HETEROGENEOUS EFFECTS OF PUBLIC INVESTMENTS IN A NAVAL COMPLEX ON LOCAL EMPLOYMENT [1]

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Abstract:
This paper investigates the effects of state support investments in the extreme south of Brazil. Large investments for the construction of oil platforms, ordered by the state-owned oil company and with subsidized credits from the federal government, were destined for that region, where a naval complex was developed. At the same time between 2007 and 2017 significant changes in the local economy occurred, especially in the labor market, with the creation of thousands of jobs. In the analysis of this relationship with the labor market, we analytically demonstrate the causality of the naval sector (and state support) on employment in other sectors (and in the aggregate) and estimate the measure of the effects, in a heterogeneous way in time and in space, through a differences-in-differences model adapted for heterogeneous identification. The results show, unlike previous literature, that the effect was significant and of great magnitude: the number of formal jobs created in the two municipalities of the complex, at the peak 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.

Keywords: state support; employment; causality; naval complex; differences in differences

Resumo:
Este artigo investiga os efeitos de investimentos sobre fomento estatal no extremo sul do Brasil. Grandes investimentos para a construção de plataformas de petróleo, encomendadas pela petroleira estatal e com créditos subsidiados pelo governo federal, foram destinados àquela região, onde se desenvolveu um polo naval. Ao mesmo tempo, nos anos entre 2007 e 2017 ocorreram alterações significativas na economia local, em especial no mercado de trabalho, com a criação de milhares de empregos. Na análise dessa relação com o mercado de trabalho, demonstramos analiticamente a causalidade do setor naval (e do fomento estatal) sobre o emprego nos demais setores (e no agregado) e estimamos a medida dos efeitos, de forma heterogênea no tempo e no espaço, através de um modelo de diferenças em diferenças adaptado para identificação heterogênea. Os resultados mostram, diferentemente da literatura anterior, que o efeito foi significativo e de grande magnitude: a quantidade de empregos formais criados nos dois municípios do polo, no auge do setor, foi equivalente a 7,8% e 10,4% das respectivas populações. Estes efeitos positivos não se mantiveram quando diminuíram os investimentos e o fomento em decorrência das investigações de corrupção na petroleira e no governo.

Palavras-chave: fomento estatal; emprego; causalidade; polo naval; diferenças em diferenças

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1. INTRODUCTION

The start of the Rio Grande Naval and Offshore Pole was in 2006, with the construction of a dry dock in the municipality of Rio Grande, in the south of Brazil - it is still the largest structure of this kind in Latin America[4]. Together with the complex that was formed, 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), a total of seven platforms were built for Petrobras, the state oil company[5] which required a large amount of labor along with goods and services to support production. As we will see in June 2013 this workforce, based over the two municipalities, totaled more than 8,100 formal workers specific to this sector – about 3.6% of the combined populations[6] and the equivalent to 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 y and the government, detailed later, terminated some contracts and decreased investments and activity at the complex.

Several pieces of research regarding this pole, such as those by Neitzke (2015), Carvalho et al. (2016), Teixeira et al. (2016), Bartz and Teixeira (2017), among others, concluded that the new activity in the region was accompanied by important economic and social changes. Some studies have cited significant variations in the level of aggregate formal employment, as well as worker migration and the likely effects of these migration movements in these municipalities. But the article that sought to measure the impact of the naval complex activity on the aggregate of formal jobs in the region concluded that there were no statistically significant effects (Teixeira et al, 2016).

In the present study, we investigated the impact of those investments under state support, with the hypothesis that the effect on aggregate formal employment was of great magnitude, at least in the short term, in line with that observed in the naval sector, and that the previous literature did not reach this conclusion due to the methodology and the sample period used. The specific objectives are to verify the causality and measure the magnitude of the effect with a less restricted methodological specification, as well as to identify if the possible effects were short term or if they were maintained after decreasing the support and the contracts of the state owned-oil company. To this end, we conducted a descriptive analysis of the employment, providing evidence of the causality and the short-term magnitude of the effect, also providing information to demonstrate the causality and calibrate the statistical model, which in turn confirmed the hypothesis of the effect on formal employment.

In the descriptive statistics, we recorded several observed and estimated characteristics of employment in the naval sector, some other selected sectors, and the aggregate. In the demonstration of causality, we carried out a conceptual analysis of the variables that, together with the information from the descriptive statistics and the reported facts of the complex, proved the causal relationship. In inferring the magnitude of the pole's effect on aggregate employment, we make use of a statistical model with panel data for the estimation with the econometric technique of differences in differences. However, we did not use the traditional model in the estimation: instead of including variables with dichotomous weights (dummies) corresponding to the time and space dimensions of the "treatment" of the naval activity, we consider variables with a continuum of weights, potentially heterogeneous over the years and municipalities under treatment.

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[4] Rank according to information from the dry dock construction company. See www.wtorre.com.br/projetos/estaleiro-rio-grande/246.

[5] 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 www.forbes.com/companies/petrobras.

[6] Based on the 2010 demographic census data, which calculated 197,228 inhabitants in Rio Grande and 25,503 in São José do Norte.

The results show that, contrary to previous literature, the impact was significant, heterogeneous and of great magnitude. The number of formal jobs created in the two municipalities of the complex, at the peak of the sector, was equivalent to 7.8% and 10.4% of the respective populations. But these positive effects were not maintained when investments and support decreased due to corruption investigations in the oil company and in the government. The effect of the actions was intense and short-term but cooled to almost nil shortly after state participation also retracted. With this analysis, we seek to contribute to the understanding of the possible results of governmental strategies to finance, promote and develop regional economic activities not yet supported by the private sector.

In the next section we present the naval complex and the data on its respective investments, as well as the literature review. In section 3 we make a detailed analysis of employment in the naval sector, as well as in other selected sectors and in the aggregate. In the fourth section, we proceed to the theoretical and statistical demonstration of causality and estimate the heterogeneous effect on aggregate employment. In the last section, we present our final concluding remarks.

