Does University Expansion Promote Entrepreneurship?*

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July 29, 2024

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Abstract

This paper investigates whether the large-scale expansion of public universities in Brazil promoted entrepreneurship in regions characterized by high fixed costs of establishing businesses and traditionally unattractive to firms. Using a staggered differences-in-differences approach, we identify a significant 21% increase in the number of companies per 1,000 inhabitants, driven primarily by small (53%) and micro enterprises (105%). Our analysis suggests two mechanisms: local demand and human capital shocks. The expansion of universities benefits sectors related to local demand, such as retail (62%) and service (39%). Moreover, we find a 112% increase in patents and 59% rise in exporting companies, which is consistent with universities enhancing local human capital by producing skilled graduates. We also observe a 75% increase in skilled workers, indicating significant development in the local labor market. To further assess the impact of universities, we evaluate machine learning-based counterfactual assignment policies that prioritize the creation of universities in localities with the highest predicted benefits. Our findings suggest that such targeted policies can enhance the average annual growth rate of entrepreneurship to more than four times the effect of the government's previous choices, particularly by selecting more disadvantaged localities. This result underscores the advantages of strategic resource allocation in maximizing the impact of university expansions on entrepreneurship in areas with limited economic infrastructure.

JEL Classification: I25, J24, R12.

Keywords: Federal University, Entrepreneurship, Innovation, Skilled workers, Optimal policy.

*We are grateful to seminar participants at FGV EESP for helpful comments and suggestions. Martins gratefully acknowledges financial support from Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES). The usual disclaimer applies. Declarations of interest: none.

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1 Introduction

Beyond their immediate role in augmenting human capital, universities can significantly influence local economic dynamics by fostering an environment conducive to new firm formation.[1] While the literature highlights the positive effects of universities on entrepreneurship, it remains unclear whether similar outcomes can be achieved in economically disadvantaged locations that lack infrastructure or sufficient demand to offset the fixed costs associated with opening a firm.

To address this gap, this paper investigates whether the expansion of public universities in Brazil from 1998 to 2019 was able to promote entrepreneurship in such regions that are not traditionally attractive to firms. Specifically, we aim to examine whether the economic shocks generated by the university expansion were sufficient to overcome local economic barriers to firm creation. Additionally, we seek to identify the characteristics of the firms established as a result of these shocks and explore the mechanisms behind their formation. Finally, to further understand the potential of these economic shocks, we estimate the value of machine learning-based counterfactual assignment policies that prioritize the creation of universities localities with the highest predicted benefits. These policies aim to maximize the average annual growth rate of entrepreneurship by strategically placing universities in regions where they are expected to have the most significant impact.

The Brazilian Government's main focus in the public universities expansion program was to address regional disparities by establishing universities in locations previously isolated from access to higher education. The regions chosen for this initiative often exhibited high levels of poverty, low levels of educational attainment, and limited attractiveness to firms due to inadequate economic infrastructure and market potential. This strategic placement of universities in economically disadvantaged areas can stimulate local economies by providing an influx of skilled individuals and increasing local demand, thereby promoting balanced economic growth and reducing regional disparities.

To analyze the impact of this university expansion, we exploit the timing of the creation of new public universities and employ a staggered difference-in-differences approach (Callaway and Sant'Anna, 2021). Our primary results indicate a positive and statistically significant effect of university creation on the number of companies per 1000 inhabitants, with a 21% increase. This result is predominantly driven by the rise in micro and small firms, which increased by 53% and 105%, respectively.

Universities can induce two primary mechanisms that influence entrepreneurship:

[1](García-Estévez and Duch-Brown, 2020, Qin and Kong, 2021 , Tartari and Stern, 2021, Nimier-David, 2023)

local demand shocks and human capital shocks. The arrival of a university can stimulate local demand through increased consumption by students, faculty, and staff. While we find that the expansion of universities influences all sectors of economic activity, we observe particularly strong effects in sectors related to local demand, such as retail (62%) and service (39%) companies.

Second, universities can enhance human capital by producing a steady stream of skilled graduates, fostering an ecosystem conducive to innovation and competitive entrepreneurial activities. In this regard, we find a significant positive impact on innovation, evidenced by a 112% increase in the number of patents per 1000 inhabitants. Additionally, we observe an increase in the competitive capacity of firms, as indicated by a 59% rise in exporting companies. Finally, we find evidence of a positive effect on the number of skilled workers per 1000 inhabitants, with a 75% increase, suggesting a substantial impact on local development by fostering a more skilled workforce.

Taken together, our findings indicate that the existing government policy leads to an increase in firm creation even in economically disadvantaged locations. To further explore the capacity of universities to promote entrepreneurship, we adapt the methodology of Zhou et al. (2023) to evaluate three different scenarios where the available budget remains unchanged but the assignment policy prioritizes localities with the highest predicted benefits. This approach potentially enhances the impact of university expansions on the average annual growth rate of entrepreneurship.

The first scenario, the Forward-Looking Policy, assumes optimal allocation of university openings across treatment periods, leading to a growth rate increase more than four times higher than the status quo. The second scenario, the Dynamic Policy, allows for period-by-period allocation, saving 29% of the budget and resulting in a growth rate 1.4 times higher. The third scenario, the Non-Dynamic Policy, considers only one treatment, dividing municipalities into treated and non-treated groups,resulting in a growth rate six times higher than the status quo. Among these, the Non-Dynamic Policy is most effective in maximizing treated municipalities and achieving significant growth without mid-period adjustments. The Dynamic and Forward-Looking Policies offer budget efficiency with varying growth benefits.

Importantly, by leveraging socioeconomic indicators to optimize allocations, these policies address regional needs more effectively than current government criteria. Our optimal policies focus on municipalities with pronounced poverty and lower human development indicators, maximizing the transformative impact on local economic development. By considering all municipalities, especially smaller and less urban ones, these inclusive policies ensure broad demographic and geographic benefits, thereby improving governmental efforts to mitigate educational and economic inequalities across Brazilian regions. This analysis underscores the value of data-driven policies for university allocations in Brazil, showing that strategic resource distribution can enhance entrepreneurial activity and address regional disparities more effectively than the status quo.

Our paper connects to the literature in economics on how shocks interfere with entrepreneurship. This literature has focused on different types of shocks, such as job loss events (e.g., Da Mata et al., 2024), temporary public budget cuts to education funding (Babina et al., 2023), commodity price shocks (Bernstein et al., 2022), international mobility (Uhlbach et al., 2022), inventor immigration (Balsmeier et al., 2020), and lottery winnings (Bermejo et al., 2020). This paper is especially related to the branch that provides empirical evidence on how the creation of universities affects entrepreneurship (e.g., García-Estévez and Duch-Brown, 2020, Qin and Kong, 2021 , Tartari and Stern, 2021, Nimier-David, 2023). Building on this literature, this paper makes two contributions. First, our paper is unique in using machine learning-based counterfactual assignment policies to understand which socioeconomic criteria impact entrepreneurship. Second, we analyze the effects of university expansion on entrepreneurship in a developing country context, whereas previous studies predominantly focus on higher-income countries. Given the potential differences in the business environments between higher-income and low- and middle-income countries, we complement the literature by showing that the effects observed in developed economies also hold in a developing country setting.[2]

At a broader level, this work builds on the literature studying human capital and entrepreneurship. This literature widely recognizes that human capital is relevant for entrepreneurship (e.g., Bates, 1990, Zucker et al., 1998, Davidsson and Honig, 2003, Colombo and Grilli, 2005, Unger et al., 2011, Marvel et al., 2016). We contribute by studying how different socioeconomic criteria—using machine learning-based counterfactual assignment policies—for territorial reallocation of universities impact the creation of firms. Our findings indicate that expanding universities in places with more poverty and lower human development indicators would generate more firm creation. Therefore, we add to the distributional debate about the expansion of human capital in lower-income regions.

The paper proceeds as follows. Section 2 presents the background related to entrepreneurship and the expansion of Federal Universities in Brazil. Section 3 describes the data sources and the construction of the treatment variable. Section 4 defines the empirical strategy, while Section 5 reports the results. Section 6 shows counterfactual

[2] In addition, we contribute to the literature on the effects of university expansion on economic indicators, such as employment and production. In Brazil, studies show that public university expansion impact employment and educational outcomes (e.g., Conceição, 2022, Casqueiro et al., 2020, Niquito et al., 2018, Barbosa et al., 2014, and Vinhais, 2013). We add by using a different identification strategy and the advances of staggered difference-in-difference literature.

phase assignment policies. Section 7 concludes.

2 Background

According to OECD (2017), entrepreneurship is a key driver of growth due to its positive impact on job creation, worker earnings, and productivity. Thus, entrepreneurship plays an important role in innovation by offering new products, improving existing products through creative destruction, and sharing ideas with co-workers. Considering this relationship between entrepreneurship, labor market, and innovation, universities could foster a conducive business environment for firm creation through immigration and human capital accumulation.

With this in mind, we choose to analyze the Brazilian Federal University expansion to measure the effect of the university on entrepreneurship. First, it is a relevant public policy that reaches thousands of students in remote areas, then it could have generated effects large enough to be captured by the model. Second, it is a public policy to raise education indicators, but also alleviate regional inequalities. Therefore, we will introduce the context in which Brazil found itself when establishing the expansion of Federal Universities, followed by an overview of the expansion itself and, finally, characterizing the bureaucracy behind the opening of companies.

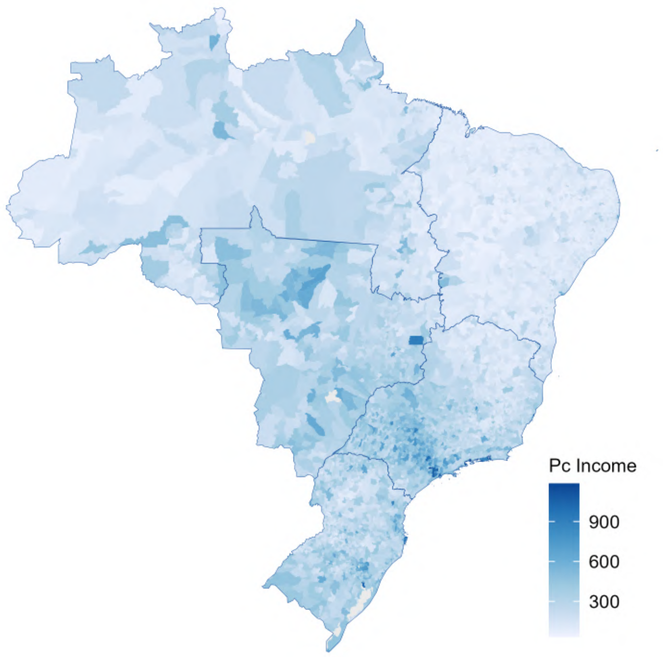
2.1 Brazilian regions

According to Barros and Mendonça (1992), despite the growth in the average income of all population groups and the reduction of poverty, income inequality in Brazil increased between 1960 and 1990. In line with the authors, this is due to greater gains in richer people relative to the earnings of poorer people.

Conforming to Monteiro Neto (2014), inequality was viewed with concern, especially among Brazilian regions. However, the economy was very troubled until the mid-1990s, so the economic reforms implemented focused on controlling hyperinflation and fiscal austerity, leaving regional development policies aside. As a result, the Brazilian scenario before the expansion of Federal Universities was one of extreme inequality between regions, as can be seen in Figure 1.

