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Introduction

1 The Rio Grande Naval and Offshore Pole began in 2006, with the construction of a dry dock in Rio Grande, a city in the south of Brazil. It is still the largest structure of this kind in Latin America[1]. Besides it, two other shipyards for large-scale vessels became part of the complex; one of them in São José do Norte, a neighboring municipality. As part of a government strategy to promote the development of the naval sector (Dores et al. 2012), Petrobras[2] built seven platforms. It required a large amount of labor along with goods and services to support production. In June 2013, this workforce was more than 8,100 formal workers specific to this sector in the two municipalities. It is about 3.4% of the combined population[3] and the equivalent of 38.2% of the total number of formal jobs created in the region since 2007. In 2014, scandals and corruption

investigations at the oil company and the government ended some contracts and decreased investments and activity at the complex.

2 Several researchers such as Neitzke (2015), Carvalho et al. (2016), Teixeira et al. (2016), and Bartz and Teixeira (2017) concluded that the new activity in the region was followed by important economic and social changes. Some studies mentioned variations in the level of aggregated formal employment, migration of workers, and the probable effects of these migratory movements in these municipalities. However, Teixeira et al. (2016) measured the impact of the naval complex activity on the aggregate of formal jobs in the region and concluded that there were no statistically significant effects.

3 Our study investigated the impact of these state-supported investments, hypothesizing that the effect on aggregate formal employment was positive, at least during the shipping boom. It contrasted previous literature that did not reach this conclusion supposedly due to the methodology and the sample period used. We selected the sample to include the year following the start of construction on the last platform and started the sample with the oldest data in the database. Therefore, the range is from 2007 to 2017, monthly.

4 Our goals are to verify the causality and measure the magnitude of the effect with a less restricted methodological specification, as well as identify if the possible effects were only short-term or if they were maintained after the decrease in support and contracts. To this end, we conducted a descriptive analysis of the employment, providing evidence of the causality and the short-term magnitude of the effect. We provided information to calibrate the statistical model and later demonstrate the causality, which confirmed the hypothesis of the effect on formal employment.

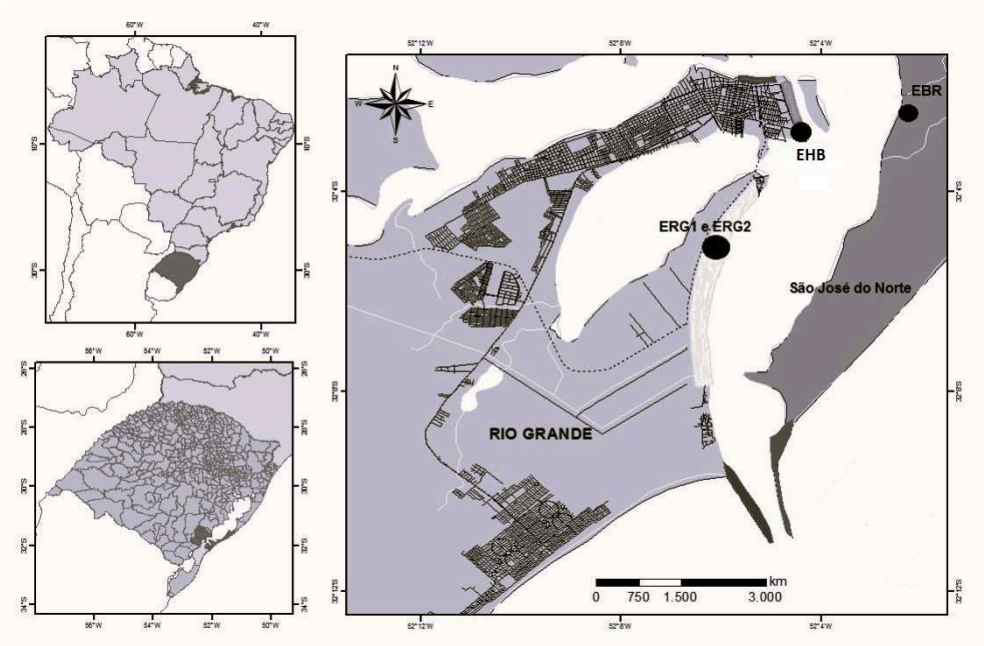
5 In the descriptive statistics, we recorded several observed and estimated characteristics of employment in the naval sector and the aggregate. We used a statistical model with panel data for the estimation with the econometric technique of differences-in-differences (DD) to infer the magnitude of the pole's effect on aggregate employment. However, instead of including variables with dichotomous weights (dummies) corresponding to the time and space dimensions of the “treatment” of the naval activity, we considered variables with a continuum of weights, potentially heterogeneous over the years and municipalities under treatment. We seek to contribute to the understanding of the possible results of government strategies for financing, promoting, and developing regional economic activities not yet supported by the private sector with this analysis. This natural experiment in the shipbuilding industry and in an emerging country is an opportunity to scientifically evaluate government strategies.

6 In the next section, we present the naval complex and the data on its investments, as well as the literature review. In section 3, we analyze employment in the naval sector, as well as in the aggregate. In the fourth section, we proceed to the statistical demonstration of causality, estimate the heterogeneous effect on aggregate employment, and discuss the policy implications. In the last section, we show our concluding remarks.