2. THE NAVAL COMPLEX AND INVESTMENTS

The Rio Grande Naval and Offshore complex (in short, the naval pole) is basically 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[7]. Its development is related to the discovery of large oil reserves in the pre-salt layers of the Brazilian coast, in 2006, by Petrobras. The company, relying on a market reserve regulation, would demand specific platforms to explore the pre-salt layer (Araújo et al, 2012). Besides the market reserve, there was an environment of state support for the development of the naval sector. Some of the government actions in this direction, in the first decade of this century, were: the requirement of national involvement in the activities of oil and gas exploration and production; interest rates and facilitated participations in financing with national involvement contracts related to the resources of a specific fund for shipbuilding; creation of a guarantee fund for the credit risk in the financing of vessel construction; the exemption of a tax levied on shipbuilding parts by national shipyards and the exemption of two taxes on materials for the shipbuilding industry (Dores et al, 2012). Concomitantly, there was an important advance in investments in the sector, which resulted in the expansion and modernization of the productive capacity of vessels and of the national fleet (idem). 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 & Rückert, 2019).

In the state of Rio Grande do Sul, a federative unit located in the extreme south of Brazil, where the municipalities of RG and SJN 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, construction began on a new platform of the same type; in 2010 Petrobras signed a contract for the construction of eight more with a business group that bought the ERG in the same year (idem). 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.

[7] In Rio Grande, the Estaleiro Honório Bicalho (EHB) shipyard and the Estaleiros Rio Grande (ERG) shipyard – the latter is divided into two: ERG1 and ERG2. In São José do Norte, the Estaleiros do Brasil (EBR) shipyard.

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

Includes only naval constructions (platforms). Source: Prepared by the authors based on information published in the local press.

Many of these constructions were financed with the Merchant Marine Fund (FMM), administered today by the Ministry of Infrastructure. This fund is intended to provide resources for the development of the Merchant Navy and the Brazilian shipbuilding and repair industry. In general, the financing conditions from this fund are more advantageous than from the private sector.

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. However, in 2014 construction contracts at the complex were interrupted. That year, Operation Car Wash, “the largest operation against corruption in Brazil's history” (Pacheco, 2017, p. 1), was initiated. Several contractors and their top executives were targeted through legal measures under the accusation of forming a cartel and the embezzlement of funds through the corruption of public entities; mainly related to bid rigging at Petrobras (idem). As a result, companies controlling the EBR shipyard became part of a list of companies prohibited from entering new contracts with Petrobras (Petrobras, 2014). In late 2016, after a disagreement between one of the construction companies and Petrobras, on the continued production of the remaining contracted platforms, the constructor laid off 3,200 of its employees in a single month (Ávila, 2016). The dismissal of the workers led to layoffs in several small companies providing indirect services. D'Avila and Bridi (2017) argued that these legal situations caused negative implications on investments in the complex and an increase in unemployment in the region. Petrobras, for example, began reducing investments during Operation Car Wash. 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, p. 24).

Cunha and Rückert (2019) argue that the naval complex was a driver for the entire industrial chain involved in the activity, highlighting the metal-mechanical sector. The authors concluded that the complex’s dependence on state support, which included subsidies, limited its competitiveness. This along with the effects of the corruption cases drove the region into stagnation and left the sector without good prospects.

Many studies have focused on this subject. Bartz and Teixeira (2017) investigated the turnover of workers[8] in the region from 2003 to 2013, relating it to investments in the complex. He used panel data in a differences-in-differences model to estimate the determinants of turnover and to analyze the subsequent impacts. One of the findings was that there was a 132% increase in labor turnover in RG, after the opening of the complex in 2006, and a 43.18% decrease in SJN. Pereira et al. (2016) sought to evaluate the effects of the expansion of the naval industry in four states of the country, including Rio Grande do Sul. They focused on the labor market of the municipalities that received these investments. They also employed the differences-in-differences method until 2011. For the RG they concluded that there was a small positive movement in the

[8] The turnover rate in period t was defined as $r_t = 100 \cdot \min(A_t, D_t)/e_{t-1}$, where A_t is the total number of admissions and D_t is the total number of dismissals in t, while e_{t-1} is the stock of jobs at t-1.

formal labor force stock in manufacturing, 2% in 2006 and 1% in 2009[9]; but this had been preceded by a reduction effect of 2.3% in 2005 in the commerce labor force stock.

In another study, Teixeira et al. (2016) evaluated the effects of shipbuilding in the region on some economic and social variables, including the 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 RG the total labor force stock was not strongly influenced by these investments, compared to the other municipalities; the same occurred in SJN. However, when they considered RG, SJN and the municipality of Pelotas (neighboring RG) combined, they estimated a 12% positive effect on their joint per capita employment stock in 2009[10]; they also found important effects on GDP per capita and job turnover.

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

Unlike these approaches, in our decomposition of sectors we are also investigating the specific role of shipbuilding: the class “construction of vessels and floating structures” (from the CNAE-2.0-class classification[11]). We will use a different specification of the differences-in-differences model to identify the effect of the naval complex on employment in those municipalities, which we assume to have been positive and intense.

3. DESCRIPTIVE EMPLOYMENT ANALYSIS

We used the CAGED database – the General Register of Employed and Unemployed, from the Ministry of the Economy (ME) – to study the employment of the municipalities of RG and SJN. This register contains monthly information on hiring and dismissal (broadly speaking, movements) of employees with a labor contract. Some employees, such as housekeepers and most civil servants, do not have their movements recorded in this register and, therefore, will not be counted 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, i.e. the relative stock (to the period prior to 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.

