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Two-sided platforms in airport privatization

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ABSTRACT

This paper develops an empirical model to examine the relationship between ownership change and two-sided-platform formation in the air transport industry. We investigate whether privatization enhances the dynamic capabilities of airports so that they more closely resemble a two-sided platform. We study the case of the recent privatization of Brazilian airports. We find evidence of a permanent, ceteris paribus increase in demand triggered after the privatization program. The results are consistent with a preemption of assets with a view to expanding operations and so benefiting from the network effects offered by a two-sided platform.

1. Introduction

The economic deregulation of airlines has produced important challenges for the air transportation industry. With increasing competition, air fares have dropped and demand has increased considerably, putting significant pressure on existing airport infrastructure. Consequently, air traffic congestion and delays have become routine for travelers around the world. The authorities in charge of the sector have considered not only regulatory reform of airports but also a change in ownership as possible solutions to the problem of airport congestion and, in some cases, a means of facilitating expansion of airport capacity. Airport privatization has become a worldwide phenomenon since the classic case of the sale of the British Airports Authority (UK) in 1987. Graham (2011) notes that, since 1990, many emerging countries have entered into short- and long-term airport privatization transactions. Examples include airports in Delhi, Mumbai, and Bangalore, in India, and Beijing and Shanghai, in China.

Airports nowadays are generally run as modern businesses rather than public utilities (Gillen, 2011). This new trend in the global airport industry means that along with delivering airside services to airlines, airports have to go to considerable lengths to, among other things, attract new services and maintain high service levels and low operating costs to enable them to face competition from other airports and transport modes, as well as to maximize the generation of non-aeronautical revenues from terminal retail services, increase accountability and transparency to investors and develop vertical relations with airlines and global airline alliances. In this context, airport privatization has been regarded in many cases as a tool not only for securing proper financing but also for inducing improvements in airport management.

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Some of the recent literature on modern airports and the air transport industry considers their potential role as two-sided platforms.[1] As such, airports must add value to their main client groups—airlines and passengers. A two-sided platform is capable of exploiting the demand interdependencies of its clients and allows direct and indirect network effects to emerge or to be more intensively generated. Airlines benefit if a two-sided-platform airport increases the number of passengers, and passengers benefit if the airport attracts more airlines, more destinations and higher flight frequencies. We investigate whether a change in ownership changes the incentives of the management and, as an outcome, enhances the dynamic capabilities of airports so that they more closely resemble a two-sided platform. Teece and Pisano (1994) employ the concept of "dynamic capabilities" to describe firms with timely responsiveness and rapid flexible product innovation. We suspect that privatization may mark the birth of an entity that acts a facilitator, allowing for previously unexploited direct and indirect network effects between airlines and passengers to emerge. We test hypotheses related to the consolidation of privatized airports as two-sided platforms by empirically examining the possible impacts of privatization on airline demand. We examine whether privatization allows for market-demand shifts associated with the emergence of network effects and the possible positive feedback loops triggered by them. To date, the existing empirical literature applied to airports is scarce – Ivaldi et al. (2012), who were the first to develop an empirical framework to investigate the potential role of airports as two-sided platforms. The literature has apparently neglected the potential role of ownership change in the formation and consolidation of two-sided platforms. We also raise the hypothesis that carriers may anticipate the benefits and the entry inducement effects associated with the enhanced two-sided platform.

We consider the case of the recent privatization of Brazilian airports and control for the sequence of public events associated with the airport privatization program since its launch in the late 2000s. We examine the effects of the privatization package of 2011–2012, which included three major airports – São Paulo/Guarulhos (GRU), Brasília (BSB) and São Paulo/Viracopos (VCP) – respectively, the country's international gateway, the geographically centrally located domestic hub, and the only major secondary airport in the country. Our methodology considers privatization in a treatment effects framework and uses a difference-in-differences estimation with two control groups and alternative control group assignment schemes. We also conduct a regression-based event study to estimate a set of time evolving privatization-related coefficients and perform empirical tests to determine the sequential impact of the different stages of privatization on demand. This paper therefore adds to the scarce literature on the econometric modeling of airport privatization and present the first study to test empirically for the possible dynamic demand-side effects associated with an orientation of airports toward two-sided platforms.

The present paper is organized in the following way: Section 2 presents a discussion of the potential role for privatization in the context of two-sided platform formation and our hypotheses proposal. Section 3 presents the empirical model development. Section 4 contains the presentation of estimation results, along with a set of robustness checks. The final section contains the concluding remarks.

2. Ownership change and two-sided platform orientation

Many governments around the world have embraced privatization programs aiming, among others, at enhancing the efficiency of state-owned enterprises. However, the conclusions regarding the relative performance of airport operators under alternative governance schemes are still not clear – See for example, Oum et al. (2008) and Scotti et al. (2012). The lack of consensus in the literature may be due to the fact that public infrastructures such as airports will never completely act like fully private entities, since there is a public interest in ensuring a minimum service, safety, and security standard that a purely private entrepreneur would potentially not strive for. This important regulatory element of the airport business substantially increases the complexity of any comparison between public and private management in the sector.

2.1. Airports as two-sided platforms

The recent literature has adopted the concept of two-sided platforms to better describe the role of airports in the modern air transport industry (Gillen, 2011; Ivaldi et al., 2012; Malavolti, 2014; Flores-Fillol et al., 2014). According to Rochet and Tirole (2003) and Evans and Schmalensee (2008), network effects emerge in a market when the more consumers use a product, the more other consumers value that product. A two-sided platform exploits these demand-side interdependencies of its two client groups with a view to fully or at least partially internalizing the network effects that exist between them. Ivaldi et al. (2012) are the first authors to consider airports as two-sided platforms both theoretically and empirically. They develop an empirical structural methodology to examine the two-sidedness of airports in the US airline industry and find empirical evidence that airports have the characteristics of two-sided platforms and that their pricing scheme allows for cross-subsidization of the two sides.

2.2. Two-sided platforms and privatization

The concept of airport as a two-sided platform and its association with privatization are at the core of our research objectives. We therefore consider a set of hypotheses to inspect that association. Our first hypothesis is the following.

[1] There is an analytical stream of the literature that studies airports. Some recent literature investigated airport privatization from a modeling perspective – Mantin (2012), Assaf and Gillen (2012), Lin (2013), Czerny (2013), Gillen and Mantin (2014), Yan and Winston (2014), Lin and Mantin (2015), Noruzoliaee et al. (2015), among others. Additionally, other modeling papers study airports as two-sided markets – for example, Fu et al. (2011) and Gillen and Mantin (2013).

H1. Privatization changes the incentives of the management and, as an outcome, enhances the dynamic capabilities of an airport so that it more closely resembles a two-sided platform.

Teece and Pisano (1994) define dynamic capabilities as a source of competitive advantage for "*firms that can demonstrate timely responsiveness and rapid and flexible product innovation, coupled with the management capability to effectively coordinate and redeploy internal and external competences*" (p. 538). In this sense, the transition from predominantly public governance to governance marked by full private management control may provide incentives for airports to become more responsive to the shifting character of the environment, especially when the timing of decision-making is critical. Teece (2007) lays out the microfoundations of dynamic capabilities as being the distinct skills, processes, procedures, organizational structures, decision rules, and disciplines. Sirmon et al. (2007) emphasize that dynamism in a market is dependent on the amount of change occurring in its environment in terms of producing uncertainty. They cite the rapid privatization of state-owned enterprises as unexpected events that may create discontinuities and uncertainty in an industry. In such environment, the emergence of dynamic capabilities are essential for firms to gain and maintain a competitive advantage.

Privatization may therefore strengthen the role of the airport in acting as a facilitator, and thus allowing the direct and indirect network effects between airlines and passengers to emerge. The direct network effects will emerge first. On the supply side, a privatized airport may be more attractive to airlines because of its more flexible management structure, which can facilitate vertical relations—there is less administrative bureaucracy, making it easier to negotiate new flights and better positioning at gates for carriers that bring profits to the airport, etc. If on the one hand a public-managed airport is likely to apply equal conditions to all of its airlines, on the other a private-run company may apply different policies and discriminate across its client base. One visible consequence of this is that joint operational and marketing practices can be more easily and frequently designed by the airport and one or a few airlines. Additionally, a privatized airport may improve its facilities. With renewed in-terminal concessions, it may improve passenger satisfaction and ultimately enhance passenger air travel frequency and loyalty. Additionally, fare competition will certainly attract price-sensitive passengers. We may therefore observe shifts and movements along the demand curve of one side of the platform (passengers) produced by the behavior of the other side of the platform (airlines). We further explore the emergence of such indirect network effects as a result of privatization by introducing our second hypothesis:

H2. When a two-sided-platform airport exploits the indirect network effects between passengers and airlines, a positive feedback loop is produced that enhances passenger demand on many of the airport's routes.

