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Estimating strategic responses to the march of a low cost carrier to primary airports

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Abstract

We empirically investigate the capacity responses of major incumbent airlines facing the entry of a new low cost carrier in a secondary airport of a multiple airports region. We develop an empirical model that allows for time-varying strategic responses, aiming at identifying possible degrees of route entry threat. We consider the case of the entry of Azul Airlines in the densest conurbation in Brazil. Our results suggest that the incumbents preemptively fortified their flight frequency positions on threatened routes to deter the anticipated march of the newcomer from the secondary airport toward the existing primary airports.

Keywords: multiple airports region; preemption; capacity; entry; air transportation.

JEL Classification: D22; L11; L93.

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1. Introduction

"*Almost any airport that we don't fly to is talking to us across Europe. (...) Increasingly in the future there's going to be a spread of bigger airports, as well as secondary ones*."
- Ryanair Chief Executive Officer Michael O'Leary - 2010.[1]

Worldwide, low cost carriers (LCCs) have become a pervasive powerhouse in the airline industry, bringing price competition and market expansion, with relevant economic welfare implications. In addition to the notable direct impacts of head-on competition with a new cost-efficient player, the airline literature has suggested that the presence of an LCC may also produce spillover price effects on adjacent routes and in markets in which they exert potential competition with incumbents - Morrison (2001), Goolsbee & Syverson (2008), and Brueckner, Lee & Singer (2013, 2014).

This paper contributes to the literature by inspecting the impacts of different degrees of LCC entry threat on the capacity setting of incumbent carriers. As far as we are aware, this is the first attempt to investigate whether the increasingly common situation of a "march" of LCCs from secondary to primary airports in regions of multiple airports may serve as a motivation for established carriers to strategically respond in capacity. That anticipated movement may be a result of an expected shift from a niche orientation, essentially targeted on leisure-related passengers, to an LCC business model more focused on operations at major, more congested and costly airports targeting the attraction of high-yield business passengers from major carriers. That shift may be regarded as an effort of product repositioning in differentiated product markets in the sense of Sweeting (2013). Among the LCCs that have initiated such movement, some of the most prominent cases are the entries of Ryanair at Barcelona El Prat, Brussels Zaventem, Copenhagen Kastrup, Glasgow and Rome Fiumicino airports in Europe, and Southwest Airlines at Los Angeles International and Washington Dulles airports in the US market, among others - Jimenez et al. (2017), Dobruszkes, Givoni & Vowles (2017), Wit & Zuidberg (2012). The key contribution of our paper lies in the integration of the models of Morrison (2001) and Goolsbee & Syverson (2008), to produce an empirical framework of the dynamic effects of the potential entry strategies of an LCC in a region of multiple airports. We propose a novel concept of "degrees of entry threat" to investigate the possible dynamics associated with incumbent preemptive behavior in airline markets when product repositioning by low cost rivals is imminent.

We develop an econometric model of flight frequencies to investigate if incumbent airlines preemptively add flights in competing airports before actual competition with an LCC materializes.

[1] "*Ryanair considers shift to major European airports to attract business passengers*" - centreforaviation.com, Sep 23, 2010.

We study the case of the São Paulo multiple airports region - the largest urban agglomeration in Brazil - during a sequence of route entries by the low cost newcomer Azul Airlines from 2008. We inspect whether the adjacent competition with the new LCC at the secondary Viracopos/Campinas Airport (VCP) has stimulated the major incumbent airlines Tam and Gol to add flights at the primary airports of São Paulo/Congonhas (CGH) and São Paulo/Guarulhos International (GRU). The newcomer has ultimately entered both airports a few years later. The motivation for the study is the potential service quality improvement caused by the amplified portfolio of flights that may have benefitted passengers at the studied primary airports. In contrast, such strategic movements in capacity may also have allowed the strengthening of the competitive advantage of incumbent carriers and prevented earlier entry at these airports, with important airport regulatory and public policy repercussions. Our empirical strategy therefore aims at inspecting the possible preemptive behavior of incumbents in response to an anticipated business model hybridization of an LCC[2] engaging in a march to primary airports within a multiple airports region.

This paper is divided into four sections. Section 1 addresses the phenomena of LCC marching toward primary airports as well as a review of the literature on the entry deterrence strategies of incumbent airlines. Section 2 presents our application - the air travel market in the São Paulo multiple airports region. Section 3 describes the empirical model, including data description, model design and estimation issues. Section 4 contains our presentation of results, which is followed by the conclusions.

2. Restrictions to LCC growth and incumbent preemptive behavior

2.1. LCC march towards primary airports

The dynamics of competition in the airline industry has progressively pushed the low cost carriers (LCCs) away from their founding mantras. A hybridization process of LCCs adapting their business models to the reality and adversities of local markets has been observed in many markets worldwide - Klophaus, Conrady & Fichert (2012) and Wit & Zuidberg (2012). Consequently, full-service carriers (FSCs) and LCCs have battled more directly for the same passengers, with a number of operating and marketing strategies once restricted to one type of carrier becoming common practice, in a clear movement of business model convergence. Francis et al. (2006) and Klophaus, Conrady & Fichert (2012), and Wit & Zuidberg (2012) argue that the cost-efficient operations obtained through the exploitation of density economies are increasingly challenging for LCCs. Attempts to

[2] Klophaus, Conrady & Fichert (2012) and Wit & Zuidberg (2012).

densify secondary airports by means of adding new flights and new destinations appear to have hit a ceiling - Wit & Zuidberg (2012), Dziedzic & Warnock-Smith (2016)

An important strategic movement adopted by LCCs to avoid the lower traffic growth-decreasing profitability trap has been to shift operations from secondary to primary airports (Dobruszkes, Givoni & Vowles, 2017). Indeed, a "march" towards primary airports has been perhaps one of the most distinguished aspects of the strategy guiding many LCCs in recent times. The most prominent cases of such an approach have been Ryanair in Europe and Southwest Airlines in the United States. Ryanair has increased and started novel operations at traditional airports such as Barcelona El Prat, Brussels Zaventem, Copenhagen Kastrup, Glasgow and Rome Fiumicino. In most of these cases, the airline had previously operated at the corresponding secondary airports of the same region.[3] In 2016, Ryanair announced it was about to reach more operations at primary than secondary airports for the first time.[4] On the other side of the Atlantic, in the US market, Southwest Airlines has trailed a similar progress, for example, with the addition of flights from Los Angeles International and Washington Dulles. Southwest has also developed in fast pace operations out of Atlanta Hartsfield, the world's busiest airport.

2.2. Potential entry and the dynamics of incumbent responses in the airline industry

Whinston & Collins (1992) examine the behavior of incumbent carriers after the entry of People Express in the US airline market. They find that incumbents on entered routes lowered their prices in response to entry by approximately 35%, with smaller price reductions of 15% on the adjacent routes in the same city-pair. In contrast to Whinston & Collins (1992), more recent airline studies have suggested that LCC entry at either nearby airports or primary hub airports does not have the effect of triggering increases in flight frequency as a competitive response of major incumbent airlines. Goolsbee & Syverson (2008) find that incumbent airlines do respond in prices, but not in flight frequencies, to the threat of entry of Southwest airlines in the US airline market. They also do not find statistically significant price reductions on adjacent routes in the same city-pair market. Fageda (2014) studies major European network airlines and finds that incumbents do not increase, but actually reduce, their flight frequencies after LCC entry. Morrison (2001) develops a classification of markets impacted by the presence of an LCC. His framework allowed for the possibility of multiple airports systems. The author estimates the full effect of the presence of

[3] Girona, Charleroi, Malmo, Prestwick and Ciampino, respectively. Note that Ryanair has reintroduced operations at Malmo airport in early 2017.

[4] "*Ryanair CEO Plans 50% of Growth at Primary Airports*" - www.bloomberg.com, Nov 3, 2014. "*Ryanair continues move towards primary airports*" - Business Traveller, Nov 7, 2016. See Jimenez et al. (2017), Dobruszkes, Givoni & Vowles (2017), Wit & Zuidberg (2012) for a discussion.

Southwest Airlines on the rival airlines' prices in the US market in 1998.