For the calculation, consider 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. Let A_t and D_t be the number of workers hired and laid off in month t, respectively. Then we calculate 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 (period immediately before the sample). Thus, in analysis of variation, evolution, correlation, and others insensitive to displacement, the results with the series $\{x_t\}$ are identical to the results with the data series of absolute stock (unknown with these data). To make the text easier, we will call x the level of employment.

To analyze the specific economic activity of shipbuilding and its relationship to other selected sectors we broke down the labor into productive sectors. We used the following form:

$$x_t^S = \sum_{\tau=t_o}^{t} A_\tau^S - D_\tau^S \tag{1}$$

[9] São José do Norte was not studied in isolation or in conjunction with Rio Grande.

[10] In the per capita variable, the authors divided the employment stock by the considered population.

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

where the superscript S denotes the considered productive sector. We considered the following S sectors of the economy[12] (in brackets, our abbreviation): *(i)* Shipbuilding and floating structures [N - Naval]; *(ii)* Accommodation [A]; *(iii)* Food [F]; and *(iv)* Education [E]. We will use 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 x_t 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 maintained 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[13]. And the higher the proportion of x^N in the production function in relation to 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 and, 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 will also be a good proxy for naval production in this complex. We had imagined so, on the grounds that the period analyzed is too short to support significant changes in shipbuilding productive technology.

Figure 1 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. From 2011 on it 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, with 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.

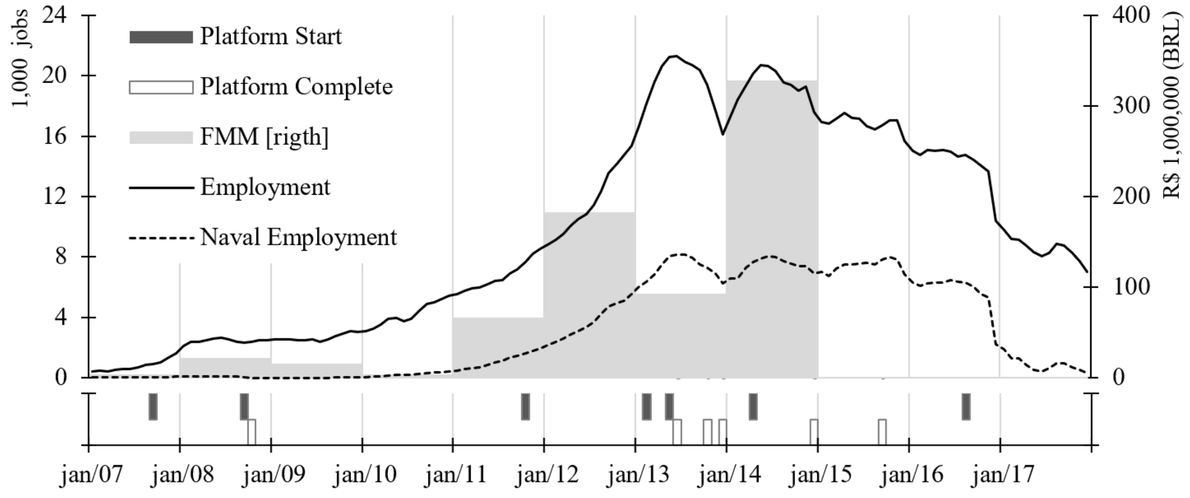

Figure 1

Level of employment (jobs) according to equation (1), with combined values for RG and SJN. Platforms starting and ending according to Table 1. The transfers from the FMM are the annual disbursements of subsidized financing, with state resources from the Merchant Marine Fund (FMM), for construction in the complex's shipyards. Source: Prepared by the authors according to data from the Ministries of Economy and Infrastructure.

[12] In the CNAE-2.0 classification, they correspond to codes 30113, 55, 56 and 85.

[13] Despite the lack of delimitation of the limits of activities considered to be of the naval complex, if the assumption of proportionality is maintained, x^N remains a good proportional proxy for the (undefined) total number of workers at the complex.

We can clearly 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[14]. 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 that two municipalities. Despite the relationship, we cannot infer causality between the variables with these statistics alone – we will do this later.

Some initial shipbuilding was accompanied by significant increases in workers. On the other hand, construction finalizations were accompanied by greater dismissals than admissions. The movements were more accentuated in seasons in which there was an accumulation of construction initiated or finalized, 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, but it was followed by the largest reduction of workers in the naval complex since its inception – a total of 3,095 dismissals in the month of 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 because they were on leave and another 200 were active in the maintenance of the shipyard (Ávila, 2016). The 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 that workers was accompanied by the largest drop in the level of aggregate employment: $\Delta x_{Dec/16} = -3{,}320$.

The change in employment in the naval sector over these years was much more intense than in the other three sectors: while the accumulated variation in education and food reached just over 400, in the naval sector it exceeded 8,000. Levels of employment in the sectors A, F and E oscillated jointly until early 2013, when employment in sector N was at its peak. The correlation between levels of employment in the food and education sectors, throughout the period, was $r(x_t^F, x_t^E) = 0.92$. These two sectors showed an upward trend which continued until 2014, whereas in the accommodation sector there was a temporary maintenance of the level of employment followed by a downward trend. This indicated an anticipation of adjustment in relation to the other two sectors, which subsequently had a similar behavior.

