246

IMPACTS OF PUBLIC PROCUREMENT ON BUSINESS R&D EFFORTS: THE BRAZILIAN CASE

André Tortato Rauen
Bianca Souza de Paiva

DISCUSSION PAPER

ipea

246
DISCUSSION PAPER
Brasilia, October 2019

IMPACTS OF PUBLIC PROCUREMENT ON BUSINESS R&D EFFORTS: THE BRAZILIAN CASE

André Rauen[1]
Bianca Souza de Paiva[2]

1. Director of the Department of Sectorial Policies and Studies, Innovation and Infrastructure (Diset) of Ipea. E-mail: <andre.rauen@ipea.gov.br>.
2. Researcher at Diset/Ipea. E-mail: <bianca.paiva@ipea.gov.br>.

DISCUSSION PAPER

A publication to disseminate the findings of research directly or indirectly conducted by the Institute for Applied Economic Research (Ipea). Due to their relevance, they provide information to specialists and encourage contributions.

Discussion paper / Institute for Applied Economic Research.- Brasília : Rio de Janeiro : Ipea, 1990-

ISSN 1415-4765

1. Brazil. 2. Economic Aspects. 3. Social Aspects. I. Institute for Applied Economic Research.

CDD 330.908

Ipea publications are available for free download in PDF (all) and EPUB (books and periodicals).
Access: http://www.ipea.gov.br/portal/publicacoes

JEL: H57, O32, O38

CONTENTS

ABSTRACT

This paper aims to evaluate the impact of federal public procurement on business R&D efforts in the 2013-2016 period regardless of the participation in any public procurement program (PPI). We conducted a quasi-experiment (with propensity score matching) in which we compared firms that sold to the federal government with firms that did not. To understand the differences between the type of procurer and type of procured goods and services, we conducted five exercises: general sample; contracts from the Ministry of Health, Ministry of Education and, Ministry of Defense, and with only high-tech suppliers. Regardless of the sample type, there was no impact on public procurement on the technology efforts of suppliers (considering the technology intensity approach). However, we found an unexpected impact on suppliers' total personnel (PO). Our results show that to produce some positive results on technological R&D, public procurement should be specifically designed to do that. In other words, without a strong PPI program, there will be no positive outcome in terms of technology development. Public procurement works as an innovation policy tool but must be designed to do so.

Keywords: public procurement for innovation; quasi-experiment; Brazil.

1 INTRODUCTION

To fulfill their social role in capitalist societies, governments must engage in market relationships. They must employ people, provide grants, regulate transactions and, above all, purchase goods and services. The main goal of this purchase is to satisfy a certain demand, which can be ordinary, like cleaning services, or more sophisticated, like sending a robot to Mars. In public procurement processes, governments usually try a "the-cheaper-the-better" strategy. However, not always.

In any given modern economy, central governments are the most powerful buyers (both in volume and in value). This is true to both the United Kingdom (UK) and the United States (US), but also to Brazil. This implies a huge power to guide and pull the market to a desired path. For instance, governments' procurement choices can create a market for hybrid cars, LED street lights, or even total autonomous factories. In fact, a purchase decision may not only signal to a certain technology trajectory but also sustain an emerging private supply. In this context, a question emerges: can governments use this power to pursue goals other than the lowest price?

The past ten years have seen a rapid rise in the use of public procurement as a major innovation policy instrument. The US, Europe, and China have used this strategy extensively (Edquist et al., 2015; Li et al., 2015). Public procurement can create and maintain the necessary demand for innovation, especially in the initial phases of a product life cycle (Nowak, 2011). In fact, this is a different way to spur innovation, since public procurement of innovations does not rest on the simple supply of resources, neither does it let technical progress follow a random path. Through procurement, governments can purchase (commissioned) efforts to develop a particular solution. In contrast, through grants, credit, and tax exemption, for instance, governments can only hope for certain development and never demand it.

With total public procurement purchases representing about 14% of the Gross Domestic Product (GDP), the Brazilian federal government is the main single buyer of the national economy; its purchases represents around 8% of the Brazilian GDP (Ribeiro et al., 2018). This means that Brazil has a strong and stable source to support innovation through demand-side economics.

The question is if this source has been exploited. According to the recent findings of Squeff and Holanda (2014) and André Rauen (2017), the most plausible scenario is that public procurement has not been widely used to spur innovation in Brazil, despite some positive experiences in technology procurement, such as the development of the KC-390 airplane and the Sirius project. Additionally, Rocha (2018) used data from the Brazilian Survey of Innovation (Pintec) to show that public procurement has had positive impacts on a small subgroup of Brazilian firms: innovative suppliers.

In the era of "machines, platforms, and crowds" (Mcafee and Brynjolfsson, 2017), research and development (R&D) have been widely recognized as the main source of the most relevant innovations. Therefore, this paper aims to evaluate the impact of public procurement on business R&D efforts in the 2013-2016 period regardless of corporate innovative behaviors.

The main assumption is that public procurement has the power to create demand for innovations. In general, this can be done through the requirement of innovation in purchase bids or in the preference for innovative suppliers. In either case, the central point is that governments can stimulate the quest for private innovation by creating and/or consolidating a market for innovation (Edler, 2013).

To achieve this aim, this paper is structured as follows: the second section discusses the relationship between public procurement and private innovation efforts; the third section provides a general understanding of the Brazilian public procurement scenario; the fourth section shows the research method and strategy; and the fifth section discusses the results. The paper ends with some final remarks.

2 PUBLIC PROCUREMENT AND PRIVATE INNOVATION EFFORTS

The basic economic rationale that links public procurement and private innovation is related to the fact that a public demand for goods and services can support the development and diffusion of innovations through the creation and consolidation of a consumption market for those innovations. In other words, through purchase, governments can guarantee sales for innovative private suppliers. As a condition for such, public contracts should allow and prefer new or improved products and services, or, according to Geroski (1990, p. 182):

> Innovation occurs as part of the process by which firms push back technological frontiers to meet user needs and a procurement policy, *which clearly expresses* a demand for services beyond current capabilities.[1]

1. The highlighted is ours.

The literature on public procurement and innovation is scarce when compared with traditional instruments, like credit, grants, and investments. However, most of studies in this area have shown a positive effect of public procurement on private innovation efforts:

> In spite of growing policy interest, which also recognizes the role of procurement in the emergence and growth of new technologies and industries, there is very limited robust statistical evidence on the link between procurement and innovation. This evidence gap is particularly relevant at a time in which several countries are considering the introduction of targets, set-asides and complementary policies to promote the use of procurement as an innovation policy tool (Appelt and Galindo-Rueda, 2016, p. 6).

Guerzoni and Raiteri (2015) showed that current studies on procurement and innovation are part of a new wave of demand-pull studies, which have been originally and heavily criticized by seminal Neo-Schumpeterian authors, like Mowery and Rosenberg (1979) and Dosi (1988). New empirical studies and a heavily fiscal crisis have led to a resurrection of this approach in a more rigorous way, which is now named as Demand-Side Innovation Policies (DSIP):

> The central idea of the new wave of demand studies is that the influence of demand upon innovation should be considered as a mixture of two elements (Guerzoni, 2010). On the one hand, the size of a market can be used as a proxy for the demand. In this case, a larger demand will create more incentives for R&D investment, since it increases the expected profits from the innovation. On the other hand, the demand can be considered as a source of information from users, which, by providing producers with knowledge about the market needs, reduce the uncertainty linked with the development of new products. Focusing on a sample of small- and medium-sized enterprises in several industries and European countries (Fontana and Guerzoni, 2008) show that the former effect is especially true for process innovation, while the latter applies for product innovation (Guerzoni and Raiteri, 2015, p. 4).