Although the north of the Southeast region is similar to the Northeast region, regional inequalities were enormous between regions. The average per capita household income in the Southeast region was around 30% higher than the average per capita household income in the Center-South and more than two times higher than that in the North and Northeast regions.

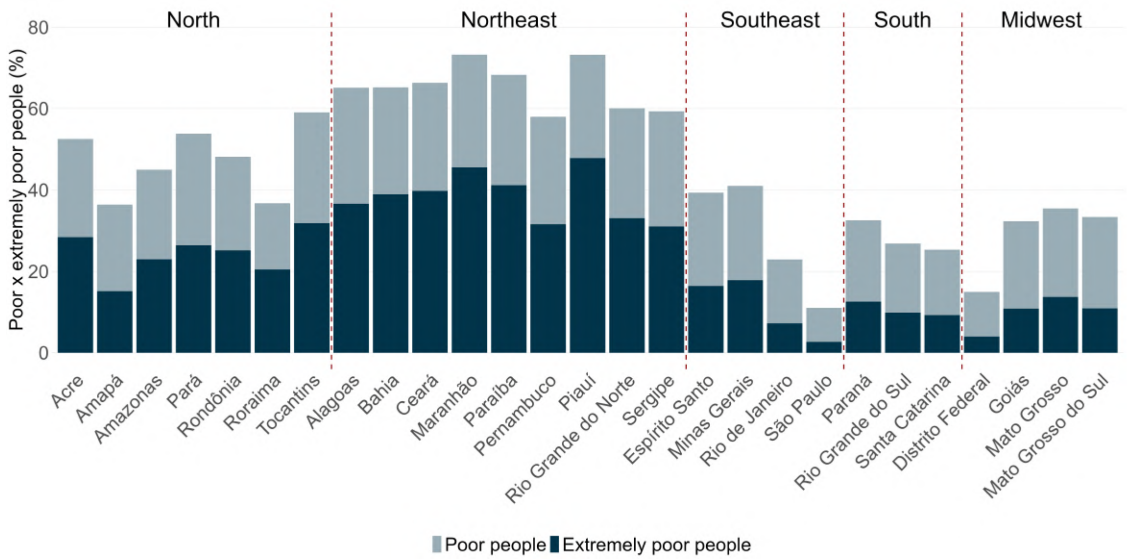
Figure 1: The average per capita household income



Notes: The average per capita household income by Brazilian municipalities. The data refer to the 1991 Census released by IBGE. The higher the average per capita household income, the darker the representative blue.

This income disparity can be seen by the percentage of poor people in each region, including extremely poor people, in Figure 2.

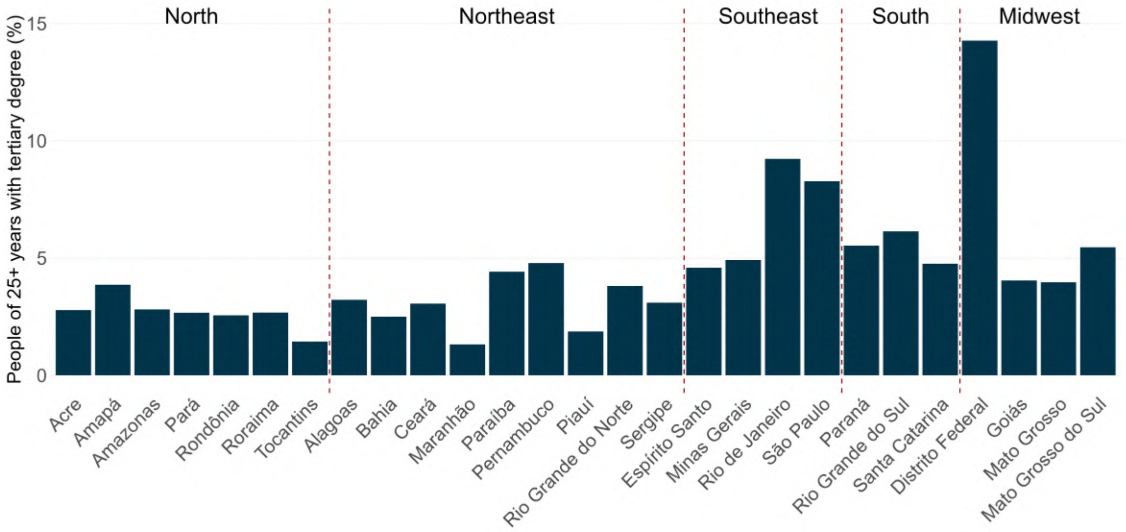
Figure 2: Poor and extremely poor population (%) - 1991



Notes: Percentage of poor and extremely poor population by Brazilian States. The data refer to the 1991 Census released by IBGE.

Inequality between regions is not limited to income but encompasses any other factors before or resulting from income inequality itself. This is the case of inequality in access to education, as in the case of our particular interest, the inequality in the percentage of people with higher education in each region, as can be seen in Figure 3.

Figure 3: People with tertiary degree (%) - 1991



Notes: The percentage of people of 25 years or more with a tertiary degree. The data refer to the 1991 Census released by IBGE.

There is a notable vicious cycle of inequality, in which some regions are poorer, more unequal, and do not have access to the necessary means to earn higher incomes. Thinking about breaking this cycle, the government implement public policies to make regions more similar and prevent productive potential from being wasted due to lack of opportunity. Such public policies only became viable after the stabilization of the economy in the late 1990s and early 2000s. Once inflation was under control, Brazil began to grow and opportunities became more feasible. The job market became more dynamic and the government advanced in implementing income transfer programs and other policies, which mainly benefited the poorest regions. As a result, it was possible to observe a reduction in inequality at the end of the 1990s, including within and between regions, as reported by Monteiro Neto (2014).

Despite the improvement in inequality rates, Brazil remains extremely unequal, which can hinder the country's overall development. According to Barros et al. (2006), the income of the poorest needs to increase more than the growth in the income of the richest, as greater income equity would improve the conditions of the poorest to compete with others (for example, in the business market). This is because a family environment with sufficient income is very important in determining the performance of children and adolescents at school and, consequently, in the job market, the authors point out. Therefore, families with less disparate incomes would have more similar opportunities to develop their potentials.

In a more recent analysis carried out by Góes and Karpowicz (2017), the authors report the reduction in the percentage of the population in extreme poverty and poverty, as well as the convergence of income between states and the fall in inequality between 2004 and 2014, including within states. According to the authors, these results are due to economic growth, formalization of the job market, income gains, increased education, and social and income inclusion policies (in particular, Bolsa Família).

In general, income inequality can be influenced by three major mechanisms, according to Barros et al. (2006): (i) demographic factors; (ii) household income – from work or another source; and (iii) access to work.

Scholars on the topic highlight the importance of household income for reducing income inequality in Brazil. The main point concerns the effect of the Bolsa Família income transfer program, responsible for increasing the per capita household income of thousands of people, in addition to secondary effects on health and education due to conditionalities. Another important factor is income from work, which also showed relevant increases, both due to the stronger economic period and the remuneration of more educated workers.

Considering such mechanisms, it is possible to use them to understand the evolution of income inequality, but they are also of utmost importance for designing public policies that can directly or indirectly affect inequality, both in aggregate at the country level, and within and between states.

From this perspective, public policies that promote access to higher education can also be seen as a means to improve educational attainment rates, but also as a tool to promote income equality for providing the possibility of greater income gains. This was one of the objectives of the expansion of Federal Universities.

2.2 Brazilian Federal Universities expansion

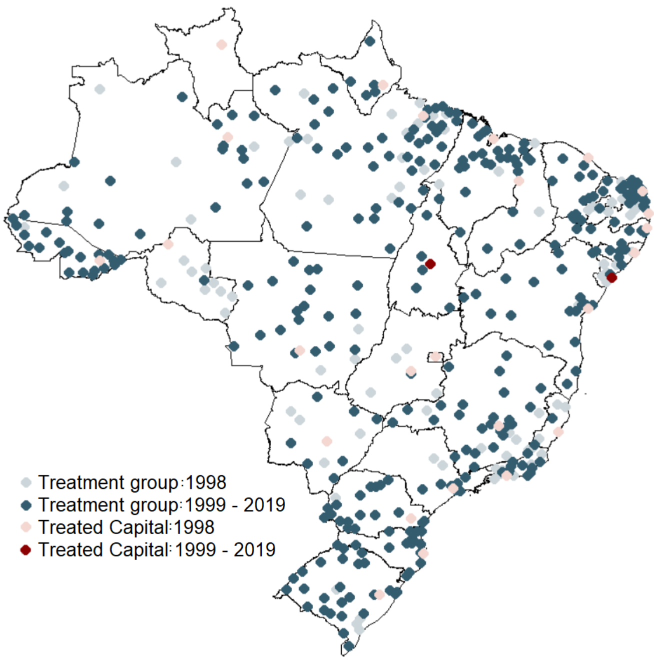
OECD (2022) indicates that people with tertiary education represent an important part of the OECD population between 25-64 years old—about 40%—while this percentage is around 20% for the Brazilian population. Although there is much to be done, progress in education has occurred recently in Brazil.

The Brazilian government has adopted policies to improve access to public tertiary education, as is the case of Federal Universities expansion. First of all, the government increased the number of Federal Universities, vacancies, and courses. Second, the government intensified the Federal Universities expansion. For this reason, the plan for Reestruturação e Expansão das Universidades Federais (REUNI) was created in

2007 by Decree Number 6096. Besides the purpose of increasing the population with tertiary degrees, REUNI also defined the role of Federal Universities as a driver of regional development. Therefore, REUNI established some criteria to choose where the expansion of Federal Universities would occur. According to the Social, Geographic and Development Dimensions, universities would be located in more vulnerable places, with difficult access to higher education and with potential for growth[3].

The program focused on increasing the number of tertiary education institutions, courses, and vacancies in the countryside, mainly at night. In addition, the program developed complementary policies to reduce the dropout rate and to use idle capacity. Therefore, this public policy was reinforced by an inclusive character in which the university should be more accessible to the most vulnerable population. We can see the Federal Universities expansion in the figure 4, which had an essential role in bringing tertiary education to remote areas. Throughout the period analyzed, around 60% of new campuses were implemented in the North and Northeast regions.

Figure 4: Geographic distribution of Brazilian Federal Universities



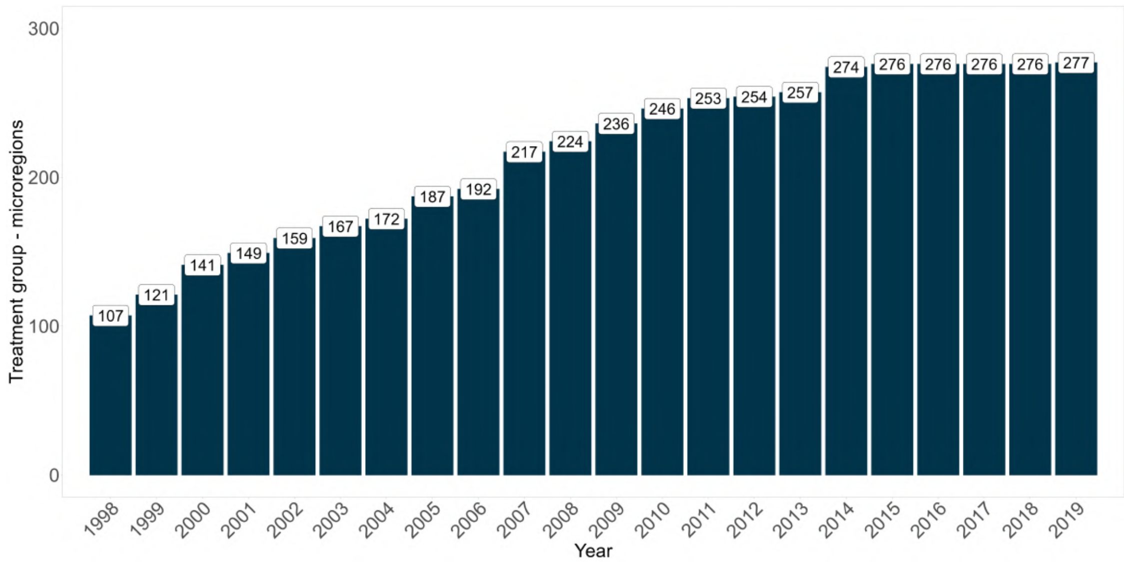
Notes: The points represent the municipalities with at least one Federal University during the period from 1998 to 2019.