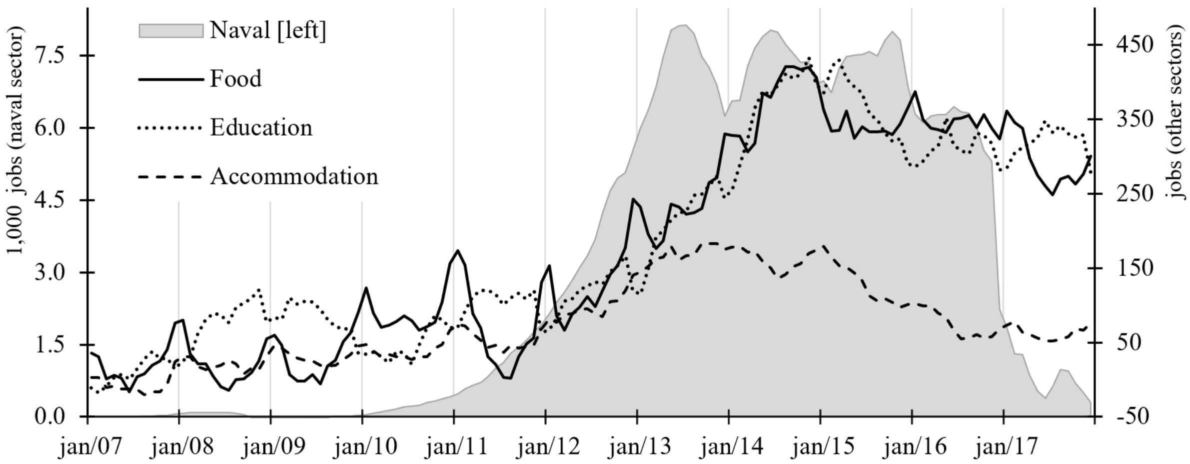

Figure 2
Level of employment (jobs) according to equation (1), with values for RG and SJN added. Source: Prepared by the authors according to data from the Ministry of Economy.

[14] All correlations reported in this study are from the Pearson method, statistically tested with the null hypothesis that the correlation is equal to zero; hypothesis that was always rejected at the significance level α=0.001.

In the correlation analysis, we identified that the level of employment in the education and food sectors is statistically lagged and strongly related to that of employment in the naval sector[15]: $r(x_{t+13}^{E}, x_t^N)$ = 0.82 and $r(x_{t+13}^{F}, x_t^N)$= 0.85. In the accommodation sector, this was also strongly related to that of the naval sector, but statistically anticipated: $r(x_{t-6}^{A}, x_t^N)$ = 0.90.

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 1. We did not obtain information on the financing contracts and the deadlines for the transfer of funds from the FMM to the construction companies, which hindered the identification of 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.

4. EFFECTS OF THE NAVAL COMPLEX ON AGGREGATE EMPLOYMENT

In this section we extrapolate the simple identification of correlation and patterns between the variables; performed in the previous section. Here we are demonstrating the causal relationship between these two, identifying at least one direction, and we are estimating the magnitude.

4.1 Causality

Let **S** = $\{S_1, S_2, \dots, S_n\}$ be the remaining set of the productive sectors such that $\{N\} \cup$ **S** is the set of all of them, where *N* is the sector of the naval complex. With the sectors distinct from each other, it follows that

$$x_t \equiv x_t^N + \sum_{k=1}^{n} x_t^{S_k} \tag{2}$$

where $x_t^{S_k}$ is the level of employment in the sector S_k at t, as described in (1). For convenience, we can interpret x_t as a linear function $x_t : \mathbb{R}^{n+1} \to \mathbb{R}$,, continuous and differentiable[16]. By the definition of x_t, we argue that x_t^N has a direct effect on x_t, since $x_t^N \neq 0$ for some *t* (what happened); therefore, x_t^N causes x_t.

There is a counter-argument that, although there are no other direct causes of x_t besides $x_t^N, x_t^{S_1}, \dots, x_t^{S_n}$, there is a possibility that x^N is not a true cause of x, but a side effect of the other direct causes $x_t^{S_k}$, as it is feasible to have[17]

$$dx_t^N = \frac{\partial x_t^N}{\partial x_t^{S_1}} \cdot dx_t^{S_1} + \cdots + \frac{\partial x_t^N}{\partial x_t^{S_n}} \cdot dx_t^{S_n} \tag{3}$$

$$\Rightarrow \quad dx_t = \left(1 + \frac{\partial x_t^N}{\partial x_t^{S_1}}\right) dx_t^{S_1} + \cdots + \left(1 + \frac{\partial x_t^N}{\partial x_t^{S_n}}\right) dx_t^{S_n} \tag{4}$$

That is, x_t^N can be fully determined by $x_t^{S_1}, \dots, x_t^{S_n}$; and x_t be caused only by these. Thus, variations in dx_t would be caused only by variations in $x_t^{S_1}, \dots, x_t^{S_n}$. The logical possibility is true,

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[15] Here, we consider the variable *y* to be statistically lagged (advanced) in relation to the variable *z* if there is a value of correlation between them with the variable *y* lagged (advanced) greater than with the contemporary *y*, with verification of the hypothesis test.

[16] Despite being $x_t : \mathbb{Z}^{n+1} \to \mathbb{Z}$, we considered the alternative way to make use of the convenient derivation operation. We could use the tedious $\Delta x_t \,/\, \Delta x_t^N$; however, the qualitative results do not differ.

[17] In the equations, dx_t^N and dx_t are the total differentials of the respective functions. Also, $\forall t \ \frac{\partial x_t}{\partial x_t^N} = \frac{\partial x_t}{\partial x_t^{S_1}} = \cdots = \frac{\partial x_t}{\partial x_t^{S_n}} = 1$ and, therefore, $\mathrm{d}x = \mathrm{d}x_t^N + \mathrm{d}x_t^{S_1} + \cdots + \mathrm{d}x_t^{S_n} \ \forall t$.

but this did not in fact occur: the platform production contracts at the pole cannot be entirely caused by the monthly movements in $x_t^{S_1}, \ldots, x_t^{S_n}$; in fact, little connection is assumed. The conclusion is that x_t^N is not entirely determined by $x_t^{S_1}, \ldots, x_t^{S_n}$; and that x_t^N causes x_t to some extent. With some additional assumptions we can also conclude that the investments and the production of the platforms cause x_t – in the figurative sense we say that the naval complex causes x_t.