By applying different methods to many objects, several studies have identified the positive effect of public procurement on private innovation efforts, such as Lichtenberg (1988), Aschhoff and Sofka (2009), Draca (2012), Guerzoni and Raiteri (2015), Slavtechev and Widerhold (2016), Appelt and Galindo-Rueda (2016), and Czarnitzki, Hunermund, and Moshgbar (2018). Briefly, they found a positive and statistically significant effect of public demand on innovation, including R&D. Guerzoni and Raiteri (2015) showed that public procurement seems to be more effective to leverage innovation than traditional instruments, like subsidies and tax credits.

In this broad demand-side approach, public procurement for innovation has gained much attention, especially in Europe. The works of Geroski (1990), Edquist and Hommen (2000), Edler et al. (2012), Edler and Georghiou (2007) and Aschhoff and Sofka (2009) are the cornerstones for the resurgence of demand-side economics.

The DSIP is the opposite of Supply-Side Innovation Policies (SSIP), which has been the most employed approach in innovation policies since the 2000s. According to Edler et al. (2012, p. 34):

> Supply-side policies are very diverse, ranging from support for investigator-driven research that feeds into innovation activity, grants for collaborative R&D and fiscal incentives for R&D more generally, support for the creation of start-up companies, all sorts of networking and brokerage schemes and specific regulation to enable and foster innovation such as intellectual property rights.

In other words, the SSIPs help firms *push* innovations into the market. It gives supply conditions of whatever firms judge relevant. By contrast, in DSIPs, governments *pull* the market towards a well-defined path, and their actions are based on a potential or existing procurement market:

> Demand-side intervention is intended to increase the demand for innovations, to improve the conditions for the uptake of innovations and to improve the articulation of demand (Edler, 2007). Cluster policies, regulation (for example, standards), public procurement (that is, R&D procurement and innovation procurement), and support of private demand are examples of demand-side innovation policy instruments (Edquist et al., 2015, p. 2).

In fiscal crisis periods, the main advantage of DSIP is that it can be done – most of times – without increasing government expenses. For instance, a market for a certain innovation can be created through a new regulation that demands better products, through a different bid design that prefers innovations, or even through a cluster policy that connects procurement processes and suppliers.

According to Edler and Georghiou (2007), demand-side measures can be expressed through *i*) systemic policies (cluster and supply chain policies); *ii*) regulation (standards and official rules that force innovation); *iii*) public procurement (R&D procurement and procurement of innovative goods); and *iv*) the support of private demand (demand subsidies, awareness, training, etc.).

The same authors identified different strategies in which public procurement can spur innovation:

> Public procurement of innovation as a strategy in innovation policy can take different forms. We can distinguish general procurement practice versus strategic procurement, direct public procurement (where the goods or services are exclusively for public use) versus catalytic procurement and, finally, commercial versus pre-commercial procurement (Edler and Georghiou, 2007, p. 953).

In the first case, governments can either procure different goods and services and use the presence of innovation as a selection criteria (general procurement), or they can procure specific technologies in order to spur a given market (strategic procurement). The second possibility is related to use: whether procurement is for the sole consumption of a given government department (direct procurement) or if it is designed to create and support a new private market (catalytic). Finally, public procurement can be a regular commercial transaction of available products (commercial procurement) or it can be an order to develop a new product, service, or system that does not exist yet (pre-commercial procurement).

Even though innovation has been one of the most relevant company strategies in the beginning of the 21st century, the use of public procurement as an innovation tool has faced many challenges. The most relevant of these challenges is the trade-off – at least in the short-run – of buying the cheapest or the newest product/service. Other challenges include *i*) high-risk aversion by public authorities; *ii*) personal liabilities on mistakes; and *iii*) lack of specific legal and paralegal instruments designed to spur innovation through procurement.

Due to these challenges, innovation impacts of public procurement should be explicitly pursued. That is, without a formal program to promote innovation, there will be no impact, since public procurement can only spur innovation when its designed to do so. Normal bids or routine procurement processes do not led to innovation.

3 FEDERAL PUBLIC PROCUREMENT IN BRAZIL: AN OVERVIEW

The main source of information regarding public procurement in Brazil is the General Services Administration Integrated System (Siasg) of the Brazilian federal government.

In 2018, 21,706 procurement contracts were signed through Siasg, which added up to R$ 24.5 billion. In 2016 – the highest value in the historical series – purchases reached a total of R$ 37.6 billion. Considering inflation in this period, these figures indicate a quite strong fall. In fact, after 2016, the trend has been negative (table 1).

TABLE 1
Total value of Siasg's contracts (2013-2018)
(In current R$)

Year of signature	Total value
2013	21,826,503,344.40
2014	20,961,055,747.60
2015	27,060,962,123.50
2016	37,645,881,153.30
2017	28,305,014,321.20
2018	26,496,167,013.30

Source: Brazil (2019).

In any case, the value of 2018 is still significant in terms of internal demand. It is important to mention that many large mixed-capital companies, like Petrobras, are not part of Siasg. Therefore, the total number of federal public procurement processes in Brazil is much higher than the one shown in Siasg (Ribeiro et al., 2018). However, Siasg is the only microdata open source regarding federal procurement in Brazil.

In contracts signed in 2018, 72.3% were service provision contracts, and, among them, the most common services included engineering and construction. Books and medicines were the most relevant products contracted. Brazil has purchase preferences for micro and small companies, but they represented only 11% of the total number of purchases in Siasg in 2018.

The ministries of Health, Education, and Transportation were the most relevant purchasers (table 3). The Ministry of Health made purchases to support the Brazilian Unified Health System (SUS), which justifies its top position among ministries. In fact, considering the current complete data available (2018) in Siasg's database, medical, dental and veterinary equipment and articles are by far the most purchased type of product (table 1).

The variety of goods and services purchased by the Brazilian federal government is huge (table 2). As in many big countries, it ranges from computers, chemical reagents, to cleaning and security services. Therefore, it is expected that any innovation impact arising from the relationship between government and suppliers be diluted in this kaleidoscope of technologies. However, the amount of medical, dental and veterinary articles in procurement creates a bias towards a more complex purchase, which may lead to more complex innovation efforts by suppliers. We are going to test that.

TABLE 2
Top 10 products or services purchased by the Federal Government in contracts signed in 2018
(In current R$)

Group	Total nominal value	% of total acquisitions
Engineering services	R$ 3,186,768,333.50	12.03
Equipment and articles for medical, dental and veterinary use	R$ 2,814,733,441.00	10.62
General construction services for civil engineering works	R$ 2,205,545,598.60	8.32
Hosting services in information and communication technology (ICT)	R$ 1,506,649,732.80	5.69
Government administrative services	R$ 1,238,877,865.10	4.68
Vehicles	R$ 1,169,638,565.20	4.41
Books, maps, and other publications	R$ 1,051,376,770.30	3.97
ICT management services	R$ 885,133,880.20	3.34
Other support services	R$ 840,555,985.30	3.17
Software maintenance and support services	R$ 735,911,488.40	2.78

Source: Brazil (2019).