The naval complex and investments

7 The Rio Grande Naval and Offshore complex (in short, the naval pole) is composed of two shipyards in the municipality of Rio Grande (RG), one shipyard in the municipality of São José do Norte (SJN), and by its local supply chain (Figure 1). Its development is related to the discovery of large oil reserves in the pre-salt layers of the Brazilian coast in 2006 by Petrobras.

Figure 1. Rio Grande, São José do Norte (Brazil) and its shipyards



On the right: Brazil above and Rio Grande do Sul below. On the left, Rio Grande and São José do Norte. In Rio Grande, the Estaleiro Honório Bicalho (EHB) shipyard and the Estaleiros Rio Grande (ERG) shipyard, which is divided into two: ERG1 and ERG2. In São José do Norte, the Estaleiros do Brasil (EBR) shipyard. Source: Cunha and Rückert (2019).

8 Petrobras, with a market reserve regulation, demanded specific platforms to explore the pre-salt layer (Araújo et al. 2012). In addition to the market reserve, there was an environment of state support for the development of the naval sector. According to Dores et al. (2012), in the first decade of the 21st century, some of the government actions were: the demand for national involvement in oil and gas exploration and production activities; interest rates, and facilitated participation in financing with national involvement contracts relating to resources from specific funds for shipbuilding; constitution of a credit risk guarantee fund to finance the construction of vessels; the exemption of a tax on shipbuilding parts by national shipyards and the exemption of two taxes on materials for the shipbuilding industry. The authors also argue that there was an important advance in investments in the sector, which resulted in the expansion and modernization of the productive capacity of vessels and the national fleet. The conclusion was that the Brazilian State played a fundamental role in the growth and consolidation of the country's naval industry, through economic support (Cunha and Rückert 2019).

9 In Rio Grande do Sul, a state in the extreme south of Brazil where the municipalities of Rio Grande and São José do Norte are located, the first platform ordered by Petrobras

and built at the naval complex was the P-53, which started in late 2007. At the time, the P-53 was the largest and most modern Petrobras FPU (Floating Production Unit) platform (Carvalho et al. 2016). In 2008, another construction began on a new platform of the same type. In 2010, Petrobras signed a contract for the construction of eight more platforms with a business group that bought the ERG in the same year (Carvalho et al. 2016). In Table 1, we list the shipbuilding carried out at that complex, specifying the shipyard, the estimated value of the investments according to the sources, and the start and end dates of the undertakings. No construction was demanded by private companies, only by Petrobras. The values listed total US$ 6.54 billion – we did not include the construction of the shipyards themselves.

Table 1. Construction in the Rio Grande naval complex

Construction	Shipyard	Estimated value (US$ Billion)	Start	Complete
P-53	EHB	0.80	Sep/2007	Oct/2008
P-55	EHB	1.60	Sep/2008	Oct/2013
P-58	EHB	1.30	Oct/2011	Dec/2013
P-63	EHB	1.30	Feb/2013	Jun/2013
P-66	ERG	0.40	May/2013	Dec/2014
P-67	ERG	0.40	Apr/2014	Sep/2015
P-74	EBR	0.74	Aug/2016	Feb/2018

It includes only naval constructions (platforms). Source: Made by the authors based on information published in the local press.

10 Many of these constructions were financed with the Merchant Marine Fund (FMM), currently administered by the Ministry of Infrastructure. This fund provides resources for the development of the Merchant Navy and the Brazilian shipbuilding and repair industry. In general, the financing conditions of this fund are more favorable than those of the private sector.

11 The peak of the Rio Grande Naval complex was in 2013 when it employed more than 8,100 formal workers (time series presented in the next section). During the following two years, this level of employment remained similar. The complex's construction contracts were interrupted in 2014, when Operation Car Wash started, known as “the largest operation against corruption in Brazil's history” (Pacheco 2017, 1). Several contractors and their main executives were the target of legal measures on the charge of forming a cartel and embezzlement through corruption of public entities; mainly related to fraud in bids at Petrobras (Pacheco 2017). As a result, the controlling companies of the EBR shipyard became part of a list of companies prohibited from arranging new contracts with Petrobras (Petrobras 2014)[4].

12 At the end of 2016, after a disagreement between one of the construction companies and Petrobras about the continuity of production on the other contracted platforms, the construction company dismissed 3,200 employees in a single month (Ávila 2016). It led to layoffs in several small companies providing indirect services. D'Avila and Bridi (2017) said that these legal situations caused negative implications on investments in the complex and increased unemployment in the region. Petrobras started to reduce investments during Operation Car Wash, and according to its 2016 administrative report, “the partnership and divestment program totaled US$ 13.6 billion for the 2015-2016 biennium. US$ 21 billion is projected for the 2017-2018 biennium”

(Petrobras 2017, 24). Part of the divestment program decision was due to the need to reduce the company's leverage, which increased because of corrupt practices the practice by some of its directors. Petrobras acknowledged having unduly paid R$ 6,194 million (more than US$ 2 billion at the time) in the acquisition of assets (Petrobras 2014).

13 Cunha and Rückert (2019) mentioned that the naval complex was the driving force behind the entire industrial chain involved in the activity, with emphasis on the metalworking sector. The authors concluded that the complex's dependence on state support, which included subsidies, limited its competitiveness. It put the region into stagnation, and with the effects of the corruption cases, left the sector without good prospects.