Although the framework of Morrison (2001) is not inconsistent with the possible notion that competition is a time process, i.e., potential competition may be a first step before either actual or adjacent competition is materialized, it is important to stress that the timing of price responses is not a topic that is directly within the author's interest. The issue of the dynamics of incumbent responses and, in particular, of *entry threats* as a possible determinant of the price rivalry between established carriers and newcomer LCCs was later addressed by Goolsbee & Syverson (2008). Indeed, some theoretical models have suggested that incumbent preemptive behavior may be a rational strategy to deter entry, for example, Dixit (1979), Spence (1977) and Milgrom & Roberts (1982). Goolsbee & Syverson (2008) investigate how the threat of entry of the LCC Southwest Airlines poses competitive pressure on incumbent airlines in the US market. The authors consider the analysis of airport-pairs and inspect the time surrounding the realization of entry. The authors therefore implicitly extend Morrison's (2001) framework to allow for the possibility of a time sequence of *potential entry-actual entry*. The authors define an "entry threat" to a given route as the event of the LCC beginning service in one of the endpoint airports of the route - or both endpoints - but *before* actually flying the route itself.[5] The authors base their definition on the argument that airport presence is a good predictor of future route entry from that endpoint - a contribution with respect to Morrison (2001). Their empirical model employs quarterly dummy variables surrounding the events of entry threats and actual entry. They restrict attention to entry threats marked by the presence in both endpoint airports. Their main finding is that incumbent airlines drop fares much in advance to Southwest Airlines actual entry, which is consistence with preemptive behavior aimed at entry deterrence: at the moment that Southwest starts operating from the second endpoint, prices are already 17% lower than in their baseline case.

The literature that quantify the impacts of LCC entry on other airlines has recently examined alternative issues such as the impacts on the level and composition of major carriers price premiums (Hofer, Windle & Dresner, 2008), the possibility of predatory behavior (Kim, 2009), the effects on passenger choice of airport/airline combinations (Pels, Njegovan & Behrens, 2009), the impacts on the stock prices of major airlines (Detzen et al., 2012), the decomposition of the traffic growth following LCC entry into different dimensions, such as carriers, airports and passenger types (Castillo-Manzano, López-Valpuesta, & Pedregal, 2012, Cho, Windle & Dresner, 2015), the effect of product differentiation from more convenient flights in weakening price reactions (Huse &

[5] "*Every time Southwest begins service in a new airport, it raises the threat that Southwest will enter routes connecting that airport with other airports in its network*." - Goolsbee & Syverson (2008), p. 1614.

Oliveira, 2012), the relevance of capacity restrictions (Sancho-Esper & Mas-Ruiz, 2016), the impact of LCC entry on market segmentation and airfare temporal profiles of incumbents (Alderighi et al., 2012, and Varella, Frazão & Oliveira, 2017), among others topics.

2.3. LCC march as a product repositioning movement

We describe the LCC "march" to primary airports as a situation of entry followed by product repositioning in regions of multiple airports. Sweeting (2013) develops an oligopoly model that includes repositioning costs.[6] The theoretical motivations behind the march of LCCs towards primary airports are related to cost efficiency and product differentiation incentives to the newcomer: the *economies of traffic density* and the *higher convenience of location* typically associated with primary airports. LCCs are faced with three alternatives: (i) not to enter any primary airport and to stick with its lower quality product, i.e., confined to the smaller and distant-located secondary airport; (ii) to enter a primary airport while keeping either the same or a reduced level of operations at the nearby airport; or (iii) to enter a primary airport while abandoning the former basis. Options (ii) and (iii) may constitute a sequence of entries that characterize the LCC march toward primary airports, with its associated costs of repositioning.

We therefore suggest that the startup of operations of an LCC at a secondary airport of a multiple airports region, and its subsequent network expansion in that airport, may be viewed by the rivals as the first step of a broader dynamic strategy aimed at ultimately transferring its operations to a primary airport of the same region. We therefore believe that the sequence of route entries of the LCC from the secondary airport may produce *entry threats* to the incumbents in such a way as to increase the probability of future route entry by the LCC at a primary airport. We also consider the possibility that the event of the first entry of the LCC at a primary airport may also constitute an entry threat, in a similar fashion as Goolsbee & Syverson (2008). Figure 1 illustrates our conceptual framework.

[6] The author considers the case of the US commercial radio industry.

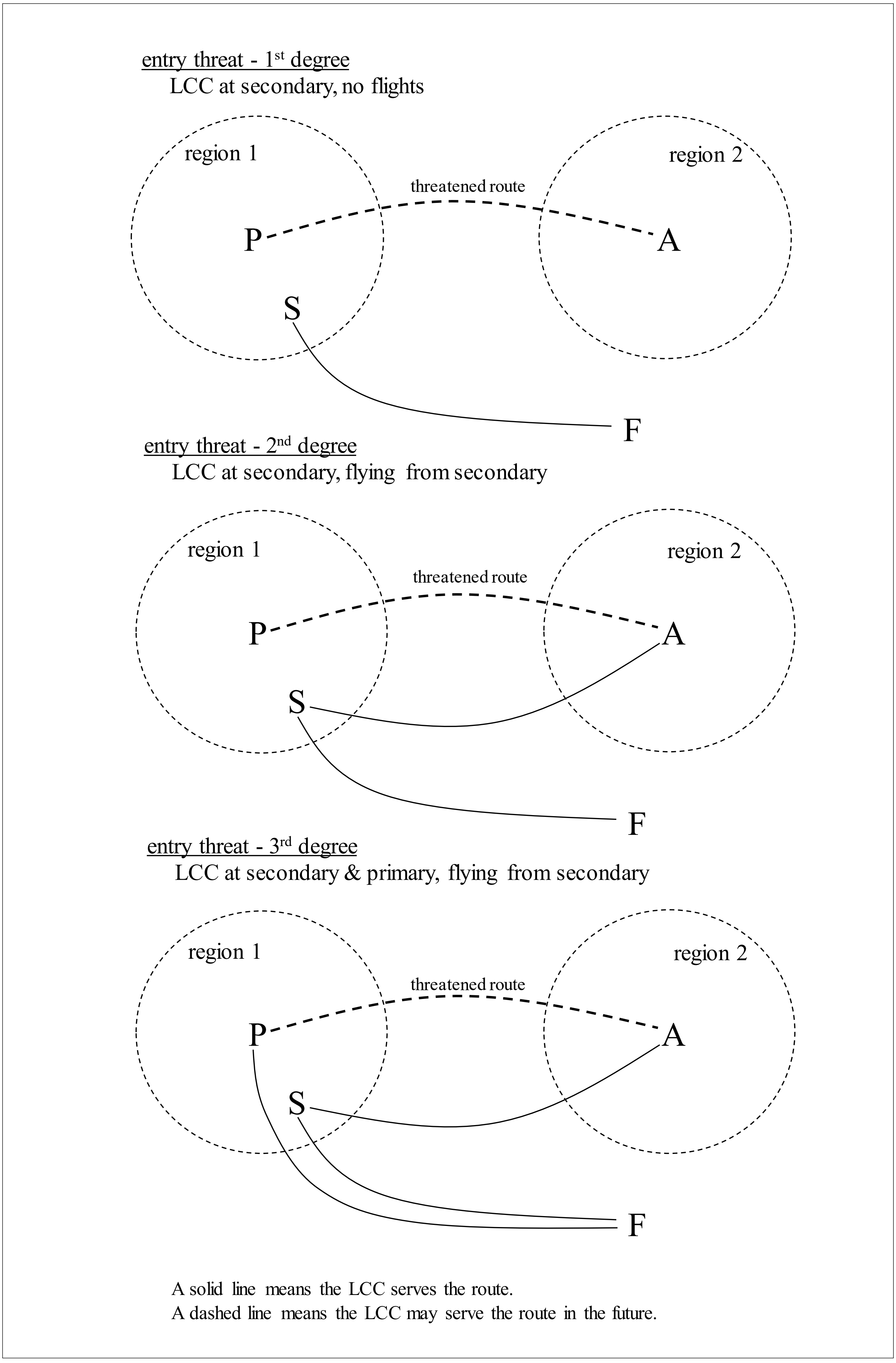

Figure 1 - LCC "march" to a primary airport - degrees of route entry threat

Figure 1 presents three diagrams containing possible situations of route entry threat to the incumbents based at the primary airport of a multiple airports region. The diagrams show the air travel market between a region with two airports - region 1, consisting of primary airport P and secondary airport S - and a region of only one airport - region 2, constituted by airport A. Point F represents one or more airports outside the zone of influence of the airports of the two regions. Assume the presence of at least one incumbent operating on route P-A. We classify the considered LCC entry threat situations according to three potentially different degrees: *1st degree - LCC at secondary, no flights; 2nd degree - LCC at secondary, flying from secondary;* and *3rd degree - LCC at secondary & primary, flying from secondary*.

In the case of "1st degree entry threat" (the upper diagram of Figure 1), we have the first threat that may affect route P-A as a real product repositioning threat. This situation is triggered when the LCC starts operation of flights in the same region of endpoint P - namely, from the secondary airport S. In this situation, although the LCC does not fly to airport A yet, i.e., it flies only to F and is absent in the city-pair market of region 1-region 2, the carrier is actually present in the geographic market of region 1 and is therefore already capable of paying some of the sunk costs associated with a possible entry on P-A. In the case of "2nd degree entry threat" (the middle diagram of Figure 1), the LCC begins to effectively carry passengers in the city-pair, by entering the S-A route. In this case, we have an *actual entry in the city-pair* region 1-region 2. The threatened P-A route will suffer losses of price sensitive passengers, which tends to produce competitive reactions from the incumbent firms. In addition to sunk costs, entry allows the LCC to reduce the asymmetries of information regarding the characteristics of passengers, their preferences and willingness to pay in the city-pair market of region 1-region 2 and, ultimately, better qualifies the entrant for decision-making regarding a sequential entry pattern with future product repositioning. Finally, in the bottom diagram of Figure 1, we have the "3rd degree entry threat" case. In this situation, the newcomer LCC actually enters primary airport P. When establishing at P to fly P-F routes, the newcomer reveals its commitment to reposition at least some of its O-D products in the city-pair market.