The reason for the Ministry of Education be in the second place is the national education system, which includes more than 60 federal universities and many actions in basic education using resources from the National Development Fund for Education (FNDE).

TABLE 3
Top 10 Ministries according to the value of contracts signed in Siasg (2018)
(In current R$)

Ministry	Total value	% of total acquisitions
Ministry of Health	R$ 5,800,337,580.60	21.9
Ministry of Education	R$ 4,875,408,386.90	18.4
Ministry of Transportation	R$ 4,716,751,895.20	17.8
Ministry of Treasury	R$ 2,566,414,284.80	9.7
Ministry of Social Security	R$ 1,266,460,294.60	4.8
Ministry of Defense	R$ 903,162,862.50	3.4
Presidency	R$ 819,645,813.60	3.1
Ministry of Planning	R$ 745,275,051.40	2.8
Ministry of Justice	R$ 740,988,855.60	2.8
Ministry of National Integration	R$ 660,018,227.70	2.5
Other ministries	R$ 3,401,703,760.40	12.8

Source: Brazil (2019).

The absence of the Ministry of Science, Technology, and Innovation in table 3 (it appears in "others") points out to what this paper shows: the use of public procurement as a technology and innovation policy is quite low in Brazil (see, for instance, Rauen, A. 2017).

Table 4 shows that, according to Siasg's database, government entities purchase products and services from each other, for instance, between the Ministry of Health and a public laboratory (public company) or between the Ministry of Transportation and the public company Serpro (Federal Data Processing Service). However, the fact that many public companies have been trading with the federal government in Brazil is an obstacle to use public demand as a private innovation tool in the country. Moreover, since that many of these public companies are totally dependent on federal financial support, there no stimulus for innovation (we exclude public companies of our empirical exercise).[2]

TABLE 4
Top 10 contractors of the Federal Government in Siasg (2018)
(In current R$)

Contractors	Value	% of the total value
Federal data processing services (Serpro)	2,419,913,735.30	9.15%
Federal savings bank (CEF)	1,672,026,167.90	6.32%
Dataprev	804,196,526.10	3.04%
Blau farmacêutica S.A.	653,162,144.80	2.47%
LCM construção e comércio	636,031,928.70	2.40%
Fiotec (foundation for scientific and technological development in health)	632,436,257.30	2.39%
Ferreira Guedes S.A.	485,771,460.50	1.84%
Hemobras	427,905,000.00	1.62%
Bionovis S.A.	420,575,085.70	1.59%
Toyota	351,551,818.00	1.33%

Source: Brazil (2019).

3.1 Public procurement as an innovation tool in Brazil

Between 2004 and 2014, the federal investment in science, technology, and innovation (ST&I) strongly and significantly increased, and new instruments, programs, and policies were created and executed. In 2015, this expansionist cycle abruptly ended. By 2016, investments in ST&I returned to their previous levels, and many new instruments, like grants to firms, virtually disappeared (Negri and Rauen, 2018).

This abrupt cut in investments is explained by a fiscal constraint, which dropped the national GDP. At the same time, analyses on output indicators showed the failure of this ST&I investment and the policy mix built around it (Rocha and Rauen, 2018).

2. In 2019, there were 135 public companies in Brazil (Brazil, 2019).

In light of these events, a new innovation policy agenda emerged. In this policy, public procurement – which does not necessarily imply an increase in expenditure – gained much attention in the country. Brazil has already somehow tried different forms of public procurement for innovation, but not in a coordinated way, nor with minimum commitment. In fact, as showed by Rauen (2016), the use of public procurement for innovation in Brazil is more about protectionism and lobby than a real innovation strategy.

Taking into account the last ten years, these are the main Brazilian government's initiatives regarding public procurement for innovation: *i*) additional preference margin; *ii*) sustainable public procurement; *iii*) Productive Development Partnerships (PDP) for healthcare products; and *iv*) some scarce pre-commercial procurement processes.

Law No. 12.349/10 changed the Brazilian procurement act (Law No. 8.666/93) and created preference margins for national suppliers on federal, state and local public procurement processes. Several decrees defined the different economic sectors that could benefit from these policies at the federal level. The normal preference margin was given to local producers of goods manufactured in the country. This margin varied according to products, but could reach 20% considering the price of foreign suppliers. The main objective was to generate wealth inside the country. In fact, this policy was a kind of "Buy Brazil Act".

According to this law, an additional margin could be added to the normal preference margin if the product or service was researched and/or developed in the country. In this case, the total margin could reach 25% of overseas suppliers' prices. The main objective was to foster innovation and private R&D efforts. So far, there has not been any knowledge of its use.

Concisely, the Brazilian preference margin policy did not work as intended. No selection criteria were used to define benefited sectors, and public buyers were not sure when to use the margins (product codes and names in the federal procurement system were different from Mercosul codes used in decrees, and there was not any translation). Due to these problems, there are just a few cases of use, and currently (since 2017) there is no preference margin in the country (Rauen, A. 2017). Therefore, Brazil tried to use a preference margin, but it failed. The majority of buyers just could not use this instrument.

Therefore, this paper cannot assess the impact of the Brazilian preference margin because it was not implemented. On the contrary, this study shows the impacts of public procurement on technology efforts in a scenario of virtual absence of a procurement-based public policy.

In this context, Oliveira and Santos (2015) showed that sustainable public procurement in Brazil is still weak, and many factors seem to prevent a more robust use, such as lack of suppliers, purchase complexity, high acquisition price, and the high risk of corruption. For these reasons, sustainable public procurement added up to up only R$ 4.7 million in 2018, totaling 123 contracts in the federal government (Brazil, 2019).

The context of healthcare products is quite different. In the 2005-2015 period, the Brazilian federal government total purchase of healthcare products (therefore excluding the procurement of services) was approximately US$ 44.8 billion (2015 prices). A huge part of this sum was used to supply drugs and precision instruments to SUS. By adding the procurement of services to this figure, the total amount of federal purchases for SUS would be higher than US$ 50 billion.

At the same time, this demand has caused a strong, persistent, growing deficit in the balance of trade. Only in 2014, this deficit was US$ 11.5 billion, with total imports of US$ 13.7 billion (Varrichio, 2017).

The Brazilian PDP program was designed to use this “market power” to foster technology transfer between multinational companies and local producers (Brazil is not a signatory of GPA (Agreement on Government Procurement)). It was launched in 2012, and the final goal was to reduce the trade deficit and the country’s international dependence. Very similar to a military offset, the central rationale of the policy is to link the sales to SUS to the total technology transfer of certain medicines.

In this model, a private firm (usually a multinational company) enters into a contract with the government for the supply of a certain drug for a certain time. During this contract, the company must transfer all the technology to a local public laboratory, which will become (when the transfer is complete) the government supplier.

At the end of 2016, there were 81 partnerships, of which 23 were in the production phase, and two were complete (a flu vaccine and a clozapine-based medicine).

The central problem of this policy is that the main agent of the technology transfer is a public laboratory, and not a private firm. This can reduce international technology dependence but will put in a public organization the main responsibility of manufacturing and supplying products to SUS. By definition, new innovations will not have the stimulus to be developed, since the public organization has no competition to face up to (Varrichio, 2017).

Since the military regime (1964-1985), Brazil has executed some technology procurement processes that can be named, more or less, as pre-commercial procurement. Unfortunately, only after the innovation act (Law No. 10.973/04), pre-commercial procurement has become a straightforward legal possibility. Currently, the most relevant technology procurement processes in Brazil are the KC-390 airplane and the Sirius project. Both used a mixed and complex approach regarding procurement.

