AIRLINE-PROVIDED CONCEPTUAL MODEL OF FACTORS FOR REGULAR COMMERCIAL SERVICES ON THIN-DEMAND REGIONAL AIR TRANSPORT ROUTES

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ABSTRACT

The literature has examined the factors influencing the entry and attractiveness of regional air transport routes for full-service and low-cost carriers. However, a gap remains in understanding the factors that determine airport choice within airlines' route networks on routes with thin demand. This paper synthesizes the literature and further examines potential factors related to thin demand or sub-regional routes. The study contributes to filling the gap in understanding airlines' entry decisions in this niche market.

Keywords: Air transport; Airport; Business; Regional aviation.

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Highlights

- Identification of factors used in the literature on the route entry decision for Airlines;
- Airline route entry literature focuses on the low-cost carrier and full-service carrier market;
- Contributes to filling the gap on which factors apply to thin-demand routes;
- Conceptual model combines classic low-cost carrier factors and general aviation contributors;
- Assist aerodrome operators in prioritizing investments to maximize potential.

1 INTRODUCTION

The airline route development theme and the airport attractiveness for an airline building their network have been the subject of several studies (Boguslaski et al., 2004; Oliveira, 2008; Müller *et al.,* 2012; Dziedzic et al., 2020;Homsombat *et. al.,* 2014; Oliveira and Oliveira, 2020, Wang *et al.,* 2017; Zhang *et al.,* 2017), mainly concerning LCCs' operations.The available literature on airport choice and airline route networks has focused on the low-cost carrier (LCC) business model, as expected given LCCs' prominence over the last few decades relative to established full-service carriers (FSCs). However, this results in less attentionbeing given to research on small airports, where demand is thinnerand insufficient to attract major LCCs due to thelack of potential economies of scale.

Studies on the route networks of LCCs show that, due to their business characteristics, they tend to use secondary or less-utilized airports to avoid the inefficiencies associated with operations at established hubs, thereby overlapping the "small airport" or "regional airport" theme. However, there is no common ground on the classification of a regional airport, either in regulatory or research consensus, regarding thresholds for air traffic movements (ATMs), passenger throughput, or other metrics.Additionally, studies on the determinants of air traffic at small airports using regression models report lower explanatory power (Dziedzic *et al.,* 2020).

In summary, factors influencing airline airport choice in smaller aerodromes with few regular operations and low-seat-capacity aircraft are commonly absent from the literature, and this research seeks to bridge this gap to complement and advance understanding of the air transportation sector.Understanding how to increase air transport capacity, why companies start serving thin-demand routes, and which characteristics matter most for airline airport choice could guide more accurate investments in smaller facilities, ensuring their long-term attractiveness.

2 AIRLINE'S ROUTE NETWORK DEVELOPMENT

From the airline perspective, the attractiveness of an airport to a specific air carrier is closely linked to each company's route network strategy and business model, with implications for themes such as competition, traffic density, and

operational costs. The study of airline airport choice factors has been relatively concentrated on the LCC business model, especially since 2000, when more airlines adopted this model. These market shifts prompted researchers to examine the evolution of trends in this type of carrier, which generally features a geographically atypical route network compared to the FCC (Warnock-Smith and Potter, 2005; Dobruszkes *et al.,* 2017).

Southwest Airlines is known as the pioneer of low-cost travel and remains recognized for the vanguard practices it helped establish in the industry. In Boguslaski *et al.,* (2004), airports and location factors such as demand, lower airport costs, absence of competition, reduced stage length, and favorable local demographic factors are most representative of their route network construction. The company initially focused on dense, short-haul routes, using regional or secondary airports to avoid the inefficiencies of operating at established hubs, such as congestion, delays, and direct competition with FCCs.

Founded in 1999, JetBlue Airways incorporated specific characteristics into its route network strategy, such as avoiding routes already served by other LCCs and targeting longer-haul markets, including transcontinental flights, while still using secondary airports for city pairs (Müller et *al.,* 2012). In the route development process of JetBlue Airways' network, although it started services decades after Southwest Airlines' benchmark, the core strategy is very similar, with few differences in business strategy and the type of focused passenger, and a “premium” approach to onboard service. Because its origin was in a more restricted market, airport capacity, slot availability, and airside congestion were additional factors when comparing JetBlue Airways' route network with Southwest Airlines'.

