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Privatization of Brazilian airports: a synthetic control approach

Caio Resende
Public Administration Post-Graduation Program. IDP

Thiago Caldeira
Economics Post-Graduation Program. IDP

Abstract

This paper evaluates the impact of privatization on commercial revenues of airports. We used a synthetic control methodology to estimate the counterfactual of how commercial revenues from privatized airports in Brazil would have evolved if Infraero - the national public company responsible for operating all major airports in Brazil - continued to operate them. Our results indicate a large, statistically significant and immediate impact in the five airports analyzed. The results were robust to a series of placebo tests.

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Contact: Caio Resende - caio.resende@idp.edu.br, Thiago Caldeira - thiago.caldeira@idp.edu.br.

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1 Introduction

Before 2011, the major Brazilian airports were operated by a single public company: Infraero. Over just three years, from 2011 to 2014, operations of six of the country's largest airports were transferred to the private sector. This paper investigates the impact of privatization on the commercial revenues of these airports.

To do so, we implement the synthetic control method formalized in Abadie, Diamond, and Hainmueller (2010). The synthetic control method uses a data-driven procedure to construct synthetic versions of the privatized airports based on a combination of airports still operated by Infraero. To the best of our knowledge, this is the first time this methodology has been used to evaluate the impact of privatization programs.

We find that privatization leads to a substantial increase in commercial revenues at all airports analyzed. For most airports, this impact appears in the first year after privatization and remains significant throughout the whole period of analysis. The estimated results were robust to a series of placebo tests.

The remainder of this article is divided into six sections. In Section 2, we briefly describe some characteristics of the airport privatization program in Brazil. Section 3 presents the databases, and Section 4 discusses the empirical strategy in detail. In Sections 5 and 6, we analyze the main results, as well as their robustness, through a series of placebo tests. Section 7 concludes the study.

2 The Privatization of Airports in Brazil

The Brazilian airport privatization program began in 2011 with the privatization of a small airport in Natal, Rio Grande do Norte. Between 2012 and 2014, five of the biggest airports in Brazil were also privatized: Brasilia (Federal District), Guarulhos and Viracopos (both serving São Paulo region), Galeão (Rio de Janeiro) and Confins (Belo Horizonte). The transfer of airport operations, however, was not immediate and was based on a schedule established in the concession contracts. Private operation of Brasília, Viracopos and Guarulhos airports began in 2013 and private operation of Confins, Galeão, and Natal airports in 2015.

The auctions attracted operators responsible for some of the largest airports in the world, such as Paris, Amsterdam, Zurich, Munich, and Singapore. A striking characteristic of the auctions was the significant premium paid by the concessionaires compared to the minimum values required by the government. For example, the privatization of Brasília, Guarulhos and Viracopos airports collected a total of $14.2 billion – against a minimum government requirement of $3.2 billion. In the third round, which involved the airports of Galeão and Confins, the federal government raised a total of $9.1 billion, a premium of more than 350% of the minimum required value ($2.6

billion). The structure of revenues in Brazilian airports prior to privatization is one of the main reasons behind these premiums.

Airport revenues can be classified into two main categories: aeronautical and non-aeronautical (or commercial). Aeronautical charges in Brazil are determined by the National Civil Aviation Agency of Brazil (ANAC) and are related to the provision of aeronautical services by the airports to passengers (boarding and connection fees), airlines (landing and parking fees) and other companies (storage and handling fees). As Brazil has adopted a price cap regulation, airport charges are adjusted annually according to a formula that takes into account an inflation index, a productivity factor, and a quality factor. There were no relevant changes to this regulatory structure since the first privatization.