The KC-390 airplane was ordered by the Brazilian Air Force (FAB) through a special procurement process. Since there was only one possible supplier – Embraer (Brazilian Aeronautics Company) –, FAB did not use the slow and bureaucratic regular competitive bidding process. Regardless of many budgetary problems, the airplane was fully developed, and the regular production started. In fact, this positive outcome happened not because there was a good legal environment, but because of the long-lasting and strong relationship between the purchaser (FAB) and the supplier (Embraer) (Ribeiro, 2017).

The Sirius project had the aim to build the new Brazilian synchrotron light source. Working like a real-time microscopy, which sees matter at the atomic level, this facility is essential to boost Brazilian science and technology. There is a large array of employment, which includes the aerospace and the oil industry, for instance. This project has been executed by the Brazilian Center for Research in Energy and Materials (CNPEM), a private not-for-profit company that operates (through a contract) with public money (similar, but not equal to the "public owned-private-operate"model). Therefore, the procurement process also happened outside the regular procurement act. The Sirius project, which is near to its conclusion, demanded a new kind of financial engineering, which put together state and federal organizations (Rauen, C. 2017).

This collection of diverse and sparse initiatives by any means imply the existence of a coordinated and strong Public Procurement for Innovation (PPI) policy in Brazil. In fact, it is the opposite case. Squeff and Holanda (2014) showed that the Brazilian federal government sells to the least innovative companies in the country. Then, considering all of the above, expecting public procurement impacts on private innovation efforts is not rational, and this is the main hypothesis of this work.

Since PPI initiatives were small, disarticulated and poorly implemented, we did not look for their impact. Instead, we assessed the impacts of public procurement on technology efforts despite them. Further studies should look for the impacts of these small PPI specific strategies.

4 DATA, EMPIRICAL STRATEGY, AND MATCHING

Public procurement in Brazil can be segregated into federal, state and local (municipalities) processes. Federal public procurement can also be divided into direct (ministries, departments, etc.) and indirect administration (state-owned companies, mixed-capital companies, public foundations, etc.). Siasg's database covers procurement processes on federal direct administration and only part of indirect administration, which is a major setback for the use of Siasg's database. Nevertheless, this database has enough content to test our hypothesis, since it covers the whole direct federal administration.

In Brazil, the only data source of business R&D expenses is Pintec, made by IBGE (Brazilian Institute of Geography and Statistics), but this survey is conducted every three years, and the latest data were collected in 2014. Therefore, this source was not adequate for our test, since we aimed to analyze annual impacts up to 2016.

Instead, we used the concept of PoTec (scientific and technological employees) as a proxy for business R&D expenditures (Araujo, Cavalcante and Alves, 2009). This concept has been widely used in Brazil mainly due to its high correlation (more than 90%) with the behavior of actual R&D expenditure, and because modern R&D expenditure relies mostly on people.[3] We extracted PoTec from Rais (Annual Report of Social Information) database. PoTec is the sum of the following occupational groups: *i*) researchers; *ii*) engineers; *iii*) R&D directors and managers; and *iv*) scientific professionals (biotechnologists, geneticists, metrology researchers and weather technicians, mathematicians, statisticians and related occupations, computer professionals, physicians, chemists, and related occupations, and biologists and related occupations).

After solving the issue of impact output, we evaluated impact as suggested by Edovald and Firpo (2016). We employed a quasi-experiment with a control group selected through a propensity score matching (PSM) technique.

The reason to choose a control group was the necessity to isolate the effect of the public intervention. In other words, by selecting a control group and comparing it with the treatment group, we estimated the impact in the absence of the intervention.

Since participation in public procurement is not random, our challenge was to define the control group and avoid biases in selection (Czarnitzki and Hussinger, 2018).

3. The high relevance of salaries on R&D total expenditure can be seen in OECD Business R&D data (OECD, 2019).

PSM is the most widespread way to overcome this challenge:

> PSM consists of finding a plausible control group of non-treated firms that are similar to the treated ones in pre-treatment characteristics, then using this group as a substitute for non-observable counterfactuals to estimate the impact of a given policy (Caliendo and Kopeinig, 2008). Treated observations are matched with non-treated ones on the basis of the so-called propensity score, $P(X) = P(D = 1|X)$, defined as the probability of being treated (treatment $D = 1$) given a set of pre-treatment characteristics X (Scandura, 2016).

Considering our data set (with many observations) and the nature of intervention (it depends on a set of observable characteristics of firms), we choose the nearest neighbor method, which matches units through the closest distance between them according to a logit model. This technique allows the selection of a control group with almost the same estimated probability of accessing intervention of the treatment group (according to a defined set of characteristics). Therefore, we compared the most similar firms regarding our object of study.

The differences in behavior variations of the control and treatment groups is the so-called "impact" of intervention. As usual in these cases, we used the ordinary least squares (OLS) to define these variations.

We defined the treatment group in the year in which the contract was signed (t), but we matched firms – with their closest firms – in the previous year (t-1) and calculated the results one year after the contract was signed (t+1). This time lag was necessary to assure that firms matched before the intervention, and the possible impacts could be observed after intervention. Therefore, we are looking for the impacts after contract signature in order to understand if this contract changed the behavior of the firm regarding innovation. If the government has a strong, broad PPI strategy, then we expect to find the creation of a public market for innovation and, as a consequence, a change in private innovation efforts.

To estimate the propensity score (which we applied for the matching), we used a logit model with control of variables in the previous year (t-1), selected according to the nature of intervention (table 5). This procedure followed the proposals of Aschhoff and Sofka (2009) and Czarnitzki, Hünermund and Moshgbar (2018).

TABLE 5
Matching variables

Variable	Source
Total personnel (log)	
Total personnel with tertiary education	
Age of firms (log)	Rais
Economic sector (CNAE 2.0)	
Region	
Nationality	Secex

Authors' elaboration.

The coefficients of determination (R^2) found for the 2013, 2014 and 2015 estimated logit models were, respectively, 0.1526, 0.1114, and 0.1031. In each year, the likelihood-ratio test was also performed to analyze the marginal contribution of each variable compared to the saturated model (with all variables selected). The results are described in the Annex (table A.1).

We defined intervention as the sales contract between a given firm and the federal government. The impacts are estimated in terms of total employment (PO) percent variation and PoTec relative to total employment absolute variation:

$$y_1 = (PO_{t+1} - PO_{t-1}) \;/\; PO_{t-1} \tag{1}$$

$$y_2 = (POTEC_{t+1} \;/\; PO_{t+1}) - (POTEC_{t-1} \;/\; PO_{t-1}) \tag{2}$$

While y_1 is an absolute estimator, y_2 is a proxy for variation on the technology intensity of suppliers. We chose a relative measure because the technological effort is better understood based on its relative relevance compared to the traditional activities of firms. That is, the core question is to understand whether intervention modified a firm's behavior in relation to what it has always done. In this sense, an absolute increase may conceal the maintenance of the relative technological effort. This is particularly true when we use PoTec as a proxy for R&D expenses, because an increase in PO raises PoTec.

However, we also estimated the impacts of public procurement on PO, since the Brazilian federal government has a concern about the use of public procurement as a social policy (the preference margin is a proof of this). Although this is out of the PPI range of analysis, the maintenance of jobs in high-level technology sectors or in innovative suppliers is also relevant for the technology efforts of a given country.