The business model developed by North American and European airlines is also being emulated in the Asian market, with AirAsia, Cebu Pacific, Jetstar Airways, and Tiger Airways among the more distinct participants. In this context, Wang et al. (2017) study the entry patterns of LCCs in Hong Kong using a probit model and a generalized least squares estimation. The results show that distance, airline competition, and population demand are the main factors LCCs consider when deciding to start serving a city pair, with Hong Kong as one of its nodes. There are relatively few secondary airports in Asia that are attractive to LCCs (Wang et al., 2017), so Asian carriers tend to be more careful in selecting destinations to sustain

their cost advantages. Idiosyncrasies related to the Hong Kong – China relationship is also a particularity of the routes studied.

In South America, specifically Brazil, the country is relatively similar in size and population to the United States of America, although the Brazilian air transport market is dominated by three airlines: Gol Airlines (Gol), LATAM, and Azul Airlines (Azul). Oliveira (2008) analyzed Gol Airlines' (Gol) entry patterns in 2001 and 2002 using Amemiya's Generalized Least Squares (AGLS) model. Among the study's main findings, the most significant determinants of Gol Airlines' entry decision were the number of passengers traveling between a city pair and the presence of a rival airline on that route. The findings show that the behavior initially resembled Southwest Airlines but later aligned more closely with the pattern observed for JetBlue, possibly due to country-specific idiosyncrasies.

Among the characteristics of the Southwest Airlines business model, still maintained by Gol Airlines, is a standardized fleet of Boeing 737 aircraft (and their variants). On the other hand, Azul Airlines took a different path, diversifying its fleet from its origins and adding new aircraft as its position in the Brazilian market evolved. The route entry determinants for Azul are studied by Oliveira and Oliveira (2022), who focus their analysis on the effects of the merger between Azul and Trip, two Brazilian airlines that became the largest Latin American regional airline. In short, after the merger, Azul moved away from the consolidated LCC benchmarks to pursue a unique entry strategy, in which it is simultaneously interested in monopolistic positions on short-haul routes and in adopting higher-capacity aircraft to capture greater market share on denser routes dominated by its major competitors. A summary of the main route entry factors used in the models described in the literature is shown in Table 1.

The most commonly used factors, as shown in Table 1, are demand, airline competition, route length, and external economic factors. Although the literature is more closely related to the LCC business model, some of these factors will also be analyzed in the model for the routes focused on in this research.

Table 1 - Route entry factors for passenger-focused airlines

Factors \ Authors	Bogulaski et al. (2004)	Dobruszkes et al. (2017)	Homsombat et al. (2014)	Muller et al. (2012)	Oliveira (2008)	Oliveira and Oliveira (2022)	Wang et. al. (2017)	Zhang et al. (2017)
Passenger demand	X		X	X	X	X	X	X
Proximity to demand		X					X	X
Potential demand growth			X				X	
Airport costs	X	X		X		X		
Business passenger attractiveness						X		X
Leisure passenger attractiveness	X			X		X		X
Airport ground accessibility		X						
Available capacity				X		X	X	
Airport competition	X	X		X				
Airline competition	X		X	X		X	X	X
Route length	X		X	X	X	X	X	
External economic factors	X			X		X	X	X

Source: research data.

In the Brazilian context, factors such as proximity to demand and airport competition may become more relevant as regional routes densify the network and reduce the distance between served airports.

3 RANKING OF AIRPORT CHOICE FACTORS

In the ranking approach, after identifying preliminary factors through the literature review, the studies then apply a specific ranking method. In this preliminary phase, a first round of questionnaire surveys can be used to confirm the applicability of the factors identified in the literature review. In the study by Lu and Mao (2015), academics received and evaluated the structure of the analysis hierarchies. Although most predefined criteria and sub-criteria were accepted, the procedure allowed removing items identified as irrelevant and adding factors that had not been previously identified.

Similarly to the route network analysis, the literature review presented in this item, although geographically diverse, is also focused on LCC airlines (Warnock-

Smith and Potter, 2005; Lu and Mao, 2015; Dziedzic and Warnock-Smith, 2016; Loh et al., 2020).

