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PRODUCTIVITY AND EFFICIENCY OF INTERNATIONAL AIRLINES

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ABSTRACT

This paper presents the published results of post-doctoral research conducted at the Brazilian Aeronautics Technological Institute (ITA), Brazil. The objective of this study is to evaluate the operational performance of the major Brazilian carriers during the period immediately following the deregulation of air transport in Brazil, comparing their performance with representative international counterparts. The process of deregulation of air transport in Brazil began in 2001 with the implementation of Law No. 10,365, known as the "Open Skies Law." This law allowed the entry of foreign airlines into the Brazilian domestic market and facilitated the operation of low-cost airlines. In this research, the aim was to compare the evolution of productivity and operational performance of full-service companies (FSC), regional airlines (RA), and low-fare/low-cost companies (LCC). The research concluded that Brazilian companies operating domestically demonstrated a productivity growth rate of 7.7% per year, surpassing the average of the sample. Additionally, the analysis revealed that low-cost companies exhibited superior operational performance compared to the full-service and regional airlines.

Keywords: Productivity, efficiency, air transport productivity.

1. INTRODUCTION

Until recently, regulations heavily controlled scheduled passenger and freight services in both domestic and international markets in most countries. However, experts in the air transport industry widely agree that unnecessary restrictive regulations have led to significant inefficiencies. Recognizing this limitation, governments, including Brazil, have initiated a deregulation process over the past two decade. The objective of the deregulation was to enhance competition among carriers, thereby improving efficiency and achieving cost reductions in air transport. This article is based on research conducted for a post-doctoral project titled “Productivity Analysis of the International Air Transport Industry” at the Brazilian Aeronautics Technological Institute.

2. PAPER STRUCTURE

Section 1 provides a brief introduction to the paper. The paper’s structure is outlined in Section 2. An overview of the Brazilian air transport market is presented in Section 3. Section 4 provides a concise theoretical framework for the paper. Section 5 covers the data, sources, and the

productivity measurement method employed in the study, along with the sampling criteria. This section also explores the potential use of the physical productivity concept within the Brazilian air transport industry context. The research findings are discussed in Section 6, and finally, Section 7 concludes the paper.

3. THE BRAZILIAN AIR TRANSPORT INDUSTRY

The Brazilian air transport domestic market holds the largest share among Latin American markets. According to the Air Transportation Action Group, Brazilian airlines account for 4.6% of America's international passenger market. According to data from the Brazilian National Civil Aviation Agency (ANAC), in 2019, air transportation in Brazil recorded the transport of approximately 103.9 million passengers. For comparison, in the same year, the air transport sector in the United States transported approximately 925.8 million passengers.

It should be mentioned, however, that the volume of passengers transported by air travel in Brazil during the year 2021 was significantly impacted by the COVID-19 pandemic. There was a considerable reduction in the number of passengers compared to previous years due to travel restrictions and implemented safety measures.

According to data from the Brazilian government available in September 2021, the Brazilian aviation industry represented approximately 3% of the Gross Domestic Product (GDP). However, it is important to note that this value may vary over time due to various factors, such as the country's economic performance, changes in the aviation sector, and external events like the COVID-19 pandemic.

According to data from the National Civil Aviation Agency (ANAC), the revenue of the aviation industry in Brazil in 2019 was approximately US$ 16.2 billion generating approximately 35,000 direct jobs.

Over the period from the late 1970s to the end of 2005, the industry's share in the Brazilian transportation matrix increased from 0.7% to 2.7%. The annual growth rate between 1997 and 2001 was 6.5%, with the peak occurring in 1998, marked by a 22% increase in passenger transportation within the domestic market.

In 2005, the Brazilian market was served by two Brazilian airlines in international markets (VARIG and TAM), and by three carriers in the national market (VARIG, TAM, and GOL).

Already in 2002, VARIG found itself in a difficult financial situation and entered bankruptcy

proceedings in 2006. After facing financial and operational difficulties, the company was unable to recover and declared bankruptcy on July 20, 2006."

Brazil stands out as the only Latin American country with a consolidated aeronautical industry, and a portion of its fleet is domestically manufactured.

Currently, in Brazil, there are 10 airlines operating, ranging from large to small, passenger to cargo carriers among them Gol Linhas Aéreas, LATAM Airlines Brasil and Azul Linhas Aéreas Brasileiras.

