering a dummy for college institutions in 2000. Columns (3) and (4) show the FES expansion effect considering a dummy for college institutions in 2010. Columns (5) and (6) show the FES expansion effect considering two college institutional dummies in 2000 and 2010. Municipal controls: see note to Table 2. The dependent variables are log-transformed to facilitate interpretation of the parameters.

important to remember that we are working with MCAs and not precisely with current municipalities. As we argued, this is necessary to make reliable comparisons through time (Reis et al., 2011; Resende et al., 2016; Lima and Neto, 2016).[13] However, we are concerned that some previous municipalities' aggregation (to form MCAs) may affect our results. The reasons for such suspicions arise because the secession of a municipality may imply additional infrastructure investments and thus can affect local attractiveness. In the first test, we consider the impact of a new FI only on MCAs that corresponded to a municipality before the FES expansion, i.e., we dropped from the sample MCAs that received a new FI and were composed of municipalities that seceded from others. Subsequently, in another exercise, we merely dropped all the MCAs composed of municipalities that launched a secession process in the last decades (not only those that received a new FI). Finally, we obtained additional results for the sample, including the 220 municipalities we dropped because they had FIs before 2000 or had new federal universities after 2000. This last exercise can more clearly the potential effect of unobservable variables on the results. Columns (1) to (6) of Table 8 present the results of these three checks.

Columns (1) and (2) of Table 8 present the new estimate when considering the impact of a new FI for MCAs that did not result from an aggregation of municipali-

[13]Brazil has had several municipal secessions since 1991 (Reis et al., 2011; Lima and Neto, 2016). Thus, the observation units usually used in the country are called Minimum Comparable Areas (MCAs) because they have constant borders over time. Thus, some MCAs represent aggregation of municipalities. The exercise considers only those MCAs in which all their municipalities received a new FI.

Table 8. Robustness Check: Federal Institute in MCA, Without MCA Divided into other Municipalities and Complete Sample

	Federal Institute in the MCA		Without MCA Divided		Complete Sample	
	New Immigrants	College Immigrants	New Immigrants	College Immigrants	New Immigrants	College Immigrants
	(1)	(2)	(3)	(4)	(5)	(6)
Federal System * Year	0.0213***	0.0035*	0.0236***	0.0040**	0.0194***	0.0064***
	(0.0081)	(0.0018)	(0.0081)	(0.0019)	(0.0046)	(0.0013)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Municipal Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.5125	0.4250	0.5330	0.320	0.4592	0.2725
Observations	871	871	722	722	8,534	8,534

Note: ***p <0.01, ** p <0.05, * p <0.1. We used robust standard errors clustered at the municipal level. The t-values are in parentheses. Columns (1) and (2) show the FES expansion effect considering only a federal institute in the MCA. Columns (3) and (4) show the FES expansion effect dropping all MCAs divided into other municipalities. Columns (5) and (6) show the FES expansion effect using the complete sample without dropping any municipalities. Municipal controls: see note to Table 2. The dependent variables are log-transformed to facilitate interpretation of the parameters.

ties. Here, we note that the effect of a new FI on new immigrants increased to 2.13%, statistically significant at 1%; thus, close to the previous one. The new estimate is slightly below the benchmark estimation for college immigrants and remained statistically significant only at 10%. Table 8, columns (3) and (4), shows the results for a sample that excluded all MCAs with municipalities that have undertaken a secession process. These results are still statistically significant and only slightly higher than those of the previous columns. The last two columns of Table 8, Columns (5) and (6), show the new results considering all the MCAs and, once more, the new estimate are close to those previously obtained.

The third set of checks considers the potential influence of spatial effects on our results. These influences might be necessary if there were spatial spillovers across neighbors' units (MCAs) and within a micro-region associated with implementing a new FI. In this case, some non-treated units would not be acceptable as counterfactuals for the treated MCAs. We deal with this potential problem using two strategies. Firstly, we identified all untreated municipalities neighbors of the treated MCAs and obtained a new estimate dropping them from the sample. Secondly, since a federal university in a micro-region may also affect the human capital and immigration variables of its MCAs (treated and untreated), we were also concerned about the possible influence of this potential effect on our baseline estimate. Thus, we obtained an additional estimate by adding a dummy variable to our principal estimation indicating the presence of one or more federal universities in the micro-regions of the MCAs. Table 9

shows these two new results.