2.3. Privatization stages, publicization and expectations

Megginson (2005) describes privatization as a process rather than a single event and emphasizes how difficult privatization is in practice, particularly the basic preparations for the sale that need to be addressed even before the actual beginning of the sale process. Carney and Mew (2003) categorize airport privatization into five types: share flotation, trade sale, concession, project finance privatization, and management contract. We are particularly interested in the analysis of the dynamic impacts of privatization. For this purpose, we consider an adaptation of the privatization timetable of Donaldson and Wagle (1995). Broadly speaking the timetable for a privatization program can contain the following four stages: 1. *Program Establishment*, where the privatization approach and institutional framework are defined; 2. *Asset Restructuring*, where the government prepares for the sale and possibly reorganizes and makes some improvements to the assets to enhance their intrinsic value; 3. *Competitive Tendering*, where the government invites bids to be submitted within a deadline; and, lastly, 4. *Private Management*, where management control and ownership is transferred to the private sector. We will consider these four stages of privatization in our empirical framework to assess the impacts of airport privatization.

It should be remembered that, in addition to ensuring the specific details related to the timing of a privatization program, governments regularly need to publish many of the procedures involved in the privatization (Dannin, 2006). In fact, when a public enterprise is being privatized, governments periodically have to make *public announcements* about crucial aspects of the privatization. Typically, these can be regarded as events that represent the beginning of the respective stages of the privatization. Examples include public announcements about the privatization, any restructuring measures that will be taken, the date of the privatization auction and the timetable for transfer to the private sector. This demand for accountability of the whole privatization process is typical in democratic countries and constitutes a transaction cost that represents a constraint on government from the very beginning of the privatization program. More importantly for our framework, this series of privatization events may act as expectation formers for market participants, particularly incumbent airlines based at the airport that is to be privatized and potentially interested newcomers. Based on this, we raise the following hypothesis:

H3. The public nature of the sequential events of a privatization program reduces the amount of incomplete information available to market participants and creates expectations of long-term contracting with the new privatized two-sided-platform entity. These expectations cause the network effects associated with the two-sided platform to be brought forward.

The airline literature suggests that, based on theoretical entry-prevention models, preemption may be a rational strategy for carriers and that investment timing decisions are affected by the competitive environment in which firms operate – see, for example, Goolsbee and Syverson (2008). In particular, we stress the relevance of the formation of expectations regarding possible long-term contracting in the sense of Aghion and Bolton (1987). Such long-term contracting may be accomplished not necessarily via formal contracts, but also via solid airline-airport vertical relationships – see Barbot et al. (2013) and D'Alfonso and Nastasi (2014) for recent examples in the literature. We suspect that the emergence of a two-sided platform may create incentives for the strengthening of such vertical relations. We argue that it may be rational for both a newcomer to enter and an incumbent to expand in order to take advantage of future gains linked to the intrinsic characteristics and effects associated with the two-sided platform. By considering H3, we suspect that if carriers anticipate the future network effects of the two-sided platform because they have an expectation that the airport will be privatized, then their strategic decisions may start producing effects even prior to the actual transfer of control to the new private administration.

3. Research design

3.1. Application

We develop an empirical model of passenger market demand based on the Brazilian airline industry and the recent Brazilian airport privatization program, in which the regulatory framework for the airport concessions was single-till regulation combined with a price cap along with service-level regulation and a capacity-expansion clause. Brazil has experienced a sharp growth in demand for air transport since 2000, particularly during the late 2000s and early 2010s. In fact, air traffic has more than tripled since 2000. This rapid growth and the decision to host the 2014 World Cup and 2016 Summer Olympic Games in Brazil forced the authorities to make major changes in the airport sector. The alternatives considered were the public flotation of Infraero, the state-owned airport infrastructure management company, which managed 67 airports across the country, or full privatization of some key airports. The privatization program was launched in 2008. In 2010, the government announced public investments of USD 3.1 billion at 13 airports in cities that were to host World Cup matches. Airports due to be privatized were also included in the public investment package. After several months of discussions, a specific privatization schedule with a first-round list of airports assigned for privatization was announced on May 31, 2011. The tendering process for a long-term contract included three major airports: São Paulo/Guarulhos (GRU), the country's international gateway and Latin American's biggest hub, Brasília (BSB), the most important domestic hub, located in the geographic center of the country, and São Paulo/Viracopos (VCP), currently the only major secondary airport in Brazil. On February 6, 2012, the auction of the three major airports was carried, with granted concessions of 20-year (GRU), 25-year (BSB) and 30-year (VCP) contracts in an ownership setup in which Infraero still holds a 49 per cent stake. Immediately after privatization, intense construction work began at all three airports to expand their capacity so that they would be ready for the increased traffic expected for the 2014 World Cup.

The impact of privatization on airports in Brazil can be visualized in Table 1, which shows the evolution of domestic air travel from 2010 to 2014. The table gives the number of daily passengers at the privatized (GRU, BSB and VCP) and non-privatized airports. The figures are broken down into major airlines and small to medium-sized airlines,[2] and are consistent with the interpretation that a more intensive two-sided platform orientation by the privatized airports was anticipated by both major and small-to-medium-sized airlines.

3.2. Data

Most data utilized in this research are publicly available from the National Civil Aviation Agency (ANAC), the Brazilian Institute of Geography and Statistics (IBGE) and the Brazilian Central Bank. Our dataset consists of a panel of routes in Brazil between January 2002 and December 2013. As with the empirical study of airport two-sidedness of Ivaldi et al. (2012), we define a product as a directional trip between origin and destination airports. As it permits developing a more detailed and disaggregated panel data of airport-pairs, instead of focusing solely on airports, the procedure of the authors allows for better controls not only for the airport and city characteristics but also for the market level factors that may be relevant in determining the passenger demand phenomena. Therefore, in our analysis, a route is defined as a domestic directional airport-pair. By considering directional airport-pairs we have, for instance, route GRU-BSB (Guarulhos Airport – Brasília Airport) treated as a different observation from route BSB-GRU. Routes with an average of less than thirty monthly passengers each way and that had less than five years of continuous scheduled traffic flow were discarded, resulting in 458 directional airport-pairs.

3.3. Treatment assignment methodology

Our proposed empirical framework considers privatization in a context of treatment effects. With this methodology, we classify the routes of privatized airports as "subjects" that receive a "treatment". To inspect the impacts of treatment on subjects we employ the difference-in-differences method (DiD) – see Kwoka and Shumilkina (2010) and Bilotkach (2011) for applications of DiD to the airline industry. With a DiD method, we need to define "treatment" and "control" groups to make comparisons with respect to the evolution of a given outcome. The sample must contain periods in which none of the subjects under investigation receive the treatment and periods in which only a subset of them actively receive the

[2] The major airlines are basically LATAM and Gol and their regional partners, such as Pantanal and Passaredo. Small & medium-sized airlines are all carriers with less than 15 per cent of the market, such as Azul and Avianca.

Table 1
Evolution of air travel in Brazil. *Source:* National Civil Aviation Agency, Route Traffic Report, available at www.anac.gov.br, 2008–2013.

Period	Privatized airports GRU + BSB + VCP					Non-privatized airports					Total domestic Brazil				
	Major airlines & partners		Small & medium-sized airlines		Total	Major airlines & partners		Small & medium-sized airlines		Total	Major airlines & partners		Small & medium-sized airlines		Total
	Daily pax (000)	Share (%)	Daily pax (000)	Share (%)	Daily pax (000)	Daily pax (000)	Share (%)	Daily pax (000)	Share (%)	Daily pax (000)	Daily pax (000)	Share (%)	Daily pax (000)	Share (%)	Daily pax (000)
2010	69.8	77.4	20.4	22.6	90.2	80.6	85.1	14.1	14.9	94.7	150.4	81.3	34.5	18.7	184.9
2011	81.0	76.7	24.6	23.3	105.6	91.9	80.9	21.8	19.1	113.7	173.0	78.9	46.3	21.1	219.3
2012	88.4	75.2	29.2	24.8	117.6	93.3	78.1	26.1	21.9	119.4	181.7	76.6	55.3	23.4	237.0
2013	86.7	69.9	37.4	30.1	124.1	86.2	75.2	28.5	24.8	114.8	172.9	72.4	65.9	27.6	238.8
2014	90.5	67.8	42.9	32.2	133.4	89.7	75.9	28.5	24.1	118.2	180.2	71.6	71.4	28.4	251.6
2012–2010															
Abs. change	18.6	−2.2	8.8	2.2	27.4	12.7	−7.0	12.0	7.0	24.7	31.3	−4.7	20.8	4.7	52.1
% growth	26.6		43.0		30.3	15.7		85.4		26.1	20.8		60.3		28.2
2014–2012															
Abs. change	2.1	−7.4	13.7	7.4	15.8	−3.6	−2.2	2.3	2.2	−1.2	−1.5	−5.0	16.1	5.0	14.6
% growth	2.3		47.1		13.4	−3.8		8.9		−1.0	−0.8		29.0		6.2
2014–2010															
Abs. change	20.6	−9.6	22.5	9.6	43.2	9.1	−9.2	14.4	9.2	23.5	29.8	−9.7	36.9	9.7	66.7
% growth	29.6		110.2		47.8	11.3		101.8		24.8	19.8		106.8		36.0

treatment. In our case, we have air travel demand as the outcome of interest and the routes associated with privatized airports as the "actively treated" group. We have to select "placebo treated" individuals, i.e., routes that appear to be similar to the routes exposed to privatization but did not have any endpoint airport privatized in the sample period. We thus employed the following four-steps procedure for subject classification in our DiD framework:

- **Step 1 – Identify the actively treated group.** Routes with at least one endpoint airport that was privatized and started operations under full private management in the sample period were classified as pertaining to the actively treated group.
- **Step 2 – Define a rule for airport matching.** Matches for privatized airports were chosen based on the following "investment" rule: airports not privatized but also subject to the public investments of the 2010–2014 restructuring program were assigned as matches for the privatized airports under consideration.[3]
- **Step 3 – Assign routes with a "placebo treated" status.** Every route in the sample that was not already assigned with an "actively treated" status and had as an endpoint airport one of the airports included in the matching group of Step 2 was classified as "placebo treated". We therefore paired the actively treated and the placebo groups by finding airports that were matches for the actually privatized airports whenever they appeared as an endpoint airport.
- **Step 4 – Assign the remaining routes with a "baseline" status.** In most experiments, we do not discard the "untreated" subjects of our sample – ie. the routes not assigned with either a actively or a placebo treatment status. These routes are related to fully public airports operated by state-owned enterprise Infraero and marked by a traditional rate of return regulation scheme. We therefore have three comparison groups: "actively treated", "placebo treated" and "baseline" (the remaining airports). To avoid the dummy variables trap, the baseline group is defined as the base case of the groups.

3.4. Regression framework

In our DiD approach, we perform a regression-based event methodology to inspect the impact of airport privatization. In such a framework, time dummies consistent with notable events in the market are inserted in the model to capture the dynamic pattern of the inspected variables over time. In the present case, we insert stage-specific time dummies to be consistent with the stages of privatization discussed in 2.3. Our objective is to estimate a set of time evolving coefficients to promote empirical tests of the sequential impact of privatization. In most analyses we estimate specific treatment effects for both the "actively treated" and the "all treated" groups, leaving the "baseline" group as the base case of the dummy variables. The estimating equation of air travel demand consists of the following equation:

$$ln\ daily\ pax_{kt} = \sum_{i=1}^{4}(\delta_i\ actively\ treated_k + \tilde{\delta}_i\ all\ treated_k)\ privatization\ stage\ i_t + X_{kt}\alpha + \gamma_k + \gamma_t + \varepsilon_{kt}, \quad (1)$$

[3] Matching airports: Rio de Janeiro's Tom Jobim and Santos Dumont airports, and the airports of Vitória, Porto Alegre, Florianópolis, Curitiba and Goiânia cities.

where *daily* pax_{kt} is the average number of daily revenue passengers on route (i.e. directional airport-pair) k and time t – Source: National Civil Aviation Agency, Traffic Report; *actively* $treated_k$, *all* $treated_k$ and *privatization stage* i_t are dummies of treatment and treatment period. X_{kt} is a vector of demand regressors; α is a vector of coefficients; δ_i is the privatization effects on the "actively treated" group; $\tilde{\delta}_i$ are the privatization effects on the "all treated" group; γ_k and γ_t are the two-way fixed effects of route (k) and time (t); ε_{kt} is the idiosyncratic error term. Note that γ_k controls for route-specific and endpoint airports-specific idiosyncrasies that do not change over time; γ_t are time effects aimed at accounting for national-level shocks related to the economic activity and the air transport sector, such as seasonal effects, common trends, and the overall impact of the 2014 World Cup.

As it can be observed in Eq. (1), we nest the two treatment groups, i.e. the "actively treated" and the "placebo treated", to form an "all treated" group. Therefore, *actively* $treated_k$ is a dummy utilized to assign route k as pertaining to the "actively treated" group of routes. Additionally, *all* $treated_k$ is a dummy variable utilized to assign route k as pertaining to either the "actively treated" or the "placebo treated" group of routes at time t. This variable nests the first dummy variable, which implies that *actively* $treated_k$ and *all* $treated_k$ are not mutually exclusive. Consequently, the estimated effects of *actively* $treated_k$ are additive in relation to the effects of *all* $treated_k$, a desirable property that allows for a more straightforward comparison with the placebo group. As an illustration of our procedure, consider the GRU-REC (São Paulo/Guarulhos Airport – Recife Airport) route. For the observations of that route, the actively treated dummy was assigned with value one after the launch of the privatization program, and zero otherwise. That observation was also assigned with one for the "all treated" dummy in the same period. Moreover, the matching routes were identified and had the "all treated" dummy also assigned with one – for example, GIG-REC (Rio de Janeiro's Tom Jobim Airport – Recife Airport), as GIG was classified as a match for GRU. As the investment rule considered a set of matching airports for the set of privatized airports, other matching routes had the same assignment and therefore for each privatized airport's route we have more than one matched observation, according to the definition of the respective matching rule.

When defining the set of dummies of *privatization stage* i_t, we utilized the actual dates of privatization announcements (events) by the Brazilian government: the announcements of the establishment of the privatization program (February 2008), the announcement of public investments in Infraero airports (March 2010), the announcement of the shortlist of airports and the preparation for the privatization auction (May 2011) and the transfer of management control to the private operators. We therefore have dummies to account for privatization stage 1 (February 2008 – February 2010), stage 2 (March 2010 – April 2011), stage 3 (May 2011 – November 2012), and stage 4 (from December 2012 to the end of sample period[4]). We leave the period previous to the establishment of the privatization program (from the beginning of sample period to December 2007) to the base case of the time dummies.

We consider the following variables in the setup of X_{kt}: *gravity* $population_{kt}$, which is the product of the population of origin and destination cities of route k and time t (in millions); *gravity* gdp_{kt}, the product of the gross domestic product (GDP) of origin and destination cities of route k and time t. These metrics have yearly periodicity and therefore had to be interpolated to produce monthly series; source: Brazilian Institute of Geography and Statistics (IBGE). $yield_{kt}$, a proxy for the market average price per kilometer on route k and time t; this series was inflation-adjusted to produce constant monetary figures; source: National Civil Aviation Agency, Yield Report. *LCC* $presence_{kt}$, a dummy for the presence of low cost carrier Azul airlines on route k and time t; source: National Civil Aviation Agency, Active Scheduled Flight Report. Henceforth, we omit indexes k and t. Table 2 presents descriptive statistics.

Although we assume that privatization may have had a relevant impact on the strategies of airlines, we recognize that the location attributes of the airport are key factors determining the performance of airports in attracting new demand. If the catchment covered by a given airport experiences specific and natural demand growth, positive network effects may occur even if the management has not yet developed strong dynamic capabilities. We certainly do not believe that airport management is more important than location attributes, but attempt to estimate a privatization effect on airports that is aimed to be as most as possible net of the location attributes – i.e., a ceteris paribus effect. We believe our fixed effects procedure is capable of accounting for origin and destination idiosyncrasies that may be related to the time invariant locational characteristics. We are aware, however, that the cities that had privatized airports may possess distinct relative economic and demographic dynamism in relation to the remaining of the country. Our two-way fixed effects procedure partially accounts for such dynamic pattern by controlling the average country wide time evolving effect. Additionally, we aim at controlling for locational-specific time varying factors of the local economies by recurring to the gravity terms of local economic activity and population – namely, *gravity population* and *gravity gdp*. Other important issues regarding our empirical model are related to airport dominance and the availability of traffic-enhancement airport management tools. For example, we have that the financial performance and strategies of airlines with more strength in each airport is an important factor that may determine airport traffic. We aim at capturing such effect with our *yield* and *LCC presence* variables that control for market structure influence in influencing demand. Additionally, the time fixed effects are able to capture the overall status of competition in the country.

To inspect the time-evolving effects of airport privatization in a deeper way – consistently with H3, we utilize the methodology of inserting lags and leads around event time, as Goolsbee and Syverson (2008) and Jaravel et al. (2015). To

[4] The dates of these events were collected from the electronic archives of the most important national newspapers. The public announcement regarding the full private management transfer was Nov 15, 2012 at GRU and BSB. As our dataset has monthly periodicity, we counted December 2012 as the actual start.