As for the magnitude, if all the variables $x_t^N, x_t^{S_1}, \ldots, x_t^{S_n}$ were independent of each other, then the value of the effect of x_t^N on x_t would be x_t^N itself, with the proportion of the effect equal to $\frac{x_t^N}{x_t}$; the same would happen with the other sectors. However, this is not the case, as seen in the previous section: there are other workers in the naval complex who are not part of what we call the naval sector (N); workers hired due to the construction of platforms, in the areas of production support (administrative, logistics, etc.). Thus, there are three possibilities: the effect of the factor x_t^N on x_t can be amplified or reduced, depending on whether there are indirect effects $\frac{\partial x_t^{S_k}}{\partial x_t^N} > 0$ or $\frac{\partial x_t^{S_k}}{\partial x_t^N} < 0$, respectively; or else be maintained, if there is no such indirect effect or if they cancel each other out among the other sectors.

As shown above, despite the theoretical verification of the causal effect of the level of employment in the naval sector on the level of aggregate employment, it is possible that in the temporal aggregation this effect will be null if (*i*) the sum of its indirect effects $\frac{\partial x_t^{S_k}}{\partial x_t^N} \cdot x_t^N$ is negative in the same magnitude as the direct effect $1 \cdot x_t^N$; or (statistically null) if (*ii*) the direct effect has great variance and the statistical model does not adequately control this possibility. The empirical facts previously analyzed (including the correlations of the data series in Figure 2) lead us to believe as to (*i*) that it is not the case of $\sum_k \frac{\partial x_t^{S_k}}{\partial x_t^N} < 0$, but it is possible to be the explanation for the result of Pereira et al. (2016), who estimated a negative effect in only one sector (in the year prior to the start of the complex) and a positive effect in two others. On the other hand, we believe that the absence of a significant effect in Teixeira et al. (2016) is due to option (*ii*).

As usual, we will have to make some assumptions to perform the inference effect. One is that the variable x_t^N is exogenous, i.e. it is neither affected / caused by $x_t^{S_1}, \ldots, x_t^{S_n}$, nor by its lags. We have already seen that this is not a very strong assumption; we even know that the demand for workers in sector N was met with many professionals from other states of the federation, which reduced dependence on the local labor market. Furthermore, it is not plausible that $x_t^{S_1}, \ldots, x_t^{S_n}$ has important effects on the platform production contracts at the complex and on the technology of its production (quantity of the labor production factor). If we also assume that x_t^N has a correlation close to 1 with the monthly production activity of the naval complex, we can use x_t^N as a proxy for this. Briefly, in the investigation of the effects we assume an ad hoc treatment of the naval complex, measured by the proxy x_t^N, on the aggregate employment of those municipalities. We will refer to this only as treatment, effect, impact, etc. of the naval complex; when the proxy is used, the result is also understood as the specific effect of x_t^N.

4.2 Estimation of effect and results

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). We use the differences-in-differences (DD) model, which seeks to isolate, from a panel data set, the effect of the treatment on the dependent variable, without the need for many control variables for unobserved characteristics[18].

Let g_1 be the treated group, i.e. the municipalities of RG and SJN, where the complex is located; and let g_0 be the control group, which municipalities with similar characteristics. Consider τ_1 the period in which the treatment took place, i.e. the period in which the complex was building platforms in the treated municipalities; τ_0 the period in which there was no treatment. We denote by $x_{g,\tau}$ the level of employment in the group $g \in \{g_0, g_1\}$ in the period $\tau \in \{ \tau_0, \tau_1\}$. And for now, we will refer to x only as "employment".

If we compare the employment of the g_1 group before and after treatment, making

$$\hat{\delta}_\tau = E[x_{g_1,\tau_1}] - E[x_{g_1,\tau_0}] \quad (5)$$

where E [·] is the mathematical expected value, this difference may be a biased estimate for the effect of the naval complex, as there may be other factors that caused the employment to vary between τ_0 and τ_1. If we compare employment in the period τ_1 between the treated and untreated groups, making

$$\hat{\delta}_g = E[x_{g_1,\tau_1}] - E[x_{g_0,\tau_1}] \quad (6)$$

then the result of this estimator may also be biased, as there may be other intertemporal factors that differentiate g_1 *and* g_0 other than the naval complex.

On the other hand, the unbiased estimator[19] of differences-in-differences compares the variation in employment between the treated group and the control group, i.e

$$\hat{\delta} = \left(E[x_{g_1,\tau_1}] - E[x_{g_1,\tau_0}]\right) - \left(E[x_{g_0,\tau_1}] - E[x_{g_0,\tau_0}]\right) \quad (7)$$

where $\hat{\delta}$ is the DD estimate of the effect of the naval complex at x_{g_1,τ_1}. Furthermore,

$$E[x_{g_1,\tau_1}] - \hat{\delta} = E[x_{g_1,\tau_0}] + \left(E[x_{g_0,\tau_1}] - E[x_{g_0,\tau_0}]\right) \quad (8)$$

is the estimated counterfactual of the natural experiment, that is, the level of employment of the group g_1 in τ_1 if there was no treatment of the naval complex. So $\hat{\delta}$ is simply the difference between the factual and the estimated counterfactual - the complex effect.

This effect can be calculated by Ordinary Least Squares (OLS) using the following econometric model:

$$x_{g,\tau} = \beta_0 + \beta_1 I_g + \beta_2 T_\tau + \delta(I_g \cdot T_\tau) + \epsilon_{g,\tau} \quad (9)$$

where I_g and T_τ are dummy variables: indicator functions with image equal to 1 if $g = g_1$ and $\tau = \tau_1$, respectively, and equal to 0 otherwise. The term $\epsilon_{g,\tau}$ is the random component, a normally distributed white noise.