Table 9. Robustness Check: Dropping all non-treated Neighbors and Federal University in the Micro-region

	Dropping all non-treated Neighbors		Federal University in the Micro-region	
	New Immigrant	College Immigrant	New Immigrant	College Immigrant
	(1)	(2)	(3)	(4)
Federal System * Year	0.0188**	0.0044***	0.0198***	0.0044***
	(0.0074)	(0.0016)	(0.0070)	(0.0016)
Controls	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes
Microregion Fixed Effects	Yes	Yes	Yes	Yes
Adjusted R^2	0.4995	0.4599	0.5097	0.4616
Observations	830	830	934	934

Note: ***p <0.01, ** p <0.05, * p <0.1. We used robust standard errors clustered at the municipal level. The t-values are in parentheses. Columns (1) and (2) show the FES expansion effect dropping all non-treated neighbors. Columns (3) and (4) show the FES expansion effect considering a federal university in a micro-region. Municipal controls: see note to Table 2. The dependent variables are log-transformed to facilitate interpretation of the parameters.

We dropped from the sample all untreated MCAs neighbors of the treated MCAs; columns (1) and (2) of Table 9 show the new estimate. The results are statistically significant and very close to our previous estimate. Columns (3) and (4) present the latest results obtained by adding a dummy variable for the presence of Federal Universities. Once again, we note that the new estimate barely changes compared to those of the initial specification. This set of recent results makes our initial results less likely to present any spatial effects bias.

Our last exercise is a falsification test related to divergences in the dependent variables' temporal trend between treated and untreated MCAs. More specifically, we obtained a new estimate of a FI's impact, falsely assuming that the expansion happened a decade earlier in the 1990s. Note that, because the common trend assumption is necessary for a causal interpretation of the effect of the expansion of the FES (Angrist and Pischke, 2008, 2014), this new evidence represents a decisive test for the credibility of our previous results. The exercise uses the 1991 and 2000 census data and falsely assumes that all municipalities treated in 2010 were treated in 2000.[14] The following Table 10 presents the latest results.

As the numbers of columns (1) and (2) of Table 10 indicates, the estimate of the effect of the Federal Education System's false expansion is not statistically significant

[14]It also applies the same previous combination of PSM and DiD strategies using data for 1991 and 2000.

Table 10. Falsification Test

	New Immigrant	College Immigrant
	(1)	(2)
Federal System * Year	-0.0067	0.0017**
	(0.0053)	(0.0008)
Controls	Yes	Yes
Time Fixed Effect	Yes	Yes
Municipal Fixed Effects	Yes	Yes
Adjusted R^2	0.2687	0.3798
Observations	934	934

Note: ***p <0.01, ** p <0.05, * p <0.1. We used robust standard errors clustered at the municipal level. The t-values are in parentheses. Columns (1) and (2) show the FES expansion effect of a false plan lunch in 2000. Municipal controls: see note to Table 2. The dependent variables are log-transformed to facilitate interpretation of the parameters.

for only one dependent variable: the new immigrants, column (1). In other words, as expected for a causal interpretation of the effects, the latest results indicate that there is no difference in the change in this dependent variable between the treated and untreated periods (Angrist and Pischke, 2008). This result contributes to discarding the influence of different trends before the policy on the proportion of new immigrants. On the other hand, the latest development indicates that we cannot assert that the expansion of the FES increased the proportion of college immigrants, column (2). Thus, we can not interpret our estimate for the impact of the evolution of the FES on the proportion of college immigrants as a causal relationship.

7. Conclusion

Higher education is seen nowadays as playing an increasingly crucial role in a country's economic well-being and development (Faggian and McCann, 2009). To promote qualified professional training, encourage regional development, stimulate permanence and attract skilled professionals in the country's interior, the Brazilian government greatly expanded its FES between 2000 and 2010 by creating more than 214 new federal institutes (MEC, 2010). As a consequence of this expansion, the plan is expected to reduce social and regional inequalities (MEC, 2016). The present study investigated whether some of the government's goals were accomplished; more specifically, it evaluated the impact of creating a federal institute on a set of immigration and human capital variables.