Commercial revenues cover a range of other non-aeronautical services offered by airports: advertising, space rental, car parking, car rental, fuel charges, duty-free, food, hotels, among others. In most airports in the world, commercial revenues are higher than aeronautical revenues (ATRS, 2011). This, however, was not the case for Brazilian airports in the pre-privatization period. None of the privatized airports had commercial revenues of over 50% of total revenues. On average, commercial revenues accounted for only 34% of total revenues in the year immediately prior to privatization. There is evidence, therefore, that commercial revenues were underexploited by Infraero, which explains, at least in part, the extremely positive valuation of airports by the companies participating in the auctions.

The existence of commercial revenues increases the challenge from the regulator's perspective. At first glance, the more important the commercial revenues, the greater the incentive for the airport to reduce aeronautical charges in order to increase the number of passengers and the demand for commercial services – the so-called "complementarity effect" (Starkie, 2001; Bilotkach and Polk, 2013). This analysis assumes that the availability and pricing of commercial services do not affect passenger demand – the so-called "demand effect". However, Czerny *et al.* (2016) show how commercial services can affect passenger demand and how this could increase aeronautical charges in a monopoly environment.

The effects of commercial revenues on airports' monopoly power is one of the most important aspects of an ongoing debate in the literature about which is the better way to regulate airports: a single-till approach, in which the profits derived from commercial activities are used to lower aeronautical charges, or a dual-till approach, in which commercial revenues are not taken into account when setting aeronautical charges. As shown by Czerny *et al.* (2016), this evaluation depends heavily on regulatory goals. A single-till approach seems a better approach if the main goal is to reduce aeronautical charges. The dual-till approach, in turn, seems to provide better incentives to invest in airport infrastructure. In Brazil, the main reason for privatization was the need for large investments in airports due to the major sporting events that would be hosted by Brazil

in 2014 (World Cup) and 2016 (Olympics) combined with Infraero's low execution capacity[1]. In this context, the Brazilian regulator's choice of a dual till approach makes sense.

Consequently, commercial revenues are deregulated in Brazil and are not considered by the regulatory agency when setting aeronautical charges. The private operators, therefore, had substantial incentives to generate commercial revenue. In practice, they did so very quickly, by building new parking facilities, expanding shopping, duty-free and food areas, increasing indoor and outdoor advertising spaces, readjusting prices, etc.

In Guarulhos, for example, just two years after privatization, commercial revenues already accounted for more than 50% of total revenues (from 38% in the year immediately prior to privatization) (GRU Airport, 2015). In 2015, most of these commercial revenues came from retail activities (60%), car parking (11%) and advertising (6%). Anecdotal evidence suggests that some of these changes improved customer welfare – e.g. a new car parking space in Guarulhos was a long-waited necessity. In other cases, the gain for consumers was less clear – e.g. an increase in parking charges in Guarulhos of more than 60% in the first year after privatization. However, it is not clear which of these were the main drivers behind the increase in commercial revenues at the privatized airports.

3 Data

To perform our analysis, we built a balanced data panel covering the period from 2004 to 2016 for the 25 Infraero airports with the largest passenger movement in 2011. The data are available for all airports in all years. The financial data related to Infraero airports were made publicly available during the privatization rounds. The other data are publicly available on the websites of the National Civil Aviation Agency of Brazil (ANAC), Infraero and private concessionaires.

4 Identification Strategy

To evaluate the impact of privatization on airport commercial revenues we used the synthetic control method introduced by Abadie and Gardeazabal (2003), with subsequent developments in Abadie, Diamond, and Hainmueller (2010, 2015). One of the main applications of the method is to carry out case studies with small samples and only

[1] It is no coincidence that the first privatized airports were those with the greatest investment needs according to a Mckinsey & Company (2010) study contracted by the federal government.

one or a few treated units. This is exactly the case of the privatization of airports, in which we only have 6 treated units and 19 units in the control group.

Let $J+1$ be the 25 largest airports in Brazil operated by Infraero in 2011. Suppose only the first airport is privatized. The remaining airports (not privatized) form the control group – which we refer to as the "donor pool."