In addition to these changes, the Federal Universities represented a large portion of public tertiary education in Brazil. Next, we present some figures to illustrate its importance to the current Brazilian educational setting: there are 63 Federal Universities (about 60% of the public universities in Brazil); there are more than 1 million students

[3] See details in: BRASIL (2007), BRASIL (2009), BRASIL (2014)

(more than 65% of public university enrollments); and there are around 100,000 teachers in these institutions. Figure 5 shows the Brazilian Federal Universities expansion at the microregion level between 1998 and 2019. Only 107 microregions were contemplated with at least one Federal University by 1998; this number gradually increased to 277 microregions in 2019. These 277 microregions encompass 2763 municipalities (50% of Brazilian municipalities).

Figure 5: Brazilian Federal Universities expansion in microregions - 1998-2019



Notes: Evolution of the number of microregions with at least one Federal University during the period from 1998 to 2019.

Despite the mechanical effect expected by the creation of universities—that is, if universities had offered more vacancies, more people would have access to the tertiary degree—it is not apparent what the effects of a new university and human capital accumulation shock on the local economy are. In this way, we are interested in analyzing the implementation of Federal Universities in Brazilian microregions as a tool for economic development, specifically by entrepreneurship. Thus, we explore the timing of Federal university expansion to solve the potential endogeneity problem to measure the causal effect and identify possible explanations.

2.3 Starting a Business in Brazil

Opening a business in Brazil involves a multifaceted environment that presents both challenges and opportunities. Several key factors impact the ease of starting and operating a business in Brazil, including regulatory hurdles, taxation, labor market regulations, and access to credit. This section delves into these aspects.

Regulatory Environment. The regulatory landscape in Brazil is complex, characterized by bureaucratic inefficiencies that pose significant challenges to new businesses. The process of starting a business in Brazil involves 11 procedures, taking an average of 17 days and costing approximately 4.2% of income per capita (World Bank (2020)). Despite efforts to streamline procedures, Brazil ranks 138th globally in ease of starting a business. Key steps include registration with the Commercial Board, obtaining a CNPJ (Brazilian Federal Tax Number), and registering with the Social Security Institute.

Taxation and Compliance. Brazil's tax system is one of the most complex in the world, with multiple taxes at the federal, state, and municipal levels. Businesses must navigate taxes such as ICMS (state VAT), ISS (municipal service tax), and COFINS (federal social contribution tax). Compliance is further complicated by frequent changes in tax regulations. Businesses in Brazil spend an average of 1,501 hours per year on tax compliance, with a total tax rate of 65.1% of profit (World Bank (2020)).

Labor Market Regulations. The labor market in Brazil is governed by the Consolidação das Leis do Trabalho (CLT), which imposes stringent regulations on employment contracts, working hours, and employee benefits. While these laws aim to protect workers' rights, they also introduce rigidity in hiring and firing practices. Employers face significant costs related to severance and mandatory benefits, which can impact operational flexibility and cost management. Brazil's redundancy cost, expressed in weeks of salary, is relatively high, affecting the ease of adjusting workforce levels.

Access to Credit. Access to credit remains a critical barrier for new businesses in Brazil. The banking sector is concentrated, with high interest rates and stringent lending criteria. Obtaining credit in Brazil is more challenging than in many other emerging economies (World Bank (2020)), primarily due to high collateral requirements and a lack of comprehensive credit information systems.

3 Data

We use Brazilian microregion data from 1998 to 2019. We do not use the years affected by the COVID-19 pandemic (2020 and 2021) and the years before 1998 because there are no necessary variables to make the data comparable. Moreover, we use data at the microregion level since the effects are primarily on the labor market and local economy, which could present spillovers to neighbors—mainly for small municipalities. The data were obtained from six sources.

Higher Education Census released by the Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira (INEP). The Higher Education Census collects detailed information on higher education institutions. This data helps in understanding the educational landscape across different regions in Brazil. We use this database to obtain the total number of students enrolled in on-site undergraduate courses in higher education institutions in each microregion over time.

From the Higher Education Censuses, we obtained the necessary information for constructing the treatment variable. We define the treatment variable as microregions with at least one Federal University and a positive number of on-site undergraduate enrollments. This way, the treatment variable will assume a value equal to 1 if treated and zero otherwise. To identify these treated microregions, we use some criteria, as defined below: (i) university as an academic organization; (ii) federal administrative category; (iii) graduation academic level; (iv) on-site classes; and (v) positive number of enrollments.

Instituto Nacional da Propriedade Intelectual (INPI). INPI is part of an international system that simplifies and reduces costs for the registration of industrial designs by Brazilian companies in other countries. INPI provides data on the number of invention patents registered. This database is valuable for evaluating innovative activities and the technological advancement of different regions.

Receita Federal. The Receita Federal provides comprehensive data on companies, which is crucial for analyzing the economic activity and business environment in various regions in Brazil. From this database, we get detailed economic information about registered companies in each microregion, including the size of their revenue, the economic sector they belong to, and the total number of companies (the main outcome).

Relação Anual de Informações Sociais (RAIS). RAIS is a socioeconomic information report requested annually by Ministério do Trabalho e Emprego from employers. RAIS offers insights into the formal labor market, which is essential for understanding employment trends and workforce composition. We use RAIS to obtain the number of employed workers and their education level in each microregion.

Secretaria de Comércio Exterior (SECEX). SECEX data includes information on foreign trade in different regions of Brazil, which is key to assessing the level of international trade and economic openness. We use this databse to obtain the number of exporting companies in each microregion.

1991 Population Census released by the Instituto Brasileiro de Geografia e Estatística (IBGE). The 1991 Population Census offers a demographic snapshot of Brazil, including total population, the share of poor population, and the share of urban and rural population. This census data is fundamental for demographic analysis and long-term trend studies. We use this information to normalize the outcomes (relative to 1000 inhabitants) as well as to include them as covariates in the models. Moreover, we use the average per capita household income, the poor and extremely poor population, and the percentage of individuals aged 25 or older with a tertiary degree to illustrate some regional inequalities previously.

Appendix shows some descriptive microregion statistics before the treatment in table A.1.

4 Empirical Strategy

To study the effects of universities on entrepreneurship, we use a staggered differences-in-differences approach (Callaway and Sant'Anna, 2021). We seek to recover a causal effect of the university on entrepreneurship, but the implementation of universities probably has an endogeneity problem, since the choice of municipalities could be correlated with some omitted variable since universities' implementation was not random. With this in mind, we choose a model that would solve this potential endogeneity problem.

Moreover, we recognize that the assumption of homogeneous treatment would not be adequate since there is a difference in the timing of intervention. In this context, the effect could be different by the year in which the treatment was implemented and how long the municipality was exposed to the treatment; that is, the instantaneous and dynamic effects could be heterogeneous.

We define the intervention as a discrete variable and assume a linear model concerning the parameters. Thus, these two simplifications exclude the need to estimate more complex models.

In addition, we also consider that if the microregion is treated in any year, it will be considered treated in all subsequent years; that is, we do not allow turn-off. This choice is due to the treatment since the microregion treated will persistently affect the population's behavior and perspective.

Finally, we use the "not yet treated" microregions as a comparison group since the never treated microregions are different.

We use the following specification to estimate the Average Treatment Effect on the Treated (ATT):

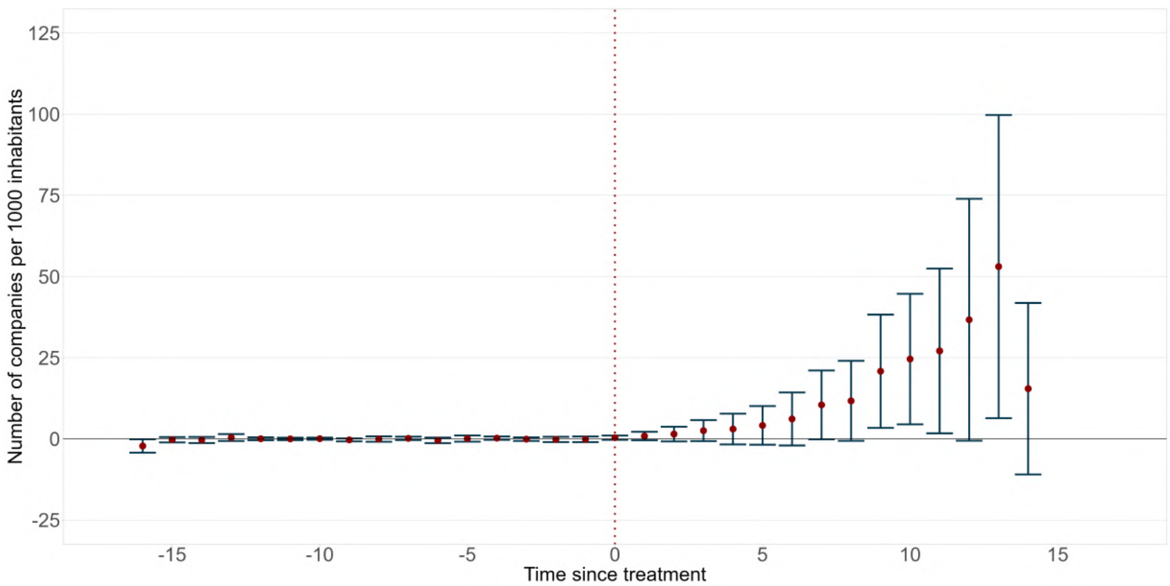
$$Y_{mt} = \sum_{\tau \neq -1} \beta_\tau \, Treat_m \mathbf{I}(t - FirstTreat = \tau) + \alpha X_{mt} + \theta_m + \theta_t + \epsilon_{mt} \quad (1)$$

in which: Y_{mt} is the outcome variable per 1000 inhabitants of microregion m in period t (number of companies; number of companies by revenue, number of workers, and sector; the number of total workers and skilled workers; exporting companies; the number of patents; and enrollments); $Treat_m \mathbf{I}(t - FirstTreat = \tau)$ indicates when the microregion m is treated; X_{mt} is a matrix of covariates of microregion m in period t; θ_m and θ_t are fixed effects; and ϵ_{mt} is the idiosyncratic error. The standard errors were calculated from the bootstrap multiplier with 1000 replications, and the standard errors are clustered at the microregion level for better inference.