14 Many studies have focused on this subject. Bartz and Teixeira (2017) investigated the turnover of workers[5] in the region from 2003 to 2013, relating it to investments in the complex. They used panel data in a differences-in-differences model to estimate the determinants of turnover and to analyze the subsequent impacts. They found that there was an increase of 132% in labor turnover in Rio Grande after the opening of the complex and a decrease of 43.18% in São José do Norte in 2006. Pereira et al. (2016) evaluated the effects of the expansion of the naval industry in four states of Brazil, including Rio Grande do Sul. They focused on the labor market of the municipalities that received these investments. They also applied the differences-in-differences method until 2011. They concluded that there was a small positive movement in the stock of formal labor in the industry, 2% in 2006 and 1% in 2009 in Rio Grande, but this was preceded by a reduction effect of 2.3% in 2005 in the trade labor stock.

15 In another study, Teixeira et al. (2016) evaluated the effects of shipbuilding in the region on some economic and social variables, including labor force stock and job turnover. They also used the differences-in-differences method on a data panel from 2000 to 2013. They concluded that in Rio Grande the total labor force stock was not strongly influenced by these investments, compared to the other municipalities; the same occurred in São José do Norte. However, when these cities and the municipality of Pelotas (neighboring RG) are considered together, they estimate a positive effect of 12% on the joint stock of jobs per capita in 2009[6]; they also found important effects on GDP per capita and job turnover.

16 No study specifically considered employment in the economic activity of shipbuilding, which is directly related to investments in the naval complex. Pereira et al. (2016) mentioned six economic activity sectors, but not shipbuilding. Bartz and Teixeira (2017) and Teixeira et al. (2016) did not separate economic sectors of employment; they only analyzed aggregate employment.

17 Unlike the studies mentioned, we are investigating the specific role of shipbuilding in our decomposition of sectors: the class "construction of vessels and floating structures" (from the CNAE-2.0-class classification[7]). We used a different specification of the differences-in-differences model to identify the effect of the naval complex on employment in those municipalities, which we believe was positive.

Descriptive employment analysis

18 We used the CAGED database – the General Register of Employed and Unemployed, from the Ministry of the Economy – to study employment in Rio Grande and São José do

Norte. This register contains monthly information on the entry and exit (in general terms, movements) of workers with an employment contract. Some employees, such as maids and most civil servants, do not have their movements registered and, therefore, are not included in the study. With these data, we do not have the number of active workers, but using the registered movements we know the accumulated variation, which is the relative stock (to the period before the sample). We selected the sample to include the year after the construction of the last platform began, and we started the sample with the oldest data from the base. Therefore, the interval is from 2007 to 2017, with monthly periodicity.

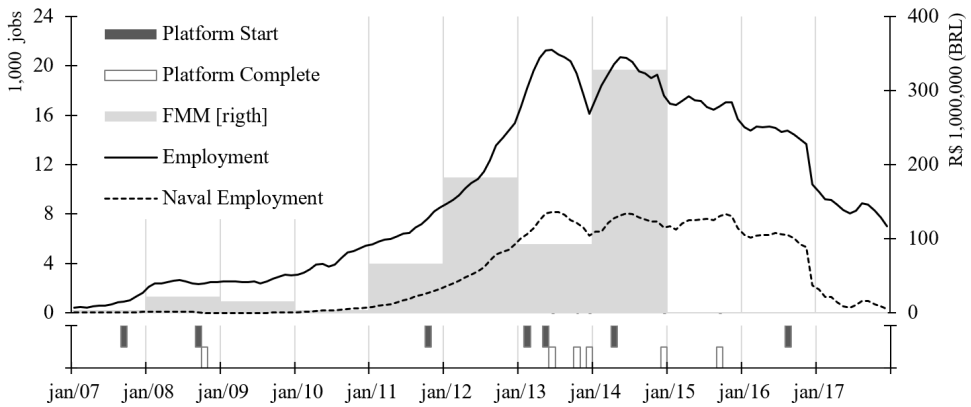
We considered x_t the accumulated variation up to month t, corresponding to the sample period starting in t_0= Jan/07 (January 2007) and ending in Dec/17. Being A_t and D_t the number of workers hired and laid off in month t, respectively. Then we calculated the accumulative variation as $x_t = \sum_{\tau=t_o}^{t} A_\tau - D_\tau$. Thus, the value x_t corresponds to the number of formal workers (taken from the register) active in t – the absolute stock –, less the number of assets in Dec/06 (the period immediately before the sample). In the analysis of variation, evolution, correlation, and others insensitive to displacement, the results with the series $\{x_t\}$ were identical to the results with the data series of absolute stock (unknown with these data). To make the text easier, we call x the level of employment.

To analyze the specific economic activity of shipbuilding, we broke down the labor and used $x_t^N = \sum_{\tau=t_o}^{t} A_\tau^N - D_\tau^N$ for the accumulated variation to this productive sector, in which the superscript N denotes the variable for this naval activity. We used x_t without a superscript to denote the aggregate level of employment (all sectors). If we do not indicate in subscript a specific municipality or region, then it refers to the sum of the level of employment in the two municipalities of the naval complex.

The value x^N does not represent the total number of formal workers employed in the naval complex companies, as they have other employees, such as those in the production support sectors (administrative, transportation, security, etc.). It quantifies only those employed in the construction of ships and floating structures in the shipyards. However, if in the shipbuilding production function, the x^N factor maintains a constant proportionality, or close to it, in relation to workers in other sectors, then it is a good proxy for the total labor force of the naval complex.