Let T be the number of years in which we observe the airports and T_0 as the last period before privatization, such that $1<T_0<T$. Let Y_{it} be the value of commercial revenues from airport i in period t, Y_{it}^N be the value of commercial revenues if the airport has not been privatized and Y_{it}^P be the value if the airport has been privatized.

The impact of the privatization of airport i in period t will be given by

$$\alpha_{it} = Y_{it}^P - Y_{it}^N \tag{4.1}$$

Let us also define D_{it} as a dummy variable equal to 1 if the airport was privatized and equal to 0 otherwise. Therefore, we can rewrite Equation (4.1) as:

$$Y_{it}^P = Y_{it}^N + D_{it}\alpha_{it} \tag{4.2}$$

For privatized airports, we did not observe Y_{it}^N after privatization (defined as commercial revenue if the airport had not been privatized). The synthetic control algorithm estimates Y_{it}^N using a weighted combination of non-privatized airports that presents a similar evolution to those privatized during their pre-privatization period.

To better illustrate how the construction of this synthetic airport is performed, suppose that Y_{it}^N can be estimated by the following equation:

$$Y_{it}^N = \beta_t X_i + \lambda_t \mu_i + \theta_t + \epsilon_{it} \tag{4.3}$$

where X_i is a vector of variables that determine commercial revenues (with its associated β parameters), μ is a vector of specific effects of airports that are part of the donor pool (with its associated λ parameters) and ϵ represents the error term, containing idiosyncratic shocks. We include in X_i the values of predictors of commercial revenues: average movement of domestic passengers, international passengers, cargo and aircraft. These variables are averaged over the 2004-2012 period for Brasília, Viracopos and Guarulhos and the 2004-2014 period for Galeão and Natal[2]. In line with the

[2] In the case of the Confins airport, the method could not be used successfully. This airport had a unique evolution prior to 2009 – until then the city of Belo Horizonte was served by another airport. Therefore, it is expected that no airport combination is able to satisfactorily reproduce Confins' characteristics in the pre-privatization period.

recommendation by Kaul *et al.* (2015), we included only one lag of the variable of interest relative to the year immediately before privatization[3].

Consider $W\ (w_2, \ldots, w_{j+1})$ = a vector $(Jx1)$, such that $w_j \geq 0$ for $j=2, \ldots, J+1$ and $w_2+\ldots+w_{j+1}=1$. Note that W is the vector of weights assigned to each airport of the donor pool. Thus, each value of the vector W represents a possible combination of weights for a "synthetic airport," i.e., a weighted average of the airports in the donor pool. According to Equation (4.3), the value of commercial revenues for each synthetic control indexed by W will be given by:

$$\sum_{j=2}^{J+1} w_j Y_{jt} = \theta_t + \beta_t \sum_{j=2}^{J+1} w_j X_j + \lambda_t \sum_{j=2}^{J+1} w_j \mu_j + \sum_{j=2}^{J+1} w_j \epsilon_{jt} \tag{4.4}$$

Suppose there is a vector $(w_2^*, \ldots, w_{J+1}^*)$ whose sum is equal to 1 such that:

$$\sum_{j=2}^{J+1} w_j^* Y_{j1} = Y_{11}, \ldots, \sum_{j=2}^{J+1} w_j^* Y_{jT_0} = Y_{1T_0} \text{ and } \sum_{j=2}^{J+1} w_j^* X_j = X_1 \tag{4.5}$$

Hence it is possible to find a weighted combination of controls – a weighted vector W – such that

$$\hat{\alpha}_{it} = Y_{it}^P - \sum_{j=2}^{J+1} w_j^* Y_{jt} \tag{4.6}$$

is an estimator of α_{It} for $t \in \{T_{0+1}, \ldots, T\}$[4].

In this case, we can use $\sum_{j=2}^{J+1} w_j^* Y_{jt}$ as an estimator of Y_{it}^N, i.e., as a counterfactual for how commercial revenues would have evolved had privatization not occurred.