It is important to emphasize the similarities and differences of our approach with respect to the previous literature. Our definitions of 1st and 2nd degree entry threats are equivalent to some of the potential and adjacent entry types defined by Morrison (2001). Additionally, our definition of 3rd degree entry threat is identical to the concept of entry threat of Goolsbee and Syverson (2008). The contribution of our approach lies in the integration of the definitions utilized by the two studies, to produce an empirical analysis of the dynamic effects of the potential entry strategies of an LCC in a region of multiple airports. We introduce the concept of "degrees of entry threat" as a way of better investigating such possible dynamic effects related to incumbent preemptive behavior in the market.

3. Research design

In this section, we develop an empirical framework to inspect and test our proposed framework to determine whether incumbent carriers at primary airports may strategically respond to the possible march of an LCC from the secondary airport to the primary airport(s) of a multiple airports region. We consider the case of the Brazilian airline industry and the entry of LCC Azul Airlines in the São Paulo multiple airports region since 2008.

3.1. Application

The Brazilian airline industry has been deregulated since the early 1990s. From 2001, when air fares were fully liberalized, to recent years, the passenger market has increased four-fold in flown passengers, while the average price has declined as much as 54%.[7] Our study focuses on the domestic routes of the São Paulo multiple airports region in Southeast Brazil. This area is the biggest aviation market in the country, with 26% of total domestic enplanements in 2012. The catchment area of this region comprises downtown São Paulo/Congonhas Airport (CGH), São Paulo/Guarulhos International airport (GRU) and secondary airports Campinas/Viracopos (VCP) and São José dos Campos (SJK), with the latter not currently used for scheduled flights. The dominant carriers in the area are Tam and Gol airlines, which in 2008, controlled 95% market share. Both carriers were financially strong in the period, since the Brazilian economy had recovered quickly from the global financial crisis of late 2008. According to the regulator, TAM and Gol together incurred operating profits (Earnings Before Interest and Taxes) of BRL 2.1 billion, equivalent to USD 1.1 billion using 2011 average exchange rates.[8] In December 2008, the LCC newcomer Azul airlines started its nationwide operations by entering this market. Since then, the carrier has expanded very fast from its operational base and main hub, VCP. In 2014, almost 10 million passengers travelled from/to the airport, up from 800,000 before the entry of Azul. Figure 2 presents the market share evolution of the major carriers and the new entrant in the São Paulo region. It is possible to see in Figure 2 how Azul was able to conquer a sizeable market stake in a few years, increasing its share from 6% in 2009 to 22% in 2013.

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[7] Source of all figures in this section: National Civil Aviation Agency (2000-2014), with own calculations.

[8] Source: National Civil Aviation Agency, Air Transportation Statistical Yearbook, 2015, Central Bank of Brazil, and own calculations.

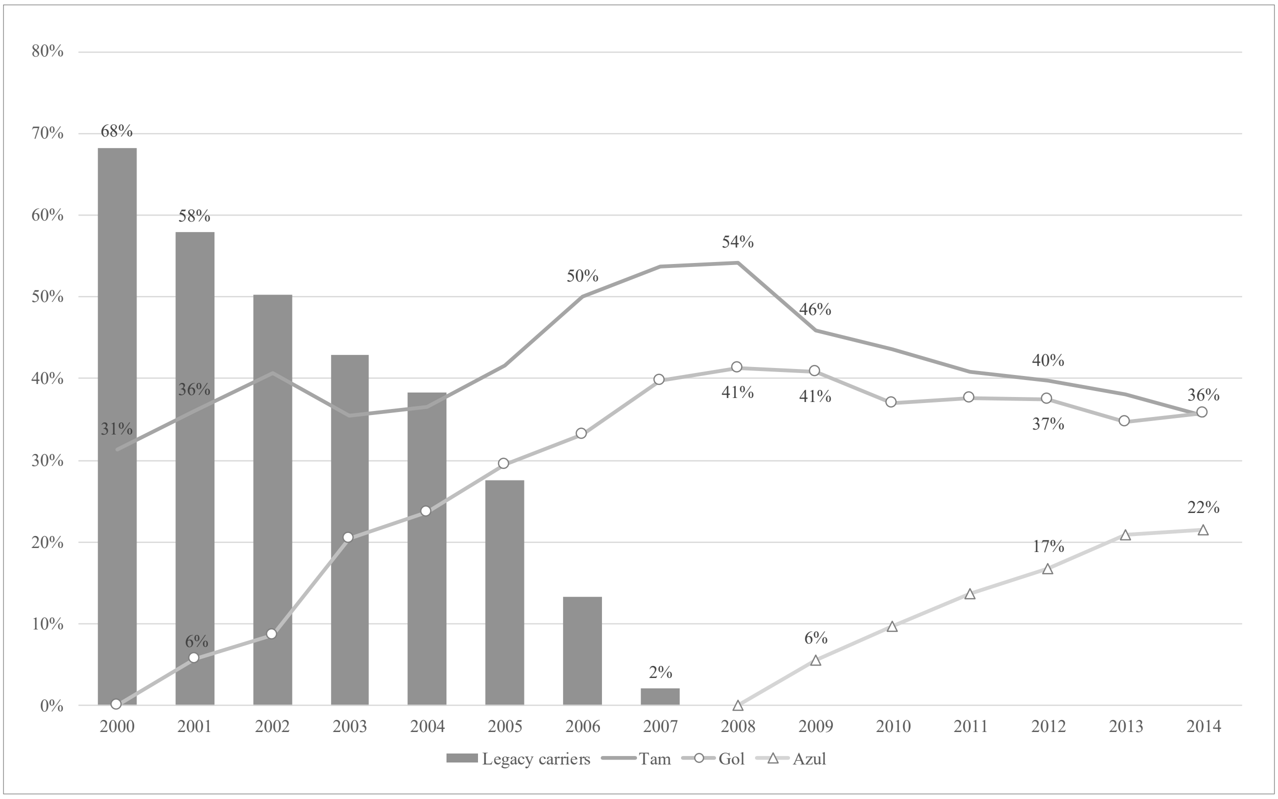

Figure 2 - Market share evolution in the São Paulo Multiple Airports Region[9]

Although successfully based at a secondary airport, since its inception, Azul has overtly stated its target at operating primary airports. The first evidence for this orientation is its publicly announced main operational base to be located at Rio de Janeiro's downtown airport Santos Dumont (SDU) - one of the core airports of that city. The initial plan was not materialized on that occasion due to the strict airport regulations that were binding just when the carrier entered the industry. Similar to the Wright Amendment in the US airline industry, which constrained Dallas' Love Field Airport for decades, the Brazilian downtown airports of the major cities of Rio de Janeiro and Belo Horizonte were restricted by safety regulations that made them not qualified for the entry of a new national player. Additionally, São Paulo city's primary downtown Congonhas Airport (CGH) was subject to stringent slot regulation. Afterward, on the occasions of two rounds of airport slot redistribution to new entrants at CGH - in April 2012 and October 2014 - Azul publicly stated its interest in entering at CGH if the offered slots had high enough quality for viable operations. The carrier eventually entered CGH in May 2010 with a single destination. In parallel, in 2012, Azul acquired the regional airline leader Trip Airlines, which had sizeable operations at GRU international airport, in a strategic movement that allowed the LCC to grant access to that primary airport of São Paulo city. From June 2012, Azul obtained access to 130 weekly departure and landing times from GRU airport and then started its own brand operations there. In a span of two years, the majority of the Trip's destinations

[9] Source: National Civil Aviation Agency (2000-2014), Air Transportation Market Statistical Database, with own calculations.

were discontinued. The most notable change was that dense destinations in which incumbents were present started being served by the LCC from GRU in place of the then-existing regional routes of the acquired carrier. In October 2014, Azul was also granted access to 26 new weekday slots at downtown CGH airport.

3.2. Data

Our dataset consists of panel data of domestic airport-pairs from/to the airports of the São Paulo multiple airports region (CGH, GRU and VCP), with monthly periodicity. The sample period is from January 2007 to December 2012. We restrict our attention to the strategic responses of the major incumbent airlines in the sample, Tam and Gol. The data are publicly available from the airline regulator, the National Civil Aviation Agency (ANAC). In particular, we utilize the Air Transportation Market Statistical Database - Monthly Traffic Report - and the Active Scheduled Flight Report (VRA). Figure 3 presents an illustration of the competitive situation in São Paulo in the period.