The higher the proportion of x^N in the production function about the other workers, the lower the distortion of the proxy when this proportionality varies. In this paper, we assumed that the proportionality is close to constant. Later, we observed some data that suggest the highest proportion of x^N. In addition, if in the production function, the proportion of the total labor force in relation to the other factors is also relatively constant, then x^N is also a good proxy for naval production in this complex. We hypothesized this to be the case since the period analyzed is short to support significant changes in shipbuilding production technology. Figure 2 shows the time series of the level of employment of the naval sector, x_t^N, and of the aggregate of sectors, x_t, in the naval complex.

Figure 2. Levels of employment in the naval sector and transfers from the FMM



Level of employment by accumulative variation, with combined values for RG and SJN. Platforms starting and ending according to Table 1. The FMM is the annual disbursement of subsidized financing, with state resources from the Merchant Marine Fund (FMM). Source: Made by the authors according to data from the Ministries of Economy and Infrastructure.

From 2011 on, the naval sector, x_t^N, experienced exponential growth and reached 8,138 workers in Jul/13, with the creation of 6,213 jobs between Jan/12 and Jun/13 – in 18 months, about 2.8% of the total population of RG and SJN. Between Jan/13 and Nov/16, it remained on a relatively constant high plateau, with seasonal variations, having an average of 7,063 active workers in the sector. After a sharp drop in Dec/16, it returned to a plateau with an average of 767 workers between Jan and Dec/17 – in the last month, 302 employees.

We can see the high correlation between the two data series, the level of employment in the naval sector, and the aggregate level of employment: coefficient r = 0.96[8]. As for the difference in the level between the two data series, we found that on average x_t was 2.56 times the value of x_t^N. In other words, on average x_t^N was approximately equal to 35.5% of the combined level of formal employment in the two municipalities. Despite the relationship, we cannot infer causality between the variables with these statistics alone – we will do this next, with the proper differences-in-differences method.

19 Some initial shipbuilding was accompanied by a significant increase in number of workers. On the other hand, construction finalizations were accompanied by greater dismissals than admissions. The movements were more pronounced at times when there was an accumulation of work started or finished, as in 2013. An unusual period is the end of 2016, when the level of employment was still high, and the construction of P-74 began. However, it was followed by the largest reduction of workers in the naval complex since its inception – a total of 3,095 dismissals in Dec/16. This coincided with the dismissal of 3,200 employees (not just from the naval sector) from a single construction company on the 12th of that month, due to the reasons outlined in the previous section. Only 500 workers remained employed; 300 were on leave and another 200 were working in the maintenance of the shipyard (Ávila 2016). This piece of information reinforces the hypothesis that the economic class N is a good proxy for employment in the naval complex, due to its large share:

> in this scenario x^N represented 84% to 97% of the total jobs in the shipyard (3,200 + 500). We can see also that the dismissal of those workers was accompanied by the largest drop in the level of aggregate employment: $\Delta x_{Dec/16}$ = -3,320.

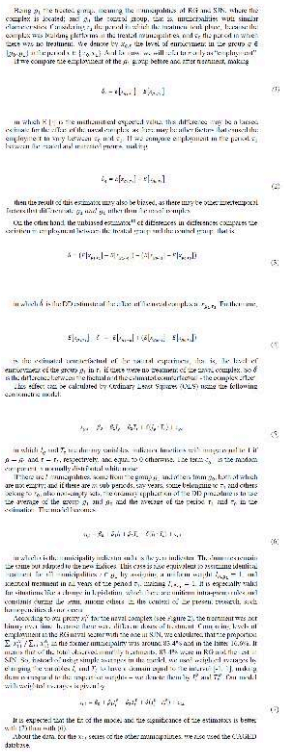
20 We also identified a temporal similarity between the level of employment in the naval sector, the transfer of resources from the state fund for shipbuilding (FMM), and the start of construction – see Figure 2. We did not obtain any information on the financing contracts and the deadlines for the transfer of funds from the FMM to the construction companies, which made it difficult to identify the relationships. However, the identification of temporal similarity corroborates the literature that employment and social impact in the complex municipalities were linked to state investments and the government's development project in this naval complex.

Effects of the naval complex on aggregate employment

21 In this section, we extrapolate the simple identification of correlation and patterns between the variables. Here we demonstrate the causal relationship between these two, identifying at least one direction, and we estimate its magnitude.

> Our empirical strategy, to estimate the impact of the naval complex on x_t, is to compare it with the level of employment of similar municipalities that did not receive the complex's treatment (natural experiment control group).

22 We used the differences-in-differences model, which seeks to isolate, from a panel data set, the effect of the treatment on the dependent variable, without the need for many controlled variables for unobserved characteristics[8]. Callaway and Sant'Anna (2021) said that this method "has become one of the most popular research designs used to evaluate causal effects of policy interventions.". Imbens and Rubin (2015) also said that the differences-in-differences model is an appropriate method for assignment mechanisms in causal inference.