According to Equation (4.5), we assumed that there is a combination of airports in the donor *pool* (W^*) such that the weighted commercial revenue is equal to the commercial revenue of the privatized airport in all the pre privatization years. In fact,

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[3] For Brasilia, Viracopos and Natal, we paired each airport with its synthetic counterpart and used the commercial revenue as the outcome variable. In the case of the Guarulhos and Galeão airports, because they are two of the largest airports of our sample, it was necessary to slightly modify the outcome variable and define it as the evolution of commercial revenues. Thus, we normalized the outcome variable and established the commercial revenue as 1 in the privatization year (2012 in the case of Guarulhos and 2014 in the case of Galeão). In this case, the main estimate model does not include any lag of the outcome variable. For simplicity and to facilitate comparing of the five airports, all graphs are presented considering the evolution of the commercial revenues.

[4] For details, see Abadie & Gardeazabal (2003) and Abadie, Diamond & Hainmueller (2010).

we do not expect that such a vector exists. We expect to find a vector W^* such that these values are very similar.

Therefore, we choose vector W to minimize the mean squared prediction error (MSPE) of the difference between the commercial revenue from the privatized airport and from the synthetic airport in the pre-privatization years:

$$\left|\left|Y_1 - Y_0 W\right|\right|_V = \sqrt{(Y_1 - Y_0 W)' V (Y_1 - Y_0 W)} \tag{4.7}$$

where V is a symmetric and positive semi defined matrix (k x k).

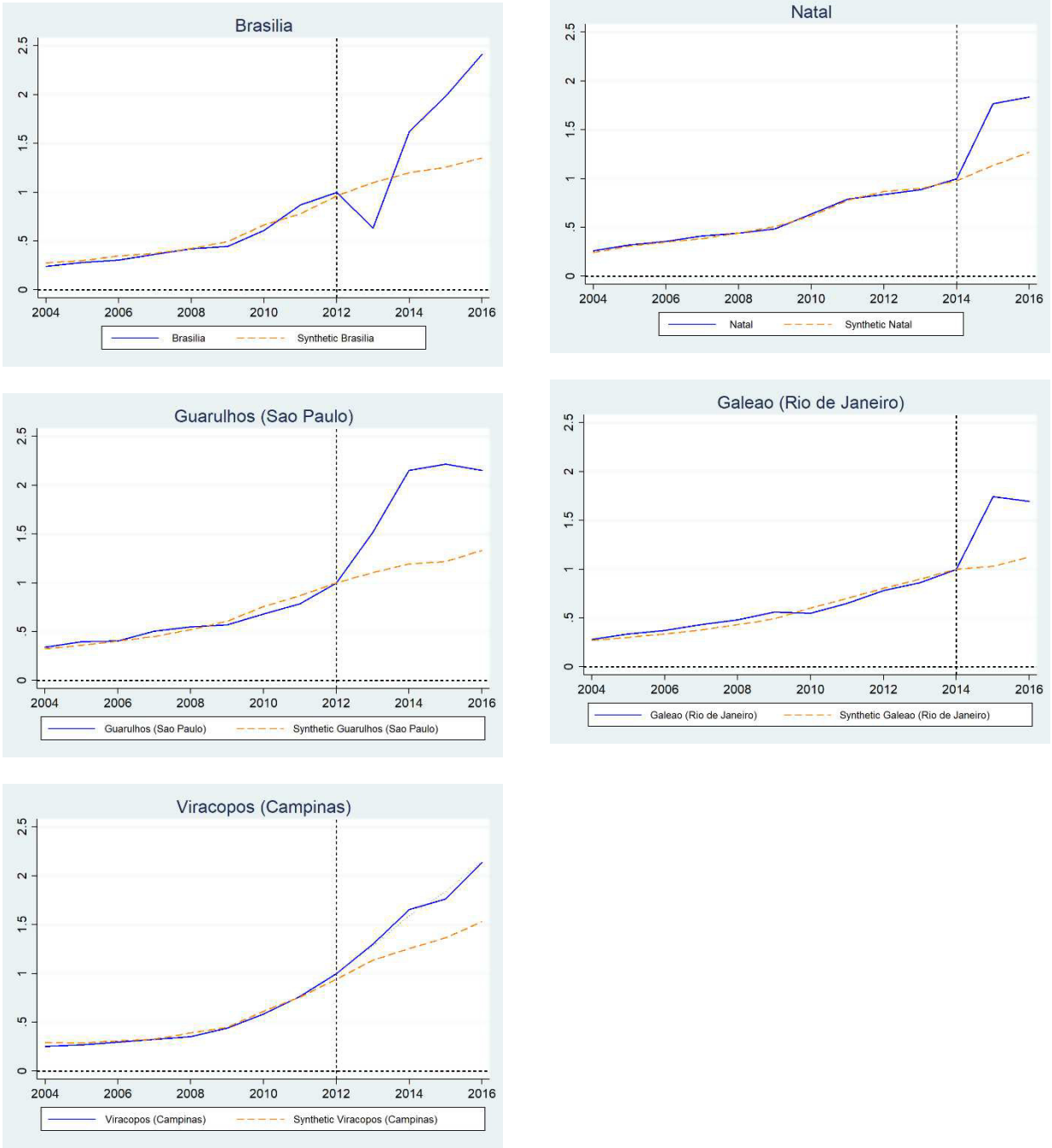
Note that, for the synthetic control method to accurately estimate the effect of privatization, it is important to assume that privatization has not affected the airports before it was actually enacted (e.g. when the airports learned they would be privatized). We believe that this was actually the case, as the time span between the privatization announcement by the government and the holding of auctions was very short (in the case of Brasilia, Guarulhos and Viracopos, for example, it was only 8 months). As a public company, it would be very hard for Infraero to make any relevant changes in such a short period of time.