Ranking the identified factors can be done through various methods. Most research follows Saaty's (1994) recommendation to use a pairwise comparison matrix to define the relative weights of elements within the same hierarchy, as in the Analytic Hierarchy Process (AHP). Both studies (Lu and Mao, 2015; Loh et al., 2020) combine this approach with fuzzy set theory to yield the Fuzzy Analytic Hierarchy Process (FAHP). Another method used was the Likert Scale, applied by Warnock-Smith and Potter (2005), ranging from 1 to 6. As an additional approach, Dziedzic and Warnock-Smith (2016) rank the factors by the frequency with which they were cited in secondary materials in which airline managers and industry executives described their network policies, without using questionnaires to rank the airport attractiveness factors.

The recipients of the questionnaires are commonly divided among academics, airport managers, and airline executives, with the latter being the most common. However, the respondents' actual roles are not always described in the three cited studies that use this approach. LCC airlines based in the UK and the European Union received the questionnaires in the Warnock-Smith and Potter (2005) and Loh et al. (2020) studies. A broader set of stakeholders was used in Lu and Mao (2015), including airport managers and academics alongside LCC airline managers to rank airport factors using the proposed scale.

The airport factors considered in each of the four studies using a ranking approach are not homogeneous. The ranked factors in each study, along with their respective positions, are shown in Table 2.

As shown in Table 2, the airport costs and/or tariffs factor ranks #1 in the three most recent studies (Lu and Mao, 2015; Dziedzic and Warnock-Smith, 2016; Loh et al., 2020), with demand identified as the most relevant by Warnock-Smith and Potter (2005). Given the literature's focus on LCCs, the high ranking of demand- and cost-related factors is consistent with the explanatory power these variables often demonstrate in route-entry models.

Table 2: Ranking factors for airport choice factors

Category	Description	Warnock-Smith and Potter (2005)	Lu and Mao (2015)	Dziedzic and Warnock-Smith (2016)	Loh et al. (2020)
Costs	Incentives	4	10		4
	Cost-conscious airport management	5			
	Airport costs		1	1	1
Demand	Demand for LCC service	1	14	2	2 / 3
	Predicted demand growth	5			5 / 8
	Business passenger attractiveness			6	
	Leisure passenger attractiveness			9	
Efficiency	Efficient turnaround	2	2	3	9
	Check-in facilities		8		14
	Efficiency in baggage handling		19		
Access	Good surface access	8	4	13	10
	Distance to the served city		12	4	
Capacity	Convenient slot times	2 / 8	7	5	
	Expansion plans	9	5		
	Airside infrastructure		17		
	Air traffic control		6 / 13		
Operations	Airport competition	7		8	
	Airline competition	15		7	7
	Dedicated LCC facility	14	16	10 / 12	6 / 13
	Aircraft maintenance support		18		
	Convenient supply of fuel		20		
Others	Environmental policy	10			
	Privatized or deregulated airport	12			
	Non-aeronautical revenues	13		11	16
	Authority support		3		

Source: research data.

Furthermore, there is a notable consistency among the highest-ranked factors, suggesting that airport choice factors are relatively universal across the LCC business model. In a sense, this also supports the validity of the hybridization process previously mentioned, as some factors are relevant across different types of airlines serving different markets.

As observed in the literature on route network development, the LCC theme is also dominant in the ranking approach. Consequently, the needs and preferences of regional airlines operating aircraft with fewer passengers require further exploration. Nevertheless, the viability of applying factors identified for LCCs is considered here for the thin-demand context.

Given its demand and aircraft-type characteristics, an airport operating in this market may share significant similarities with airports operating in the General Aviation (GA) market. Airports with such thin commercial routes were dedicated to general aviation before regular service began. Thus, airports operating low volumes of commercial service may be located on the border between general and commercial aviation passenger demand thresholds, at least where that airport is the only available option, with demand capable of sustaining only the operation of smaller aircraft with low seat counts.

With the aforementioned in mind, airport factors relevant to general aviation may help clarify the low-demand commercial service market. In a study focused on identifying criteria for prioritizing investment in general aviation aerodromes, Caetano et al. (2022) use variables that incorporate demand, geography, airport infrastructure, and operational conditions. Some factors, such as the type of operation and pavement surface, are not addressed in the previously analyzed studies focused on the LCC sector, potentially because when traffic volumes are higher, operators and regulators already demand this infrastructure to ensure operational safety, making it seem obvious or minimal in that context.