If there are l municipalities, some from the group g_1 and others from g_0, both of which are not empty; and if there are m sub-periods, say years, some belonging to τ_1 and others belong to τ_0, also non-empty sets, the ordinary application of the DD procedure is to use the average of the group g_1 and g_0 and the average of the period τ_1 and τ_0 in the estimation. The model becomes:

$$x_{i,t} = \beta_0 + \beta_1 I_i + \beta_2 T_t + \delta(I_i \cdot T_t) + \epsilon_{i,t} \quad (10)$$

where i is the municipality indicator and t is the year indicator. The dummies remain the same but adapted to the new indices. This case is also equivalent to assuming identical treatment for all municipalities $i \in g_1$ by assigning a uniform weight $I_{i\in g_1} = 1$; and identical treatment in all years of the period τ_1, making $T_{t\in\tau_1} = 1$. It is especially valid for situations like a change in legislation, where there are uniform intragroup rules and constants during the term, among others. In the context of the present research, such homogeneities do not occur.

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[18] We will describe this model and its characteristics only partially. For more information see e.g. Angrist & Krueger (1999).

[19] It is unbiased when its premises are satisfied, such as exogeneity of treatment (which we assume to be valid) and similarity between groups, i.e. same average trend in both (which we will assume to be true).

According to our proxy x_t^N for the naval complex (see Figure 1), the treatment was clearly not binary over time – there were different doses of treatment over time. Comparing levels of employment in the RG naval sector with that of SJN, we calculated that the proportion $\sum_t x_{i,t}^N / \sum_{i,t} x_{i,t}^N$ in the former municipality was around 83.4% and in the latter 16.6% – that is, of the total observed monthly treatments, 83.4% were in RG and the rest in SJN. So, instead of using simple averages in the model, we used weighted averages by changing the variables I_i and T_t to have a domain equal to the interval [-1, 1], making them correspond to the respective weights – we denote them by I_i^p and T_t^p. Our model with weighted averages is given by

$$x_{i,t} = \beta_0 + \beta_1 I_i^p + \beta_2 T_t^p + \delta\left(I_i^p \cdot T_t^p\right) + \epsilon_{i,t} \quad (11)$$

It is expected that the fit of the model and the significance of the estimators will be better with (12) than with (11).

As for the data, for the $x_{i,t}$ series of the other municipalities, we also used the CAGED database. 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[20], 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 to the homogeneous policies of the state. However, 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[21], 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 ofx_t in the group $g_1 = \{\mathrm{RG}, \mathrm{SJN}\}$ and $g_0 = \{i \in \mathrm{COREDE_{Sul}} \mid i \neq \mathrm{RG}, \mathrm{SJN}, \mathrm{Pelotas}\}$ are parallel. In addition, to control the heterogeneous characteristics of the municipalities, but fixed in time, we include in (12) a set (denoted by ef.M) of municipality dummies – i.e. we control for individual fixed effects.

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 requires 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. We also included in (12) 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 $I_{\mathrm{RG}}^p = 0{,}834$, $I_{\mathrm{SJN}}^p = 0{,}166$ and that $I_{i \in g_0}^p = 0$. For the variable of treatment weights over time, we make

$$T_t^p = \frac{x_t^N}{\sum_t x_t^N} \quad \in [-1, 1] \quad (12)$$

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. The result of the estimates and diagnostic tests, referring to model (12) 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

[20] 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.

[21] In regression tests with our model, we identified significant effects of the complex on $x_{\mathrm{Pelotas},t}$, 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.

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[22]. In the same year, this effect on SJN was 2,715 (10.4% of that 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	–	yes	yes	yes
ef.M	yes	–	yes	yes	yes
R_{adj}^2	0,954	0,926	0,915	0,812	0,790
Durbin-Watson	[0,777]	[<0,001]	[0,821]	[0,765]	[0,783]
Wooldridge	[0,122]	[0,041]	[0,198]	[0,142]	[0,154]
King-Wu (time)	[0,992]	[0,652]	[0,992]	[0,992]	[0,992]
King-Wu (indiv)	[0,999]	[<0,001]	[0,999]	[0,999]	[0,999]

Estimation by OLS (pooling). Calculated by the authors based on Ministry of Economy data. Estimates robust a la White covariance matrix for panel models – see Arellano (1987). Durbin-Watson test for panel: alternative hypothesis (H1) of serial correlation in idiosyncratic errors. Wooldridge test (2010, p. 299-300) for unobserved individual effects: H1 for unobserved effects. King and Wu (1997) LM test for time (*time*) or individual (*indiv*) effects: H1 of significant effects. 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 $\hat{\delta} \cdot T_t^p$. In Figure 3 we present this data series, together with that of the observed level $x_{g_1,t}$, that of the level estimated by the model $\hat{x}_{g_1,t}$ and that of the estimated counterfactual, given by $\hat{x}_{g_1,t} - \hat{\delta} \cdot T_t^p$. The level of employment in the naval sector, a proxy for the economic activity of the naval complex, has 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.

[22] According to estimates by the Department of Economics and Statistics of the State of Rio Grande do Sul, in 2015 the total population in RG was 211,081 and in SJN it was 26,038.

In 2015, with the level of employment in the naval sector equal to $x_{2015}^{N} = 7{,}423$ and using the estimate $\hat{\delta} \cdot T_{2015}^{p} = 19{,}309$, we calculated that the indirect effect of x_{2015}^{N} on $\hat{x}_{2015}$ in equation (3) was $19{,}309 - 7{,}423 = 11{,}886$, about 1.6 times the direct effect. Therefore, in 2015 the effect of employment in the naval sector is greater than zero on at least one sector k; in addition, the sum $\sum_k \frac{\partial x}{\partial x^{S_k}} \frac{\mathrm{d}x^{S_k}}{\mathrm{d}x^{N}}$ was equal to 1.6 that year. 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. This confirms our previous theoretical analysis.