Our main results indicate that, while the Federal Education System's expansion achieved a more spatially balanced distribution of FIs across the country (nowadays, all Brazilian micro-regions have a FI). This increased the local proportion of new immigrants. Actually, we found that the proportion of recent immigrants (living less than

five years in the municipality) grew about 1.98% in the municipalities with a new FI, which corresponds to 11% of the decrease proportion between 2000 and 2010. Thus, for municipalities with new federal institutes, the proportion of new immigrants fell less than for municipalities without a new FI, indicating that the expansion of the FES avoided a more significant fall of this ratio. It is necessary to emphasize that the goal of the FES expansion policy was not to increase regional migration. However, the increase in school openings and the expansion to several micro-regions in Brazil encouraged this movement.

The results suggest that the expansion of FES positively affected local attractiveness, perhaps through expanding employment opportunities. However, we did not find any effect of the expansion of FES on human capital variables. Thus, our set of evidence does not support the idea that universities have a fundamental role in increasing local human capital or play an essential role in attracting qualified labor to less developed regions. A possible explanation for this result may be associated with the absence of other services (for example, health services and cultural activities) and infrastructure, which are highly valued by higher education students and highly skilled professionals in the treated MCAs. Thus, the FES expansion would not be enough to attract these individuals.

Nevertheless, note that two contingencies can also potentially help explain the results. First, as the numbers in Table 1 make clear there was a robust expansion of the number of students in higher education levels (high school and college) between 2000 and 2010, a movement associated with student expansion in primary levels of education during the 1990s. We cannot entirely rule out the possibility that this general movement had a greater benefit on bigger cities and metropolitan regions or their neighboring MCAs, where there were more higher education institutions. Second, it is also possible that our study period is too short to identify any impact on local human capital variables associated with the FES expansion. Thus, based on the results found, the expansion of the FES did not reach its proposed objectives, which suggests that the federal spatial expansion may have been exaggerated and more dynamic centers should now be prioritized.

In any case, we cannot disregard the fact that the choice of municipalities with new federal institutes may have a political rather than a technical bias, which can partially explain the result found. Since the expansion of FES is relatively recent, we also cannot entirely discard the possibility of effects on local human capital variables when considering a longer time frame. Due to the current temporal limitation of the available census data, the suggestion for future work is to verify whether there was an effect on the human capital in municipalities in the last decade with new FIs.

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Appendix

Table A1 shows the FES expansion effect considering one neighbor, five neighbors, and ten nearest neighbors for the dependent variables that were statistically significant in our results section. The results remained robust regardless of the choice of the nearest neighbors. Tables A2 to A4 do the same exercise for variables that were not statistically significant in our results section. The results for these variables confirm their initial values and non-significance.

Table A1. 1, 5, and 10 Nearest Neighbors

	One Nearest Neighbor		Five Nearest Neighbor		Ten Nearest Neighbor	
	New Immigrants	College Immigrants	New Immigrants	College Immigrants	New Immigrants	College Immigrants
	(1)	(2)	(3)	(4)	(5)	(6)
Federal System * Year	0.0220**	0.0036*	0.0151**	0.0044***	0.0187***	0.0046***
	(0.0094)	(0.0020)	(0.0068)	(0.0016)	(0.0056)	(0.0014)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Municipality Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.5224	0.5112	0.4880	0.4688	0.4730	0.3604
Observations	511	511	994	994	2,011	2,011

Note: ***p <0.01, ** p <0.05, * p <0.1. We used robust standard errors that clustered at the municipal level. The t-values are in parentheses. Columns (1) and (2) show the FSE expansion effect considering one nearest neighbor. Columns (3) and (4) show the FES expansion effect considering five nearest neighbors. Columns (5) and (6) show the FSE expansion effect considering ten nearest neighbors. Municipal controls: see note to Table 2. The dependent variables are log-transformed to facilitate interpretation of the parameters.