As usual in this kind of quasi-experiment, we estimated impacts using an OLS model comparing treated and non-treated (control) firms after intervention.

After these definitions, we applied the following procedures to Siasg's database before the matching:

1) Inclusion of only procurement contracts signed between 2013 and 2015.
2) Exclusion of non-private companies.
3) Exclusion of firms with missing values.
4) Exclusion of firms with PO less than 10 employees in t-1.
5) Exclusion of firms with zero PoTec in t-1.
6) Inclusion of only the first year that a given firm appeared.

These procedures were necessary to avoid public companies bias, allow compatibility with Rais' and Secex's databases (available only up to 2016), reduce the high heterogeneity of the treatment group, and avoid an overdose effect. As a result, the treatment group had 3,180 new coming firms between 2013 and 2015.

As a result, our model was as follows:

$$p = \frac{\exp\,(X_{t-1}\beta)}{1 + \exp\,(X_{t-1}\beta)} \tag{3}$$

Where p is the estimated probability for a successful event (sale to the federal government at time t regardless of contract or selection type), and β is a set of estimated parameters for covariates observed at t-1.

On the other hand, the impacts were estimated based on:

$$Y_i = \beta_0 + \beta_1 Control_i + \varepsilon_i \tag{4}$$

where Y is the r esult of measures described above, and β is the estimated regression parameters. The control variable assumes a value equal to zero for the control group and 1 for the treatment group. The estimate of β_0 is given by the mean variation of the control group, and β_1 by the difference of mean variations between control group and treated groups.

In order to understand the differences between type of procurer and type of procured goods and services, we repeated this exercise with three subsamples of buyers: *i*) Ministry of Health; *ii*) Ministry of Education; and *iii*) Ministry of Defense. They are the main federal purchasers in Siasg's database. In addition, to narrow down the analysis, we selected another subsample and tested the model with only high-tech suppliers.[4] Therefore, we searched the impacts of five different models.

While the general sample gave a broad idea of the impact of the federal government (regardless of the product or service purchased), the other subsamples indicated impacts in more specific segments, in which we expected to find positive results. This approach allowed us to test the main hypothesis of this paper.

TABLE 6
Contracts by Original Samples, 2013-2015 (prices of 2017, using IPCA (cumulative inflation rate))

Sample	Contracts	**Total R$**	Median value	Mean value
Total	**32,955**	**65,077,612,896**	**130,932**	**1,974,742**
Health	3,307	**16,749,782,975**	151,630	5,064,948
Education	12,815	**18,544,346,569**	139,270	1,447,081
Defense	884	**3,754,519,433**	377,840	4,247,194
High Tech	4,643	**22,909,926,454**	212,892	4,934,294

Authors' elaboration.

Table 6 shows the number and values of contracts in all samples. As expected, the high-tech sample is the one with the highest total contract value, whereas defense contracts were fewer in the same period. This is possibly due to the specific nature of these kinds of contracts (very complex, customized and strategic contracts). Nevertheless, these figures gave us enough observations to conduct the quasi-experiment in each subsample.

Considering only the main sample, table 7 shows the high quality of the matching using the currently methodological strategy. The same quality was observed in the matching of subsamples (Annex).

4. We considered the following sectors according to the National Classification of Economic Activities (CNAE) 2.0: 21, 26, 58, 59, 60, 61, 62, 63, 64, 65, 66, 69, 70, 71, 72, 73, 74, 75, and 304.

TABLE 7
Variables of interest before and after the matching of the main sample

Variable	Treatment	Control	p-value
		Before the matching	
Number of firms	3,197	81,463	-
Age of firms (log)	2.92	2.84	5.85E-09
Total personnel (log)	4.86	4.41	2.24E-49
Total personnel with tertiary education	266.38	104.95	0.001198961
High-tech sectors (%)	24.59	15.49	9.52E-45
Nationality (%)	7.85	4.35	1.03E-21
South or Southeast regions (%)	65.99	74.60	1.90E-28
		After the matching	
Number of firms	3,181	3,181	-
Age of firms (log)	2.91	2.88	0.1162
Total personnel (log)	4.84	4.83	0.7578
Total personnel with tertiary education	215.75	260.21	0.6804
High-tech sectors (%)	24.59	24.90	0.7714
Nationality (%)	7.86	7.17	0.2954
South or Southeast regions (%)	66.16	66.51	0.7704

Authors' elaboration.

The Annex shows the kernel density estimates for all subsamples. As expected, after the matching, subsamples showed a strong improvement in the distribution of estimates probabilities of accessing the intervention.

After ensuring the quality of the matching between the treatment and the control groups, and, therefore, establishing the necessary causality, we proceeded to the results of the OLS models.

5 RESULTS AND DISCUSSION

Table 8 shows the results of the OLS regression for all five models. Regardless of the sample type, there was no impact of public procurement on the technology efforts of suppliers (considering the technology intensity approach). These results contrast with those found by Rocha (2018), which were obtained using only innovative firms and another database (Pintec). The author found an increase up to 6% in the R&D intensity (of already innovative firms) due to participation in PPI programs.

We were expecting these results for the total sample but not for the Ministry of Health or the high-tech suppliers. The purchases of this ministry, for instance, are quite complex in terms of technology, then we expected some positive impact. In fact, between 2014 and 2018, the most relevant (in terms of value) products purchased by this ministry were vaccines and medicines.

Additionally, as expected, the PDP policy was not strong enough to force a positive impact. Therefore, table 6 confirms our main hypothesis.

TABLE 8
Results of the OLS Model for all samples

Sample	Impact variables according to estimators of differences between treated and control groups	
	$(PO_{t+1} - PO_{t+1}) / PO_{t-1}$	$(POTEC_{t+1} / PO_{t+1}) - (POTEC_{t-1} / PO_{t-1})$
Total	0.139768**	0.00096299
Health	0.2145870***	0.0014305
Education	0.21482934***	0.0002791
Defense	0.312423**	-0.0009970
High Tech	0.2781874***	-0.00018768

Authors' elaboration.
Note: *; **; *** 10%, 5%, and 1% of significance, respectively.

No estimators for the variations on PoTec were statistically significant. However, table 8 shows an unexpected impact on suppliers' PO: according to all models, public procurement increases suppliers' PO. This positive impact is higher in the purchases by the Ministry of Defense and lower in the total sample. Nevertheless, it is positive and statistically significant for all samples.

For instance, high-tech suppliers' PO increased 28% more than the PO of firms that did not negotiate with the federal government. This is quite surprising considering that Brazil does not have a strong and effective public procurement policy. These results point out that public procurement does not affect R&D innovation efforts, but it changes suppliers' PO.

This positive result on PO is relevant mainly because the Brazilian preference margin was poorly implemented. In other words, even without an effective procurement-based policy, the regular bidding process already favors local firms. Therefore, there is no need to pay more in public procurement in order to boost employment. Our data showed that this will happen regardless of the execution of a preference margin policy.

6 FINAL REMARKS

This study investigated procurement processes regardless of any kind of PPI policy (preference margin, pre-commercial procurement, etc.), because these strategies were small, disarticulated, and poorly implemented in Brazil. In fact, quasi-experimental studies may not be able to investigate such subject.