23 Like Bartz and Teixeira (2017) and Teixeira et al. (2016), we chose the municipalities that are part of the so-called COREDE-Sul, corresponding to a portion of municipalities in Rio Grande do Sul with adjacent geographical spaces in the south of the state[9], including RG and SJN – total of $l = 22$. This choice is justified by the economic similarity of these units; in general, they are also subjected to the same specific strategies of COREDE-Sul and the homogeneous policies of the state. We excluded from the sample the municipality of Pelotas, which due to its proximity to the naval complex and great economic interaction with RG and SJN was significantly influenced by the complex[10], despite not having received the treatment. The maintenance of Pelotas in the control group would result in biased estimates. With the exclusion, we are left with $l = 21$.

Thus, we believe that the average trend of x_t in the group $g_1 = \{\text{RG}, \text{SJN}\}$ and $g_0 = \{i \in \text{COREDE}_{\text{Sul}} \mid i \neq \text{RG}, \text{SJN}, \text{Pelotas}\}$ are parallel.

24 In addition, to control the heterogeneous characteristics of the municipalities, but fixed in time, we include in (7) a set (denoted by ef.M) of municipality dummies – that is, we control for individual fixed effects.

25 The periodicity of CAGED data is monthly, and totals 132 observations in the sample period, from Jan/2007 to Dec/2017 (the same as in the previous sections). However, if we chose to use all the monthly data in the estimation, we would have to employ a dynamic panel model (due to the strong autocorrelations identified); and this would

require more sophisticated identification, estimation, and diagnosis procedures, which is outside the scope of this paper. As an alternative, we aggregated the levels of employment of each year by the simple average and used the annual periodicity (total of $m = 11$) –

an aggregation applied to the x_i series of each municipality, and to the x_t^N proxy.

26 We also included in (7) a set (denoted by ef.A) of year dummies to control the fixed effects of time.

Due to the comparison of treatment proportions in RG and SJN, we make $I_{\text{RG}}^p = 0.834$, $I_{\text{SJN}}^p = 0.166$ and that $I_{i \in g_0}^p = 0$. For the variable of treatment weights over time, we make

$$T_t^p = \frac{x_t^N}{\sum_t x_t^N} \quad \in [-1, 1] \tag{8}$$

Despite the heterogeneity of the effects, the weight T_t^p does not differ across municipalities, so part of the effect is still aggregated by the average.

4.1 Results and Discussion

27 The result of the estimates and diagnostic tests, referring to model (7) plus the dummies of fixed effects, are shown in column M1 of Table 2.

We found that the estimated weighted average effect of the complex on x_t was approximately $\hat{\delta} = 74{,}684$. A positive, significant, and high effect. According to our weighting, the estimated maximum effect was in RG in 2015: $I_{\text{RG}}^p \cdot T_{2015}^p \cdot \hat{\delta} =$ 16,392 more formal workers in the labor market due to the naval complex, which represented 7.8% of the municipality's inhabitants.

28 In the same year, this effect on SJN was 2,715 (10.4% of its population). Table A1 in the appendix explains all the effects.

Table 2. Estimates and diagnosis for DD models

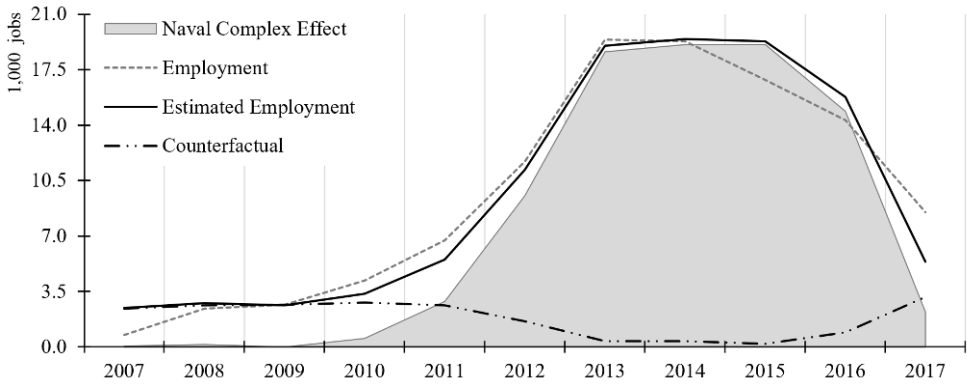
Variable	Models and their Coefficients				
	M1	M1.1	M2	M3	M4
$I^p \cdot T^p$	74,684 *(2,376)***	74,346 *(2,319)***			
I^p	-3,721 *(1,049)***	3,642 *(111)***	-3,026 *(1,191)**		
T^p	20,945 *(10,309)**	761 *(718)*		21,257 *(10,382)**	
$I \cdot T^p$				34,061 *(22,409)*	
$I^p \cdot T$			12,997 *(424)***		
$I \cdot T$					5,912 *(3,916)*
I				-2,617 *(2,126)*	-2,235 *(1,892)*
T			283 *(129)**		339 *(144)**
ef.A	yes	no	yes	yes	yes
ef.M	yes	no	yes	yes	yes
R^2_{adj}	0.95	0.93	0.91	0.81	0.79
Durbin-Watson	[0.77]	[<0.01]	[0.82]	[0.76]	[0.78]
Wooldridge test	[0.12]	[0.04]	[0.19]	[0.14]	[0.15]
King-Wu (time)	[0.99]	[0.65]	[0.99]	[0.99]	[0.99]
King-Wu (indiv)	[0.99]	[<0.01]	[0.99]	[0.99]	[0.99]

Estimation by OLS (pooling). Calculated by the authors based on Ministry of Economy data. Estimates robust a la White covariance matrix for panel models. Significance codes: 0.01 (***); 0.05 (**); 0.10 (*). In parentheses, the robust standard error of the estimated coefficient; between square brackets, the p-value for the test statistic.