Tables A5 to A15 repeat the same robustness tests performed in our robustness section, although only for variables that were not statistically significant in the result section. In general, these variables continued to be unaffected by the FES expansion.

Table A2. 1 Nearest Neighbor

	High School Students	College Students	Complete High School	College Education	High School Immigrant
	(1)	(2)	(3)	(4)	(5)
Federal System * Year	-0.0034	-0.0007	0.0098	-0.0016	0.0019
	(0.0094)	(0.0042)	(0.0105)	(0.0050)	(0.0025)
Controls	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes
Municipality Fixed Effects	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.7718	0.8948	0.6406	0.9212	0.2981
Observations	511	511	511	511	511

Note: ***p <0.01, ** p <0.05, * p <0.1. Note: ***p <0.01, ** p <0.05, * p <0.1. We used robust standard errors that clustered at the municipal level. The t-values are in parentheses. Columns (1) to (5) show the FES expansion effect considering one nearest neighbor for the variables not statistically significant in our result section. Municipal controls: see note to Table 2. The dependent variables are log-transformed to facilitate interpretation of the parameters.

Table A3. 5 Nearest Neighbors

	High School Students	College Students	Complete High School	College Education	High School Immigrant
	(1)	(2)	(3)	(4)	(5)
	(0.0073)	(0.0036)	(0.0084)	(0.0041)	(0.0020)
Controls	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes
Municipality Fixed Effects	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.7129	0.8655	0.5640	0.8983	0.1359
Observations	994	994	994	994	994

Note: ***p <0.01, ** p <0.05, * p <0.1. We used robust standard errors that clustered at the municipal level. The t-values are in parentheses. Columns (1) to (5) show the FES expansion effect considering five nearest neighbors for the variables not statistically significant in our result section. Municipal controls: see note to Table 2. The dependent variables are log-transformed to facilitate interpretation of the parameters.

Table A4. 10 Nearest Neighbors

	High School Students	College Students	Complete High School	College Education	High School Immigrant
	(1)	(2)	(3)	(4)	(5)
Federal System * Year	-0.0014	0.0031	0.0047	0.0058	0.0017
	(0.0058)	(0.0031)	(0.0069)	(0.0035)	(0.0017)
Controls	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes
Municipality Fixed Effects	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.7592	0.8515	0.6231	0.8839	0.1625
Observations	2,011	2,011	2,011	2,011	2,011

Note: ***p <0.01, ** p <0.05, * p <0.1. We used robust standard errors that clustered at the municipal level. The t-values are in parentheses. Columns (1) to (5) show the FES expansion effect considering five nearest neighbors for the variables not statistically significant in our result section. Municipal controls: see note to Table 2. The dependent variables are log-transformed to facilitate interpretation of the parameters.

Table A5. Without Federal Universities

	High School Students	College Students	Complete High School	College Education	High School Immigrant
	(1)	(2)	(3)	(4)	(5)
Federal System * Year	0.0051	0.0011	0.0131	0.0026	0.0019
	(0.0071)	(0.0035)	(0.0084)	(0.0040)	(0.0021)
Controls	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes
Municipality Fixed Effects	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.7708	0.8785	0.6308	0.9061	0.1890
Observations	892	892	892	892	892

Note: ***p <0.01, ** p <0.05, * p <0.1. We used robust standard errors that clustered at the municipal level. The t-values are in parentheses. Columns (1) to (5) show the FES expansion effect by dropping all Federal Universities in the sample for the variables not statistically significant in our result section. Municipal controls: see note to Table 2. The dependent variables are log-transformed to facilitate interpretation of the parameters.

Table A6. Prouni Scholarship Grant

	High School Students	College Students	Complete High School	College Education	High School Immigrant
	(1)	(2)	(3)	(4)	(5)
Federal System * Year	0.0541	0.0479***	0.1286***	0.0713***	0.0095
	(0.0372)	(0.0160)	(0.0471)	(0.0169)	(0.0058)
Controls	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes
Municipality Fixed Effects	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.9491	0.9347	0.9105	0.9525	0.8804
Observations	499	499	499	499	499

Note: ***p <0.01, ** p <0.05, * p <0.1. We used robust standard errors that clustered at the municipal level. The t-values are in parentheses. Columns (1) to (5) show the FES expansion effect by dropping all the municipalities that received the Prouni scholarship grant for the variables not statistically significant in our result section. Municipal controls: see note to Table 2. The dependent variables are log-transformed to facilitate interpretation of the parameters.