For the first time in Brazil, this paper evaluated the impacts of public procurement on business R&D efforts using Siasg's database, and it confirmed our initial hypothesis: general public procurement does not affect the relative R&D efforts of suppliers. There was no impact even in more complex purchases, like those made by the Ministry of Health or involving high-tech products and services. Therefore, to produce some positive results on technological R&D, public procurement should be specifically designed to do that. In other words, without a strong PPI program, there will be no positive outcome in terms of technology development. Public procurement works as innovation policy tool (Rocha, 2018), but must be design to do so.

Even without a federal central coordination, public procurement had a positive and strong effect on suppliers' PO. This finding is a strong argument against the re-implementation of the normal preference margin policy, since positive impacts have happened without the execution of this policy, and Brazil has been facing a major fiscal crisis. Considering this scenario, the most effective ways to spur innovation through public procurement should include *i*) a strong program of technology procurement; and *ii*) the insertion of innovation requirements into the regular bidding process. After all, there is no need to spend more money to generate employment through public procurement, as it has been already happening.

Brazil has already tried to spur innovation by means of technology procurement. Decree No. 8.269/14 created the National Platform Program to procure solutions for many Brazilian social problems. Due to a huge political turmoil, it was abandoned, but it should be recovered.

The insertion of innovative requirements into the regular bidding process is less complex, but there is a relevant risk aversion behavior in the federal government. Some proposals have been presented, but they are scarce and disconnected.

The new technology procurement legislation (Decree No. 9.283/18) and the discussions conducted in the Congress regarding a new hiring act (Bill No. 1.292/95) could make a difference soon. However, Brazil has been wasting its procurement power instead of using it to boost innovation.

REFERENCES

APPELT, S.; GALINDO-RUEDA, F. **Measuring the link between public procurement and innovation**. Paris: OECD, 2016.

ARAÚJO, B. C.; CAVALCANTE, L. R.; ALVES, P. Variáveis proxy para os gastos; empresariais em inovação com base no pessoal ocupado técnico-científico disponível na Relação Anual de Informações Sociais (Rais). **Radar**: tecnologia, produção e comércio exterior 5. Ipea, 2009.

ASCHHOFF, B.; SOFKA, W. Innovation on demand: can public procurement drive market success of innovations? **Research Policy**, v. 38, n. 8, p. 1235-1247. 2009.

BRAZIL. Federal Government. Painel de Compras do Governo. Retrieved March 20, 2019, from: <https://is.gd/SFAA1K>.

CALIENDO, M.; KOPEINIG, S. Some practical guidance for the implementation of propensity score matching. **Journal of economic surveys**, v. 22, n. 1, p. 31-72, 2008.

CZARNITZKI, D.; HÜNERMUND, P.; MOSHGBAR, N. **Public procurement as policy instrument for innovation**. Bélgica: ZEW (Centre of European Economic Research), 2018.

CZARNITZKI, D.; HUSSINGER, K. Input and output additionally of R&D subsidies. **Applied Economics**, v. 50, n. 12, p. 1324-1341, 2018.

DOSI, G. Sources, procedures, and microeconomic effects of innovation. **Journal of economic literature**, v. 26, n. 3, p. 1120-1171, 1988.

DRACA, M. **Reagan's Innovation Dividend? Technological Impacts of the 1980s US Defence Build-up**. London: London School of Economics. 2012.

EDLER, J. Review of policy measures to stimulate private demand for innovation: concepts and effects. In: **Compendium of Evidence on the Effectiveness of Innovation Policy Intervention**, organized by Manchester Institute of Innovation Research. Manchester: MIoIR and Nesta, 2013.

EDLER, J. et al. **Public procurement and innovation in an evolutionary framework**: evidence from public sector suppliers. Presentation, Demand, Innovation and Policy Underpinning Policy Trends with Academic Analysis conference, Manchester Institute for Innovation Research, MBS, University of Manchester, March 22-23, 2012.

EDLER, J.; GEORGHIOU, L. Public Procurement and innovation: resurrecting the demand side. **Research Policy**, v. 36, n. 7, p. 949-963, 2007.

EDOVALD, T.; FIRPO, T. **Running randomized controlled trials in innovation, entrepreneurship, and growth**: an introductory guide. London: Nesta. Retrieved Sept. 20, 2016, from: <https://is.gd/y8PpqQ>.

EDQUIST, C. et al. **Public Procurement for Innovation**. Cheltenham: Edward Elgar. 2015.

EDQUIST, C.; HOMMEN, L. Public technology procurement and innovation theory. In: **Public Technology Procurement and Innovation**, organized by Charles Edquist and Leif Hommen, p. 5-70. Boston: Springer, 2000.

GEROSKI, P. A. Procurement Policy as a Tool of Industrial Policy. **International Review of Applied Economics**, v. 4, n. 2, p. 182-198, 1990.

GUERZONI, M.; RAITERI, E. Demand-side vs. supply-side technology policies: hidden treatment and new empirical evidence on the policy mix. **Research Policy**, v. 44, n. 3, p. 726-747, 2015.

LI, Y. et al. Public procurement for innovation elements in the Chinese new energy vehicles program. **Public Procurement for Innovation**, edited by C. Edquist, 179-208. Cheltenham: Edward Elgar Publishing. 2015.

LICHTENBERG, F. R. The private R and D investment response to federal design and technical competitions. **American Economic Review**, v. 78, n. 3, p. 550-559, 1988.

MCAFEE, A.; BRYNJOLFSSON, E. **Machine, platform, crowd**: Harnessing Our Digital Future. New York: WW Norton & Company, 2017.

MOWERY, D.; ROSENBERG, N. The influence of market demand upon innovation: a critical review of some recent empirical studies. **Research Policy**, v. 8, n. 2, p. 102-153, 1979.

NEGRI, F.; RAUEN, A. **Innovation policies in Brazil during the 2000s**: the need for new paths. Brasília: Ipea, 2018.

NOWAK, P. **Sex, bombs, and burgers**: how war, pornography, and fast food have shaped modern technology. Lanham: Rowman & Littlefield, 2011.

OECD – ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT. **Science, Technology and Patents**. OECD.Stat. 2019. Available at: <https://stats.oecd.org>.

OLIVEIRA, B. C. S. C. M.; SANTOS, L. M. L. Compras públicas como política para o desenvolvimento sustentável. **Revista de Administração Pública**, v. 49, n. 1, p. 189-206, 2015.

RANDOLPH, J. J.; FALBE, K. A step-by-step guide to propensity score matching in R. **Practical Assessment, Research & Evaluation**, v. 19, n. 18, p. 1-6. 2014.

RAUEN, A. T. **Margens de preferência**: limites à avaliação de resultados e impactos. Brasília: Ipea, 2016. (Nota Técnica Diset n. 26).

______. (Ed.). **Políticas de inovação pelo lado da demanda no Brasil**. Brasília: Ipea, 2017.

RAUEN, C. O Projeto Sirius e as encomendas tecnológicas para a construção da nova fonte de luz Síncrotron brasileira. In: RAUEN, A. (Ed.). **Políticas de inovação pelo lado da demanda no Brasil**. Brasília: Ipea, 2017.

RIBEIRO, C. Desenvolvimento tecnológico nacional: o caso do KC-390. In: RAUEN, A. **Políticas de inovação pelo lado da demanda no Brasil**. Brasilia: Ipea, 2017.

RIBEIRO, C. G. et al. Unveiling the public procurement market in Brazil: a methodological tool to measure its size and potential. **Development Policy Review,** v. 36, n. S1, p. O360-O377, 2018.