Another important assumption is that none of the airports in the donor pool were affected by the privatization of the five airports. This actually could have happened, as one important feature of the concession agreements was that Infraero must be a minority partner of all winning consortia, with a 49% stake (with the exception of Natal). The Brazilian government expected that this participation would enable the public company to learn and replicate private company practices. Since we are evaluating the impact of privatization in the very short term, we do not believe that there was enough time for this "learning effect" to take place, but we cannot completely rule out the possibility that it happened. If it did, this could lead to a downward bias in our estimates – the impact of privatization on commercial revenues would be even bigger. This is because privatization would also have positively affected the evolution of commercial revenues from non-privatized airports, leading the synthetic method to overestimate the counterfactual scenario. The presence of Infraero as a minority partner in all privatized airports also decreases the chances of any action by these airports aiming to directly negatively affect any non-privatized airport, easing our concern that privatization could also negatively affects airports in the donor pool.

5 Results

Figure 1 depicts the evolution of commercial revenues for real and synthetic airports before and after privatization. Each synthetic airport was constructed as a weighted average of the 19 airports in the donor pool – the weights are listed in Table A.1 of the appendix.

Figure 1 - Evolution of commercial revenues at privatized and synthetic airports



Note: Graphic illustrations of commercial revenue evolution of privatized airports. The solid lines represent the real evolution of commercial revenues. The dotted lines represent the counterfactual evolution of commercial revenues if privatization had not occurred. The dotted line represents the year of privatization of each airport.

First, we note that before privatization commercial revenues in synthetic airports closely follow the trajectory of commercial revenues in real airports for all the five airports analyzed[5]. In the post-privatization period, the opposite is observed: the trajectory of real airports is significantly different from the synthetic trajectory, indicating a large effect of privatization on commercial performance.