The company 'GOL Linhas Aéreas Inteligentes' was founded in 2001 and officially launched in January 2001. The Brazilian airline is known for its low-cost approach and was a pioneer in the concept of "intelligent airline" in the country. Since then, GOL has become one of the leading airlines in Brazil, offering domestic and international flights.

Azul Linhas Aéreas, established in 2008, is a prominent Brazilian airline renowned for its extensive domestic and international flight network. With a market share of approximately 28%, it provides a diverse array of destinations and has garnered acclaim for its customer service and innovative amenities.

The domestic passenger air market in Brazil in 2023 is heavily concentrated among three major companies: Gol Linhas Aéreas (38%), LATAM Airlines Brasil (34%), and Azul Linhas Aéreas Brasileiras (28%).

4. THEORETICAL FRAMEWORK

Deregulation of the US airline industry in 1978 initiated an abundance of literature concerned with the effect these recent changes have had on productivity (and, similarly, whether changes to European legislation would precipitate similar observed productivity advances). The demonstrable effects of successful US deregulation and ongoing inefficiency in the industry may have influenced the European Commission to introduce certain reforms to promote competition and thus increase the efficiency and productivity of the European airlines.

Much of the literature has concentrated on productivity in the United States compared against that in Europe (McGowan and Seabright 1989; McKinsey 1992, Good et al 1993), whereas only a small proportion of papers present productivity estimates for the European countries individually (Encaoua 1991). Moreover, many authors prefer to concentrate on Total Factor Productivity (Windle

1991) in favour of a labour productivity measurement.

The deregulation of the air transport industry in the United States and Europe had several significant consequences. Below, we mention some of the consequences regarding the deregulation of air transport in the United States and literature references that discuss them:

- *Increased competition and market entry*: Deregulation led to increased competition as new airlines were allowed to enter the market more easily, resulting in more choices for consumers and lower fares. Existing airlines had to adapt to the new competitive environment. See "Productivity Growth and Deregulation in the U.S. Airline Industry" by Morrison, C.J., and Winston, C. (1995).
- *Improved efficiency and productivity*: Deregulation incentivized airlines to become more efficient in order to remain competitive. It led to cost reductions, improved operational practices, and increased productivity in the industry. See "The Effects of Airline Deregulation on Airline Efficiency and Productivity Growth" by Bitzan, J.D., and Peoples, J.H. (2007).
- *Consumer benefits: Deregulation resulted in greater accessibility to air travel, leading to increased passenger numbers and improved affordability for travelers.*
- See "Deregulation and the Evolution of the Airline Industry" by Gaggero, A.A., and Piga, C.A. (2005).
- *Industry consolidation and bankruptcies:* Deregulation brought about structural changes in the industry, leading to consolidation and bankruptcies of some airlines as they struggled to adapt to the new competitive landscape.
- See "The Effects of Deregulation on Airline Competition: The Experience of Continental Airlines" by Brueckner, J.K., and Whalen, W.J. (2000).
- *Innovation and service differentiation:* Deregulation encouraged airlines to innovate and differentiate their services to attract customers, leading to the introduction of new business models and service offerings.
- See "The Role of Low-Cost Carriers in Air Transport Markets" by Alderighi, M., Cento, A., and Nijkamp, P. (2012).

References provided in this article are just a sample of the extensive literature available on the consequences of deregulation in the air transport industry. Further research and exploration of academic databases will provide a more comprehensive understanding of the topic.

5. METHOD AND DATA

5.1 PRODUCTIVITY MEASUREMENT METHOD

A Multi-Factor Productivity (MFP) index, encompassing the key production factors of labor and capital, was employed to gauge the productivity of the surveyed companies from 2000 to 2005.

5.2 MULTI-FACTOR PRODUCTIVITY

Total Factor Productivity (TFP) or Multifactor Productivity (MFP) refers to the ratio of quantities/volumes produced to a weighted combination of quantities and volumes of various inputs employed in the production process. The productivity measurement method utilizing changing-weight indices of outputs and inputs was employed by Creamer (1976) and Kendrick (1991). The Multi-Factor Productivity Index (MFP) is calculated as the ratio of the output index to the input index, with inputs weighted according to their share in production costs.