5 Results

The first step is to estimate the effect of the Federal University on the number of companies per 1000 inhabitants. We see a positive and statistically significant effect in figure 6. The ATT is 14.57 on the average number of companies per 1000 inhabitants (70.23), which means an effect of about 21% on average.

Figure 6: Effect of university on number of companies per 1000 inhabitants



Notes: This figure explores the effects of the Federal Universities on the number of companies per 1000 inhabitants, according the Equation 1. We use not yet treated as the comparison group. The covariates are the share of poor population in 1991 and the share of the urban population in 1991. The significance level is 5%. Standard errors are clustered at the microregion level.

The last period of the graph (period 14) refers to the effect in 2013 of the group of 14 microrregions treated starting from 1999. Subsequent periods were not estimated due to the insufficient number of control groups for the chosen method. It is important to note that this drop in effect in the last period is mechanical, as the group of microrregions treated starting from 2000 is not included in this aggregated effect, and this group represents the highest annual effects.

In table 1, we compare the effects on the number of companies per 1000 inhabitants between the specification without (column 1) and with (column 2) covariates. Despite a small difference in magnitude, both specifications estimate a positive and significant effect on the main outcome.

Table 1: Effect of university on number of companies per 1000 inhabitants

Model	**Companies per 1000 pop.**	
	(1)	(2)
Effect	17.76***	14.57***
	(5.59)	(4.47)
Microregion FE	Yes	Yes
Year FE	Yes	Yes
Covariates	No	Yes

Notes: This table presents the overall summary of ATT based on the dynamic aggregation of the effects of Federal Universities on the number of companies per 1000 inhabitants, according to Equation 1. We use not yet treated as the comparison group. The covariates in the column (2) are the share of poor population in 1991 and the share of the urban population in 1991. Standard errors are clustered at the microregion level (in parentheses). ***p<0.01, **p<0.05, *p<0.10.

As we find a positive effect of the university on the number of companies, the next step is to analyze the characteristics of these companies and explore possible explanations for this effect.

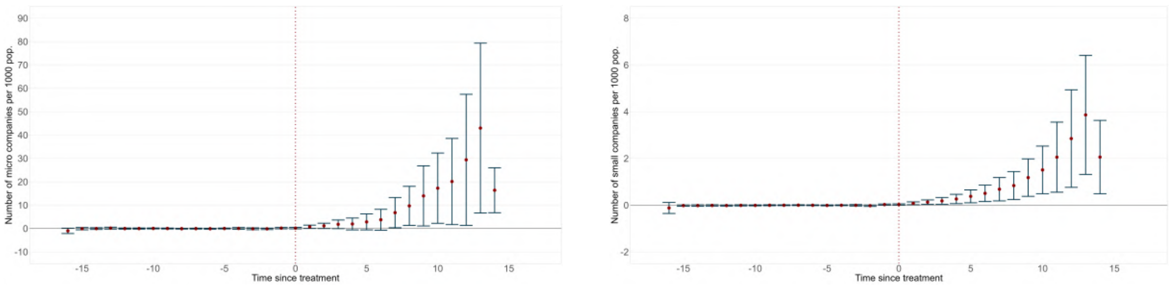
5.1 Heterogeneity

We explore these new firms to understand what the implementation of the university caused. Thus, we estimate the effect considering the company size by revenue[4]. As we can see in the figure 7, there is a predominant effect on micro and small companies. The effects of the university are 53% on micro companies and 105% on small companies, both statistically significant. In contrast, there is no significant effect on

[4]Companies are classified according to their annual revenue: micro-companies – less than R$360 thousand per year; small companies – between R$360 thousand and R$4.8 million per year; and large companies – more than R$4.8 million per year.

large companies, as shown in figure B.1. Therefore, the effect of the university on entrepreneurship is driven mainly by micro and small companies.

Figure 7: Federal University effect on number of companies - size by revenue



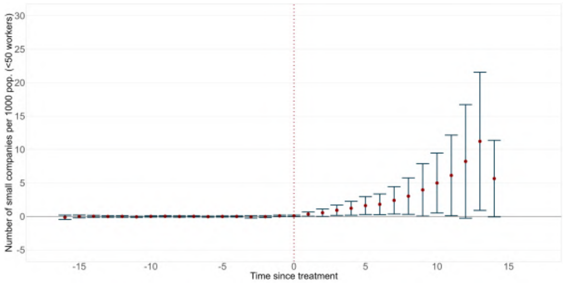
(a) Micro companies **(b)** Small companies

Notes: This figure explores the effects of the Federal Universities on (a) the number of micro companies per 1000 inhabitants, and (b) the number of small companies per 1000 inhabitants, according the Equation 1. We use not yet treated as the comparison group. The covariates are the share of poor population in 1991 and the share of the urban population in 1991. The significance level is 5%. Standard errors are clustered at the microregion level.

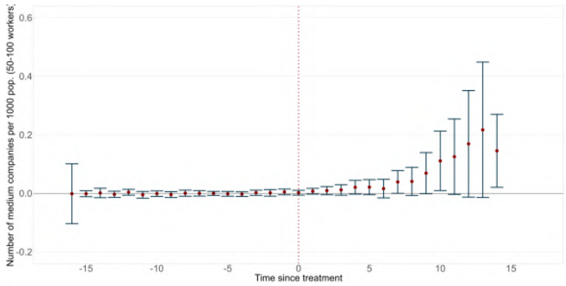
Moreover, we analyze the effect according to the company size by number of workers. In figure 8, the effect is positive and statistically significant for all sizes of companies: 42% in small companies, 51% in medium companies, and 39% in large companies. [5]

[5] We classified companies conforming to the number of employees: small - up to 50 workers; medium - between 50 and 100 workers; and large - more than 100 workers.

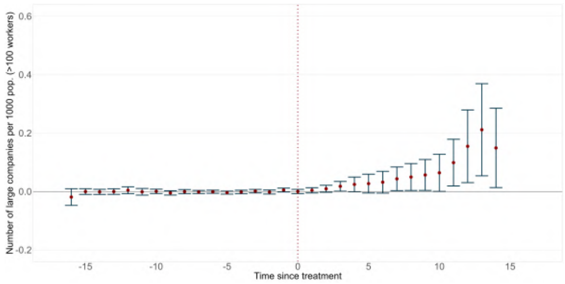
Figure 8: Federal University effect on number of companies - size by number of workers



(a) Small companies (<50 workers)



(b) Medium companies (50-100 workers)



(c) Large companies (>100 workers)

Notes: This figure explores the effects of the Federal Universities on (a) the number of small companies – with fewer than 50 employees – per 1000 inhabitants, (b) the number of medium companies – with 50 to 100 employees – per 1000 inhabitants, and (c) the number of large companies – with more than 100 employees – per 1000 inhabitants, according the Equation 1. We use not yet treated as the comparison group. The covariates are the share of poor population in 1991 and the share of the urban population in 1991. The significance level is 5%. Standard errors are clustered at the microregion level.

5.2 Mechanisms

In this section, we seek evidence of two possible mechanisms to explain the positive effect we found in the previous section. These mechanisms are (i) immigration and (ii) change in the composition of workers. We focus on testing (1) whether the demand for services and goods increased due to the Federal university expansion and (2) whether skilled workers affected innovative entrepreneurship.[6]

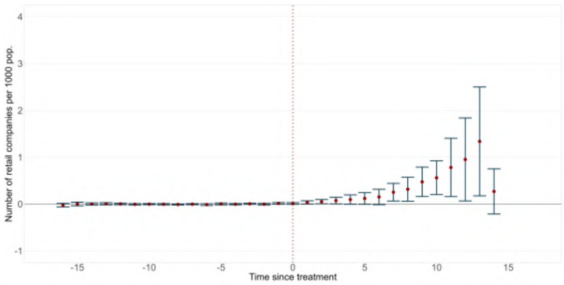
According to the literature, the implementation of the university could attract immigrants to its microregions. People could move to study or work at the university. People could see the university as a business opportunity. With immigration, incumbent companies may not be able to satisfy an increase in demand for goods and services, so new companies could open to satisfy the demand of new consumers. Thinking about testing this mechanism, we estimate the effect of the university for

[6]We define skilled workers as those with tertiary education.

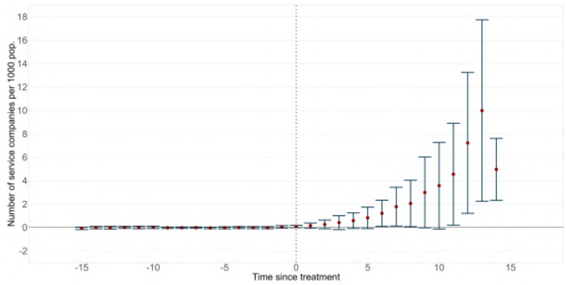
each sector (retail, service, and others) to verify if there is an increase in the number of companies to supply these day-to-day needs.

As we can see in figure 9, the university increases, on average, the number of companies in retail (62%) and services (39%), but also it raises the number of firms in other sectors of the economy (18%). Although the effect was not immediate, it has persisted over time, which can be explained by the gradual increase in course supply.

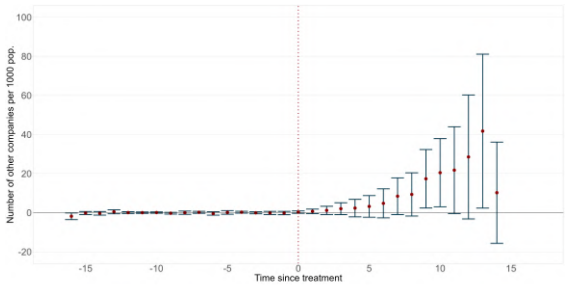
Figure 9: Federal University effect on number of companies - sectors



(a) Retail companies



(b) Service companies

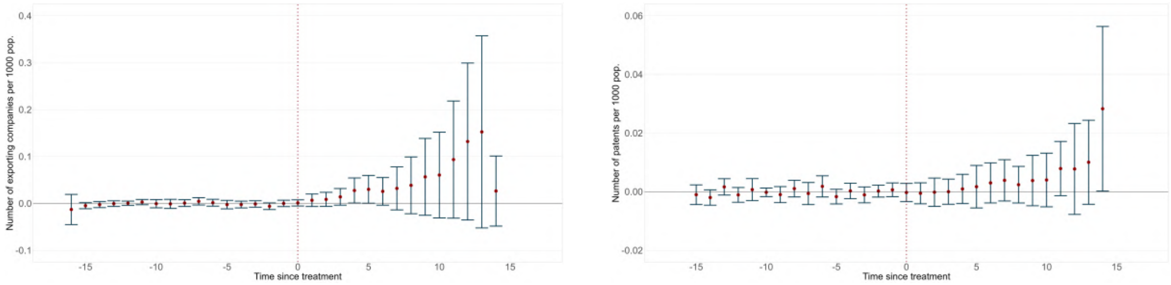


(c) Other sectors

*Notes:*This figure explores the effects of the Federal Universities on (a) the number of retail companies per 1000 inhabitants, (b) the number of service companies per 1000 inhabitants, and (c) the number of other companies per 1000 inhabitants, according the Equation 1. We use not yet treated as the comparison group. The covariates are the share of poor population in 1991 and the share of the urban population in 1991. The significance level is 5%. Standard errors are clustered at the microregion level.