We also obtained the time series of the effect on the joint level of employment of the two municipalities of the complex, defined by $\hat{\delta}T_t^p$. In Figure 3, we present this data series, together with one of the observed levels $x_{g_1,t}$, one of the levels estimated by the model $\hat{x}_{g_1,t}$ and the one of the estimated counterfactual, given by $\hat{x}_{g_1,t} - \hat{\delta}T_t^p$.

29 The level of employment in the naval sector, a proxy for the economic activity of the naval complex, greatly affected employment in these municipalities. Between 2013 and 2016 the average level of employment in the complex municipalities was over 17,000, but in the simulated alternative with the absence of the complex treatment (counterfactual), the average between 2013 and 2016 would be only 466 jobs – almost a return to the pre-2007 level.

Figure 3. Effects of the naval complex on the level of employment in its municipalities



Employment data series obtained by summing the level of employment observed in the two municipalities in the complex (monthly average in each year)[11].

In 2015, with the level of employment in the naval sector equal to $x^N_{2015} = 7{,}423$ and using the estimate $\hat{\delta}T^p_{2015} = 19{,}309$, we calculated that the indirect effect of x^N_{2015} on $\hat{x}_{2015}$ in equation (3) was $19{,}309 - 7{,}423 = 11{,}886$, about 1.6 times the direct effect.

30 Therefore, in 2015 the effect of employment in the naval sector is greater than zero in at least one other sector. That is, employment in the naval sector positively affected employment in other sectors and, in the aggregate of sectors, it was also positive – a result that occurred in most years of the sample.

31 The evolution of the naval complex effect, as expected, follows the level of employment in the naval sector, the beginning, and the end of the construction of the platforms with some lag, and the transfers from the state fund. Following the legal and political issues of Operation Car Wash, along with the end of fund transfers and divestments from Petrobras there, there was a fall in the previously mentioned effects. This corroborates the thesis that the government's development agenda through its support of the naval sector did not generate a long-term impact. In 2015 and 2016, the increase in all formal jobs due to the complex was 19,107 (8.1% of the population) and 14,880 (6.2%), respectively – see Table A1 in the appendix. However, in 2017 with no forecast of new construction to be ordered by Petrobras, but still with a platform in production, the pole effect decreased by 85%, almost returning to the initial pre-complex level.

32 Therefore, in the short term, the economic policy of supporting investment and the use of the state company was effective in increasing employment in the region that received the investments. However, when the state demand scenario ceased and the industrial complex was exposed to competition from the international market, there was a large drop in employment, which returned to a level close to the initial one. The positive effect was present only as long as the state investments were maintained. We conclude that this type of policy must be designed so that, in the medium term, it is not dependent on the incentive or demand promoted by the State. Otherwise, the positive effect obtained in the short term may not even exceed the public cost of the incentive produced.

33 This result is not limited to the naval industry. On the drug industry in Brazil, for example, Sperancini et al. (2013) said that "the current development strategy for the health industrial complex has regressed only to seek national content through preferential purchase of national products" (14). They concluded that the health

industrial complex promoted by the government, to replace imports, would hardly have international competitive capacity without having public support infrastructures.

4.2 Model specification analysis

34 Regarding the diagnosis of the M1 econometric model, according to the results of the tests presented in Table 2, our model was reasonably well specified, despite not including additional controls.

It presented a good fit to the data, with a R^2_{adj} greater than 0.95, and no evidence was found for the serial correlation of errors or unobserved effects.

We also calculated estimates with modifications to this econometric model. If we do not include the sets of dummies ef.A and ef.M, the estimate $\hat{\delta}$ maintains a similar and significant value; and the model remains well adjusted to the data.

35 However, it presents a significant serial correlation between the errors and unobserved effects of the individual.

Comparing the results of the M2 and M3 models, we find that the most important differential of our main model M1 is the weighting of the treatment between the municipalities, given by I_i^p.

36 It is this weighting that contributed most to the accuracy of M1[12].

Another interesting result is the M4, the standard DD model with fixed effects control. For T_t we define $\tau_1 = \{2012, \dots, 2016\}$; the treatment interval that implied best fit to M4.

37 Adopting this simple average model, we rejected the hypothesis of the effect of the naval complex on the level of employment of those municipalities. The signs remained the same, but the distribution of the effects was not correct, due to the assumption of much homogeneity of the treatment, in time and space. According to these results, despite the difference in the database, there are two reasons that we believe led the study by Teixeira et al. (2016) to statistically reject this effect of the complex. It concluded that the stock of jobs in RG and SJN (separately and by level) was not strongly influenced by the naval complex, compared to the other municipalities in COREDE-Sul[13]. The first fact is that the study investigated the possible effects only from 2003 to 2009, while the production of the platforms started only at the end of 2007 (the dry dock in 2006). Moreover, as shown in Figure 3, it was only in 2010 and 2011 that the effects on the level of employment started to be important, with consolidation beginning in 2012. Another reason is that the authors used the M4 type model, with the simple average of the treatments, without relevant statistical effects. Furthermore, in that study during the identification phase, of the 5 combinations of municipalities considered treated, which included RG, SJN, and Pelotas, the choice made in our work (RG and SJN together) was not tested.