The gap between the real and synthetic airports – which represents our estimate of the effect of the privatization policy – suggests that privatization immediately increases commercial revenue at all five airports. For example, in 2014 (two years after privatization) Viracopos' commercial revenues were 66% higher than in the last year before privatization, while our estimates suggest that it would be only 26% higher if privatization had not taken place. The estimated impacts have similar magnitude, even for airports of very different sizes, such as Galeão and Natal.

We also see that, in all five cases, the positive impacts of privatization result from a significant increase in revenues at privatized airports – and not from a decrease in revenues from synthetic airports. In fact, at the five synthetic airports, revenues followed a growth trajectory at a rate similar to the pre-privatization period, which reinforces the assumption that the observed effects are the result of a positive impact of privatization at privatized airports and not of a negative impact on the airports in the pool of donors.

Privatization, therefore, generated immediate and extremely significant revenue gains in the five cases evaluated, demonstrating a large gap between Infraero and private companies regarding the ability to manage airport infrastructure in order to generate commercial revenues.

6 Robustness Checks

To assess the robustness of our results, we conducted a series of placebo tests by applying the synthetic control method to each of the 19 airports in our donor pool as if each of them had been the object of privatization (Abadie, Diamond & Hainmueller, 2010). The idea is to calculate the likelihood that impacts as extreme as those estimated for privatized airports could be achieved by chance. As usual, the estimated impact of privatization is given by the difference between the real evolution of commercial revenues and the evolution of their synthetic counterpart. Figure 2 shows that in each case the estimated gap

[5]Table A.2 of the appendix shows that the pre-privatization characteristics of the synthetic airports are very similar to the pre-privatization characteristics of the real airports.

between our five airports and its synthetic counterparts after privatization is larger than all placebo gaps.

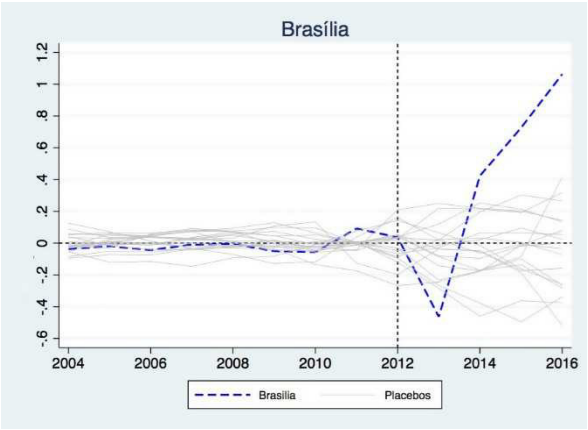
Following the method developed by Abadie, Diamond, & Hainmueller (2010), we can rank the airport results and calculate the implicit p-value as the probability of obtaining an estimate as large as those obtained for the privatized airports when the treatment is randomly assigned to all airports. Note that as each of our estimations consists of 20 airports (1 privatized and 19 controls), the smallest value assumed by p is 0.05, which occurs if the estimated effect in the privatized airport is the biggest of all. This was exactly the case for the five privatized airports – as illustrated in Figure 2. That means the probability of estimating an impact as large as those estimated for the privatized airports under a random permutation of the privatization in our data is only 5 percent – which is the most common test level used in conventional tests of statistical significance.

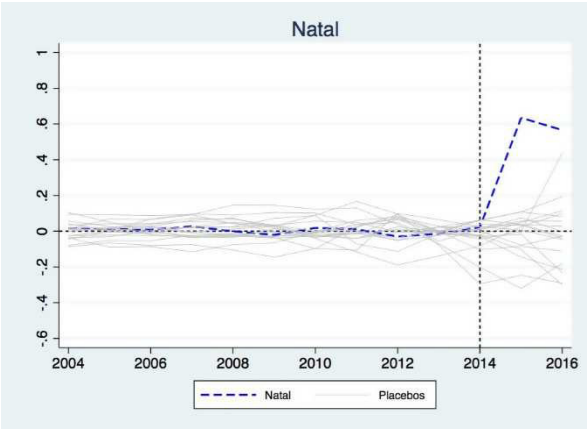
Another way to evaluate pairing quality is to compare the post and pre-intervention MSPE ratio for all airports in our sample (the average of the squared discrepancies between the evolution of commercial revenues in real airports and in its synthetic counterparts before and after privatization). This is a more robust method, as it considers the quality of pre-intervention adjustment for all airports. Again, we want to evaluate the likelihood that impacts of a magnitude similar to those observed at privatized airports are the result of chance. The results can be viewed in Figure A.1 of the Appendix. Once again, the values at the privatized airports clearly stand out. For the five airports analyzed, the post/pre-privatization MSPE ratio was the highest observed – which means that the probability of estimating a post/pre MSPE ratio as large as those observed at privatized airports by randomly assigning the intervention in the data is again $1/20 = 0.05$.