Table 2
Descriptive statistics – variables of the empirical model.

Variable		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Pearson's correlation										
Daily pax	(1)	1.00								
Population	(2)	0.44	1.00							
gdp per capita	(3)	0.34	0.21	1.00						
Yield	(4)	−0.02	0.13	−0.14	1.00					
LCC presence	(5)	0.07	−0.14	0.07	−0.26	1.00				
Prop flights in congested hours	(6)	0.15	0.16	0.12	0.13	0.14	1.00			
Growth gravity gdp per capita	(7)	0.00	0.01	0.00	0.02	0.00	0.00	1.00		
Privatization program – active	(8)	0.22	0.10	0.58	−0.29	0.09	0.06	0.00	1.00	
Privatization program – all treated	(9)	0.30	0.12	0.54	−0.38	0.22	0.03	−0.01	0.71	1.00
Univariate statistics										
Mean		364.7	6228.0	2367.8	0.59	0.13	0.10	1.93	0.20	0.33
Standard deviation		516.1	4336.4	876.7	0.35	0.33	0.23	109.71	0.40	0.47
Minimum		30.0	290.3	496.6	0.09	0.00	0.00	−1.00	0.00	0.00
Maximum		5888.2	17625.3	5644.0	3.00	1.00	1.00	23104.0	1.00	1.00

accomplish that, we consider stage-specific quarter dummies. We configure the time setup with up to six quarter period dummies, starting from quarter $q_i^* - 1$, where q_i^* is the quarter of the public announcement that triggers stage i. The extended empirical model is therefore:[5]

$$ln\ daily\ pax_{kt} = \sum_{i=1}^{4}\sum_{\tau=-1}^{4+}\left(\delta_{i,q_i^*+\tau} actively\ treated_k + \tilde{\delta}_{i,q_i^*+\tau} all\ treated_k\right) privatization\ stage\ i_t + X_{kt}\alpha + \gamma_k + \gamma_t + \varepsilon_{kt} \quad (2)$$

3.5. Sample selection

We must acknowledge that the decision to privatize an airport is neither random nor exogenous to demand. In fact, governments typically contemplate a broad range of criteria when considering privatization, and as a result the decision-making process that leads to the definition of a short list of airports to be privatized clearly brings econometric problems related to sample selection. Some of these governmental motivations may be associated with many of the airline demand unobservables, such as political factors and pressures of interest groups that are correlated with origin and destination population density as well as with the relative strength of the local economies. Other key factors may be financial reasons such as public debt reduction and resources saving, as privatization is more likely for airports with more need of investments – to save public expenditure – and good demand growth perspectives – to achieve more revenues with the sale.

To deal with sample selectivity, we utilize a Heckit model, in which a selection decision equation is firstly estimated using a probit model and, in a second stage, the observed factors that determine such selection are included in the estimating equation in the form of an inverse Mills ratio variable. Our specification of the first-stage probit model has *privatization program* as the regressand and the following regressors: *ln gravity gdp per capita*, *ln gravity population*, and *ln yield*, defined as described above. These variables aim at accounting for socio-economic and competition factors that may influence the government's decision to select airports for privatization. Other variables are *yoy gravity gdp per capita*, calculated as the year-over-year percentage variation in *gravity gdp per capita* – source: Brazilian Institute of Geography and Statistics (IBGE); this metric captures the record of recent growth of the economies linked by route k at time t and may be regarded as a proxy for the growth perspectives of the related airports. This variable aims to control for the expectations of authorities regarding future enhanced organic traffic growth at the airports. And finally, *prop flights in congested hours*, measured as the proportion of daily scheduled flights of route k and time t that operate during congested hours. We define "congested hour" as a full clock hour characterized by operations of flights (arrivals plus departures) in a higher amount than the official declared capacity. Sources: National Civil Aviation Agency, Active Scheduled Flight Report and an airport capacity study of the Brazilian government (2010).[6] This variable was conceived to be a proxy for the financial motivation regarding the need of investments at congested airports.

[5] Note that stage 2 is the exception, with three post announcement quarter dummies instead of four.

[6] "*Study of the Air Transport Sector in Brazil*" (text in Portuguese) – Brazilian Development Bank, Jan, 25, 2010, available at www.bndes.gov.br. It is important to emphasize that we do not include all the regressors of (1) and (2) in our probit specification. Including all regressors of the estimating equation into the first-stage regression typically introduces severe multicollinearity in the second-stage model. A standard procedure to prevent such problem is therefore to impose exclusion restrictions.

3.6. Identification

To account for the endogeneity of regressor ln *yield* of X_{kt} in Eqs. (1) and (2), we utilize an instrumental variables estimator to implement our fixed effects model. The estimation method employed was the two-step feasible efficient generalized method of moments estimator (2SGMM) with standard errors robust and efficient to arbitrary heteroscedasticity. We assume that the demand unobservables are mean independent of a set of exogenous airline cost shifters. In particular, we utilized as instruments a set of proxies for the unit cost of airline inputs, as they are natural price drivers not directly related to the unobserved shocks of demand, ie. $E[\varepsilon_{kt}(\Theta_0)|W_{kt}] = 0$, where W_{kt} is the set of exogenous cost shifters, and Θ_0 is the vector of true parameters. To obtain the unit cost proxies, we utilized an unpublished monthly report of costs, expenses and operations disaggregated by aircraft type and airline provided by the National Civil Aviation Agency. We then extracted unit costs of fuel, insurance, leasing, navigation fees, maintenance and station by airline-aircraft type. We did not utilize landing charges as they are potentially correlated with demand. Landing charges can be strategically used by the privatized airport under price-cap regulation as a way to induce network effects, to attract more flights or, in case of market power exertion, to restrict demand. In such circumstances, unobserved demand shocks may be either positively or negatively correlated with the levied landing charges, and therefore this variable is not a candidate for being a good instrument. Using a similar reasoning, we did not consider labor costs (pilots and crew), as unionization may be a source of endogeneity.

To calculate average airline-aircraft costs, we utilized each of the following metrics as denominators: available-seat kilometers (ASK), number of flights, flown hours and flown kilometers. With aircraft-specific unit costs, we subsequently calculated route-specific costs by extracting a weighted average with weights being the flight frequencies of each airline-aircraft pair. We also produced alternative versions of all proposed instruments by adjusting them with the conversion of airline system wide unit costs to route-specific unit costs proposed by Brander and Zhang (1990, p. 573). With the above procedures, we were able to produce instruments that had variation not only across time (months) but also across routes, making them potential candidates for effective instrumentation. We experimented with several combinations of unit costs (in logarithms) to instrument ln *yield*. The best results in terms of validity and relevance of instruments were the unit costs of maintenance, station and aircraft lease, extracted per available seat-kilometer, per kilometer, and per flown hour, respectively.

We challenged our instrumentation approach with tests of validity and relevance of the proposed set of instruments. First, the validity of the full set of over identifying conditions was analyzed by utilizing Hansen J tests. Rejection of the null hypothesis implies that instruments are not satisfying the orthogonality conditions, one obvious reason being that they are not truly exogenous. For most considered specifications, the Hansen J tests did not reject orthogonality. Second, the relevance of the proposed set of instruments was challenged by underidentification tests. The test employs the Kleibergen-Paap rk LM statistic (KP). The tests led to the rejection of the null of underidentification. Finally, we also tested for weak identification. Considering both the Cragg-Donald Wald F statistic and the Kleibergen-Paap rk Wald F statistic (Weak CD and Weak KP), we had enough evidence for rejecting the hypothesis of weak instruments. The results of all performed tests on the quality of instruments are reported in the tables of Section 4.

4. Results

Tables 3 and 4 present the main estimation results of our empirical model. First, Table 3 presents the results of the probit estimation, in which the regressand is the limited-dependent variable *privatization program*. Note that we include four different specifications – Columns (1)–(4), aiming at checking the sensitivity to changes in the regressor set. The last model, in Column (5), presents the result of a simpler model in which a probit is used to estimate the results without accounting for the panel structure of data – a "pooled" probit.

The results of the sample selection models of Table 3 indicate that income – measured by ln *gravity gdp per capita*, capacity shortage – assessed by the proxy *prop flights in congested hours*, and airline competition – assessed by ln *yield*, are the most important drivers of the government selection of airports for privatization. In fact, all three variables were statistically significant at one per cent level in all specifications. The positive estimated coefficients of ln *gravity gdp per capita* and *prop flights in congested hours* probably indicate that the government prefers selecting airports in which the local economy has higher income and with more prominent problems of congestion than the remaining airports. In contrast, the negative estimated coefficient of ln *yield* suggests that the government appear not to be willing to select airports with many concentrated routes in which airline competition is missing – it seems that the government anticipates that the new private airport administration will likely engage in vertical relations with the existing airlines and therefore aims at avoiding price-increasing outcomes.