The second mechanism is whether the increased number of skilled workers generated more innovative businesses. The first step is to verify if the university increased the number of skilled workers in the treated microregions. According to figure B.2, we observe an average increase of 75% in the number of skilled workers. Next, we verify if the firms become more innovative with the advent of the university. So, we measure the effect of the university on the number of exporting companies and the number of patents, shown in figure 10. Although it is unclear graphically, the average effects are positive and statistically significant (59% and 112%, respectively).

Figure 10: Federal University effect on innovative entrepreneurship



(a) Exporting companies **(b)** Number of patents

Notes: This figure explores the effects of the Federal Universities on (a) the number of exporting companies per 1000 inhabitants, and (b) the number of patents per 1000 inhabitants, according the Equation 1. We use not yet treated as the comparison group. The covariates are the share of poor population in 1991 and the share of the urban population in 1991. The significance level is 5%. Standard errors are clustered at the microregion level.

Considering all these findings, the university's implementation improves productivity probably due to more skilled workers available.

5.3 Robustness

Sanity check. First, we check if the expected mechanical effect for the university occurred, i.e., if the university increases the number of people enrolled in higher education. Figure C.1 shows a positive effect on the number of enrollments per 1000 inhabitants. On average, this effect is 72%.

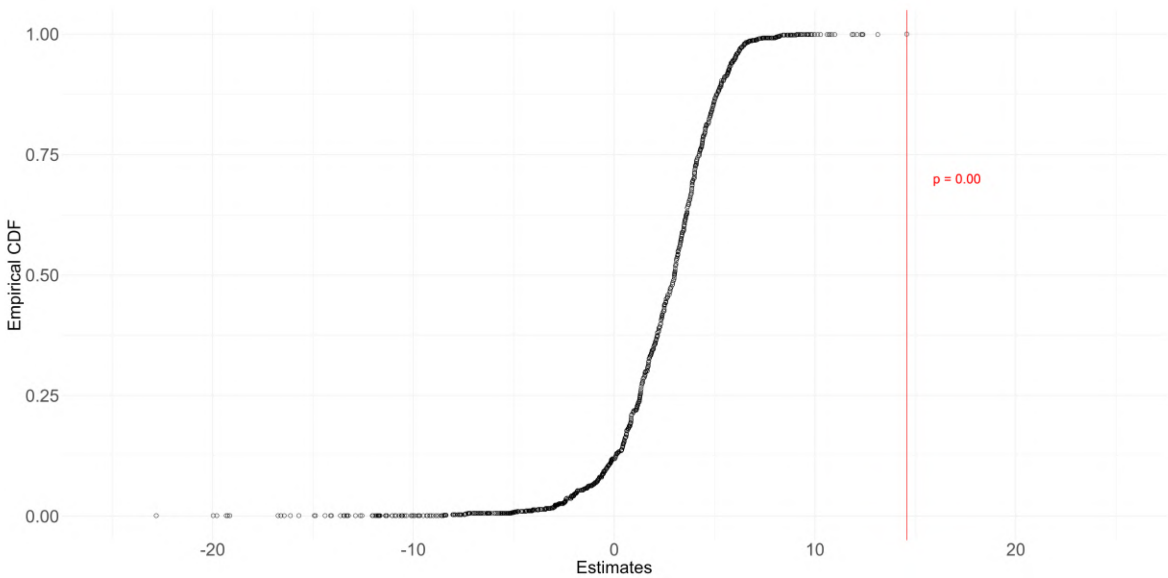
Covariates. We estimate the effect of the university on the number of companies per 1000 inhabitants without the covariates. We can observe a similar effect to that estimated with covariates (see Table 1), while also satisfying the Parallel Trends hypothesis (see Figure C.2).

Other estimators. In order to provide further evidence to corroborate the results estimated by the Callaway and Sant'Anna (2021) method, we also estimated the effect using similar estimation methods. Although Parallel Trends is satisfied in all periods only in Callaway and Sant'Anna, we can observe a positive trend in the effect of Federal Universities on the number of companies per 1000 inhabitants across the different methods used from Figure C.3. It is worth noting that all specifications do not include covariates and use not yet treated as the control group for a better comparison.

Some caveats regarding the comparison between methods must be made. First, it is likely that the TWFE estimate is biased, as the effects are heterogeneous between groups. Second, the method by Borusyak et al. (2024) requires stronger identification assumptions, which is excessive considering that there are other viable methods to estimate the effect of interest in this study. Third, the method by De Chaisemartin and d'Haultfoeuille (2022, 2024) imposes some degree of homogeneity in covariates, which could result in a loss of information. Finally, the result most similar to the estimate is from Sun and Abraham (2021), although this method uses only the treated group in the last period as the control.

Fake treatment. Lastly, we do a fake treatment exercise. We reallocate the year of the treatment for the treated microregions at some point, maintaining the number of microregions treated each year. Then, we estimate the ATT for the 1000 replications and plot the effects altogether. The true effect is the extreme case, as we can observe in the Figure 11. Thus, we interpret this result as evidence favoring our findings.

Figure 11: Federal University effect on number of companies - placebo treatment



*Notes:*we use not yet treated as the comparison group. The covariates are the share of poor population in 1991 and the share of the urban population in 1991.

6 Counterfactual phase assignment policies

The government budget for investing in universities is limited. Both the total amount available for university funding and the budget allocated for each specific timing of university openings are constrained. Opening a university earlier incurs a higher future cost due to the increasing operational expenses over time. For each government decision regarding the timing of a university opening, we consider the present value of the average maintenance cost of a university.

Given the substantial treatment effects associated with different timings of university openings, relaxing these budget constraints could potentially create significant value. However, budget constraints are likely to remain a persistent issue for the government. Therefore, it is crucial for the government to reallocate resources more efficiently based on local development objectives. In this context, we focus on promoting entrepreneurship growth. With heterogeneous treatment effects, assignment policies that prioritize specific municipal characteristics could enhance the impact of university expansions in entrepreneurship growth.

This section aims to quantify the potential gains from such policies. We conduct an analysis to estimate the benefits of introducing a policy that, within given budget constraints for each government expansion phase, assigns universities to municipalities in a way that maximizes the sum of predicted treatment effects across different timing scenarios.

An assignment policy maps municipalities' characteristics $X \in \mathcal{X}$ and budget constraints for each government expansion phase $C = (C^1, C^2, \ldots, C^A) \in \mathcal{C}$ to assignments: $\pi : \mathcal{X} \times \mathcal{C} \to \mathcal{A}$, where $\mathcal{A} \equiv \{P^1, P^2, \ldots, P^A, N\}$. Here, P^a denotes *the a-th government expansion phase*, and N denotes *No-Treatment*. $\mathcal{C}$ represents the grid of possible budget (capacity) levels under consideration. Policy estimation and evaluation are conducted separately. The objective of policy estimation is to derive a mapping from municipalities' characteristics and the government's budget (capacity) level to the decision of opening a university in the municipality.

This mapping, $\hat{\pi}$, is estimated using a training set. Across all analyses, we obtain training and testing sets by randomly splitting the data at the municipality level with equal probability. To evaluate a policy, we proceed in two steps: first, we apply the estimated mapping to the testing set, where for each municipality m in the test set and each $C \in \mathcal{C}$, we obtain the counterfactual assignment of municipalities to receive a university, $\hat{\pi}(X_m, C) \in \mathcal{A}$. Second, for each $C \in \mathcal{C}$, we construct the Augmented Inverse Propensity Weighting (AIPW)[7] estimates of the "policy value," which is the value of the outcome when treatments are assigned according to $\pi(X_m, C) \in \mathcal{A}$. We achieve this using cross-fitting in the testing sample, where we estimate new outcome and propensity models and obtain AIPW estimates of the policy values in held-out folds.

[7] Zhou et al. (2023)

6.1 Optimal Assignment Policies

Let $z_{ma} \in \{0, 1\}$ be a variable indicating whether municipality m is assigned to receive a university $a \in \mathcal{A}$, and let z^*_{ma} be the arguments maximizing the sum of treatment effects given by Equation 2:

$$\begin{aligned} &\max_{z_{ma}} \sum_{m=1}^{M} \sum_{a \in \mathcal{A}} z_{ma} \tau_m^a \\ &\text{s.t.} \quad \sum_{m=1}^{M} z_{ma} \leq C^a \quad \forall a \quad \text{and} \quad \sum_{a \in \mathcal{A}} z_{ma} = 1 \quad \forall m, \end{aligned} \tag{2}$$

where $\tau_m^a = \mathbb{E}[Y(a) - Y(O)]$. The first constraint ensures that the budget (capacity) limits are not violated, and the second ensures that each municipality is assigned to one treatment period. A policy that induces the allocation z^*_{ma} is termed the *optimal policy*. In Appendix D, we provide further details on the estimation of the *optimal policy* using training data, where $\hat{\pi}$ denotes the estimate.

We use the average treatment effect as the metric to compare policies. The outcome variable used in the algorithm's maximization is the average annual growth rate of entrepreneurship, measured in percentage points. We use several key variables to characterize municipalities[8]. We consider the following policies:

Forward-looking Policy: This policy assumes that the government can observe and optimally allocate the opening of universities across the possible treatment periods before the start of the treatment years.

Dynamic Policy: This policy allows the government to decide whether to open universities each period. If no universities are opened in a treatment period, the resulting budget can be rolled over to subsequent periods[9].

Non-dynamic Policy: This policy considers only one treatment, dividing municipalities into treated and non-treated groups, and uses the total budget allocated to

[8] Income per Capita in 10th Decile, Fundamental Education Rate (15-17), High School Rate (18-24), Proportion of Poverty, Income Share of Bottom 20%, Income Share of Top 20%, Ratio of Top 20% to Bottom 40%, Income per Capita in Poverty, Human Development Index,education component of HDI, and income component of HDI, Population Share Aged 18-24, Urban Population Share, Total Population, and Income per Capita

[9] To implement the "Forward-looking" and "Dynamic" policies, we divided the 21-year university expansion period into six Government expansion phases: $P^1 = 1999, 2000, 2001$, $P^2 = 2002, 2003, 2004$, $P^3 = 2005, 2006, 2007$, $P^4 = 2008, 2009, 2010$, $P^5 = 2011, 2012, 2013$, $P^6 = 2014, 2015, 2019$ and allow N as No-Treatment. The government's budget is set as the present value of the average cost of a university for each expansion phase: $C^1 = 1999, 2000, 2001$, $C^2 = 2002, 2003, 2004$, $C^3 = 2005, 2006, 2007$, $C^4 = 2008, 2009, 2010$, $C^5 = 2011, 2012, 2013$, $C^6 = 2014, 2015, 2019$.

Table 2: Results

	Forward-Looking	Dynamic	Non-Dynamic
Value diff p.p	0.46	0.06	0.79
x Status quo	4.15	1.43	6.43
% Government Spending Status quo	99.81	71.26	100.00
% Universities Status quo	93.19	97.02	100.00

Government growth rate: 0.1413 p.p (the number of firms increases by about 0.1413 p.p per year)

municipalities treated during the period.

The results, presented in Table 2, reveal distinct outcomes for each policy scenario. The “Forward-looking” policy utilizes almost the entire available budget, allocating resources exclusively to treatment phase P^2, and leads to a 7% reduction in treated municipalities. Despite this reduction, it achieves an increase in the annual growth rate of 0.46 percentage points, with the policy’s expected value more than quadrupling compared to the status quo.