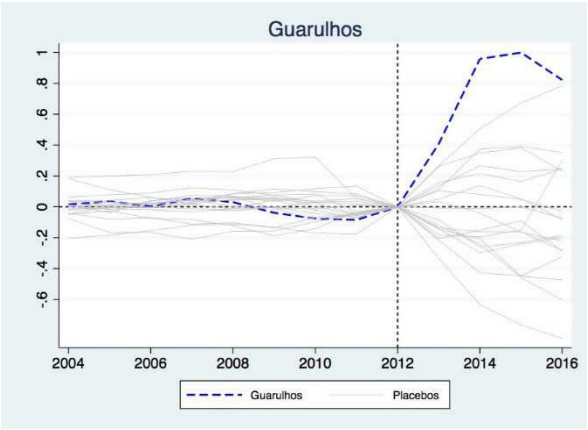
7 Conclusion

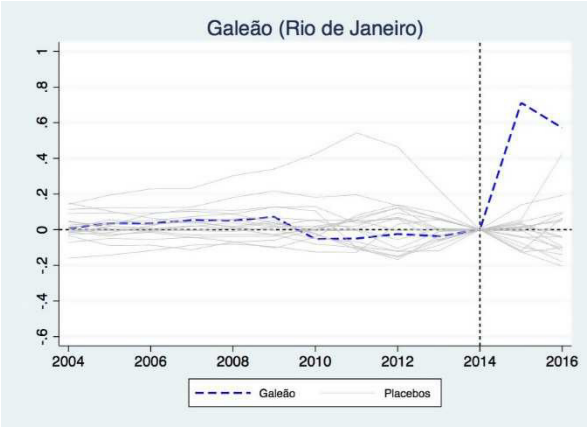
This study aimed to evaluate the impact of privatization on the commercial performance of Brazilian airports. For this purpose, we used the synthetic control method to construct counterfactual data on how commercial revenues from privatized airports would have evolved had privatization not occurred. The estimated results indicate a large and significant positive impact of privatization on commercial performance.

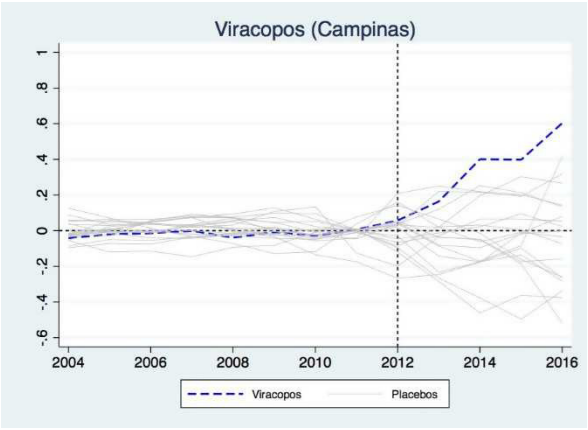
Figure 2 – Differences in commercial revenue evolution between privatized and placebo airports (20 airports)











Note: Graphic illustrations of the difference between the actual evolution and counterfactual evolution in privatized and placebo airports. Each gray line represents the difference between the actual evolution and the counterfactual evolution of commercial revenues in a placebo airport.