Figure 3 contains a representation of the air travel market between the São Paulo multiple airports region and the Curitiba Airport (CWB), located in Southern Brazil. Azul has been present at VCP since December 2008. On the occasion that Azul entered the city-pair market São Paulo city-Curitiba city, from VCP, in the first quarter of 2009, Tam and Gol together already operated 366 weekly flights from the primary airports CGH and GRU. Tam had 200 flights (116 at CGH and 84 at GRU), and Gol had 166 flights (124 at CGH and 42 at GRU). Azul airlines entered this market offering 17 flights departing from the secondary São Paulo/VCP airport. As we can infer from the timeline at the bottom of Figure 3, even prior to Azul's entry, the incumbents Tam and Gol started adding flights in the market. In mid-2008, two quarters before the new LCC's actual entry, Tam added nine new flights on the routes from both CGH and GRU. Later, in the last quarter of 2008, Gol added 11 flights out of GRU and Tam added 7 flights out of CGH.

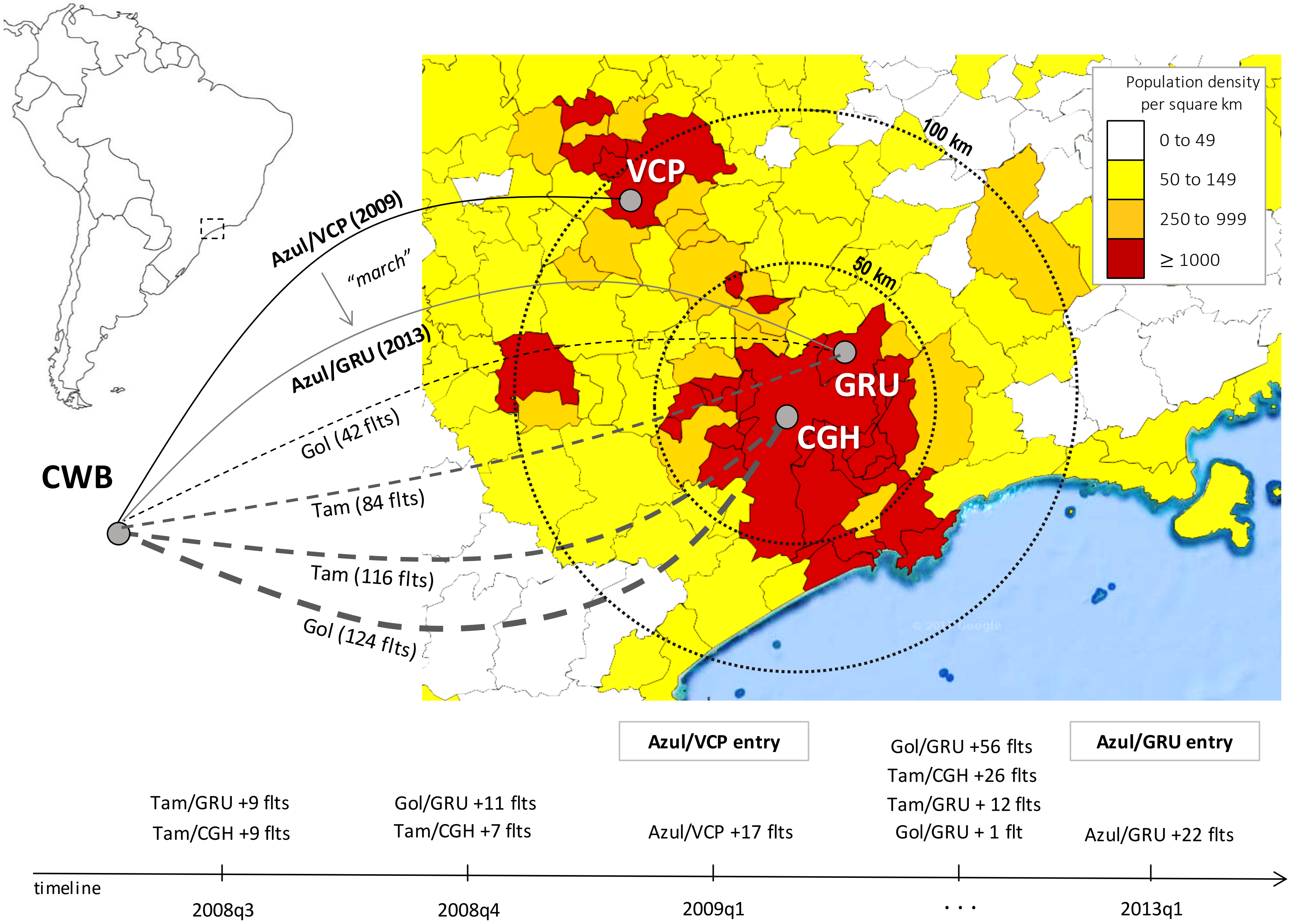

Figure 3 - Illustration - source: IBGE, ANAC, with own calculations

The timeline at the bottom of Figure 3 also shows important evidence suggesting an intensification of responses by incumbents: between the first quarter of 2009, when Azul entered the city-pair from VCP, and the first quarter of 2013, when the airline started flights to CWB from GRU, both Tam and Gol kept adding flights out of CGH and GRU. In total, Gol added 57 flights (56 at GRU and 1 at CGH) and Tam added 38 flights (26 at CGH and 12 at GRU), which represents a growth of 34.3% and 19.0% in each incumbent flight frequency in the period, respectively. We suspect that these important capacity movements from 2009 to 2013 may be consistent with a preemptive behavior of incumbents regarding the anticipated march of Azul targeting the entry at GRU/CGH. Azul also eventually entered CGH in the fourth quarter of 2014.

Table 1 and Figure 4 present further evidence suggesting that the incumbents engaged in a preemptive increase in flight frequency on the threatened airport-pairs following the adjacent entry of Azul.

Table 1 - Markets entered by Azul from the airports of São Paulo region and incumbent responses in flights[10]

Destination	(A) Entry from Secondary		(B) Entry from Primary		Var. (B)-(A)	Var. (B)-(A) %
	Period	# Weekly Flights	Period	# Weekly Flights		
1 Porto Alegre (POA)	08q4	328	13q1	445	117	*36%*
2 Salvador (SSA)	08q4	285	13q1	282	-3	*-1%*
3 Curitiba (CWB)	09q1	366	13q1	461	95	*26%*
4 Vitória (VIX)	09q1	167	12q2	159	-8	*-5%*
5 Recife (REC)	09q1	171	12q4	236	65	*38%*
6 Fortaleza (FOR)	09q1	96	14q1	173	77	*80%*
7 Rio de Janeiro (SDU)	09q1	791	12q4	884	93	*12%*
8 Manaus (MAO)	09q2	60	12q2	79	19	*31%*
9 Navegantes (NVT)	09q2	90	13q4	153	63	*70%*
10 Campo Grande (CGR)	09q2	95	12q2	122	27	*29%*
11 Maringá (MGF)	09q2	10	12q2	38	28	*280%*
12 Maceió (MCZ)	09q2	35	13q4	87	52	*149%*
13 Belo Horizonte (CFN)	09q3	333	12q2	361	28	*8%*
14 Florianópolis (FLN)	09q4	225	12q3	273	48	*21%*
15 Natal (NAT)	09q4	79	12q4	84	5	*7%*

Note: The table lists the first fifteen destinations served by the newcomer from the São Paulo region. "# weekly flights" is the average number of weekly flights out of the primary airports of the region by incumbent airlines Gol and Tam during the respective quarter. (B) considers the first entry of the newcomer at one of the primary airports.

Table 1 displays the number of weekly flights of incumbent airlines at the primary airports of São

[10] Source: National Civil Aviation Agency (2000-2014), Active Scheduled Flight Report - VRA, with own calculations base, with own calculations. For each destination market, flights in both directions are accounted for.

Paulo to the first fifteen destinations served by the newcomer from the secondary airport VCP. The table contrasts the events of (A) entry from the secondary airport and (B) entry from the primary airport, i.e. the moment of first entry serving the route from any primary airport of the region. It is possible to observe in Table 1 a notable increase in the number of flights of the incumbent carriers across most destinations. For example, considering Maceió airport (MCZ) in Northeast Brazil, the number of weekly flights of incumbents from any primary airport of São Paulo increased from 35 in 2009q2 - the moment of entry of Azul on the route from the secondary airport VCP -, to 87 in 2013q4 - the moment of entry of Azul from the primary airport GRU on the route. Such capacity movement by incumbents represents a 149% increase in flight frequency on that route when comparing events (A) and (B).