Table A7. Higher Institution in 2000

	High School Students	College Students	Complete High School	College Education	High School Immigrant
	(1)	(2)	(3)	(4)	(5)
Federal System * Year	0.0068	0.0025	0.0165*	0.0035	0.0035*
	(0.0073)	(0.0035)	(0.0084)	(0.0040)	(0.0021)
Controls	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes
Municipality Fixed Effects	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.7662	0.8814	0.6291	0.9082	0.2043
Observations	934	934	934	934	934

Note: ***p <0.01, ** p <0.05, * p <0.1. We used robust standard errors that clustered at the municipal level. The t-values are in parentheses. Columns (1) to (5) show the FES expansion effect considering a dummy for college institutions in 2000 for the variables not statistically significant in our result section. Municipal controls: see note to Table 2. The dependent variables are log-transformed to facilitate interpretation of the parameters.

Table A8. Higher Institution in 2010

	High School Students	College Students	Complete High School	College Education	High School Immigrant
	(1)	(2)	(3)	(4)	(5)
Federal System * Year	0.0089	0.0003	0.0183**	0.0009	0.0037*
	(0.0068)	(0.0034)	(0.0081)	(0.0038)	(0.0020)
Controls	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes
Municipality Fixed Effects	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.7688	0.8843	0.6335	0.9109	0.2092
Observations	934	934	934	934	934

Note: ***p <0.01, ** p <0.05, * p <0.1. We used robust standard errors that clustered at the municipal level. The t-values are in parentheses. Columns (1) to (5) show the FES expansion effect considering a dummy for college institutions in 2010 for the variables not statistically significant in our result section. Municipal controls: see note to Table 2. The dependent variables are log-transformed to facilitate interpretation of the parameters.

Table A9. Higher Institution in 2000 and 2010

	High School Students	College Students	Complete High School	College Education	High School Immigrant
	(1)	(2)	(3)	(4)	(5)
Federal System * Year	0.0084	0.0012	0.0185**	0.0018	0.0039*
	(0.0071)	(0.0034)	(0.0083)	(0.0039)	(0.0021)
Controls	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes
Municipality Fixed Effects	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.7689	0.8851	0.6335	0.9115	0.2097
Observations	934	934	934	934	934

Note: ***p <0.01, ** p <0.05, * p <0.1. We used robust standard errors that clustered at the municipal level. The t-values are in parentheses. Columns (1) to (5) show the FES expansion effect considering two college institutions' dummies in 2000 and 2010 for the variables not statistically significant in our result section. Municipal controls: see note to Table 2. The dependent variables are log-transformed to facilitate interpretation of the parameters.

Table A10. Federal Institute in MCA

	High School Students	College Students	Complete High School	College Education	High School Immigrant
	(1)	(2)	(3)	(4)	(5)
Federal System * Year	0.0007	0.0022	0.0032	0.0019	0.0007
	(0.0026)	(0.0044)	(0.0100)	(0.0050)	(0.0026)
Controls	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes
Municipality Fixed Effects	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.1895	0.8794	0.6041	0.9036	0.1895
Observations	871	871	871	871	871

Note: ***p <0.01, ** p <0.05, * p <0.1. We used robust standard errors that clustered at the municipal level. The t-values are in parentheses. Columns (1) to (5) show the FES expansion effect considering only a Federal Institute in the MCA for the variables not statistically significant in our result section. Municipal controls: see note to Table 2. The dependent variables are log-transformed to facilitate interpretation of the parameters.