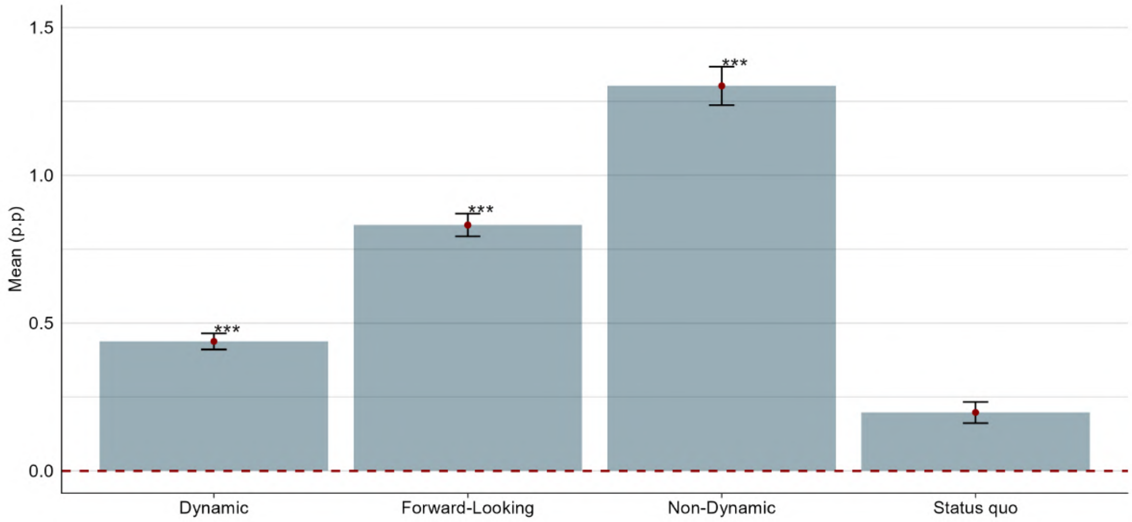
Conversely, the “Dynamic” policy treats 3% fewer municipalities than the status quo while using only 71% of the total budget. Despite the budget savings, this policy results in an annual entrepreneurial growth rate increase of 0.06 percentage points. Demonstrating that the ability to allocate resources optimally each period allows for targeted investments where the growth in entrepreneurship can be maximized.

The “Non-dynamic” policy maintains the government’s full treatment capacity, resulting in an annual entrepreneurial growth rate increase of 0.76 percentage points – over six times the growth rate of the status quo.

In summary, while the “Non-Dynamic” policy stands out for maximizing the number of treated municipalities and achieving significant growth in entrepreneurship without requiring mid-period adjustments, the ”Dynamic” policy demonstrates budget efficiency with modest growth benefits. Meanwhile, the “Forward-Looking” policy combines budget efficiency with growth advantages, presenting a balanced approach to resource allocation and potential impact.

Building on the analysis of optimal policy effects at the municipal level, Figure 12 expands the evaluation to Brazilian micro-regions, maintaining the treatment timing discussed in section 4.

Figure 12: Evaluation of Counterfactual Policies - Micro-regions



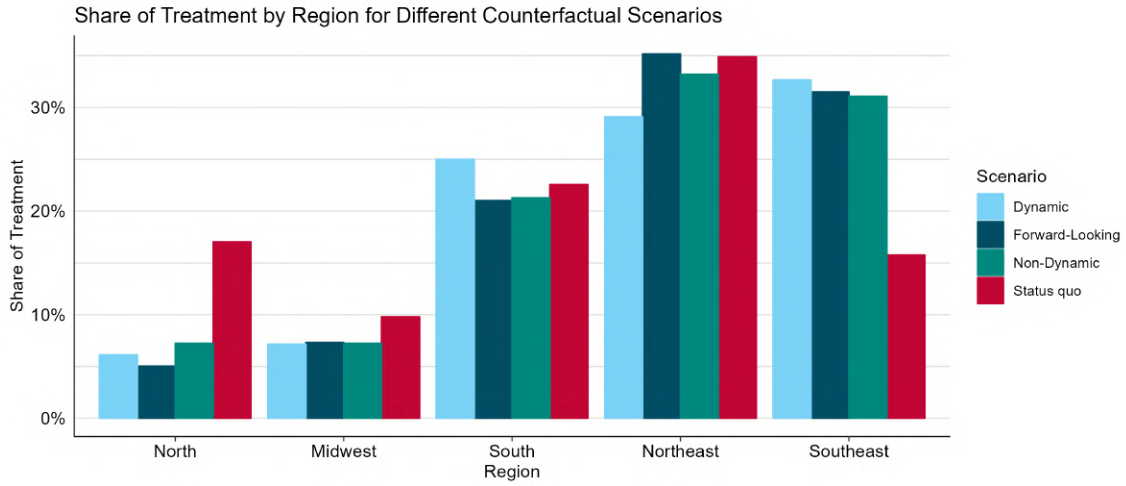
Note: Estimates of policy values. The policy value is the average annual growth rate of entrepreneurship in percentage points, measured by the mean of AIPW scores under allocation induced by each policy across all participants. *** represents 1% significance of the t-test of difference of means between the measures and the "Status Quo". All measures use the existing capacity levels.

The figure illustrates that the "Non-Dynamic" policy provides the most substantial increase in the average annual growth rate of entrepreneurship across micro-regions, with a gain of 1.30 percentage points. This is followed by the "Forward-Looking" policy at 0.83 percentage points and the "Dynamic" policy at 0.43 percentage points. All policies outperform the status quo, which has an average annual growth rate of 0.1931 percentage points in these regions.

6.2 Regions

This section contrasts the geographic allocation of university expansion under the government's status quo with that proposed by our optimal policies across three counterfactual scenarios—Dynamic, Non-Dynamic, and Forward-Looking. Figure 13 and Figure 14 illustrate, respectively, the regional distribution of treatment and the socioeconomic and demographic profiles of the selected municipalities.

Figure 13: Share of treatment - Regions



Note: the regional distribution of treatment for each counterfactual scenario and status quo.

According to the Brazilian Government, the distribution of university campuses is guided by criteria aimed at addressing educational needs, socio-economic conditions, and regional development demands[10]. While these criteria provide a benchmark they are not binding in our analysis. Instead, we improve the evaluation framework with additional development variables publicly available, such as the Human Development Index (HDI), income per Capita, and population characteristics.

The primary objective of the governmental initiative is diminish regional educational disparities, a goal reflected in the geographic distribution of the campuses. As shown in Figure 13, the status quo allocates a substantial proportion of resources to the North and Northeast, targeting historically underprivileged areas, yet it also extends significant resources to the Southeast and South.

Our optimal policies recalibrate this distribution, aiming to enhance the entrepreneurship efficacy of the initiative. By leveraging an array of socioeconomic indicators, these policies not only continue to address the needs of the Northeast but also refine the allocations to optimize the impact across all regions.

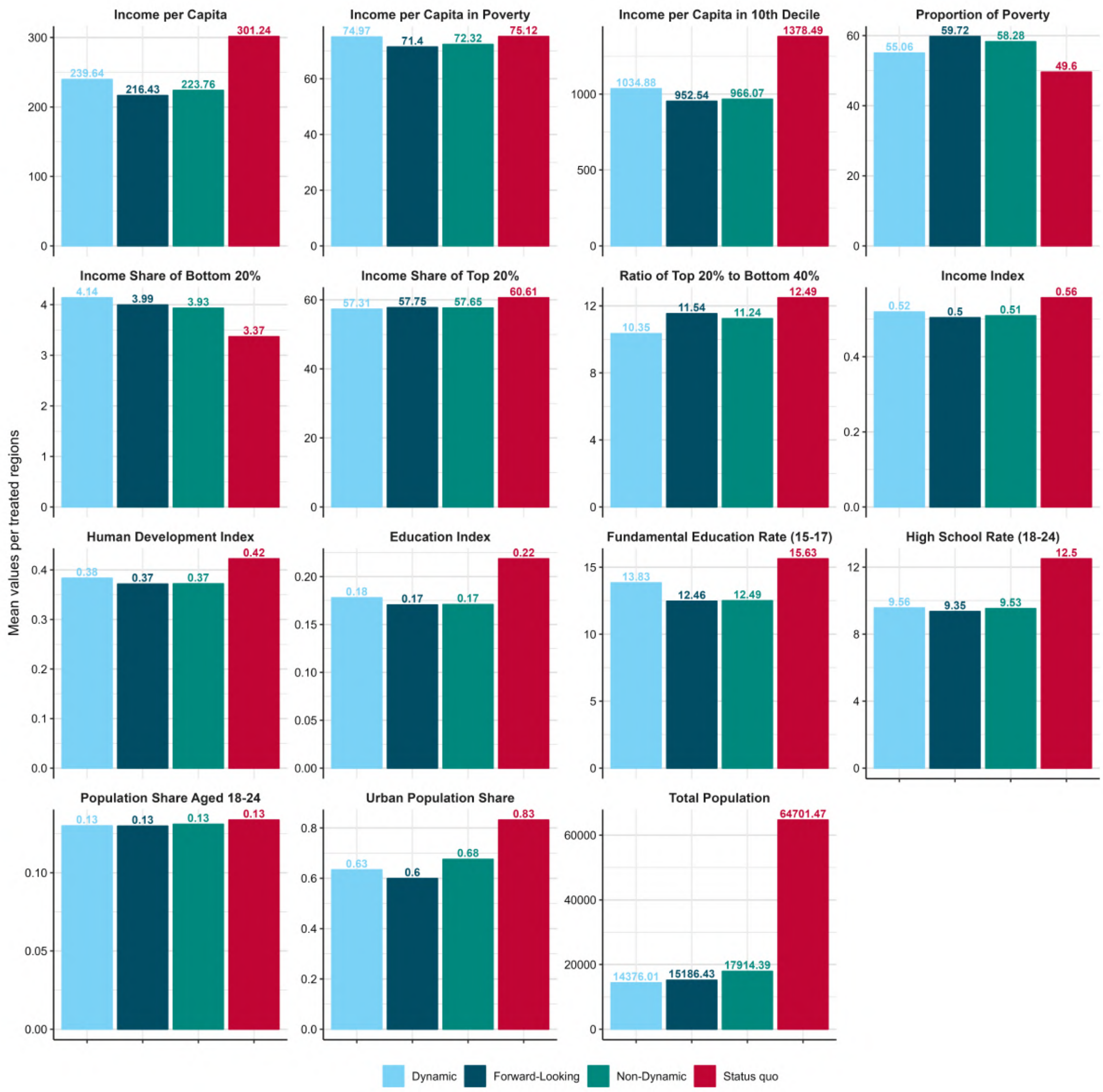
[10] "Criteria – To determine the number of university campuses and vocational education schools per state, the federal government followed a set of criteria, which include low basic education development indices (Ideb) and the percentage of youth aged 14 to 18 in the final grades of elementary education. In selecting the municipalities to be included, considerations were made for the universal provision of services to citizenship territories, high percentages of extreme poverty, municipalities or microregions with populations exceeding 50,000 inhabitants, and municipalities with local productive arrangements (APL)."

In this study, our optimal policies strategically diverge from government criteria by focusing on municipalities with pronounced poverty, thereby maximizing the transformative impact of university expansions on local economic development. These policies specifically target areas with suboptimal educational outcomes and lower income per capita, as well as regions with lower Human Development Index scores, emphasizing support for locales that are lagging in both educational attainment and economic resources.