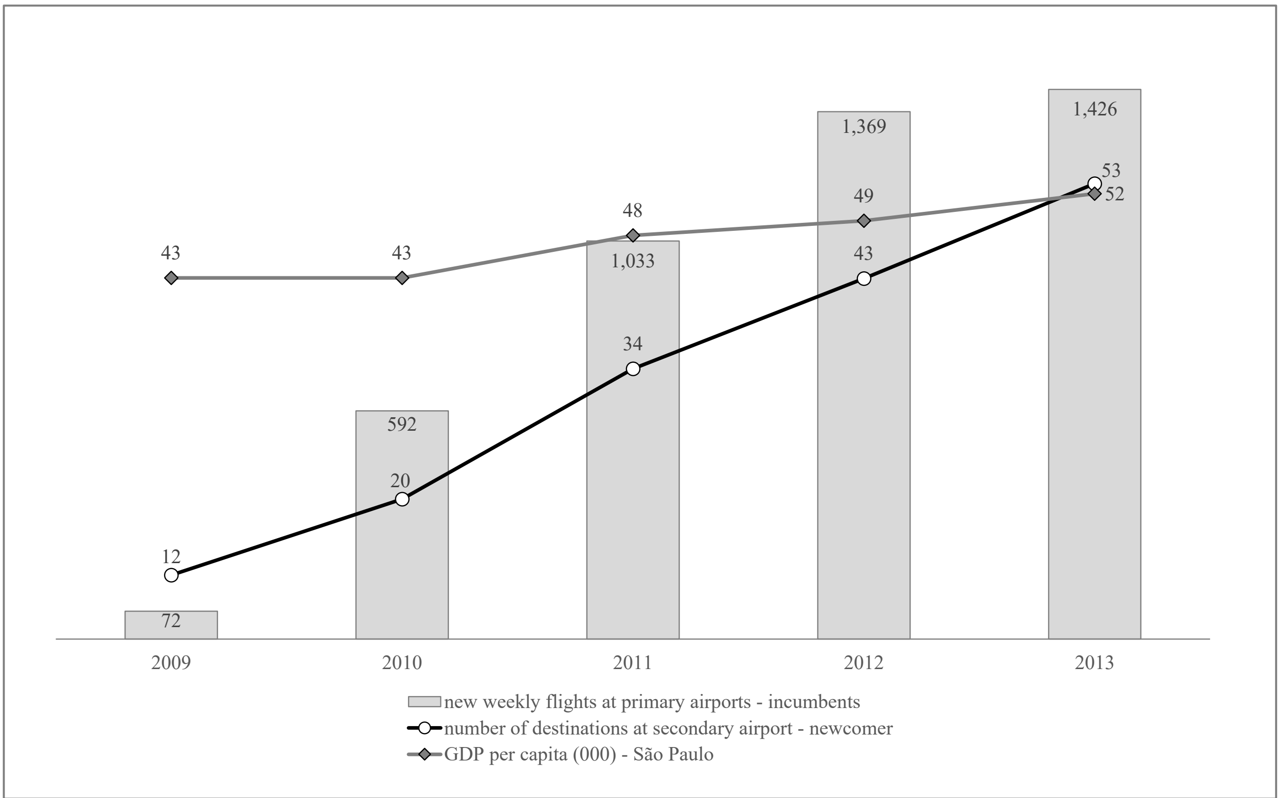

Figure 4 - Addition of flights by incumbent airlines at São Paulo's primary airports (Reference year: 2008)[11]

[11] Source: National Civil Aviation Agency (2000-2014), Active Scheduled Flight Report - VRA, with own calculations, and Ipeadata, with own calculations. GDP per capita n BRL - 2015 constant values.

Figure 4 presents the evolution of the new flights of incumbents at São Paulo primary airports from 2009 to 2013. It is possible to observe that the addition of flights by the major incumbents Tam and Gol rapidly increased from 72 new flights in 2009 to 1,426 in 2013 - almost 20 times higher. That impressive expansion is highly correlated with the series of number of destinations served by the newcomer airline at the secondary airport, also depicted in Figure 4. The number of Azul's destinations increased more than fourfold from 12 to 53 in the same period, indicating that the capacity movements by the incumbents at primary airports may have followed that expansion pattern. Figure 4 also shows the evolution of the GDP per capita in the period, which increased to a much smaller extent, from 43 to 52 thousand BRL - a 21% increase. Finally, note that many key market entries of Azul Airlines from the primary airports eventually happened between 2012 and 2013, as indicated in Table 1. It is possible to observe in Figure 4 that the movement of flight additions by incumbent carriers reached its peak in 2013 but this time notably with a lower growth rate pattern: 57 new weekly flights (1,426 - 1,369) when comparing 2013 to 2012, which represents an year-over-year growth rate of only 4.2%. That growth rate contrasts with the former period (2012 against 2011), in which we observe an increase of 336 flights (1,369 - 1,033) - a notable expansion of 32.5%. Although our analysis does not focus on the post-actual entry at the primary airports of São Paulo, we therefore suggest that after the entry of Azul the flight frequency expansion of incumbents in those airports has apparently reached a saturation point.

3.3. Econometric framework

Equation (1) presents our baseline empirical model for investigating the strategic responses of incumbent airlines to the entry threats of the LCC Azul Airlines in São Paulo, Brazil. The baseline model is consistent with the framework of Goolsbee & Syverson (2008).

$$ln\, fligths_{ri,t} = \gamma_{ri} + \mu_{it} + \sum_{\delta=1}^{3}\sum_{\tau=0}^{6+} \beta_{\delta,\tau}(entry\_threat\_degree\_\delta)_{r,t_{\delta,\tau}} + X_{ri,t}\alpha + \varepsilon_{ri,t}, \qquad (1)$$

where r denotes the route, i.e., the non-directional airport-pair having either CGH or GRU as one of the endpoint airports, i denotes the incumbent carrier (Tam and Gol), and t denotes the time period. The components of Equation (1) are the following:

- $flights_{ri,t}$ is the total number of scheduled flights operated by incumbent carrier i on route r and time t. Source: National Civil Aviation Agency, Active Scheduled Flight Report - VRA, with own calculations;

- $(entry\_threat\_degree\_\delta)_{r,t_{\delta+\tau}}$ are mutually exclusive time dummies surrounding the period when a given route entry of Azul airlines triggers an entry threat of degree δ to incumbent carriers i on route r out of a primary airports at time t. $\delta = 1$, $\delta = 2$ and $\delta = 3$ denote, respectively, 1st, 2nd and 3rd entry threats degrees. $t_{\delta,\tau}$ $(\tau = 1,2,3,\ldots,6,6+)$ denotes the τ-th time period since the entry threat of degree δ.

- $X_{ri,t}$ is a set of control variables that is described below; γ_{ri} are incumbent-specific city-pair fixed effects; μ_{it} are incumbent-specific time fixed effects - a two-way fixed-effects procedure; the α's β's are unknown parameters; $\varepsilon_{ri,t}$ is the associated error term.

Our implementation of $X_{ri,t}$ in the baseline model is similar to the full model proposed by Goolsbee & Syverson (2008). The authors discuss and treat the potential role of cost shocks as an alternative explanation for the intensity of responses to entry threats by the LCC. They argue that if the newcomer's decision to enter is driven by the choice of markets with falling operating costs, then there will be a confounding effect between the responses to the entry threats and the responses due to the declining costs. To address this issue and account for possible cost shocks, they insert operating costs controls in the regressions. In a similar fashion, we utilize operating cost controls in Equation (1). Among the controls that we include in $X_{ri,t}$, we have the following cost shifters in the baseline model:

- $pax_{ri,t}$ is the total number of revenue passengers carried by incumbent i on route r and time t. Under of economies of density, the higher the output the lower its unit costs and the less costly it is to the carrier to keep higher flight frequencies. Source: National Civil Aviation Agency, Traffic Report.

- $aircraft\ size_{ri,t}$ is the average size of the aircrafts operated by incumbent i on route r and time t. Conditional on the total output, we expect a tradeoff between flight frequency and the average aircraft size. Source: National Civil Aviation Agency, Traffic Report.
- $served\ points_{ri,t}$ is a proxy for the economies of scope, being the maximum number of served points between the endpoint airports incumbent i on route r and time t. Source: National Civil Aviation Agency, Traffic Report.
- $fuel\ unit\ cost_{ri,t}$ is a proxy for the fuel costs incurred by carriers on a route-level basis. It is the mean unit cost of jet fuel per available seat-kilometer of all airplanes with flight assignment on the route. Source: National Civil Aviation Agency's unpublished monthly report of costs, expenses and operations disaggregated by aircraft type and airline; National Civil Aviation Agency's Active Scheduled Flight Report (VRA), where we extracted carrier-specific information of aircraft type assignment of scheduled flights for each domestic airport-pair of the sample.