Table A11. Without MCA Divided into other Municipalities

	High School Students	College Students	Complete High School	College Education	High School Immigrant
	(1)	(2)	(3)	(4)	(5)
Federal System * Year	-0.0025	0.0028	0.0016	0.0038	0.0010
	(0.0084)	(0.0044)	(0.0103)	(0.0051)	(0.0026)
Controls	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes
Municipality Fixed Effects	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.7621	0.8766	0.6149	0.9013	0.2018
Observations	722	722	722	722	722

Note: ***p <0.01, ** p <0.05, * p <0.1. We used robust standard errors that clustered at the municipal level. The t-values are in parentheses. Columns (1) to (5) show the FES expansion effect dropping all MCAs divided into other municipalities for the variables not statistically significant in our result section. Municipal controls: see note to Table 2. The dependent variables are log-transformed to facilitate interpretation of the parameters.

Table A12. Complete Sample

	High School Students	College Students	Complete High School	College Education	High School Immigrant
	(1)	(2)	(3)	(4)	(5)
Federal System * Year	0.0064	0.0087***	0.0091	0.0113***	0.0022
	(0.0049)	(0.0029)	(0.0062)	(0.0032)	(0.0015)
Controls	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes
Municipality Fixed Effects	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.6969	0.8084	0.5385	0.8478	0.1311
Observations	8,534	8,534	8,534	8,534	8,534

Note: ***p <0.01, ** p <0.05, * p <0.1. We used robust standard errors that clustered at the municipal level. The t-values are in parentheses. Columns (1) to (5) show the FES expansion effect dropping all MCAs divided into other municipalities for the variables not statistically significant in our result section. Municipal controls: see note to Table 2. The dependent variables are log-transformed to facilitate interpretation of the parameters.

Table A13. Dropping all non-treated Neighbors

	High School Students	College Students	Complete High School	College Education	High School Immigrant
	(1)	(2)	(3)	(4)	(5)
Federal System * Year	0.0090	0.0014	0.0168**	0.0020	0.0037*
	(0.0072)	(0.0036)	(0.0082)	(0.0041)	(0.0021)
Controls	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes
Municipality Fixed Effects	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.7661	0.8813	0.6341	0.9089	0.9089
Observations	830	830	830	830	830

Note: ***p <0.01, ** p <0.05, * p <0.1. We used robust standard errors that clustered at the municipal level. The t-values are in parentheses. Columns (1) to (5) show the FES expansion effect dropping all non-treated neighbors for the variables not statistically significant in our result section. Municipal controls: see note to Table 2. The dependent variables are log-transformed to facilitate interpretation of the parameters.

Table A14. University in the Microregion

	High School Students	College Students	Complete High School	College Education	High School Immigrant
	(1)	(2)	(3)	(4)	(5)
Federal System * Year	0.0056	0.0026	0.0134	0.0039	0.0028
	(0.0070)	(0.0034)	(0.0082)	(0.0039)	(0.0020)
Controls	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes
Municipality Fixed Effects	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.7659	0.8814	0.6270	0.9082	0.1995
Observations	934	934	934	934	934

Note: ***p <0.01, ** p <0.05, * p <0.1. We used robust standard errors that clustered at the municipal level. The t-values are in parentheses. Columns (1) to (5) show the FES expansion effect considering a Federal University in a microregion for the variables not statistically significant in our result section. Municipal controls: see note to Table 2. The dependent variables are log-transformed to facilitate interpretation of the parameters.

Table A15. Falsification Test

	High School Students	College Students	Complete High School	College Education	High School Immigrant
	(1)	(2)	(3)	(4)	(5)
Federal System * Year	-0.0125**	0.0051*	-0.0168**	0.0073**	0.0007
	(0.0060)	(0.0027)	(0.0073)	(0.0029)	(0.0014)
Controls	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes
Municipality Fixed Effects	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.8878	0.7362	0.9005	0.7626	0.6092
Observations	934	934	934	934	934

Note: ***p <0.01, ** p <0.05, * p <0.1. We used robust standard errors that clustered at the municipal level. The t-values are in parentheses. Columns (1) to (5) show the FES expansion effect of a false plan lunch in 2000 for the variables not statistically significant in our result section. Municipal controls: see note to Table 2. The dependent variables are log-transformed to facilitate interpretation of the parameters.