Furthermore, diverging from the government's criterion of a 50,000 inhabitant minimum, our policies consider all municipalities, with a preference for those smaller in size and less urban. This inclusive approach ensures the benefits of university expansions reach a wide demographic and geographic spectrum, fostering sustainable regional growth.

This analysis illustrates the value of employing data-driven optimal policies for university allocations in Brazil. By aligning resource allocation with predicted treatment effects, these policies not only boost entrepreneurial activity but also more effectively address regional disparities than the status quo. The results affirm the significant role that policy tools can play in enhancing resource distribution and maximizing socioeconomic returns, thus building upon and improving governmental efforts to mitigate educational and economic inequalities across Brazilian regions.

Figure 14: Variables



Note: This figure presents the mean values for each variable per treated region under each scenario. All variables were employed in applying the counterfactual scenarios described in section 6.

7 Concluding Remarks

This paper contributes to the literature on the role of universities in fostering entrepreneurship, particularly in economically disadvantaged regions. Our findings suggest that the expansion of Federal Universities in Brazil from 1998 to 2019 had a substantial impact on firm creation, even in areas that traditionally lacked the infrastructure and demand necessary to support new businesses.

The analysis reveals that university-induced economic shocks are effective in overcoming local barriers to entrepreneurship. Specifically, the creation of new Federal Universities led to a 21% increase in the number of companies per 1000 inhabitants, driven primarily by significant rises in micro and small firms. The mechanisms behind these outcomes include local demand shocks, evidenced by increased activity in retail and service sectors, and human capital shocks, marked by a rise in skilled graduates and innovative activities.

Our methodological approach, employing a staggered difference-in-differences design, robustly supports these findings. Moreover, we demonstrate the potential of machine learning-based counterfactual assignment policies to optimize the placement of universities. These policies, which prioritize regions with the highest predicted benefits, significantly enhance the average annual growth rate of entrepreneurship.

The findings of our study carry significant policy implications. The Forward-Looking Policy, Dynamic Policy, and Non-Dynamic Policy scenarios illustrate different strategies for optimizing university placements, each with varying budget efficiencies and growth outcomes. Importantly, these optimized policies address regional disparities more effectively than the current government criteria by focusing on municipalities with pronounced poverty and lower human development indicators.

In summary, our results underscore the transformative potential of strategically placed universities in promoting entrepreneurship and reducing regional inequalities. By leveraging data-driven approaches to resource allocation, policymakers can significantly enhance the impact of university expansions, fostering economic development even in the most disadvantaged areas. This also underscores the importance of informed policy design in maximizing the full potential of higher education institutions to drive local economic growth and innovation.

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Online Appendix to "Does University Expansion Promote Entrepreneurship?"

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July 29, 2024

A Descriptive statistics

Table A.1: Summary statistics

Variables per 1000 inhabitants	Mean	Std. Dev.
Main variable		
Number of companies	70.23	37.84
Company size by revenue		
Micro	21.38	14.34
Small	1.05	0.92
Large	29.57	17.28
Company size by number of workers		
Small (<50)	8.23	6.00
Medium (50-100)	0.13	0.12
Large (>100)	0.16	0.11
Company sector		
Retail	0.59	0.59
Services	6.98	4.99
Others	62.67	33.06
Workers		
Workers	117.4	86.26
Skilled workers	10.40	12.62
Innovative entrepreneurship		
Exporting companies	0.08	0.11
Patent	0.004	0.010
Sanity check		
Enrollments	11.08	11.25
Covariates - 1991		
% poor population	0.57	0.21
% urban population	0.59	0.18
Population	239339.3	225510.6
Microregions: 277		
Years: 22		

Notes: The mean and the standard deviation are calculated for the microregions in the pre-treatment period.

Table A.2: Effect of university on number of companies per 1000 inhabitants - Heterogeneity

Model	**Size by revenue**					
	Micro		**Small**		**Large**	
	(1)	(2)	(3)	(4)	(5)	(6)
Effect	11.57***	11.27***	1.21***	1.11***	5.09	2.20
	(4.27)	(2.99)	(0.31)	(0.24)	(1.96)	(2.81)
Model	**Size by number of workers**					
	Small		**Medium**		**Large**	
	(1)	(2)	(3)	(4)	(5)	(6)
Effect	3.77***	3.48***	0.06***	0.07***	0.06***	0.06***
	(1.13)	(1.01)	(0.02)	(0.02)	(0.01)	(0.01)
Microregion FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Covariates	No	Yes	No	Yes	No	Yes

Notes: This table presents the overall summary of ATT based on the dynamic aggregation of the effects of Federal Universities on the number of companies per 1000 inhabitants by revenue and number of workers, according to Equation 1. We use not yet treated as the comparison group. The covariates in the column (2), (4), and (6) are the share of poor population in 1991 and the share of the urban population in 1991. Standard errors are clustered at the microregion level (in parentheses). ***p<0.01, **p<0.05, *p<0.10.

Table A.3: Effect of university on number of companies by sector per 1000 inhabitants and on innovative indicators- Mechanisms

Model	**Sector**					
	Retail		**Services**		**Other sectors**	
	(1)	(2)	(3)	(4)	(5)	(6)
Effect	0.34***	0.37***	2.91***	2.71***	14.52***	11.50***
	(0.10)	(0.10)	(0.95)	(0.65)	(4.56)	(3.94)
Model	**Innovative entrepreneurship**					
	Skilled workers		**Exporting companies**		**Patents**	
	(1)	(2)	(3)	(4)	(5)	(6)
Effect	7.55***	7.83***	0.05**	0.05**	0.008***	0.005**
	(2.05)	(1.91)	(0.02)	(0.02)	(0.003)	(0.002)
Microregion FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Covariates	No	Yes	No	Yes	No	Yes

Notes: This table presents the overall summary of ATT based on the dynamic aggregation of the effects of Federal Universities on the number of companies per 1000 inhabitants by sector, and on the innovative indicators (number of skilled workers, number of exporting companies, and number of patents per 1000 inhabitants), according to Equation 1. We use not yet treated as the comparison group. The covariates in the column (2), (4), and (6) are the share of poor population in 1991 and the share of the urban population in 1991. Standard errors are clustered at the microregion level (in parentheses). ***p<0.01, **p<0.05, *p<0.10.

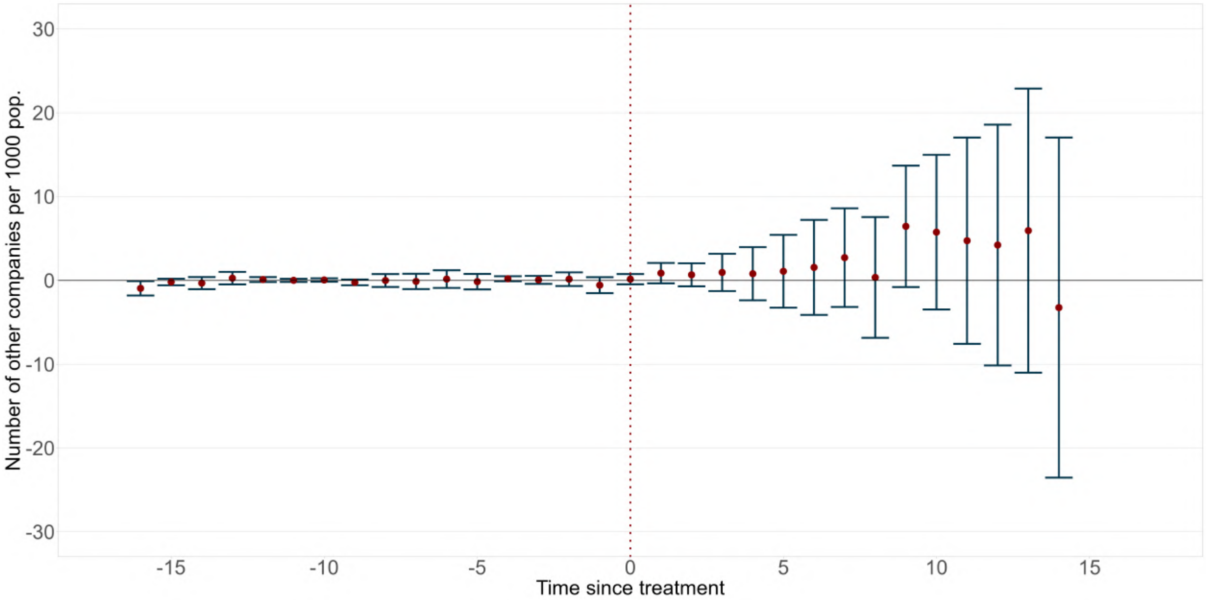
Table A.4: Effect of university on number of enrollments per 1000 inhabitants - Sanity check

Model	**Sanity check**	
	Number of enrollments	
	(1)	(2)
Effect	8.45***	7.97***
	(2.56)	(2.28)
Microregion FE	Yes	Yes
Year FE	Yes	Yes
Covariates	No	Yes

*Notes:*This table presents the overall summary of ATT based on the dynamic aggregation of the effects of Federal Universities on the number of enrollments per 1000 inhabitants, according to Equation 1. We use not yet treated as the comparison group. The covariates in the column (2), (4), and (6) are the share of poor population in 1991 and the share of the urban population in 1991. Standard errors are clustered at the microregion level (in parentheses). ***p<0.01, **p<0.05, *p<0.10.

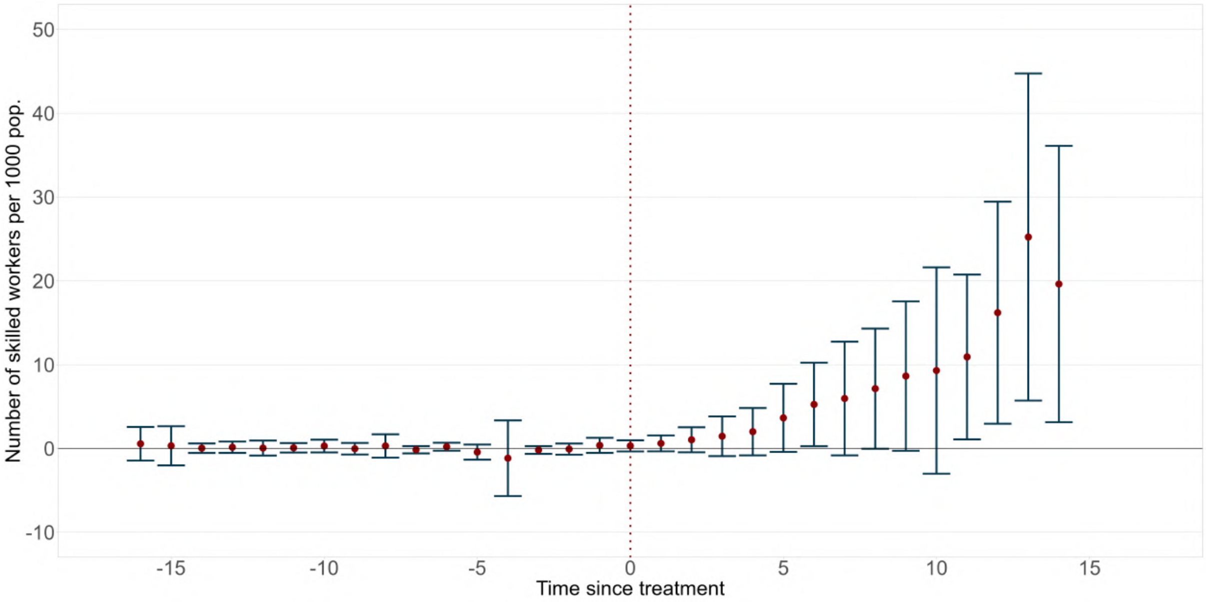
B Extra results

Figure B.1: Effect of university on number of large companies per 1000 inhabitants



Notes: This figure explores the effects of the Federal Universities on the number of large companies per 1000 inhabitants, according the Equation 1. We use not yet treated as the comparison group. The covariates are the share of poor population in 1991 and the share of the urban population in 1991. The significance level is 5%. Standard errors are clustered at the microregion level.