$$MFP = \frac{VA_t}{a_0(L_t) + b_0(K_t)} x100 \quad \text{(Equation 1)}$$

MFP in equation (1) indicates the Multi-Factor Productivity index measured in monetary terms, according to Kendrick's method, which in this case is calculated from the ratio between the added value of the airlines in year t and the weighted relationship of labor, e.g., salaries (L_t), and capital assets (K_t) in the same year, where a_0 and b_o represent labor and capital weights, respectively.

$$MFP = \frac{VA_t / VA_0}{a_0(L_t / L_0) + b_0(K_t / K_0)} x100 \quad \text{(Equation 2)}$$

Equation (2) is derived from equation (1), enabling the calculation of productivity growth in physical terms within a time period [0, t]. In this equation, AV_t represents the number of passengers transported or Revenue seat-kilometers (RSK), L_t corresponds to the number of employees at the end of period t (December 31st), and K_t denotes the number of aircraft operated at the end of the same period. The weights for labor and capital productivity, were obtained from information provided by the IATA Yearbook 2005, and consider the inputs 'share in the carriers' operational costs, as illustrated in Table 1.

In this instance, the productivity growth of the sampled companies was assessed within the timeframe of 2000 to 2005, which coincides with the immediate aftermath of the deregulation of the Brazilian air market. The weights assigned to labor (a_0) and capital (b_0) were determined based on the values specified in Table 1.

Table 1 | Weights for Labour and Capital Productivity

Airlines	(a_0)	(b_0)
North American	0,66	0,34
European	0,72	0,28
Asian	0,57	0,43
South American	0,61	0,39

Some authors, such as Moreira (1994, p.12), suggest the periodic substitution of weights a_0 and b_o to account for changes in the production structure and fluctuations in the relative prices of capital and labor. This proposal aligns with the recommendation of certain organizations like the American National Bureau of Economic Research, which advises updating these weights every five years.

5.3 THE CHOICE OF PHYSICAL PRODUCTIVITY

An important question in the context of productivity measurement is whether the productivity index should be measured in physical or monetary terms. However, measuring productivity in monetary terms for the Brazilian air transportation sector, where revenue is generated in an unstable currency and costs are either incurred or indexed to a stable currency such as the American dollar, can lead to distortions. To avoid measurement biases in Brazilian air transport, a physical productivity method was chosen.

5.4 PERFORMANCE METRICS

Besides the productivity index measured in physical terms the following metrics were used to assess the operational performance of the airlines:

- Transported passenger per employee;
- Revenue seat-km per employee and aircraft;
- Passenger load factor;
- Hours flown per aircraft and day

The data for the years 2000 and 2005 were gathered from various international and Brazilian publications, including the World Air Transport Statistics (IATA), the Digest of Statistics (ICAO), Fleet and Personnel Series (ICAO), Financial Data Series (ICAO), and the Brazilian ANAC commercial aviation yearbook. Two categories of inputs were considered: labor and flight equipment.

Labor was calculated using a composite index comprising five categories: pilots, co-pilots, other cockpit personnel, cabin attendants, and other personnel. Output consisted of two distinct components: scheduled revenue passenger-kilometers and the number of passengers transported. Capital was represented by the number of aircraft in operation.

5.5 SAMPLING CRITERIA

A total of 45 carriers were chosen for the sample and categorized as follows:

- 23 full-service airlines
- 4 low-cost/low-fare airlines
- 8 regional airlines

The selection of these airlines was based on the following criteria: (I) Representation and significance of the airlines in their respective markets (market share) and (II) consideration of carriers with accessible data and previous studies indicating favorable operational performance and productivity.

The detailed list included in the sample is provided below:

- Full service companies like Aeroflot, Aerolineas, Air France, Alitalia, Austrian, American Airlines, British Airways, China Southern, Continental, Delta, Iberia, JAL, Korean, Lan, Lufthansa, Air Canada, Singapore Airlines, Swiss, TAP, Thai, Turkish Airlines, TAM, and VARIG;
- Low-cost/low-fare companies like Air Berlin, Virgin Atlantic, America West, GOL, and
- Regionals companies like Pantanal, Penta, Portugalia Airlines, Rico, Riosul, Total, US Airways and America West.

Airlines that underwent significant output and input variations due to restructuring processes were excluded from this productivity analysis.