Apart from the baseline model built upon the empirical framework of LCC entry threats with cost controls of Goolsbee & Syverson (2008), we present and extend the model in which we include market share and market structure variables. We suspect that the baseline model based solely on the authors' approach may suffer from additional confounding effects other than potential unobserved cost shocks. Motivated by the empirical specification of Fageda (2014), we believe that further confounding factors in this case may be implied by the market conditions at both the route and the airport levels. Building upon his framework, we claim that relevant market-related variables, such as the market share of incumbents and the concentration levels, are potentially correlated with the responses to the LCC entry threats and therefore must be accounted for in Equation (1) to avoid estimation bias caused by omitted variables. We therefore include the following in the specification of $X_{ri,t}$:

- $route\ share_{ri,t}$ is the market share of revenue passengers of incumbent i on route (airport pair) r and time t. Source: National Civil Aviation Agency, Air Transportation Market Statistical Database - Monthly Traffic Report, with own calculations;
- $route\ HHI_{rt}$ is the Herfindahl-Hirschman index (HHI) of concentration of revenue passengers on route r and time t. Source: National Civil Aviation Agency, Air Transportation Market Statistical Database - Monthly Traffic Report, with own calculations;
- $airport\ share_{ri,t}$ is the maximum airport share of revenue passengers between endpoint airports of incumbent i, route r and time t. Source: National Civil Aviation Agency, Monthly Traffic Report, with own calculations.
- $airport\ HHI_{rt}$ is the maximum Herfindahl-Hirschman index of concentration of revenue passengers between endpoint airports of route r and time t. Source: National Civil Aviation Agency, Monthly Traffic Report, with own calculations.

Finally, we also develop a set of overview regressions based on the framework of Equation (1). These overview regressions allow for a broader picture of the evolution of key competition variables in the market and the possible factors that may be changing in our sample period that may be correlated with the incumbent responses in flight frequencies. One of the most important results of the overview regressions is that, consistent with Goolsbee & Syverson (2008) we find evidence of statistically significant price cuts - i.e. reductions in the average yields of incumbents - provoked by the newcomer's entry threats in the period. We present the methodology and the results of the overview regressions in the Appendix, along with the descriptive statistics of the variables utilized in the study.

3.4. Estimation strategy

3.4.1. Endogeneity and instrumental variables

We treat $pax_{ri,t}$, $aircraft\ size_{ri,t}$, $route\ share_{ri,t}$, $route\ HHI_{rt}$, $airport\ share_{ri,t}$ and $airport\ HHI_{rt}$ as endogenous variables and therefore utilized an instrumental variables estimator. Our identification strategy employed a combination of structural and BLP-type instruments, where BLP stands for Berry, Levinsohn and Pakes (1996). The structural instruments consider a supply-demand motivation in which exogenous demand shifters are used to identify supply. In our case, the empirical framework of Equation (1) constitutes a flight frequency relation, which is part of supply side decision-making problem of airlines. We therefore use demand shifters associated with the size of the air travel market of the endpoint cities of a route: the gross domestic products (GDP) of endpoint cities, the population size of endpoint cities, the GDP per capita, and the residential electricity consumption in MWh of endpoint regions.[12] The first two metrics have yearly periodicity and therefore required interpolation to produce monthly series.[13] As all routes in our dataset are related to the airports that have São Paulo city as one of the endpoint cities, we considered only the demand shifters associated with the other endpoint cities of each route. We also utilized lagged versions of these variables and, in the case of GDP figures, included the 12- and 24-month growth to capture the demand effect of these variables. Another set of structural instrumental variables was the number of international served points from the origin and destination endpoint airports. The data source is the Brazilian Institute of Geography and Statistics (IBGE) and the Brazilian Energy Research Company (EPE). With respect to the BLP approach, we utilized the characteristics of the rival incumbent airline as instruments. In particular, we included the rival's number of domestic and international served points from the origin and destination endpoint airports.

[12] Many of these shifters would be candidates for a direct insertion in the right-hand side of the regression. However, as we employ a more structural estimation approach instead of a reduced-form model, we use pax as a proxy for market density and output. That variable is very correlated with the market demand shifters such as the GDP and population.

[13] The main limitation of the interpolation procedure of our demand-side instrument generation is related to the potential lack of variability of the proposed instruments. With lower variability caused by the use of annual rates in a model that uses monthly data, the instruments set tends to be less relevant and consequently to perform poorer. This problem was circumvented by the combined utilization of BLP instruments. Additionally, it was systematically inspected by the hypothesis tests of under and and weak-identification discussed below.

Specifically, to treat the endogeneity of $route\ share_{ri,t}$ $route\ HHI_{rt}$, $airport\ share_{ri,t}$ and $airport\ HHI_{rt}$, we utilize additional instruments based on the same empirical strategy described above. We therefore inserted the instrument set and the airline rival's route and airport share, along with the rival's number of flights and the flights HHI during congested hours.

We inspected the quality of our instruments by conducting several statistical tests of the validity and relevance of the instrumental variables. We utilized Hansen J tests to check the validity of the full set of over-identifying conditions - denoted "J overidentif stat" - and Kleibergen-Paap rk LM underidentification tests - denoted "KP underidentif stat" - to check the relevance of the instruments. We present the results of all of the above tests in the bottom of the result table in Section 4. We also report the minimum F-Statistic of excluded instruments estimated in the first stage of each regression - denoted "Min 1st Stage F stat". With the analysis of all hypothesis tests regarding the instrumentation approach, we obtained evidence suggesting the orthogonality and relevance of the proposed set of instrumental variables.

3.4.2. Estimation

We checked for autocorrelation and heteroscedasticity in our data generation process. We utilized the Cumby-Huizinga autocorrelation tests and the Pagan-Hall, White/Koenker and Breusch-Pagan/Godfrey/Cook-Weisberg heteroscedasticity tests in the residuals of Equation (1). All tests indicated the presence of autocorrelation and heteroscedasticity. We therefore employed the Newey-West procedure to adjust the standard error estimates[14]. We estimated Equation (1) with the two-step feasible efficient generalized method of moments estimator (2SGMM) with standard errors that are robust and efficient to autocorrelation and arbitrary heteroscedasticity. To allow for easy comparison between the relative importance of each coefficient in the regressions, we utilize standardized variables, with a mean of zero and a standard deviation of 1. The estimation results therefore can be interpreted as standardized beta coefficients.

[14] We utilized the Bartlett kernel function with a bandwidth of $\text{round}(T^{1/4})$, where $T = 61$. See Baum, Schaffer and Stillman (2007).

As discussed before, we implement the estimation of Equation (1) with a two-way panel estimator. As in Goolsbee & Syverson (2008), we account not only for incumbent-specific route fixed effects (γ_{ri}), but also for incumbent-specific *time* fixed effects (μ_{it}). Accounting for time effects is an important procedure in panel data estimation as it allows for proper control of the common evolution of the panel individuals. In our case, it controls not only the overall, time-varying, socio-economic conditions of São Paulo region, but also of the Brazilian economy and the air transport sector. During the sample period, the airline industry was affected by major fluctuations in fuel prices and Brazil experienced expressive economic growth. Without accounting for time effects, these factors would have a confounding effect on the empirical analysis, and as a consequence would potentially lead to a biased estimation of the determinants of flight frequencies in our case study.

4. Estimation results

4.1. Baseline model

In Table 2, Column (1), we present the results of our baseline model of flight frequency determination, stated by Equation (1). It is possible to observe in Column (1) that, particularly in the episodes of 2nd and 3rd degree entry threats, we have a sequence of coefficients that are statistically significant, which is indicative of increases in flight frequencies of approximately 30% on the threatened routes of incumbent carriers. These results indicate a preemptive movement of incumbents established at primary airports in the face of the entry threats of the LCC possibly engaging in a march toward the existing primary airports. Our baseline model of Column (1), Table 2 indicates a permanent increase in flight frequency from the 2nd degree entry threat that is neither attenuated nor intensified over time. Note that in Column (1), pax and $aircraft\, size$ are the statistically significant cost shifters, whereas $served\, points$ and $fuel\, unit\, costs$ are not significant. The lack of significance of the two latter regressors is due to the fact that they have lower within route variability and therefore tend to present higher correlation with the carrier-time fixed effects utilized in all estimations.[15]

[15] Goolsbee & Syverson (2008) had a similar estimation issue with the operating cost controls in their expanded specification.