ROCHA, F. Does public procurement for innovation increase innovative efforts? The case of Brazil. ENCONTRO NACIONAL DE ECONOMIA INDUSTRIAL E INOVAÇÃO, IERI--UFU, 3. **Anais**... Minas Gerais, Uberlândia, 2018.

ROCHA, G.; RAUEN, A. **Mais desoneração, mais inovação**? Uma avaliação da recente estratégia brasileira de intensificação dos incentivos fiscais à pesquisa e desenvolvimento. Brasília: Ipea, 2018.

SLAVTCHEV, V.; WIEDERHOLD, A. Technological intensity of government demand and innovation. **Ifo Working Paper**, n. 135, 2016.

SQUEFF, S.; HOLANDA, F. **O poder de compras governamental como instrumento de desenvolvimento tecnológico**: análise do caso brasileiro. Brasília: Ipea, 2014.

VARRICHIO, P. C. As Parcerias para o Desenvolvimento Produtivo da Saúde. In: RAUEN, A. **Políticas de inovação pelo lado da demanda no Brasil**. Brasília: Ipea, 2017.

ANNEX

TABLE A.1
Analysis of deviance (type II tests)

Year	Variable	LR Chisq	Df	Pr(>Chisq)
2013	Age of firms (log)	52.64	1	4E-13
	Total personnel (log)	301.25	1	1.76E-67
	Total personnel with tertiary education	6.25	1	0.012409
	Economic Sector (CNAE 2.0)	2,077.97	86	0
	Region	114.91	4	6.49E-24
	Nationality	41.28	1	1.31E-10
2014	Age of firms (log)	46.07	1	1.14E-11
	Total personnel (log)	68.27	1	1.42E-16
	Total personnel with tertiary education	0.14	1	0.699003
	Economic Sector (CNAE 2.0)	926.68	86	4.3E-141
	Region	118.92	4	9.07E-25
	Nationality	4.52	1	0.033378
2015	Age of firms (log)	21.05	1	4.47E-06
	Total personnel (log)	24.38	1	7.89E-07
	Total personnel with tertiary education	16.47	1	4.93E-05
	Economic Sector (CNAE 2.0)	555.64	86	8.01E-70
	Region	40.21	4	3.91E-08
	Nationality	5.37	1	0.0204

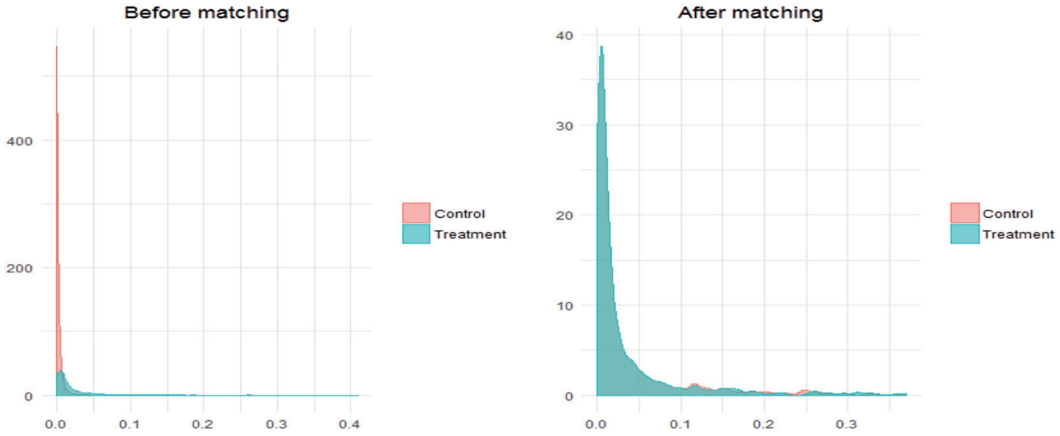
Authors' elaboration.

TABLE A.2
Variables of interest before and after the matching, health sample

Variable	Treatment	Control	p-value
		Before the matching	
Number of firms	678	8,4709	
Age of firms (log)	3.024306524	2.841717783	8.54E-09
Total personnel (log)	5.266729437	4.438189326	3.04E-28
Total personnel with tertiary education	479.9233781	114.1258573	0.013002055
High-tech sectors	0.253687316	0.159811294	2.87E-11
Nationality	0.14159292	0.044597513	4.58E-34
South or Southeast regions	0.706489676	0.740735827	0.042270615
		After the matching	
Number of firms	677	677	
Age of firms (log)	3.022590788	2.986849493	0.421780173
Total personnel (log)	5.26311761	5.328455662	0.524197409
Total personnel with tertiary education	478.059165	364.7805755	0.4786667
High-tech sectors	0.252584934	0.267355982	0.535527996
Nationality	0.140324963	0.152141802	0.538355783
South or Southeast regions	0.70605613	0.704579025	0.952466027

Authors' elaboration.

FIGURE A.1
Kernel density, health sample



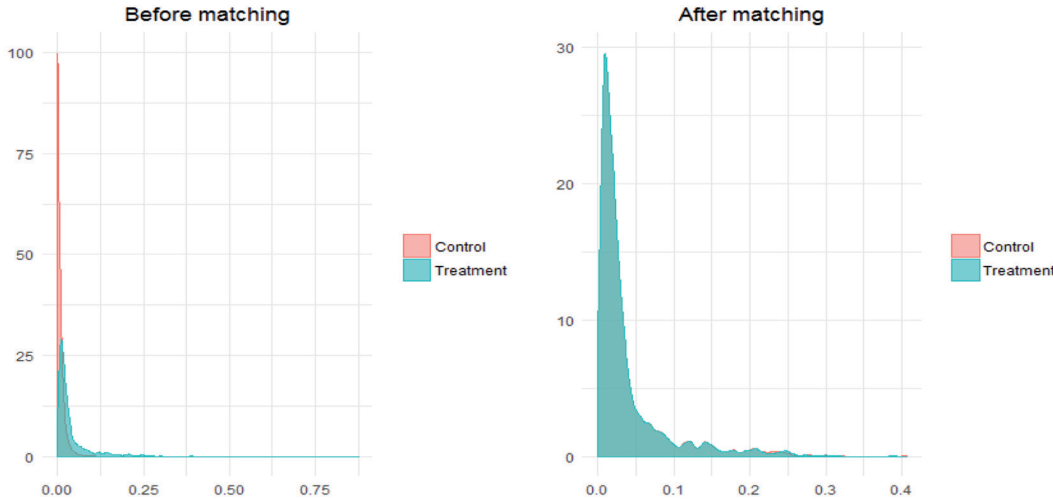
Authors' elaboration.

TABLE A.3
Variables of interest before and after the matching, education sample

Variable	Treatment	Control	p-value
		Before the matching	
Number of firms	1,751	8,3285	
Age of firms (log)	2.931532556	2.839541793	1.84E-06
Total personnel (log)	4.850555325	4.432479222	1.79E-24
Total personnel with tertiary education	240.2897067	114.8946306	0.029890506
High-tech sectors	0.214734437	0.159103526	2.52E-10
Nationality	0.08452313	0.044535272	8.92E-16
South or Southeast regions	0.679040548	0.742568384	1.48E-09
		After the matching	
Number of firms	1,742	1,742	
Age of firms (log)	2.925481728	2.945880702	0.454942312
Total personnel (log)	4.832144062	4.881908616	0.37213112
Total personnel with tertiary education	171.1221249	132.4156742	0.098720608
High-tech sectors	0.211825488	0.22445465	0.366786692
Nationality	0.082663605	0.07749713	0.574266634
South or Southeast regions	0.679104478	0.684270953	0.743419335

Authors' elaboration.