General aviation dedicated aerodromes may be limited to this type of service due to infrastructure, competition, or even regulatory constraints on receiving regular commercial flights. At the other end, even studies addressing the “small airport choice” theme commonly use passenger volume thresholds that are not comparable to this niche market, which lies at the transition between general aviation traffic and regular commercial service.

Although some factors, such as population and GDP, are expected to be relevant across all market niches, comparing the airport choice factors identified in the literature review for aerodromes with different traffic types reveals a potential research gap regarding the airport factors relevant to an airline's choice of airport for thin-demand routes.

4 CONCEPTUAL MODEL

Airport choice factors related to LCC operations may not align with the idiosyncrasies of thin-demand route needs. The limited resources available to small

airports receiving those operations mean that some characteristics considered essential or minimum requirements for regular commercial passenger air transport may be absent to an extent that renders them irrelevant to attracting operations.

Some of the previously listed factors may be considered “universal,” such as catchment area, distance to a nearby airport, and demographic and economic characteristics. Nonetheless, LCC-related factors, including airline competition, are unlikely to be applicable in this context (Fageda *et al.,* 2019) and are therefore discarded.

Airports operating in the thin-demand market would be classified as General Aviation Aerodromes without regular air transport service, as this type of service tends to sit on the cusp between general and commercial aviation. Additionally, thin-demand routes rely on subsidies to remain viable.

In this context, factors affecting GA aerodrome attractiveness and subsidized routes are potentially similar to those affecting small aircraft operating on thin-demand routes. Table 3 presents the characteristics of the variables studied and considered for the conceptual model.

Table 3 - Variable definitions

Variable	Details
Population	Number of inhabitants in the served area
GDP per capita	Gross Domestic Product per inhabitant
Stage length	Air distance in kilometers
Touristic activity	Demand for tourism passengers
Business activity	Demand for business passengers
Runway length	Corrected runway length measured in meters
Runway width	Runway width measured in meters
Ground connectivity	Number of road axes serving a locality
Runway surface	Type of pavement / paved or unpaved
Type of operation	VFR Daily or other (VFR Daily+Night or IFR D/N)
Capacity for bigger aircraft	If the airport can receive regular commercial aviation aircraft
Alternative airport service volume	The ratio between ASK and the distance to the surrounding airports

The factors used in the criteria prioritization for investment policies in GA structures (Caetano *et al.,* 2022) and in understanding the geographical characteristics of subsidized air routes (Silva *et al.,* 2022) could provide insights consistent with those of the new sector. In the research, quantitative variables include population, GDP per capita, distance, runway dimensions, and degree of ground connectivity. In contrast, qualitative variables are runway surface, type of

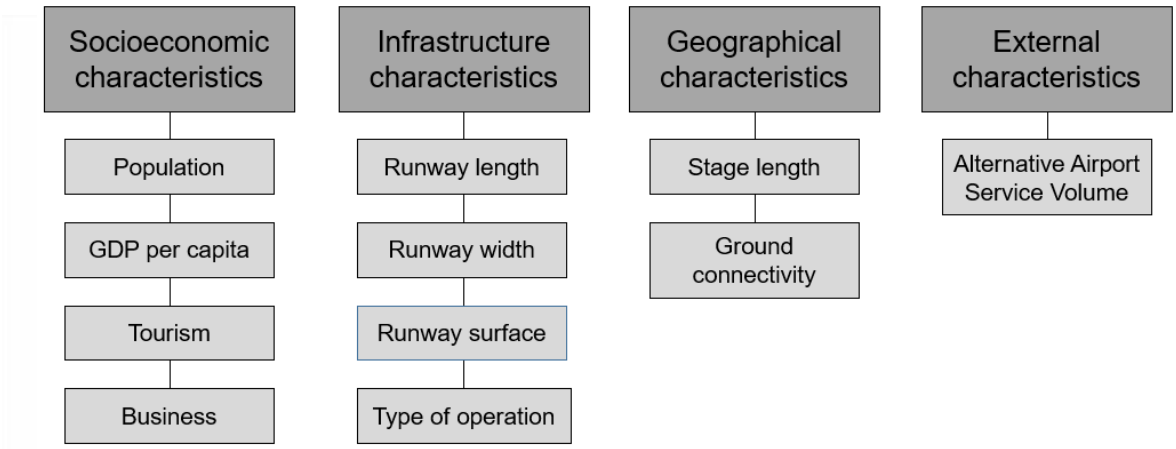
operation, industry and tourism activity, airport capacity for larger aircraft, and type of operator.