Table 2 - Estimation results - flights - full specification

	(1) ln flights	(2) ln flights	(3) ln flights	(4) ln flights
entry threat - degree 1				
t_1	0.1844	0.2225	0.2835*	0.2564
$t_1 + 1$	-0.0194	0.0335	0.0870	0.0645
$t_1 + 2$	0.0551	0.0592	0.0968	0.1183
$t_1 + 3$	0.0658	0.0719	0.0905	0.1134
$t_1 + 4$	0.1935	0.2312	0.2418	0.2922
$t_1 + 5$	0.1903	0.2121	0.2491	0.2480
$t_1 + 6$	0.3179**	0.3215**	0.3833**	0.3428**
$t_1 \geq 6$	0.2252*	0.2341	0.2813**	0.2728*
entry threat - degree 2				
t_2	0.2022	0.2029	0.2389	0.2468
$t_2 + 1$	0.2774**	0.2757	0.3101*	0.3386**
$t_2 + 2$	0.2929**	0.2703	0.3056*	0.3389**
$t_2 + 3$	0.3047**	0.2812	0.3249*	0.3398**
$t_2 + 4$	0.3350**	0.3274*	0.3637**	0.4110***
$t_2 + 5$	0.3863***	0.3362**	0.3803**	0.4004***
$t_2 + 6$	0.3709***	0.3294**	0.3685**	0.3918***
$t_2 \geq 6$	0.3482***	0.3234**	0.3590**	0.3881***
entry threat - degree 3				
t_3	0.2906**	0.3080*	0.3484**	0.3177**
$t_3 + 1$	0.3327**	0.3365**	0.3843**	0.3410**
$t_3 + 2$	0.3388***	0.3297**	0.3762**	0.3304**
$t_3 + 3$	0.3435**	0.3453**	0.3806**	0.3480**
$t_3 + 4$	0.3696***	0.3729**	0.4094**	0.3795***
$t_3 + 5$	0.3414**	0.3289**	0.3664**	0.3356**
$t_3 + 6$	0.3387**	0.3203**	0.3452**	0.3193**
$t_3 \geq 6$	0.3070**	0.3317**	0.3544**	0.3316**
costs and market structure controls				
pax (*endogenous*)	0.4340**	0.4088*	0.4519**	0.4279**
aircraft size (*endogenous*)	-0.2630***	-0.2433***	-0.2268***	-0.2623***
served points	0.0121	0.0317*	0.0314	0.0339*
fuel unit cost	0.0043	-0.0027	-0.0032	-0.0058
route share (*endogenous*)		0.3982***	0.3138**	0.5630***
route HHI (*endogenous*)		-0.3447***	-0.3032***	-0.3780***
airport share (*endogenous*)		0.2068	0.2920**	
airport HHI		-0.1442**	-0.2058***	
airport congestion			-0.0424***	-0.0407***
hubbing activity			-0.0070	-0.0091
means tests				
entry threat - degree 1	0.1516	0.1732	0.2141	0.2136
entry threat - degree 2	0.3147**	0.2933*	0.3314**	0.3569**
entry threat - degree 3	0.3328**	0.3342**	0.3706**	0.3379**
fixed effects				
route-carrier fixed effects	*yes*	*yes*	*yes*	*yes*
carrier-time fixed effects	*yes*	*yes*	*yes*	*yes*
Adjusted R-squared	0.9157	0.9349	0.9353	0.9346
RMSE stat	0.2737	0.2405	0.2398	0.2410
KP underidentif stat	29.5322	16.4976	28.6775	29.1447
Min 1st Stage F stat	3.1907	3.6186	4.1576	4.1590
J overidentif stat	5.7825	5.1845	3.6895	2.1788
Nr Observations	2,942	2,942	2,942	2,942

*Notes: Results produced by the two-step feasible efficient generalized method of moments estimator (2SGMM); statistics robust to heteroscedasticity and autocorrelation; standard errors of the estimated coefficients in brackets. P-value representations: ***p<0.01, ** p<0.05, * p<0.01.*

We are aware that our results are in sharp contrast with the results of Goolsbee & Syverson (2008) regarding the preemptive use of flight frequencies by incumbents in airline markets. The authors found no evidence of anticipated capacity reactions by incumbents when threatened by the entry of LCC Southwest Airlines in the US market. In the Brazilian case, our estimates do indicate statistically significant additions of flight frequencies before entry. The explanation for such divergence of results can be reconciled if we consider the financial health of incumbent airlines in both studies. While in the United States, most of the incumbent firms went bankrupt by entering Chapter 11 for much of the authors' sample period, in our case, we observed the two incumbents, Tam and Gol, in a period of excellent financial health. As discussed in 3.1, both airlines' profitability was notably high in the period of analysis, which characterizes a situation similar to the "deep pocket" hypothesis of predation models.[16] The financial health and potential higher market capitalization of incumbents in our case possibly explain the estimated results, as they may have constituted the necessary backing for the preemptive movements aimed to invest in raising entry barriers at primary airports in Brazil.

4.2. Extended model

As discussed before, we suspect that the baseline model may suffer from additional confounding effects and that only controlling for unobserved costs shocks would not be sufficient to address the issue of potential inconsistent estimation. Table 2, Column (2) constitutes our preferred model, with the empirical results of the extended model in which we include market share and market structure variables as additional controls. Remember that, among the inserted market structure and cost controls, we consider $pax_{ri,t}$, $aircraft\ size_{ri,t}$, $route\ share_{ri,t}$, $route\ HHI_{rt}$, $airport\ share_{ri,t}$ and $airport\ HHI_{rt}$ as endogenous variables and, as with Column (1), here we also employ an instrumental variables estimator. Note that both the market structure on the route and the airport have estimated *ceteris paribus* effects on the capacity setting of flights of the incumbent airlines: both $route\ HHI$ and the $airport\ HHI$ variables are statistically significant and negative in Column (2). These results are consistent with the fact that incumbents soothe competition by increasing prices and reducing output when market and airport concentration is higher. Our results also

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[16] See Ordover and Saloner (1989) for the airline industry.

accommodate the intuitive notion that the route market share of passengers of a given incumbent is positively related to its flight frequency. Note that the inclusion of these additional control variables does not have a major impact on the estimates of the effects of the entry threat dummies. The most important specific impacts occur in the estimates related to the first three months after the establishment of 2nd degree entry threat, which become statistically insignificant.

4.3. Robustness checks

We implement two robustness checks of our extended model, which are displayed in Table 2, Columns (3) and (4). First, in Column (3), we insert two airport-related variables and check the impact of the insertion of these factors on the entry threat dummies. We consider the following variables to account for airport congestion and the potential hubbing activity in our framework.[17]

- $airport\ congestion_{rt}$ is the proportion of daily scheduled flights operated during congested hours route r and time t. We define "congested hours" as any full clock hour in which the number of arrival plus departure flights in the airport was higher than the official declared capacity. Sources: National Civil Aviation Agency, Active Scheduled Flight Report (VRA Report) and an airport capacity study commissioned by the Brazilian government (2010);[18]
- $hubbing\ activity_{rt}$ is the product of the number of connecting passengers (in millions) at both endpoint airports of route r at time t. Source: Infraero's Airport Traffic Movement reports, with own calculations.[19]

The main impact observed in the model caused by the first proposed robustness check is the return of the statistical significance of the effects of the coefficients relative to the first months following the 2nd degree entry threat, when contrasted with Column (2). This effect is suggestive that the reactions to the threat of entry at this stage are correlated with competitive and operational factors associated with the airports, in particular with congestion, as the $airport\ congestion$ variable is

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[17] See the Appendix for descriptive statistics of both variables.

[18] "Study of the Air Transport Sector in Brazil" (text in Portuguese) - Brazilian Development Bank, Jan 25, 2010, available at www.bndes.gov.br.

[19] We also experimented with the maximum number of connecting passengers at the endpoint airports and the results remained the same.

statistically significant. The other results of Column (3) remain basically the same as our most important results of Column (2).

Our second robustness check is presented in Table 2, Column (4), in which we performed the model specification challenge proposed by Evans & Kessides (1993, p 72). This robustness test is a specification check that implies the discarding of competition variables related to the airport level and to report the impact in the estimation of the remaining variables. In our configuration, we discarded both the market share and the market concentration variables associated with the airports, namely, $airport\ share$ and $airport\ HHI$. As with the first robustness check, here, most results also remain the same, which confirms the robustness of our main empirical results of the extended model in Column (2). It is important to note that, again, the coefficients relative to the first months following the 2nd degree entry threat are benefited and this time become even more statistically significant when compared to Columns (2) and (3). This finding reinforces the association between entry threat responses at this stage and airport-related factors known by the incumbents.

5. Conclusion

This paper developed an econometric model to inspect the role of different degrees of entry threat on the capacity setting of incumbents in the airline industry. We present the first analysis to empirically test the possible preemptive behavior of incumbent airlines with respect to the imminence of a product repositioning by a newcomer LCC aiming at gaining access to primary airports of a multiple airports region. We utilized the case of the entry of Azul Airlines in the region of São Paulo city, the mostly populated conurbation in Brazil. We focus on the study of the flight frequencies adjustments by the major incumbent airlines facing the entry threats of the LCC initially established at the secondary airport but possibly migrating its operations to the existing primary airports.

We provide evidence that the incumbents preemptively increased their flight frequencies on the threatened airport-pairs. These movements are inferred in our empirical model from an estimated permanent upward shift in flight frequencies that is observed from the 2nd degree entry threat, i.e., after the beginning of adjacent route competition from the secondary airport. Such movement persists but is not intensified with the trigger of the 3rd degree entry threat, i.e., a stage in which the

LCC enters the primary airport but still does not fly the associated airport-pair. Our results are in contrast with the previous literature based on the US airline market experience in which incumbents engaged in preemptive behavior only in prices but not in the capacity dimension. We suggest that the financial conditions of incumbents matter to explain possible preemption in airline markets. Different from the US case, the strong financial health of the incumbents in our sample period may have allowed the emergence of a "deep pocket situation" that facilitated the preemptive capacity responses to the threats of entry.