From a political perspective, this article advances the existing literature by introducing the use of the synthetic control method – specially developed for case studies with small samples – to evaluate the impact of privatization policies. One of the great advantages of synthetic control is that the choice of the units used to construct the synthetic counterparts is performed objectively, based on available data (data-driven), which reduces the discretion of the researcher in the choice of comparison units. In addition, because in practice it is very difficult to find a single untreated unit (e.g., a non-privatized airport) whose characteristics are close to the characteristics of the treated unit (e.g., privatized airport), the method generates a weighted combination of units, which, in general, forms a better basis for comparison than any of the untreated units, considered individually. Particularly in a discussion in which ideological arguments tend to prevail, the use of a more objective method of impact evaluation can shed light on several socially and economically relevant issues.

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Appendix

Table A.1 – Weight of donor pool airports at each synthetic airport [6]

	Synthetic Weights				
Airport	Brasilia (1)	Guarulhos (2)	Viracopos (3)	Galeão (4)	Natal (5)
Belem	0.00	0.00	0.00	0.00	0.00
Campo Grande	0.00	0.00	0.00	0.00	0.00
Congonhas	**0.42**	**0.64**	0.00	**0.49**	0.00
Curitiba	0.00	0.00	0.00	0.00	0.00
Cuiaba	0.00	0.00	0.00	0.00	0.00
Florianopolis	0.00	0.00	0.00	0.00	0.00
Fortaleza	0.00	0.00	0.00	0.00	**0.14**
Foz do Iguaçu	0.00	0.00	**0.30**	0.00	**0.82**
Goiania	0.00	0.00	0.00	0.00	0.00
Joao Pessoa	0.00	0.00	0.00	0.00	0.00
Maceio	0.00	0.00	0.00	0.00	0.00
Manaus	0.00	0.00	0.00	**0.27**	0.00
Navegantes	0.00	**0.36**	0.00	0.00	0.00
Porto Alegre	**0.58**	0.00	**0.16**	0.00	**0.02**
Recife	0.00	0.00	0.00	0.00	0.00
Sao Luis	0.00	0.00	0.00	0.00	0.00
Salvador	0.00	0.00	0.00	**0.24**	**0.02**
Santos Dumont	0.00	0.00	**0.54**	0.00	0.00
Vitoria	0.00	0.00	0.00	0.00	0.00

Note: The table reports the synthetic weights of each airport in each of the simulations. The synthetic weight is the weight assigned to each airport by the synthetic control algorithm. See the text for details.

[6] The weights of each airport are the result of the optimization process made by the synthetic control algorithm (i.e., they reflect the optimal W*).

Table A.2 - Predictors of commercial revenues before the privatization of airports

	Donor Pool	Brasília		Guarulhos		Viracopos	
		Real	Synthetic	Real	Synthetic	Real	Synthetic
Domestic Passengers	3.097	10.988	8.840	11.445	9.913	3.072	3.981
International Passengers	66	191	187	8.517	482	27	58
Aircrafts	39	122	101	182	113	46	48
Cargo	22.200	74.000	39.100	391.000	78.700	211.000	84.400

	Donor Pool	Natal		Galeão	
		Real	Synthetic	Real	Synthetic
Domestic Passengers	2.894	1.527	1.651	9.010	9.384
International Passengers	59	64	59	2.853	106
Aircrafts	35	18	17	115	104
Cargo	20.000	7.496	7.452	96.900	70.000

Note: Domestic passengers, international passengers, aircraft and cargo averages for the 2004-2012 period in the case of Brasília, Guarulhos and Viracopos and the 2004-2014 period for Natal and Galeão. The first column (Donor Pool) reports the average of variables for the 19 donor pool airports.

Figure A.1 –Ratio of Post-Privatization MSPE and Pre-Privatization MSPE: Privatized and Non-Privatized Airports