6. RESEARCH RESULTS

6.1 Productivity growth and operational performance

Table 2 presents a descending rank order of the sampled airlines based on MFP change from 2000 to 2005. Air Berlin is ranked first, followed by GOL and TAM, the two largest Brazilian airlines, in second and fifth positions, respectively. Among the top 10 in productivity growth, four are low-cost/low-fare companies, one is a regional airline, and five belong to the full-service category. The average productivity growth of the sample during the 2000-2005 period

was 16.0%, equivalent to 3.0% per annum, which exceeds the MFP growth of the air transport industry from 1972 to 2001 (2.0% per annum), as estimated by Duke and Torres (2005).

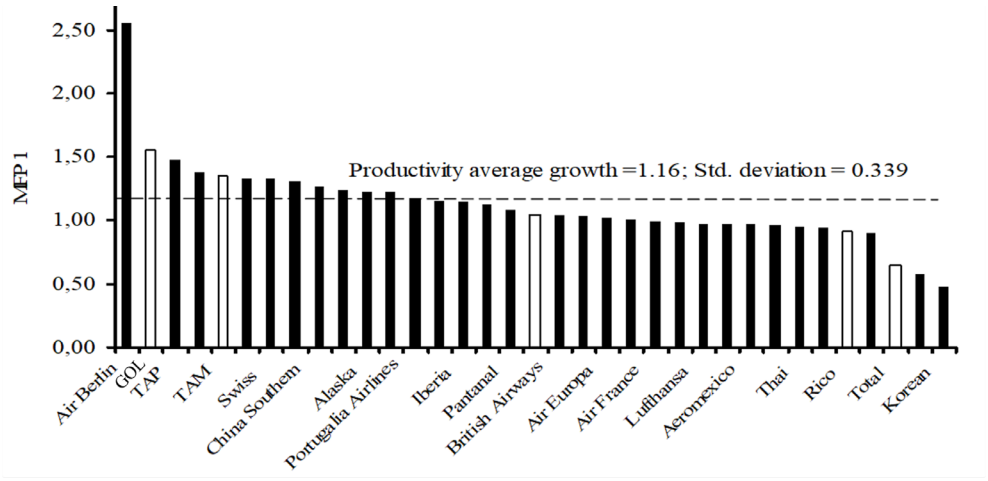
Table 2 | MFP1 Growth between 2000 and 2005

Pos.	Airlines	MFP 1	Pos.	Airlines	PMF 1
1	Air Berlin	2,556	19	British Airways	1,042
2	GOL	1,551	20	Continental	1,040
3	TAP	1,478	21	Air Europa	1,028
4	JAL	1,384	22	Singapore Airlines	1,008
5	TAM	1,346	23	Air France	0,995
6	Aeroflot	1,327	24	Lan	0,982
7	Swiss	1,327	25	Lufthansa	0,978
8	US Airways	1,305	26	Turkish Airlines	0,976
9	China Southern	1,266	27	Aeromexico	0,974
10	American Airlines	1,235	28	Virgin Atlantic	0,959
11	Alaska	1,231	29	Thai	0,949
12	Austrian	1,227	30	Jet Airways	0,939
13	Portugalia Airlines	1,162	31	Rico	0,910
14	Delta	1,153	32	Alitalia	0,900
15	Iberia	1,145	33	Total	0,650
16	America West	1,131	34	Aerolineas	0,583
17	Pantanal	1,083	35	Korean	0,480
18	VARIG	1,047			

Average productivity growth in 2000-2005 = 1.16; Standard deviation = 0.339.
Source: the author.

The two largest Brazilian airlines (GOL and TAM) experienced significantly higher productivity growth, at a rate of 7.7% per annum, compared to the average for the sample. However, the productivity performance of all Brazilian airlines, including the regional carriers, falls below the international standard for regional airlines during the same period (1.8% per annum) and lags behind foreign regional airlines' performance during the same period (+1.9% per annum). This situation is visually depicted in Figure 2. Multi-factor productivity was measured in two ways: MFP1 considered the number of passengers transported as the output, while MFP2 considered the number of Revenue Pax-km. Brazilian airlines are indicated by vertical bars, in white, in Figure 3.

Figure 3 | MFP1 growth in 2000 -2005.