The preemptive behavior of incumbent airlines in the market may have caused benefits to passengers in the short run. The estimated permanent increase in flights of approximately 30%, along with the observed price cuts that occurred concomitantly, may have induced higher consumer surplus and service quality improvements due to the augmented menu of flights and lower schedule delay at primary airports. In the long run, however, the preemptive behavior of major carriers may have constituted investments in raising entry barriers at primary airports that strengthened the market positioning of incumbents and ultimately avoided or discouraged more intense competition in many relevant city-pair markets of the region.

One important limitation of our work is that we perform a local case study to investigate a general competition research issue - the behavior of incumbent airlines in response to LCC entry threats. We believe our study could be viewed as representing the reality of emerging airline markets with quick demand growth, being therefore more comparable to the Asia Pacific markets rather than to the more mature markets in the US and Europe. We think it is possible to extrapolate some of our conclusions to other markets or countries, however. As a general conclusion, we can suggest that our main results are consistent with the behavior of incumbents that had previously been used to little actual and potential competition, which started engaging in capacity building and rapid new demand generation in the competing airports of an LCC newcomer after its startup of operations. These incumbent carriers had been previously financially stronger before LCC entry than the incumbents studied by the previous literature. We think that these general economic aspects, namely 1. the demand growth potential of the market, and 2. the financial conditions of incumbents, are crucial to any analysis of airline rivalry. We therefore suggest that the conclusions of the empirical studies aiming at pinpointing preemptive behavior in the airline industry will likely be conditional on relevant period-specific and geography-specific elements that airline researchers must be aware and discuss. Our results may constitute evidence that further investigation in the field is needed, with applications to different realities and market situations until a consensus on the subject could be reached.

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Appendix A

Table 3 - Descriptive statistics - variables of the empirical model

Variable	Mean	Std. Dev.	Minimum	Maximum
entry threat - degree 1	0.249	0.433	0.000	1.000
entry threat - degree 2	0.458	0.498	0.000	1.000
entry threat - degree 3	0.183	0.387	0.000	1.000
traffic density	14,513.377	12,582.708	78.000	95,566.000
weekly passengers	3,337.334	2,888.570	17.613	21,579.420
average aircraft size	164.700	19.792	45.000	213.500
served points	29.972	4.350	18.000	49.000
fuel unit cost	0.044	0.056	0.020	1.394
route share	0.525	0.191	0.033	1.000
route HHI	0.534	0.165	0.274	1.000
airport share	0.500	0.106	0.330	1.000
airport HHI	0.464	0.091	0.343	1.000
airport congestion	0.013	0.037	0.000	0.292
hubbing activity	1.297	3.308	0.000	28.910

Appendix B

We developed a set of overview regressions based on the framework of Equation (1). These overview regressions allow for a broader picture of the evolution of key competition variables in the market and the possible factors that may be changing in our sample period that may be correlated with the incumbent responses in flight frequencies. In these regressions, we do not set the control variables vector $X_{ri,t}$ of Equation (1) but utilize only the entry threat dummies in the empirical specifications. These overview regressions utilize not only $flights_{ri,t}$ as the regressand but also the above defined $pax_{ri,t}$ and $aircraft\,size_{ri,t}$ variables, and $seats_{ri,t}$, $load\,factor_{ri,t}$ and $yield_{ri,t}$, which we define below.

- $seats_{ri,t}$ is the total number of seats on scheduled flights operated by incumbent carrier i on route r and time t. Source: National Civil Aviation Agency, Active Scheduled Flight Report - VRA, with own calculations;
- $load\,factor_{ri,t}$ is the average percentage of aircraft occupation on scheduled flights operated by incumbent carrier i on route r and time t. Source: National Civil Aviation Agency, Traffic Report, and Active Scheduled Flight Report - VRA, with own calculations;
- $yield_{ri,t}$ is a proxy for the market average price per kilometer of incumbent carrier i on route r and time t. This series was inflation-adjusted to produce constant monetary figures. Source: National Civil Aviation Agency, unpublished Monthly Revenues Report by Airline and Aircraft, with own calculations.[20]

The results of the overview regressions are displayed in Table 4.

[20] This measure is not originally incumbent-route specific but is rather aggregated to the airline-aircraft level. To construct this variable, we first calculate the average yield in the airline-aircraft-time level and then allocate each value to the corresponding airline-aircraft-route-time observation. Subsequently, we compute an average yield weighted by the number of flights of each carrier. We performed such a methodological procedure to obtain a proxy variable due to the Brazilian regulator having denied our request to provide more disaggregated yield data.

Table 4 - Estimation results - overview regressions

	(1) ln pax	(2) ln yield	(3) ln load factor	(4) ln seats	(5) ln aircraft size	(6) ln flights
entry threat - degree 1						
t_1	0.0044	-0.2077***	0.0847	0.0847	0.0225	0.0621
$t_1 + 1$	0.3095*	-0.2010***	0.2589***	0.0550	0.0058	0.0492
$t_1 + 2$	0.3392**	-0.2279***	0.2887***	0.1419	0.0134	0.1285
$t_1 + 3$	0.4132***	-0.1963***	0.2704***	0.2003	0.0200	0.1804
$t_1 + 4$	0.4531***	-0.1872***	0.3021***	0.2997*	0.0215	0.2783*
$t_1 + 5$	0.2526*	-0.2201***	0.1806***	0.2188	0.0350	0.1838
$t_1 + 6$	0.3288**	-0.2177***	0.1145**	0.3045**	0.0507	0.2538*
$t_1 \geq 6$	0.3726***	-0.2065***	0.2106***	0.2646**	0.0657	0.1989*
entry threat - degree 2						
t_2	0.3093**	-0.2099***	0.1851***	0.2327*	0.0472	0.1855
$t_2 + 1$	0.3889***	-0.2082***	0.2197***	0.3286***	0.0525	0.2760**
$t_2 + 2$	0.4477***	-0.2094***	0.2148***	0.3477***	0.0521	0.2955**
$t_2 + 3$	0.4835***	-0.2218***	0.2337***	0.3593***	0.0584	0.3009***
$t_2 + 4$	0.3858***	-0.2241***	0.2180***	0.3738***	0.0638	0.3100***
$t_2 + 5$	0.4515***	-0.2258***	0.1835***	0.4130***	0.1003	0.3128***
$t_2 + 6$	0.4461***	-0.2399***	0.1765***	0.3895***	0.1086*	0.2809***
$t_2 \geq 6$	0.4876***	-0.2277***	0.1861***	0.3960***	0.1151*	0.2809***
entry threat - degree 3						
t_3	0.4948***	-0.2042***	0.2580***	0.3508***	0.1093	0.2414**
$t_3 + 1$	0.4444***	-0.2198***	0.2112***	0.3478***	0.1042*	0.2436**
$t_3 + 2$	0.4383***	-0.2336***	0.1813***	0.3654***	0.1059*	0.2594**
$t_3 + 3$	0.5510***	-0.2216***	0.2079***	0.4201***	0.1124*	0.3077***
$t_3 + 4$	0.5330***	-0.2227***	0.2080***	0.4211***	0.1181*	0.3029***
$t_3 + 5$	0.5430***	-0.2399***	0.2255***	0.3803***	0.1190*	0.2613**
$t_3 + 6$	0.5443***	-0.2540***	0.2377***	0.3817***	0.1216**	0.2601**
$t_3 \geq 6$	0.4538***	-0.2615***	0.2268***	0.3128***	0.1321**	0.1807*
means tests						
entry threat - degree 1	0.3092**	-0.2080***	0.2368***	0.1962	0.0293	0.1669
entry threat - degree 2	0.4250***	-0.2209***	0.2022***	0.3551***	0.0748	0.2803***
entry threat - degree 3	0.5003***	-0.2322***	0.2196***	0.3725***	0.1153*	0.2571***
fixed effects						
route-carrier fixed effects	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
carrier-time fixed effects	*yes*	*yes*	*yes*	*yes*	*yes*	*yes*
Adjusted R-squared	0.8836	0.9052	0.5389	0.9054	0.6415	0.9057
RMSE stat	0.3028	0.0849	0.1175	0.2918	0.0904	0.2895
Nr Observations	2,942	2,942	2,942	2,942	2,942	2,942

*Notes: Results produced by a Least Squares Dummy Variable (LSDV) procedure implemented with the OLS estimator; statistics robust to heteroscedasticity and autocorrelation; standard errors of the estimated coefficients in brackets. P-value representations: ***p<0.01, ** p<0.05, * p<0.01.*