Table 4 presents the estimation results for our demand model, after accounting for the governmental selection of airports with the inverse Mills ratio estimated with the first probit model of Table 3. It is possible to see in Table 4, Columns (1) and (2), that the demand shifters ln *gravity population*, ln *gravity gdp* and ln *yield* are statistically significant at the one per cent level and have their coefficients estimated in line with the theory of air travel demand. Note that the

Table 3
Estimation results – Selection model – dependent variable: privatization program.

	(1)	(2)	(3)	(4)	(5)
ln gravity gdp per capita	1.3341***	1.0185***	1.2302***	1.2154***	1.3331***
ln gravity population	0.0240	0.0235	−0.0049	−0.0122	0.0240***
Growth gravity gdp per capita	−0.0368		−0.0250	−0.0230	−0.0363***
Prop flights in congested hours	1.0379***			0.6577***	1.0377***
ln yield	−1.1787***				−1.1788***
Probit model	Panel population-averaged	Panel population-averaged	Panel population-averaged	Panel population-averaged	Pooled
Pseudo *R*-squared	0.6824	0.6477	0.6372	0.6686	0.3689
ρ Statistic	0.9810	0.9758	0.9671	0.9560	n/a
ρ Nullity Test *P*-Value	0.0001	0.0001	0.0001	0.0001	n/a
χ^2 Statistic	16385.84	8244.08	2421.48	7754.67	10894.92
χ^2 *P*-Value	0.0001	0.0001	0.0001	0.0001	0.0001
Nr Observations	49,305	54,278	49,305	49,305	49,305

Results in Columns (1)–(5) produced by a maximum-likelihood probit model and in Column (6) by a panel data population-averaged probit model (PA) with robust and autoregressive specification; pseudo *R*-squared and χ^2 Statistic in Column (6) extracted from a random-effects probit model with identical specification; standard errors in brackets; *p*-value representations.
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

coefficient of *LCC presence* suggests a positive and significant ceteris paribus effect on demand of the low cost carrier presence on the route.[7] With respect to the estimation of the treatment effects of privatization, we have two sets of regressions in Table 4: the first including only one privatization dummy – the *privatization program* variable, and the second including each privatization stage dummy. These specifications are presented in Columns (1) and (2) of Table 4, respectively. The results of Table 4 suggest a positive and permanent impact in the average number of daily passengers since privatization. It is important to emphasize that these results represent isolated effects of the actively treated group when compared to the all treated group displayed at the bottom of Table 4. These results are consistent with hypotheses H1 and H2 regarding the improved dynamic capabilities of the privatized airports as a two-sided platform. An airport with enhanced two-sided platform capabilities would be able produce direct and indirect network effects that would ultimately provoke demand shifts.

The results of the single dummy variable of Table 4, Column (1), are corroborated by the analysis of the alternative disaggregated results of Column (2), which confirms the existence of statistically significant and time evolving effects of the privatization program. It is possible to note that most effects are triggered from privatization stage 1, when the privatization program was established. For example, the estimated coefficient of the privatization program is 0.1073 on stage 1 and then keeps growing in stage 2 (0.2510), reaching more than 0.3837 in stage 4. Note that these estimates reveal statistically significant effects that are ceteris paribus to the traditional demand regressors that control for income, market size and price – namely, ln *gravity gdp per capita*, ln *gravity population*, and ln *yield*. These results are consistent with the reduction of incomplete information of airlines and the formation of expectations of long-term contracting with the two-sided platform, raised by H3.

4.1. Robustness checks

To check the validity and sensitivity of our results, we implemented an analysis of common trend and a set of robustness checks that address important concerns that could lead our estimates to overstate the strength of the impact of airport privatization on airline demand. The common trend analysis is presented in Fig. 1. It contains the evolution of the indexes of mean daily passengers for both the actively and the placebo treated groups (2002 = 100). In Fig. 1, the visual inspection of the pre-treatment trends for both the actively treated and the placebo treated groups revealed a pattern that is suggestive not only of a common trend before the establishment of the privatization program but also of a structural break in that trend in the subsequent period.

In the first robustness check, we changed the airport classification procedure for placebo treated designation to inspect whether our results are not driven solely by this specific methodological choice. Although the chosen rule for finding airport matches of the privatized airports to proceed with our treatment effects approach was the above described "investment"

[7] We believe that *LCC presence* may be positively correlated with the unobserved demand term, as demand attracts entry. As *LCC presence* is clearly negatively correlated with the average yields (see Table 2), than, by using the commonly used reasoning for guessing the direction of the estimation bias of a possibly endogenous regressor, we may have underestimated the effect of *LCC presence* on demand. On the other hand, our estimates may be viewed as conservative measures of the LCC effect on the generated traffic. The ideal procedure should be to instrument that variable together with *ln yield*, but we do not believe that problems with the estimation of the LCC effect would change our main results regarding privatization, however.

Table 4
Estimation results – Heckit model – dependent variable: ln daily pax.

	(1) ln daily pax	(2) ln daily pax	(3) ln daily pax	(4) ln daily pax	(5) ln daily pax	(6) ln daily pax	(7) ln daily pax	(8) ln daily pax	(9) ln daily pax	(10) ln daily pax
ln gravity population	2.1173***	1.7410***	1.9489***	1.6455***	2.0894***	1.5900***	1.9961***	1.5537***	2.0533***	1.6561***
ln gravity gdp per capita	0.3638***	0.2547**	0.3255***	0.1772*	0.3244***	0.1414	0.4502***	0.3342***	0.3508***	0.2237**
ln yield	−1.6153***	−1.2833***	−1.4541***	−1.1333***	−1.6552***	−1.2011***	−1.9356***	−1.5926***	−1.7338***	−1.4164***
LCC presence	0.3388***	0.3459***	0.3095***	0.3127***	0.3428***	0.3344***	0.3594***	0.3651***	0.3562***	0.3655***
Actively treated										
Privatization program	0.2314***		0.1632***		0.2539***		0.3183***		0.4487***	
Privatization stage 1 – program establishment		0.1073***		0.1093***		0.2259***		0.1981***		0.2859***
Privatization stage 2 – asset restructuring		0.2510***		0.1784***		0.2672***		0.3119***		0.4564***
Privatization stage 3 – competitive tendering		0.3255***		0.2562***		0.3340***		0.4432***		0.5684***
Privatization stage 4 – private management		0.3837***		0.2855***		0.3960***		0.5231***		0.6832***
All treated (actively and placebo)										
Privatization program	0.0918***		0.2635***		0.0470***		−0.5045***		−0.1890***	
Privatization stage 1 – program establishment		0.1244***		0.1766***		−0.0461***		−0.3581***		−0.1218***
Privatization stage 2 – asset restructuring		0.0526**		0.2271***		0.0399**		−0.5351***		−0.2085***
Privatization stage 3 – competitive tendering		0.1280***		0.2926***		0.1165***		−0.4751***		−0.1887***
Privatization stage 4 – private management		0.1541***		0.3747***		0.1358***		−0.5151***		−0.2375***
Inverse Mills ratio	0.3850***	0.2901***	0.3596***	0.2701***	0.3957***	0.2629***	0.4725***	0.3735***	0.4169***	0.3261***
Placebo assignment rule	Investment	Investment	Sequence	Sequence	Growth	Growth	Mega-event	Mega-event	Capacity exp	Capacity exp
Fixed effects	Two-way	Two-way	Two-way	Two-way	Two-way	Two-way	Two-way	Two-way	Two-way	Two-way
Adj. R-squared	0.8215	0.8451	0.8341	0.8546	0.8192	0.8489	0.8002	0.8263	0.8138	0.8369
RMSE statistic	0.4654	0.4337	0.4487	0.4206	0.4685	0.4283	0.4925	0.4592	0.4755	0.4450
F statistic	767.36	892.84	855.59	991.48	754.54	939.22	656.12	769.56	738.67	864.48
KP statistic	147.67	150.00	157.57	149.26	155.31	179.19	134.03	144.23	154.86	171.37
KP P-Value	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
J Statistic	0.7120	0.5350	0.1340	1.8460	0.9030	0.1200	0.8270	0.3910	0.9980	0.4260
J P-Value	0.3989	0.4646	0.7138	0.1743	0.3421	0.7292	0.3632	0.5316	0.3179	0.5139
Weak CD statistic	75.007	76.619	80.342	74.797	80.444	93.747	68.200	73.844	79.819	88.869
Weak KP statistic	75.842	77.263	81.181	62.542	79.991	92.590	68.152	73.863	79.741	88.650
Nr observations	49,143	49,143	49,143	49,272	49,143	49,143	49,143	49,143	49,143	49,143

Results produced by a fixed effects procedure with the implementation of the two-step feasible efficient generalized method of moments estimator (2SGMM); statistics robust to heteroscedasticity; first-stage results produced with the probit model of Table 3, Column (1); standard errors of the estimated coefficients (in brackets) were bootstrapped to account for the two-stage nature of the Heckit method; R-squared and RMSE produced with the equivalent least-squares dummy variable model (LSDV); p-value representations.

* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

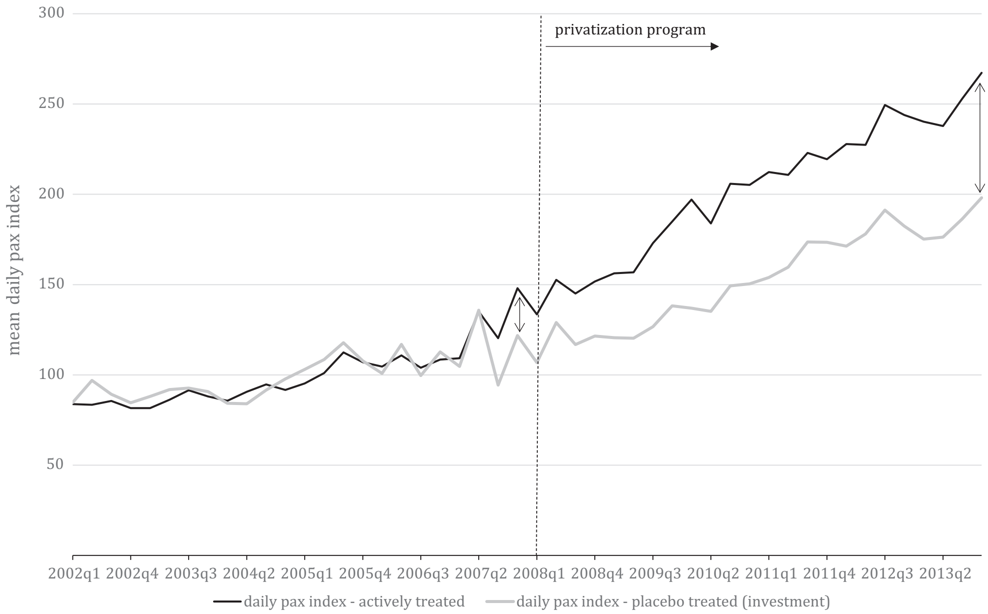

Fig. 1. Common trend analysis. *Source:* National Civil Aviation Agency, Route Traffic Report, available at www.anac.gov.br. Period: 2002–2013, with own calculations. Index basis: mean 2002–2007 = 100. The other placebo assignment rules utilized in this research produced similar trend patterns.

rule, we are aware of its caveats. In particular, it is debatable whether the three privatized airports in our sample are comparable with any possibly formed subset of the remaining domestic airports group. Under imperfect matching conditions, our empirical approach may cause biased estimates and therefore invalid conclusions.

We also considered the alternative matching rules in the empirical model of demand. Firstly, we experimented with other reasonable a priori airport matching rules. We employed the following alternative configurations to examine the robustness of the main results produced with the "investment" rule: (1) a "sequence" rule, which utilizes airports eventually privatized or assigned to be privatized after the end of the sample period;[8] (2) a "growth" rule – airports with similar growth perspectives;[9] (3) a "mega-event" rule – airports of the cities that hosted 2014 World Cup matches;[10] and (4) a "capacity expansion" rule – airports with similar long-run capacity expansion.[11] In Columns (3)–(10) of Table 4, we present the results produced by changing the airport match assignment rule from the "investment" rule to the following rules: "sequence" (Columns 3 and 4), "growth" (Columns 5 and 6), "mega-event" (Columns 7 and 8) and "capacity expansion" (Columns 9 and 10). Again, each set of results is presented with and without the insertion of disaggregated dummies of privatization stages. The final results are robust to the utilization of alternative placebo assignment rules.

The second robustness check was accomplished by inserting a variable related to the possible confounding effects of unobserved airport capacity that could produce effects on observed passenger traffic and, consequently, on demand. As some of the most important airport management tools are related with capacity constraints and the consequent pressures for expansions, we need to control for their demand-side effects. What is more, the complexity of slots and gate allocation management is partially driven by the magnitude of such capacity constraints.[12] We explicitly deal with capacity constraints in the model by inserting the variable *prop flights in congested hours*, as defined earlier. We believe that

[8] Matching airports: Belo Horizonte's Confins Airport, Rio de Janeiro's Tom Jobim airport, Natal's São Gonçalo do Amarante airport, and the airports of Porto Alegre, Salvador, Florianópolis and Fortaleza cities.

[9] For each privatized airport, we included three matched airports. We included only airports of state capitols with more than 1.5 million pax/year in 2011 that were in the top-20 list of highest long-run average growth in passenger traffic (2001–2011). Source: Infraero, with own calculations. Matching airports: Belo Horizonte's Confins Airport and the airports of Vitória, Uberlândia, Cuiabá, João Pessoa, Teresina, São Luiz, Foz do Iguaçu and Campo Grande cities.

[10] Matching airports: Belo Horizonte's Pampulha and Confins airports, Rio de Janeiro's Santos Dumont and Tom Jobim airports, São Paulo's Congonhas airport, and the airports of Curitiba, Cuiabá, Fortaleza, Manaus, Natal, Recife and Salvador.

[11] For this rule, we aimed at creating a very restrictive list. We therefore considered only the next neighbor in percentage capacity growth from 2004 to 2015 of each of the privatized airports. Source of airport capacity figures: Infraero and private airport operators. Matching airports: Cuiabá airport, Rio de Janeiro's Santos Dumont airport, and Porto Alegre airport.

[12] In Brazil, only São Paulo's Congonhas airport was officially a slot-constrained airport in the sample period.

Table 5
Robstness check: Effect of airport capacity – Heckit model – dependent variable: ln daily pax.

	(1) ln daily pax	(2) ln daily pax	(3) ln daily pax	(4) ln daily pax	(5) ln daily pax	(6) ln daily pax	(7) ln daily pax	(8) ln daily pax	(9) ln daily pax	(10) ln daily pax
ln gravity population	1.9930***	1.8603***	1.9386***	1.3717***	1.9896***	1.6647***	1.8819***	1.5796***	1.9312***	1.7171***
ln gravity gdp per capita	1.0059***	0.9451***	0.9614***	0.4778***	0.9967***	0.7596***	1.1653***	1.0700***	1.0459***	0.9127***
ln yield	−2.3645***	−2.2532***	−2.2320***	−1.3614***	−2.3497***	−1.9155***	−2.6732***	−2.4365***	−2.4700***	−2.2231***
LCC presence	0.2458***	0.2601***	0.2371***	0.2391***	0.2453***	0.2480***	0.2530***	0.2629***	0.2575***	0.2695***
Prop flights in congested hours	1.2016***	1.1442***	1.1315***	0.7735***	1.1955***	1.0146***	1.2911***	1.1889***	1.2464***	1.1357***
Actively treated										
Privatization program	0.0686*		0.0288		0.0535		0.0802		0.2703***	
Privatization stage 1 – program establishment		−0.0339		0.0644*		0.0947**		0.0220		0.1872***
Privatization stage 2 – asset restructuring		0.1217***		0.1468***		0.1261***		0.1192**		0.3179***
Privatization stage 3 – competitive tendering		0.1314***		0.1645***		0.1160**		0.1682***		0.3568***
Privatization stage 4 – private management		0.1737***		0.1694***		0.1342**		0.2159***		0.3998***
All treated (actively and placebo)										
Privatization program	−0.0053		0.1057***		0.0186		−0.5008***		−0.2494***	
Privatization stage 1 – program establishment		0.0638**		0.1116***		−0.0677***		−0.3046***		−0.1978***
Privatization stage 2 – asset restructuring		−0.0653		0.1167***		0.0022		−0.5625***		−0.2656***
Privatization stage 3 – competitive tendering		−0.0113		0.1663***		0.0807***		−0.5696***		−0.2598***
Privatization stage 4 – private management		−0.0049		0.2598***		0.1286***		−0.5694***		−0.2540***
Inverse Mills ratio	0.8524***	0.8101***	0.8090***	0.4796***	0.8479***	0.6829***	0.9592***	0.8690***	0.8940***	0.8003***
Placebo assignment rule	Investment	Investment	Sequence	Sequence	Growth	Growth	Mega-event	Mega-event	Capacity exp	Capacity exp
Fixed effects	Two-way	Two-way	Two-way	Two-way	Two-way	Two-way	Two-way	Two-way	Two-way	Two-way
Adj. *R*-Squared	0.7855	0.7931	0.7957	0.8531	0.7867	0.8202	0.7540	0.7797	0.7743	0.7962
RMSE Statistic	0.5102	0.5012	0.4980	0.4224	0.5088	0.4672	0.5464	0.5171	0.5234	0.4974
F Statistic	686.03	712.65	720.45	1041.1	677.96	823.76	594.85	653.82	650.33	716.61
KP Statistic	93.023	71.687	91.912	123.29	100.56	98.769	88.398	79.875	99.311	93.782
KP *P*-Value	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
J Statistic	0.1360	0.5480	0.2810	0.2860	0.1380	0.6370	0.2020	1.3930	0.1250	1.0260
J *P*-Value	0.7123	0.4590	0.5962	0.5929	0.7099	0.4247	0.6530	0.2379	0.7236	0.3111
Weak CD Statistic	50.684	40.305	50.007	70.902	56.705	57.688	48.873	45.303	55.784	54.257
Weak KP Statistic	47.164	36.136	46.680	60.832	51.281	50.100	44.782	40.435	50.605	47.578
Nr Observations	49,143	49,143	49,143	49,272	49,143	49,143	49,143	49,143	49,143	49,143