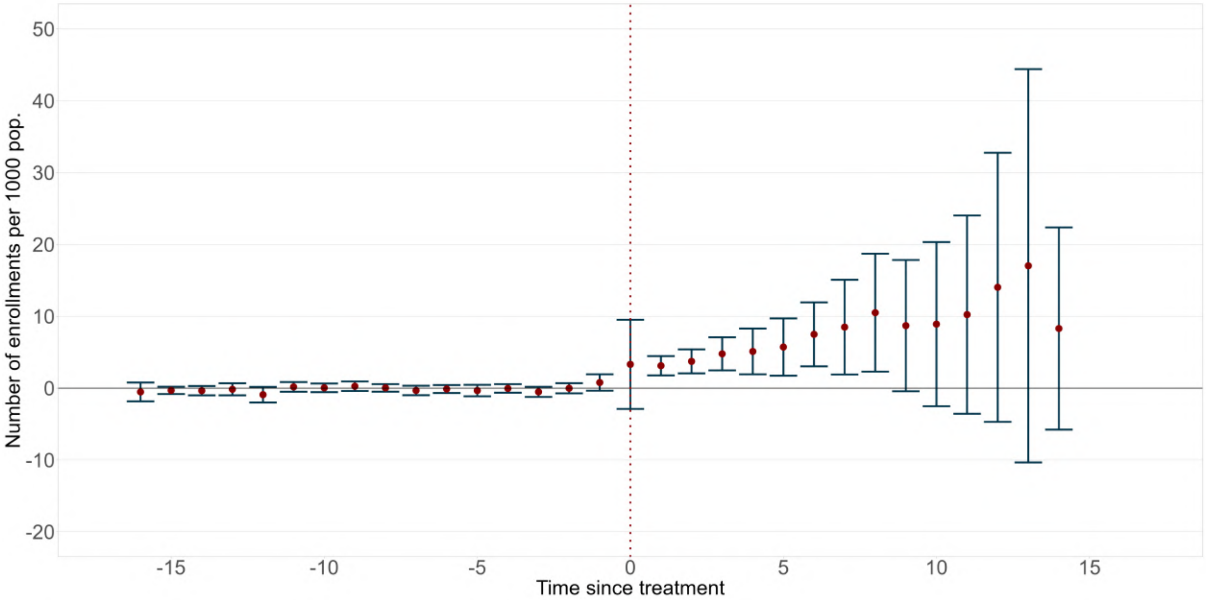
Figure B.2: Effect of university on number of skilled workers per 1000 inhabitants



Notes: This figure explores the effects of the Federal Universities on the number of skilled workers per 1000 inhabitants, according the Equation 1. We use not yet treated as the comparison group. The covariates are the share of poor population in 1991 and the share of the urban population in 1991. The significance level is 5%. Standard errors are clustered at the microregion level.

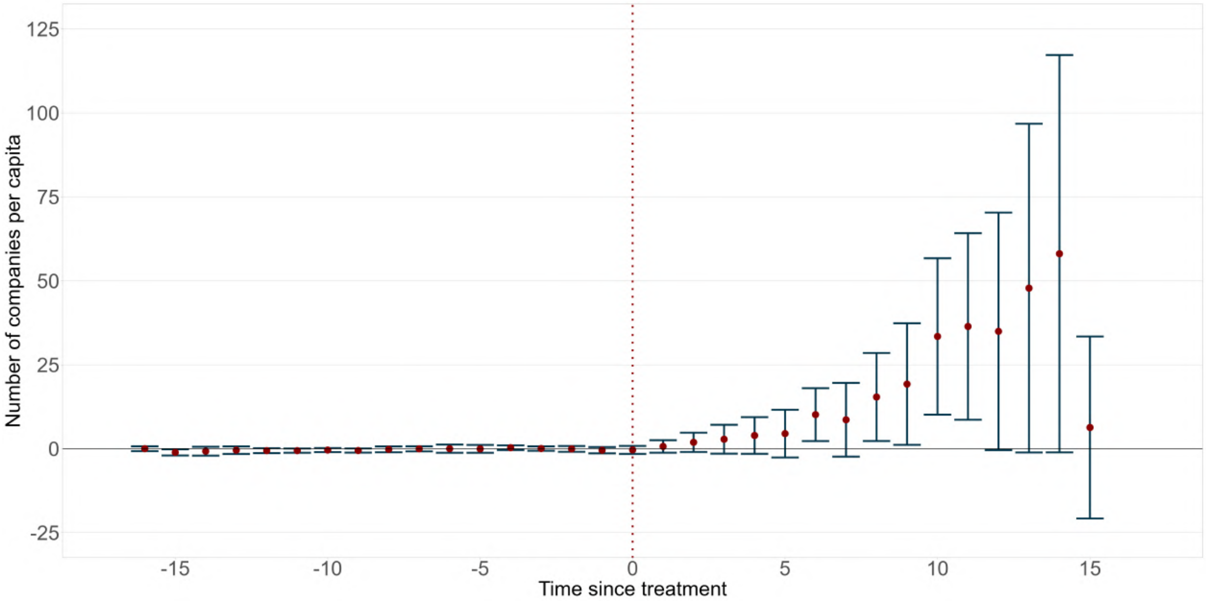
C Robustness Checks

Figure C.1: Effect of university on number of enrollments per 1000 inhabitants - Sanity check



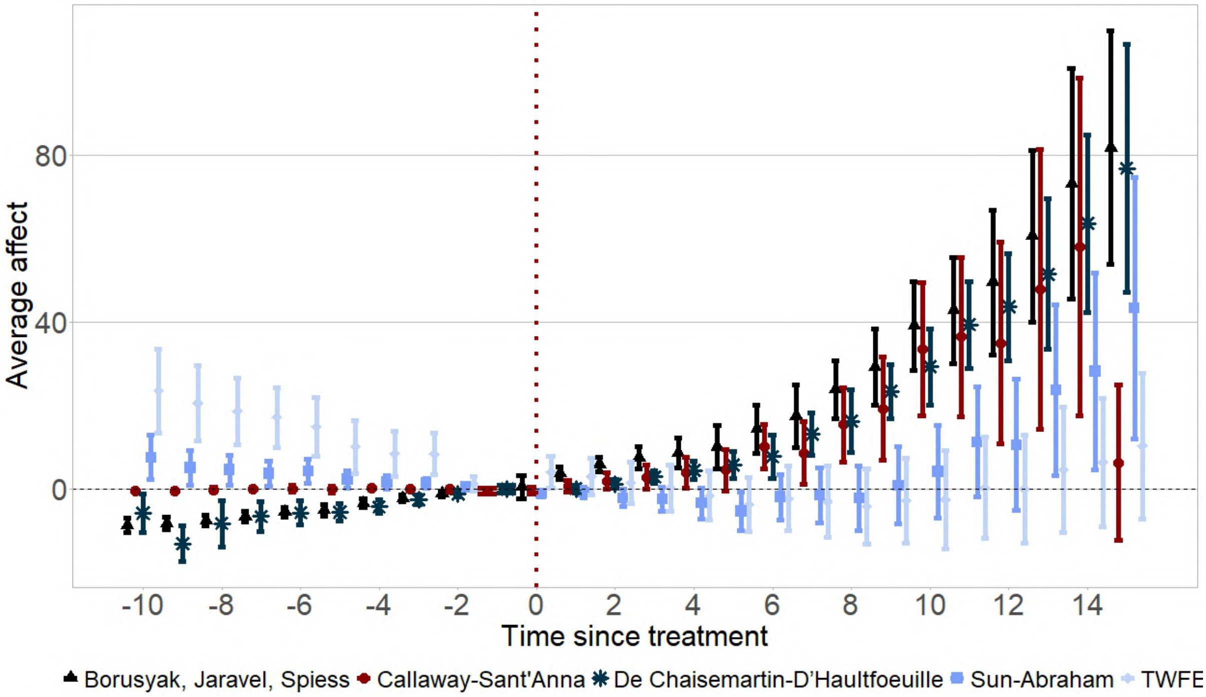
Notes: This figure explores the effects of the Federal Universities on the number of enrollments per 1000 inhabitants, according the Equation 1. We use not yet treated as the comparison group. The covariates are the share of poor population in 1991 and the share of the urban population in 1991. The significance level is 5%. Standard errors are clustered at the microregion level.

Figure C.2: Effect of university on number of companies per 1000 inhabitants - without covariates



Notes: This figure explores the effects of the Federal Universities on the number of companies per 1000 inhabitants, according the Equation 1. We use not yet treated as the comparison group. The significance level is 5%. Standard errors are clustered at the microregion level.

Figure C.3: Event study estimators



Notes: This figure explores the effects of the Federal Universities on the number of companies per 1000 inhabitants, considering five different estimators. We use not yet treated as the comparison group. The significance level is 5%. Standard errors are clustered at the microregion level.

D Algorithm

This section describe algorithm of the Cross-fitted Augmented Inverse Propensity Weighted Learning (CAIPWL) from Zhou et al. (2023).

Algorithm 1 Cross-fitted Augmented Inverse Propensity Weighted Learning (CAIPWL)

Input: Dataset $\{(X_i, A_i, Y_i)\}_{i=1}^n$
Choose $K > 1$
for $k = 1, 2, \ldots, K$ **do**
    Build estimators $\hat{\mu}^{-k}(\cdot) = \begin{bmatrix} \hat{\mu}_{a_1}^{-k}(\cdot) \\ \hat{\mu}_{a_2}^{-k}(\cdot) \\ \vdots \\ \hat{\mu}_{a_d}^{-k}(\cdot) \end{bmatrix}$, $\hat{e}^{-k}(\cdot) = \begin{bmatrix} \hat{e}_{a_1}^{-k}(\cdot) \\ \hat{e}_{a_2}^{-k}(\cdot) \\ \vdots \\ \hat{e}_{a_d}^{-k}(\cdot) \end{bmatrix}$ using the rest $K-1$ folds.
end for
Form the approximate value function $\hat{Q}_{\mathrm{CAIPWL}}(\pi) = \frac{1}{n}\sum_{i=1}^n \left\langle \pi(X_i), \frac{Y_i - \hat{\mu}_{A_i}^{-k(i)}(X_i)}{\hat{e}_{A_i}^{-k(i)}(X_i)} \cdot A_i + \begin{bmatrix} \hat{\mu}_{a_1}^{-k(i)}(X_i) \\ \hat{\mu}_{a_2}^{-k(i)}(X_i) \\ \vdots \\ \hat{\mu}_{a_d}^{-k(i)}(X_i) \end{bmatrix} \right\rangle$
Return $\hat{\pi}_{\mathrm{CAIPWL}} = \arg\max_{\pi \in \Pi} \hat{Q}_{\mathrm{CAIPWL}}(\pi)$