Population, GDP per capita, stage length, tourism, and business activity are commonly used alongside demand in related studies in the air transportation sector. A positive correlation between flight service and variables such as population and GDP is expected (Boguslaski *et al.,* 2004; Muller *et al.,* 2004). Regarding the stage length (distance) between cities, the literature reports mixed results: Boguslaski *et al.,* (2004) report a negative correlation for Southeast Airlines, whereas Wang *et al.,* (2017) report a positive impact in Hong Kong's context. Although some authors have explored both business and leisure passenger variables (Boguslaski *et al.,* 2004; Muller *et al.,* 2012), leisure passenger variables are more frequently reported in the literature (Oliveira and Oliveira, 2022; Zhang *et al.,* 2017).

However, some variables used in the literature, mostly focused on the LCC market, are not applicable to thin-demand routes. Those routes commonly operate under incentives and are served by a single airline; thus, variables such as Airline Competition and Available Capacity (Wang *et al.,* 2017) do not affect this market niche. Others, such as Potential Growth (Homsombat *et al.,* 2014), are difficult to measure when incentives are present, although the variable Capacity for larger aircraft attempts to capture this.

The variables for ground connectivity, runway dimensions and surface, and type of operation are proposed in studies involving aerodromes with less infrastructure (Caetano *et al.,* 2022; Silva et al., 2022). On the other hand, the variables for the capacity to accommodate larger aircraft and alternative airport service volume are created to capture the idiosyncratic characteristics of airlines operating those services and the impact of surrounding airports on the analyzed infrastructure.

Figure 1 - Conceptual model



In Figure 1, the selected variables are categorized by their characteristics. Socioeconomic factors are driven by the environment in which the aerodrome is located. Variables such as population, GDP, tourism, and business attractiveness are expected to be positively correlated with flight service provision, as observed in the LCC market.

Geographic variables are determined by an aerodrome's location, although political decisions can influence and enhance the ground connectivity of an aerodrome and its served city. Within this market niche, where smaller aircraft are used, shorter flight distances are expected, given these aircraft's limitations.

The Alternative Airport Service Volume variable aims to capture the Airport Competition factor in thin-demand markets, where competitive infrastructure is commonly located in neighboring cities and a greater number of flight schedules and airlines can compensate for the impact of travel time to those better-served locations.

The only variables under the aerodrome operator's control are infrastructure characteristics, and understanding the most effective ones is relevant to optimizing investments, whether to increase aerodrome operability via equipment and surface enhancements or to expand the current infrastructure to accommodate higher-capacity aircraft.

5 CONCLUSION

This study aims to fill a research gap in the commercial air service market for small aircraft serving smaller airports. This research is not exhaustive. Here, the

focus is on identifying factors that lead companies to choose airports that will receive this specific type of service (thin-demand routes).

Other potential factors were identified, but no reliable data source was found to inform future models. One example is the impact of a passenger terminal and its constructed area. Although most airport structures can be identified in aerial images, it is not always clear whether the identified construction constitutes a passenger terminal, the extent of its footprint, or the level of service provided.

Additionally, the methodology does not address other relevant themes identified in the literature review, such as the coexistence of subsidies and thin-demand routes and the challenges of operating smaller structures. These themes will contribute to a more comprehensive view of the problem and a better understanding of this niche of the air transport service.

After future models identify the relevant factors, aerodrome operators should be able to assess their infrastructure's potential to receive air transport services and prioritize investments to attract airlines operating in the thin-demand market niche, if desirable.

Ethics approval and consent to participate

Consent for publication

The authors have consented to the submission of the case report to the journal.

Availability of data and material

Data Will be made available up on request from the corresponding author.

Competing interests

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Authors' contributions

PTMR: Conceptualization, Research, Data Collection, Data Analysis, Validation, Final Version; MC: Conceptualization, Data Analysis, Validation, Final Version, Supervision. All the authors revised the paper.

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