Results produced by a fixed effects procedure with the implementation of the two-step feasible efficient generalized method of moments estimator (2SGMM); statistics robust to heteroscedasticity; first-stage results produced with the probit model of Table 3, Column (1); standard errors of the estimated coefficients (in brackets) were bootstrapped to account for the two-stage nature of the Heckit method; *R*-squared and RMSE produced with the equivalent least-squares dummy variable model (LSDV); *p*-value representations.

* $p < 0.10$.

** $p < 0.05$.

*** $p < 0.01$.

prop flights in congested hours may work as a proxy for airport bottlenecks and congestion, and may therefore be correlated with demand-side unobservables that shift demand. In that case, by omitting this variable, we would produce biased estimations of the treatment effects when capacity expansion is undertaken by the airport. Another issue is that airline non-price competition may be more intense in airports with prospects of more ambitious capacity expansions. The sign of this variable is uncertain, however, and depends on the tradeoff between schedule delay and congestion on demand – see Noruzoliaee et al. (2015). The results of this robustness check experiment are presented in Table 5. It can be seen from Table 5 that the coefficient of *prop flights in congested hours* is always positive – indicating a lower schedule delay effect, and demand enhancement, of higher airport capacity filled with more flights – and statistically significant in all specifications. Additionally, the results of the estimated treatment effects of privatization remain the same in most cases. These estimates are clearly lower, however, confirming our a priori expectations of correlation between the privatization effects and the shortage of airport capacity.

The other experiments utilized as robustness checks for our main empirical results were the following: (1) the use of alternative estimators such as the one-way and two-way fixed effects without instrumentation, and the two-way fixed effects implemented with the limited-information maximum likelihood estimator (LIML); (2) the estimation of a random effects procedure in which some time-invariant shifters were included, such as the route distance, a metric of route tourism intensity and a proxy for the intensity of hub use in the network at the endpoint airports;[13] and finally, (3) the implementation of an estimation setting in which only two strictly comparable groups – namely, the actively and the placebo treated groups – were considered and therefore the baseline group containing the remaining airports was discarded; The estimation results of most robustness checks are presented in Appendix A. The joint analysis of these and the above experiments allows us to infer that the main results of Table 4 are not sensitive to any of the proposed model challenging procedures.

4.2. Deeper demand impacts of privatization

We now turn to the presentation of the results of Eqs. (1) and (2), i.e. the impacts of privatization on demand when using group-specific, stage-specific, quarterly leads and lags dummies. The results are presented in Table 6, which contains the estimates for all five airport matching assignment rules. Remember that in this experiment, we interact each privatization stage dummy with up to six quarter period dummies, starting from quarter $q_i^* - 1$, where q_i^* is the quarter of the public announcement that triggers stage *i*. Note that the insertion of deeper time effects to assess the privatization impacts allows for a more detailed inspection of the evolving nature of demand since the establishment of the privatization program. The results of Table 6 confirm the findings of the main results of Tables 4 and 5, and thus exhibit a demand progression pattern. The most important and statistically significant results are observed from the last two periods of privatization stage 2 on. Results are robust across the columns of Table 6, and are consistent with H3, in which an anticipated airline competition and preemption of assets aiming at expanding operations at the privatized airports was likely triggered by an expectation of long-term contracting with the enhanced two-sided platform.

Our results must be interpreted with caution, however. As our sample is constituted by a time span of only a few periods in which the actual private management was under control, we are aware that our approach disregards possible additional dynamic effects of the privatization potentially materialized after the end of the present sample period. Additionally, in the sample period, most post-privatization construction works were still being undertaken. As airport pre-expansion periods usually represent stages in which the passenger experience is typically worsened due to the short run limitations of the unfinished facilities, we therefore believe our estimates indicate a lower bound for the actual effects of a privatized two-sided platform.

Additionally, we stress that our empirical results suggest neither that public-owned airports are not capable of being two-sided platforms nor that privately-owned airports are more efficient in achieving that characteristic. The evidence found here must not be interpreted as a proof that publicly managed infrastructures are unable to develop dynamic capabilities, establish a two-sided platform, and improve attractiveness and efficiency of their infrastructure. It is important to emphasize that our results are confined to the Brazilian case and its regulatory, political and social-economic idiosyncrasies. For example, Infraero, the state-owned enterprise that operated most airports for decades in the country was considered highly inefficient by many industry analysts, and therefore our pre-privatization case may not be comparable to other international experiences in public management. Moreover, as the reviewed literature shows that there are no clear effects of privatization on efficiency, airport charges and capacity expansions, it is still possible that competition and regulation may matter more than ownership in inducing the two-sidedness of airports. We therefore acknowledge that further investigation is needed, as airports may operate as a two-sided platform with public production if state owned

[13] Respectively, variables *miles*, *tourism* and *connect*. *miles* is the great-circle distance between origin and destination in miles; *tourism* is the route-specific proportion of leisure purpose travelers and *connect* is the route-specific proportion of connecting passengers – source: "Study of the Air Transport Sector in Brazil" (text in Portuguese) – Brazilian Development Bank, Jan, 25, 2010, available at www.bndes.gov.br.

Table 6
Estimation results: deeper time effects of privatization – Heckit model – dependent variable: ln daily pax.

	(1) ln daily pax	(2) ln daily pax	(3) ln daily pax	(4) ln daily pax	(5) ln daily pax
ln gravity population	1.7983***	1.5748***	1.6207***	1.5521***	1.6854***
ln gravity gdp per capita	0.8922***	0.6481***	0.7294***	1.0480***	0.8922***
ln yield	−2.1451***	−1.6579***	−1.8654***	−2.3952***	−2.1852***
LCC presence	0.2615***	0.2432***	0.2489***	0.2659***	0.2703***
Prop flights in congested hours	1.1014***	0.8856***	0.9956***	1.1707***	1.1211***
Actively treated					
Privatization stage 1 – program establishment (q_1^*)					
q_1^*-1	−0.0800*	−0.0268	0.0489	0.0719*	0.1483**
q_1^*	−0.0547	−0.0700	0.0826	0.0751*	0.3328***
q_1^*+1	−0.1176**	−0.0403	0.0141	0.0100	0.1355**
q_1^*+2	−0.0578	0.0511	0.0709	0.0419	0.1584**
q_1^*+3	−0.0510	0.0191	0.1303**	0.0643	0.4187***
q_1^*+4	0.0295	0.0807**	0.1600***	0.0335	0.1853***
Privatization stage 2 – asset restructuring (q_2^*)					
q_2^*-1	−0.0406	0.0513	0.0400	−0.0434	0.0116
q_2^*	0.1103*	0.0768*	0.1333**	0.0787	0.3282***
q_2^*+1	0.1078**	0.1055**	0.0534	0.0086	0.2677***
q_2^*+2	0.1450***	0.1642***	0.1395***	0.1437**	0.2933***
q_2^*+3	0.0861*	00,910***	0.1061**	0.1143*	0.2616***
Privatization stage 3 – competitive tendering (q_3^*)					
q_3^*-1	0.1846***	0.1480***	0.2393***	0.2852***	0.4961***
q_3^*	0.1306***	0.1562***	0.1081**	0.1526**	0.3408***
q_3^*+1	0.1582***	0.1503***	0.0847*	0.1876***	0.3424***
q_3^*+2	0.1567***	0.1536***	0.1855***	0.2336***	0.4437***
q_3^*+3	0.1444***	0.1026***	0.1063*	0.1698***	0.3354***
q_3^*+4	0.1154**	0.1292***	0.1345**	0.1507**	0.3761***
Privatization stage 4 – private management (q_4^*)					
q_4^*-1	0.1068*	0.1068**	0.1325**	0.1737**	0.3761***
q_4^*	0.1104**	0.0861*	0.1153*	0.1892***	0.3681***
q_4^*+1	0.2283***	0.1208**	0.2191***	0.2884***	0.5709***
q_4^*+2	0.1879***	0.1297**	0.1247*	0.1864**	0.3581***
q_4^*+3	0.2143***	0.1697***	0.1279**	0.2339***	0.3712***
q_4^*+4	0.1579***	0.1340***	0.1418**	0.2331***	0.3947***
Inverse Mills ratio	0.7678***	0.5924***	0.6632***	0.8519***	0.7855***
Placebo assignment rule	Investment	Sequence	Growth	Mega-event	Capacity exp
Fixed effects	Two-way	Two-way	Two-way	Two-way	Two-way
Adj. *R*-Squared	0.8032	0.8357	0.8248	0.7849	0.8030
RMSE Statistic	0.4889	0.4468	0.4613	0.5112	0.4892
F Statistic	704.70	331.28	792.83	635.47	685.89
KP Statistic	76.229	78.301	104.71	83.945	97.555
KP *P*-Value	0.0001	0.0001	0.0001	0.0001	0.0001
J Statistic	0.9060	2.2940	0.8870	1.3600	1.1970
J *P*-Value	0.3412	0.3175	0.3463	0.2436	0.2740
Weak CD Statistic	43.698	79.342	61.715	47.936	56.993
Weak KP Statistic	38.576	22.463	53.097	42.498	49.503
Nr Observations	49,143	49,143	49,143	49,143	49,143