Conclusions

38 We investigated the effects of investments in the Rio Grande Naval and Offshore complex, in the extreme south of Brazil. These investments were mainly from State development strategies and the effects specifically measured the number of jobs in the region. We constructed the data series of accumulated variation (which we called the level of employment) of jobs in the two municipalities of the naval complex. The investigation identified several movements in these data series related to the beginning

and end of the various platforms constructed at the complex, as well as the legal issues of Operation Car Wash involving cases of corruption between the state oil company and the shipbuilding companies. The most successful phase in employment in the sector was from 2013 to 2016. From December 2016 on, the level of employment fell sharply until the end of 2017.

39 With the econometric approach of the differences-in-differences model, we employed a different model specification from the traditional one: instead of using variables with dichotomous weights (dummies) for the treatment, in the dimensions of time and municipality, we allowed a continuum of weights. These weights were determined by the treatment proxy, the level of employment in the naval sector. We estimated a large and positive effect, distinct across municipalities and over time. For example, in Rio Grande, the estimated average effect of the naval complex in 2015 on the level of aggregate employment was 16,392 formal jobs – about 7.8% of the population. Our causal effects estimation results differed from other similar papers. In one of them, no statistically significant mean effects were found; in another, very small effects. Despite other differences between the studies, we believe that the statistical rejection of the effect hypothesis or the small magnitude of the effects in those studies was mainly due to the period analyzed and the ordinary differences-in-differences model used.

40 The identified positive effects of the naval complex diminished as the anti-corruption police operation began in 2014. As demonstrated, all the platforms in the Rio Grande naval complex until then were being demanded by Petrobras. However, the company was prohibited from contracting with the hub shipyards due to the corruption found in Operation Car Wash. This resulted in the reduction of state funding resources and the end of new contracts by Petrobras for the construction of platforms. By 2017, the major effects of the previous years on formal employment in the region had almost been completely canceled. This corroborated the thesis that the government's development agenda with the support of the naval sector did not generate a long-term impact; with the positive effect only being present during the maintenance of demand promoted by the state.

41 Therefore, we suggest that this type of incentive policy should be designed in a way that, in the medium term, it does not depend on this incentive. Otherwise, the positive social effect obtained in the short term may not even exceed the public cost of state participation. A possible strategy, as proposed by Sperancini et al. (2013), is to support the inclusion of local companies in global production chains, boosting the demand for their products.´

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APPENDIXES

Table A1. Effects of the naval complex on the level of employment in its municipalities

Year	Employment RG+SJN		Estimated Effect on			Counterfactual Estim. RG+SJN
	Observed	Estimated	RG+SJN	RG	SJN	
2007	775.25	2,469.60	39.25	33.68	5.58	2,430.34
2008	2,432.34	2,760.57	143.28	122.92	20.36	2,617.28
2009	2,650.17	2,631.50	-19.95	-17.11	-2.83	2,651.45
2010	4,184.25	3,356.20	559.41	479.92	79.49	2,796.79
2011	6,727.08	5,500.57	2,875.54	2,466.94	408.60	2,625.03
2012	11,699.50	11,196.36	9,561.40	8,202.76	1,358.64	1,634.95
2013	19,394.92	19,000.33	18,624.32	15,977.87	2,646.45	376.01
2014	19,292.91	19,446.15	19,074.12	16,363.75	2,710.37	372.04
2015	16,865.66	19,308.79	19,106.93	16,391.90	2,715.03	201.85
2016	14,317.92	15,794.03	14,880.49	12,766.03	2,114.47	913.54
2017	8,499.59	5,375.50	2,209.32	1,895.38	313.94	3,166.18

Level of employment according to equation (1). Estimates resulting from the M1 model in Table 2.

NOTES

1. Rank according to information from the dry dock construction company.

2. Mixed economy company, controlled by the Brazilian government, which operates in an integrated and specialized manner in the oil, natural gas, and energy industry. Ranked 159th largest public company in the world in 2021 by Forbes Global 2000 – see in www.forbes.com/companies/petrobras.

3. Based on estimates from the Department of Economics and Statistics of the State of Rio Grande do Sul, which calculated that in 2015 the total population in Rio Grande was 211,081 and in São José do Norte was 26,038.

4. The shipyards were owned by a group of companies: Queiros Galvão, IESA, UTC and ENGEVIX (Cunha and Rückert 2019). All these companies were prohibited from being hired by the state-owned company due to corruption investigations (Petrobras 2014).

5. The turnover rate in period t was defined as , in which is the total number of admissions and is the total number of dismissals in t, while is the stock of jobs at t-1.

6. In the per capita variable, the authors divided the employment stock by the considered population.

7. National Classification of Economic Activities, prepared by the Brazilian Institute of Geography and Statistics (IBGE).

8. We described this model and its characteristics only partially. For more information see e.g., Angrist and Krueger (1999) or Angrist and Pischke (2009).

9. The 28 Regional Development Councils (COREDE) of the state of Rio Grande do Sul are representative entities with the objective of developing these represented regions, preparing strategic plans for policies and guidelines for their group of municipalities, among other activities.

10.

In regression tests with our model, we identified significant effects of the complex on $x_{\text{Pelotas},t}$, but not on the other municipalities in the control group. Bartz and Teixeira (2017) and Teixeira et al. (2016) also found significant effects of the complex on Pelotas.

11.