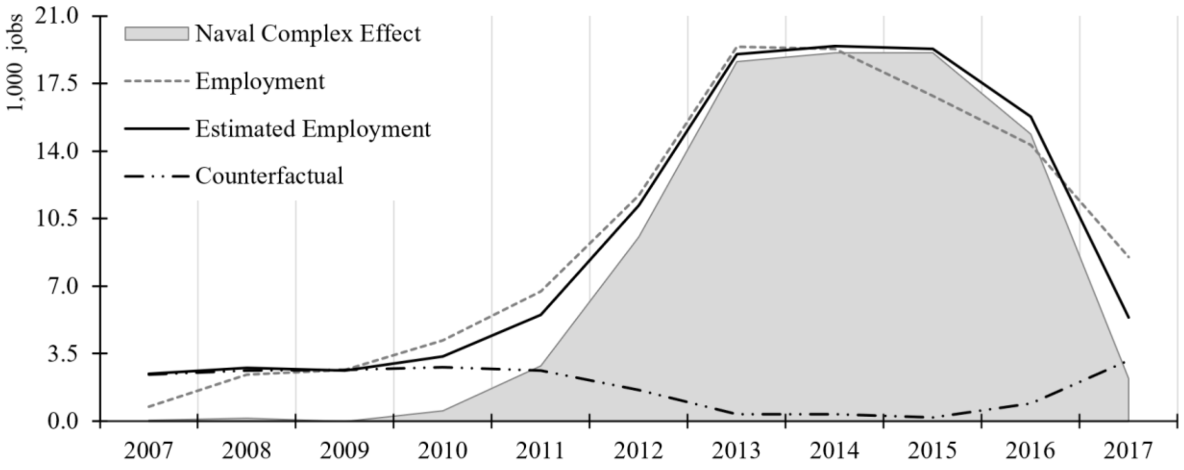

Figure 3

Employment data series obtained by summing the level of employment observed in the two municipalities in the complex (monthly average in each year). Remaining data series calculated by the result of the M1 model, in Table 2, and according to the weighting $I_{\mathrm{RG}}^{p} = 0.834$, $I_{\mathrm{SJN}}^{p} = 0.166$, $I_{i \in g_0}^{p} = 0$ and $T_t^{p} = x_t^{N} / \sum_t x_t^{N}$, with weighted average of the effects estimated at $\hat{\delta} = 74{,}684$.

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 the Car Wash Operation, along with the end of fund transfers and divestments from Petrobras there coincided a fall in the previously mentioned effects. This corroborates the thesis that the government's development agenda through its support of the naval/shipping sector did not generate a long-term impact. The positive effect was present only for as long as the incentives were maintained. In 2015 and 2016, the increase in all formal jobs due to the complex was 19,100 and 14,900, respectively (see Table A1 in the appendix); however, in 2017 with no forecast of new construction, but still with a platform in production (see Table 1), the increase was only 1,900, almost returning to the initial pre-complex level.

Regarding the diagnosis of the M1 econometric model, according to the results of the tests presented in the table, our model was reasonably well specified, despite not including additional controls. It presented a good fit to the data, with an R_{adj}^{2} 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 the 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. However, it presents a significant serial correlation in the errors and unobserved effects of the individual. Comparing the results of the M2 and M3 models, it appears that the most important differential of our main model M1 is the weighting of the treatment between the municipalities, given by I_i^p. It was this weighting that contributed most to the accuracy of M1[23].

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. 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 too 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 particular effect of the complex. It concluded that the stock of jobs in RG and SJN (separately and by level) were not strongly influenced by the naval complex, compared to the other municipalities in COREDE-Sul[24]. The first fact is that the study investigated the possible effects only for the years 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 starting in 2012. Another reason is that the authors used the M4 type model, with the simple average of the treatments, without relevant statistical effects, as seen. Furthermore, in that study during the identification phase, of the 5 combinations of municipalities considered treated which included RG, SJ and Pelotas, the choice made in our work (RG and SJN together) was not tested.

Pereira et al. (2016) used the same type of M4 model, using all the municipalities in Brazil as a control group, except those considered influenced by the treatment. Again, despite the glaring differences, we believe that with the traditional model used most of the effects were nullified in the estimation due to the simple average. That study found very small average effects compared to our heterogeneous estimates. In the most impacted sector in RG after the start of the complex[25], the effect captured was 2% in 2006 and 1% in 2009 – there was no significant effect in 2011, which differs from our findings.

5. FINAL CONSIDERATIONS

In this study, we investigated the effects of investments in the Naval and Offshore complex of Rio Grande, in the extreme south of Brazil. These investments were mainly from state development and development strategies – the effects specifically measured the number of jobs in the region. We documented several observed and estimated characteristics of aggregate employment and the naval sector in the municipalities that are part of the complex: Rio Grande (RG) and São José do Norte (SJN). After a brief description and review of some papers that previously studied the naval complex, we constructed the data series of accumulated variation (which we called level of employment) of jobs in the two municipalities. We 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 (Petrobras) 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.

We also studied the level of employment data series in the economic sectors of food (F), accommodation (A) and education (E). We found that they were highly correlated to employment in the naval/shipping sector (N). Another high correlation with the naval sector was the aggregate employment data series (all sectors); a correlation that resulted in a coefficient equal to 0.96. With this indication and the theoretical intuition that employment in the naval sector and the economic

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[23] Weighting like M2 was made by Postali (2009), who in equation (11) multiplied $(I_i \cdot T_t)$ by the vector of observed values of treatment per individual.

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

[25] The authors of that study also analyzed the impact in the period prior to the beginning of the complex and found that there was a significant effect in 2005: a 2.3% drop in the commerce labor force stock.

activities that depend on it had caused important effects on aggregate employment, we proceeded to investigate the causality and the magnitude of the effect. We demonstrated, through the definition of aggregate employment and the rejection of hypotheses through the observation of the facts, the causality of the naval complex on aggregate employment.

With the econometric approach of differences-in-differences (DD) models, we verified causality and further quantified the effects. 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 the municipality of RG, 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 effects hypothesis or the small magnitude of the effects in those studies was mainly due to the period analyzed and the ordinary DD model used.