Results produced by a fixed effects procedure with the implementation of the two-step feasible efficient generalized method of moments estimator (2SGMM); statistics robust to heteroscedasticity; standard errors of the estimated coefficients (in brackets) were bootstrapped to account for the two-stage nature of the Heckit method; *R*-squared and RMSE produced with the equivalent least-squares dummy variable model (LSDV); *p*-value representations.
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

airports operate in a context of enough competition to attract airlines and with a regulation that sets the correct incentives for investments and prices.

Another important limitation of our approach is related to the regulatory regime regarding airport charges and the balance between profitability and service-safety-security-standards mandatory for the airport management. For decades, the airport industry had been regulated with a methodology of rate of return with cross-subsidization from large profitable airports to small unprofitable airports. This framework has been partially reformed since privatization and now regulation also considers incentives for operational efficiency via an X-factor scheme. Infraero's major airports are also included in the new regulatory framework but with one important exception: they are excluded from the regulatory scheme of higher incentives for better customer-oriented management provided by the recently introduced "Q-factor" – i.e. price cap regulation with incentives for quality and better service levels at airports. We are aware that the exclusion from the quality-incentive schemes may produce a more pronounceable gap between privatized and non-privatized airports than we would obtain when modeling the effects of privatization in other countries.

5. Conclusion

The present paper developed an econometric model of passenger demand for routes of recently privatized airports. With a regression-based event methodology of treatment effects and two control groups, we tested whether air travel demand presented a dynamic pattern across the identified stages of privatization for a set of privatized airports in Brazil. With the estimated set of privatization-related coefficients, we then tested some hypotheses regarding the formation and consolidation of the privatized airports as two-sided platforms. As far as we are concerned, this is the first paper to examine the association between ownership change and two-sided platform orientation. Additionally, this was the first attempt to directly estimate the impacts of airport privatization on air transportation demand, contributing to the scarce empirical literature on airport ownership change and its consequences.

Our main results provided evidence that privatization enhanced the dynamic capabilities of airports toward a two-sided platform orientation, with a statistically significant ceteris paribus rise in airline demand. We find evidence of a permanent increase in air travel that was possibly triggered some quarters after the establishment of the privatization program but prior the transfer of assets to the new private administration. Results are consistent with a movement of anticipated airline competition and preemption of assets aiming at expanding operations in an expectation to benefit from the network effects and positive feedback loops allowed by the two-sided platform.

Our study has a number of limitations. As a case study, it is confined to the experience of airport privatization in Brazil and its specificities. Additionally, the time span of the privatization period under analysis was restricted to a few years, and therefore, possible additional dynamic effects of privatization were potentially not captured. Another major challenge is that we examine a period with three interrelated shocks – namely, the privatization program, the 2014 Fifa World Cup, and the program of investments for airport capacity expansions. These shocks are clearly not homogeneous as the magnitude of the investment programs differ for each considered airport. Our approach to deal with such problems considered the following procedures: (1) the utilization of a Heckit model to account for the criteria of airport selection by the government, (2) the application of some alternative placebo-treated assignment rules that considered the cities that hosted the 2014 mega-event and the airports that were granted with public investments targeted at capacity expansion, and (3) an investigation of the sensitivity of the results when inserting a proxy for airport bottleneck as a regressor to control for the asymmetric necessity of investments of each airport. Although most results were robust to all robustness check procedures, we must emphasize that the individual identification of these shocks does not have an easy solution. Notwithstanding these and other limitations discussed in the text, we believe our analysis contributes to the debate over the efficiency enhancement attributable to the privatization of stated-owned enterprises and to the better understanding of the role of airports as two-sided platforms and their effects. In many situations, a higher efficiency with respect to new demand creation is likely to be a key element toward a successful privatization outcome for both passengers and operators.

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Appendix A. Alternative estimation results

See Table 7.

Table 7
Robustness check: alternative specifications – Heckit model – dependent variable: ln daily pax.

	(1) ln daily pax	(2) ln daily pax	(3) ln daily pax	(4) ln daily pax	(5) ln daily pax	(6) ln daily pax
ln gravity population	1.1786***	1.1034***	1.9925***	1.7747***	1.4641***	1.3116***
ln gravity gdp per capita	0.7067***	0.7186***	1.0049***	0.8762***	1.0011***	0.9466***
ln yield	−1.2150***	−1.2389***	−2.3577***	−2.1124***	−2.3219***	−2.2250***
LCC presence	0.2110***	0.2014***	0.2456***	0.2567***	0.2403***	0.2549***
Prop flights in congested hours	0.9184***	0.9078***	1.1988***	1.0900***	1.2053***	1.1530***
ln miles					−0.7732***	−0.7288***
Tourism					−0.7915***	−0.7931***
Connect					0.1751***	0.1711***
Actively treated						
Privatization program	0.2158***		0.0661		0.0970***	
Privatization stage 1 – program establishment		0.1735***		0.0254		−0.0075
Privatization stage 2 – asset restructuring		0.1871***		0.1014*		0.1528***
Privatization stage 3 – competitive tendering		0.2572***		0.1445**		0.1576***
Privatization stage 4 – private management		0.3111***		0.1920***		0.2042***
All treated (actively and placebo)						
Privatization program					−0.0181	
Privatization stage 1 – program establishment						0.0527*
Privatization stage 2 – asset restructuring						−0.0822
Privatization stage 3 – competitive tendering						−0.0277
Privatization stage 4 – private management						−0.0202
Inverse Mills ratio	0.5827***	0.5970***	0.8500***	0.7568***	0.8439***	0.8056***
Placebo assignment rule	Investment	Investment	Investment	Investment	Investment	Investment
Estimator	One-way FE	One-way FE	Two-way FE	Two-way FE	Two-way RE	Two-way RE
Baseline treated in the sample	Yes	Yes	Yes	Yes	Yes	Yes
Adj. *R*-Squared	0.8459	0.8449	0.7838	0.8050	0.7978	0.8060
RMSE Statistic	0.4319	0.4333	0.5122	0.4865	n/a	n/a
F Statistic	1318.4	1288.0	679.05	751.47	n/a	n/a
KP Statistic	228.35	206.15	101.61	93.757	n/a	n/a
KP *P*-Value	0.0001	0.0001	0.0001	0.0001	n/a	n/a
J Statistic	37.220	36.125	0.1380	0.9030	n/a	n/a
J *P*-Value	0.0001	0.0001	0.7104	0.3419	n/a	n/a
Weak CD Statistic	576.94	452.99	57.539	54.481	n/a	n/a
Weak KP Statistic	114.63	103.05	51.836	47.659	n/a	n/a
Nr Observations	49,143	49,143	49,143	49,143	49,143	49,143

Results produced by a fixed effects procedure with the implementation of the two-step feasible efficient generalized method of moments estimator (2SGMM); statistics robust to heteroscedasticity; first-stage results produced with the probit model of Table 3, Column (1); standard errors of the estimated coefficients (in brackets) were bootstrapped to account for the two-stage nature of the Heckit method; *R*-squared and RMSE produced with the equivalent least-squares dummy variable model (LSDV); *p*-value representations.
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

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