Remaining data series calculated by the result of the M1 model, in Table 2, and according to the weighting $I^p_{\text{RG}} = 0.834$, $I^p_{\text{SJN}} = 0.166$, $I^p_{i \in g_0} = 0$ and $T^p_t = x^N_t / \sum_t x^N_t$, with weighted average of the effects estimated at $\hat{\delta} = 74{,}684$.

12. Weighting like M2 was made by Postali (2009), who in equation (11) multiplied by the vector of observed values of treatment per individual.

13. *However, the authors estimated an effect of a 12% increase in the labor force stock per capita in 2009.*

ABSTRACTS

This paper investigates the heterogeneous effects, in space and time, of Brazilian government investments in the naval sector on formal employment. Large investments for the construction of oil platforms were allocated to the municipalities of Rio Grande and São José do Norte between 2007 and 2017, where a naval complex was developed. Using a differences-in-differences model adapted for heterogeneous identification, we verified causality and estimated the extent of the effects of the shipping sector (and state support) on aggregate employment. The results showed that the effect was significant and of great magnitude: the number of formal jobs created in the two municipalities of the complex, at the height of the sector, was equivalent to 7.8% and 10.4% of the respective populations. These positive effects were not maintained when investments and incentives decreased due to corruption investigations in the oil industry and the government. Therefore, this type of policy must be designed so that, in the medium term, it is not dependent on the incentive or demand promoted by the State. Otherwise, the positive social effect obtained in the short term may not even exceed the public cost of the incentive produced.

Este artigo investiga os efeitos heterogêneos, no espaço e no tempo, de investimentos do governo brasileiro para o setor naval no emprego formal. Entre 2007 e 2017, com créditos subsidiados e outros incentivos, grandes investimentos para a construção de plataformas de petróleo foram destinados aos municípios de Rio Grande e São José do Norte, no extremo sul do Brasil, onde um complexo naval foi desenvolvido. Usando um modelo de diferenças-em-diferenças adaptado para identificação heterogênea, verificamos a causalidade e estimamos a extensão dos efeitos do setor naval (e do apoio do estado) no emprego agregado. Os resultados mostram que o efeito foi significativo e de grande magnitude: o número de empregos formais criados nos dois municípios do complexo, no auge do setor, equivaleu a 7,8% e 10,4% das respectivas populações. Esses efeitos positivos não foram mantidos quando os investimentos e incentivos diminuíram devido a investigações de corrupção na indústria do petróleo e no governo. Portanto, esse tipo de política deve ser projetado de tal maneira que, a médio prazo, não dependa do incentivo ou da demanda promovida pelo Estado. Caso contrário, o efeito social positivo obtido a curto prazo pode nem mesmo superar o custo público do incentivo produzido.

Este artículo investiga los efectos heterogéneos, en el espacio y en el tiempo, de las inversiones del gobierno brasileño en el sector naval en el empleo formal. Entre 2007 y 2017, con créditos subsidiados y otros incentivos, se destinaron grandes inversiones para la construcción de plataformas petroleras a los municipios de Rio Grande y São José do Norte, en el extremo sur de Brasil, donde se desarrolló un complejo naval. Utilizando un modelo de diferencias en diferencias adaptado para la identificación heterogénea, verificamos la causalidad y estimamos la extensión de los efectos del sector naval (y del apoyo estatal) en el empleo agregado. Los resultados muestran que el efecto fue significativo y de gran magnitud: el número de empleos formales creados en los dos municipios del complejo, en el apogeo del sector, equivalió al 7,8% y 10,4% de las respectivas poblaciones. Estos efectos positivos no se mantuvieron cuando las inversiones e incentivos disminuyeron debido a las investigaciones de corrupción en la industria petrolera y en el gobierno. Por lo tanto, este tipo de política debe diseñarse de tal manera que, a medio plazo, no dependa del incentivo o la demanda promovida por el Estado. De lo contrario, el efecto social positivo obtenido a corto plazo puede no superar siquiera el costo público del incentivo producido.

Cet article étudie les effets hétérogènes, dans l'espace et le temps, des investissements du gouvernement brésilien dans le secteur naval sur l'emploi formel. Entre 2007 et 2017, avec des crédits bonifiés et d'autres incitations, d'importants investissements pour la construction de plates-formes pétrolières ont été alloués aux municipalités de Rio Grande et de São José do Norte, à l'extrême sud du Brésil, où un complexe naval a été développé. En utilisant un modèle de différences dans les différences adapté à l'identification hétérogène, nous avons vérifié la causalité et estimé l'ampleur des effets du secteur naval (et du soutien de l'État) sur l'emploi agrégé. Les résultats montrent que l'effet était significatif et d'une grande ampleur : le nombre d'emplois formels créés dans les deux municipalités du complexe, au pic de l'activité, correspondait à 7,8% et 10,4% de leurs populations respectives. Ces effets positifs n'ont pas été maintenus lorsque les investissements et les incitations ont diminué en raison d'enquêtes sur la corruption dans l'industrie pétrolière et au gouvernement. Par conséquent, ce type de politique doit être conçu de manière à ne pas dépendre de l'incitation ou de la demande promue par l'État à moyen terme. Sinon, l'effet social positif obtenu à court terme peut ne pas dépasser le coût public de l'incitation produite.

INDEX

Mots-clés: soutien de l'État ; effets hétérogènes ; emploi ; industrie navale ; Brésil
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