FIGURE A.2
Kernel density, education sample



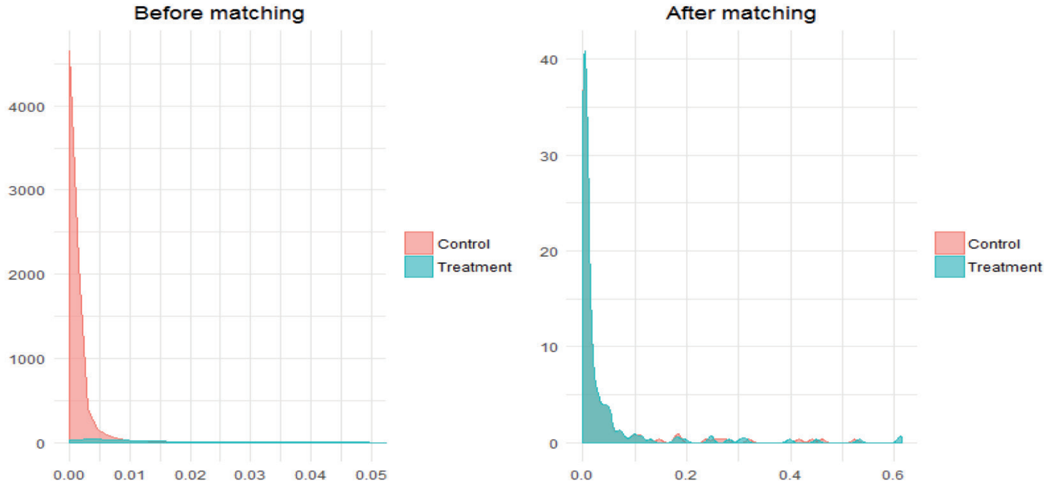
Authors' elaboration.

TABLE A.4
Variables of interest before and after the matching, defense sample

Variable	Treatment	Control	p-value
		Before the matching	
Number of firms	216	8,5276	
Age of firms (log)	3.03931956	2.843767806	0.000893014
Total personnel (log)	5.522133172	4.446138153	1.90E-13
Total personnel with tertiary education	720.4900037	116.4062789	1.99E-05
High-tech sectors	0.287037037	0.160688666	4.38E-07
Nationality	0.143518519	0.045685066	6.23E-12
South or Southeast regions	0.541666667	0.741219565	2.22E-11
		After the matching	
Number of firms	215	215	
Age of firms (log)	3.033629512	3.001959889	0.698866467
Total personnel (log)	5.508325903	5.341486077	0.388810526
Total personnel with tertiary education	705.0063748	589.208695	0.533116828
High-tech sectors	0.28372093	0.297674419	0.750027191
Nationality	0.144186047	0.158139535	0.686300947
South or Southeast regions	0.544186047	0.544186047	0.999999

Authors' elaboration.

FIGURE A.3
Kernel density, defense sample



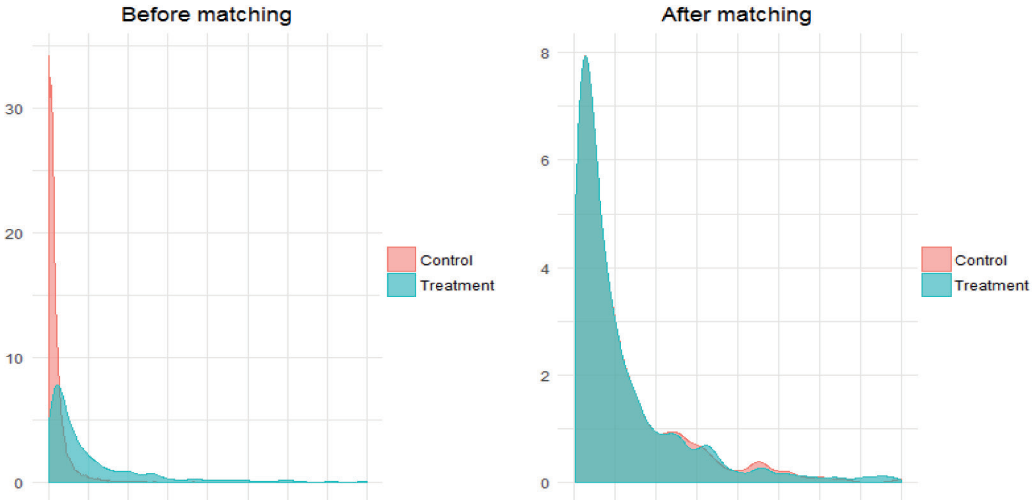
Authors' elaboration.

TABLE A.5
Variables of interest before and after the matching, high tech sample

Variable	Treatment	Control	p-value
		Before the matching	
Number of firms	786	13,099	
Age of firms (log)	2.963880209	2.554206432	3.75E-42
Total personnel (log)	4.825900426	3.712636295	5.58E-62
Total personnel with tertiary education	699.5693213	53.03001254	0.001140944
High-tech sectors	0.108142494	0.064366146	1.02E-06
Nationality	0.763358779	0.829059208	1.55E-06
South or Southeast regions	786	13099	
		After the matching	
Number of firms	778	778	
Age of firms (log)	2.951475023	2.913112388	0.324821955
Total personnel (log)	4.774718517	4.802258002	0.737091058
Total personnel with tertiary education	337.5094785	279.2722855	0.607511709
High-tech sectors	0.106683805	0.097686375	0.557958517
Nationality	0.763496144	0.767352185	0.857558329
South or Southeast regions	778	778	

Authors' elaboration.

FIGURE A.4
Kernel density, high-tech sample



Authors' elaboration.

Ipea – Institute for Applied Economic Research

Press and Communications Office

PUBLISHING DEPARTMENT

Coordination
Reginaldo da Silva Domingos

Coordination Assistant
Rafael Augusto Ferreira Cardoso

Supervision
Camilla de Miranda Mariath Gomes
Everson da Silva Moura

Typesetting
Bernar José Vieira
Cristiano Ferreira de Araújo
Danilo Leite de Macedo Tavares
Herllyson da Silva Souza
Jeovah Herculano Szervinsk Junior
Leonardo Hideki Higa

Cover design
Danielle de Oliveira Ayres
Flaviane Dias de Sant'ana

Graphic design
Renato Rodrigues Buenos

The manuscripts in languages other than Portuguese published herein have not been proofread.

Ipea Bookstore
SBS – Quadra 1 – Bloco J – Ed. BNDES, Térreo
70076-900 – Brasília – DF – Brazil
Tel.: + 55 (61) 2026 5336
Email: livraria@ipea.gov.br

Composed in Adobe Garamond 11/13.2 (text)
Frutiger 47 (headings, graphs and tables)
Brasília – DF – Brazil

Ipea's mission
Enhance public policies that are essential to Brazilian development by producing and disseminating knowledge and by advising the state in its strategic decisions.

ipea Institute for Applied Economic Research

MINISTRY OF
ECONOMY

PÁTRIA AMADA
BRASIL
BRAZILIAN GOVERNMENT

ISSN 1415-4765
9 771415 476001