The identified positive effects of the naval complex diminished as the anti-corruption police operation began in 2014. This resulted in the reduction of state funding resources and the termination of new contracts by the state-owned oil company for the construction of platforms. By 2017, the major effects of the previous years on formal employment in the region had almost been completely cancelled. This corroborates 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 incentives.

REFERENCES

Angrist, J. D., & Krueger, A. B. (1999). Empirical Strategies in Labor Economics. In: Ashenfelter, O. C.; & Card, D. (Eds.). *Handbook of Labor Economics* (Vol. 3, pp. 1277-1366). Elsevier. https://doi.org/10.1016/S1573-4463(99)03004-7

Araújo, B. P., Mendes, A. P. A., & Costa, R. C. (2012). Perspectivas para o desenvolvimento industrial e tecnológico na cadeia de fornecedores de bens e serviços relacionados ao setor de P&G [Perspectives for industrial and technological development in the supply chain of goods and services related to the P&G sector]. In: Banco Nacional de Desenvolvimento Econômico e Social, *BNDES 60 anos: perspectivas setoriais* (Vol. 1, pp. 224-273).

Arellano, M. (1987). Practitioners’ Corner: Computing Robust Standard Errors for Within-groups Estimators. *Oxford Bulletin of Economics and Statistics, 49*(4), 431-434.

Ávila, V. K. (2016, December 16). *Ecovix demite 3,2 mil funcionários de estaleiro do polo naval de Rio Grande* [Ecovix fires 3,200 shipyard employees at the Rio Grande naval complex]. GaúchaZH. https://gauchazh.clicrbs.com.br/economia/noticia/2016/12/ecovix-demite-3-2-mil-funcionarios-de-estaleiro-do-polo-naval-de-rio-grande-8715565.html

Bartz, M. L., & Teixeira, G. S. (2017). Rotatividade do mercado de trabalho no COREDE Sul: uma análise ex-ante e ex-post à implementação do polo naval no município de Rio Grande. [Labor market turnover in COREDE Sul: an ex-ante and ex-post analysis of the implementation of the naval pole in the city of Rio Grande]. *Sinergia, 21*(2), 21-29.

Carvalho, A. B., Moraes, G. I. D., & Hoeckel, P. H. (2016). Polo naval e offshore do Rio Grande: desafios colocados ao COREDE Sul [Rio Grande naval and offshore complex: challenges for COREDE Sul]. *Economia e Desenvolvimento, 28*(2), 473-496.

Cunha, R. B., & Rückert, A. A. (2019). Polo naval e offshore de Rio Grande: da formação ao princípio da decadência [Rio Grande naval and offshore complex: from formation to the precipice of decline]. *Geosul, 34*(70), 239–260.

D'avila, A. P. F., & Bridi, M. A. (2017). Indústria naval brasileira e a crise recente: o caso do Polo Naval e Offshore de Rio Grande (RS) [The Brazilian naval industry and the recent crisis: the case of Naval Complex and Offshore in Rio Grande (RS)]. *Cadernos Metrópole, 19*(38), 249-268.

King, M. L., & Wu, P. X. (1997). Locally optimal one-sided tests for multiparameter hypotheses. *Econometric Reviews, 16*(2), 131-156.

Neitzke, A. C. A., Gonçalves, G. P., Oliveira, R. M., Machado, D. G., & Gibbon, A. R. O. (2015). Custos ambientais: um estudo exploratório em um estaleiro da região sul do Brasil [Environmental costs: an exploratory study in a southern Brazilian shipyard]. *Revista de Gestão, Finanças e Contabilidade, 5*(2), 71-86.

Pacheco, F. (2017). *Operation car wash: understand the investigation that unveiled Brazil's largest ever corruption scheme*. Amazon. https://www.amazon.com/dp/B073PLFYLF/

Pereira, D. B., Moraes, I. S., Menezes, G., & Orellana, V. Q. (2016, May 19-20). Avaliação da expansão do polo naval sobre o desempenho do mercado de trabalho dos arranjos produtivos locais [Assessment of the expansion of the naval complex on the performance of the labor market of local productive arrangements] [Paper presentation]. In: 8º Encontro de Economia Gaúcha, Porto Alegre, RS, Brazil. https://www.pucrs.br/face/wp-content/uploads/sites/6/2016/03/33_DOUGLAS-BALDUINO-PEREIRA.pdf

Petrobras (2014, December 30). Abertura de comissões para análise de aplicação de sanção administrativa e bloqueio cautelar [Opening of commissions to analyze the application of administrative sanctions and precautionary blocking]. *Fatos e Dados*. http://www.petrobras.com.br/fatos-e-dados/abertura-de-comissoes-para-analise-de-aplicacao-de-sancao-administrativa-e-bloqueio-cautelar.htm

Petrobras (2017). *Relatório da Administração 2016* [Management Report 2016]. https://www.investidorpetrobras.com.br/apresentacoes-relatorios-e-eventos/relatorios-anuais/

Postali, F. A. S. (2009). Petroleum royalties and regional development in Brazil: The economic growth of recipient towns. *Resources Policy, 34*(4), 205-213.

Teixeira, G. S., Ribeiro, F. G., Abdallah, P. R., & Gonçalves, R. R. (2016). Indústria da construção naval e economia regional: uma análise via diferenças em diferenças para os municípios inseridos no Corede Sul [The shipbuilding industry and regional economy: an analysis via differences in differences for municipalities inserted in Corede Sul]. *Ensaios FEE, 37*(2), 459-488.

Wooldridge, J. M. (2010). *Econometric Analysis of Cross Section and Panel Data* (2nd ed.). MIT Press.

APPENDIX

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 calculated according to equation (1) with data from the Ministry of Economy. Estimates resulting from the M1 model in Table 2.