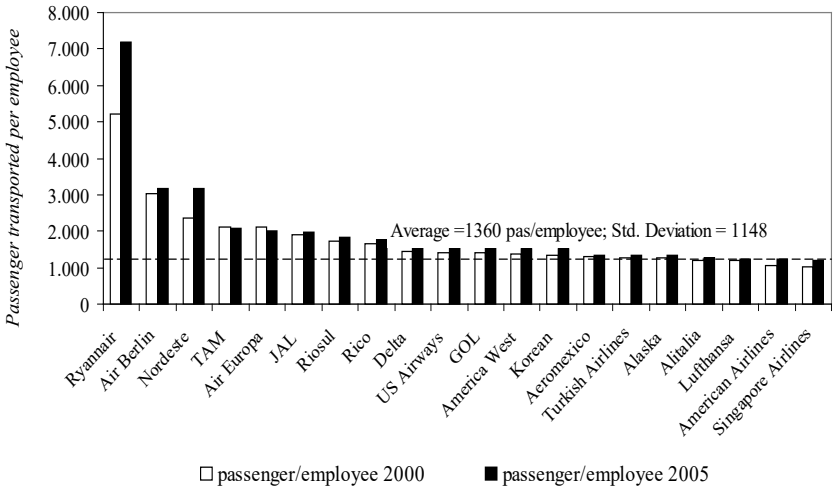


Source: the authors.

6.2 TRANSPORTED PASSENGERS PER EMPLOYEE

Regarding labor productivity (passengers transported per employee) in 2000, none of the traditional full-service companies were among the top 5 airlines, and only 6 of the top 20 carriers are represented among the most productive in terms of passengers transported per employee, as depicted in Figure 4. Almost all the companies improved their performance from 2000 to 2005. Low-cost carriers (LCC) Ryannair and Air Berlin had the best performance, in this regard. The hypothesis has been confirmed that, due to a better load factor and a lean personnel structure, low cost companies transport more passengers per employee than full-service carriers (FSC).

Figure 4 | Comparison of passengers transported per employee in 2000-2005 (20 best performance from the sample).

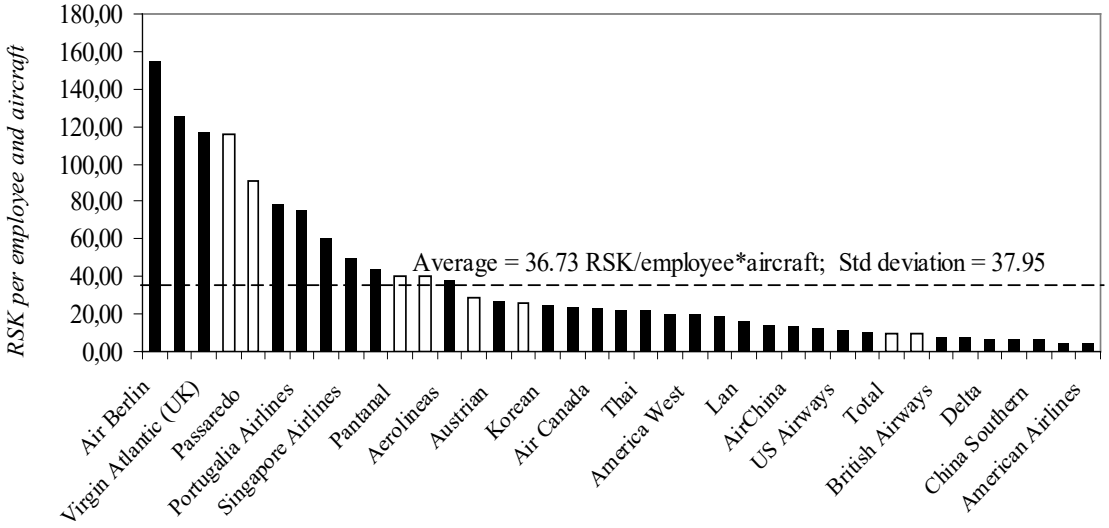


Source: the author.

6.3 REVENUE SEAT-KILOMETERS PER EMPLOYEE AND AIRCRAFT

Figure 5 illustrates that Air Berlin and Virgin Atlantic, two well-known European low-cost/low-fare companies, demonstrated the best performance in this metric in 2005. On the other hand, large full-service airlines such as American Airlines, British Airways, and Delta did not perform well due to their extensive personnel and fleet structures. The range of values in this metric is quite broad due to significant differences in company profiles and operational approaches. Among the sampled airlines, the largest full-service companies (FSC) exhibited the poorest performance. The standard deviation in this case was particularly high.

Figure 5 | RSK per employee and aircraft in 2005.

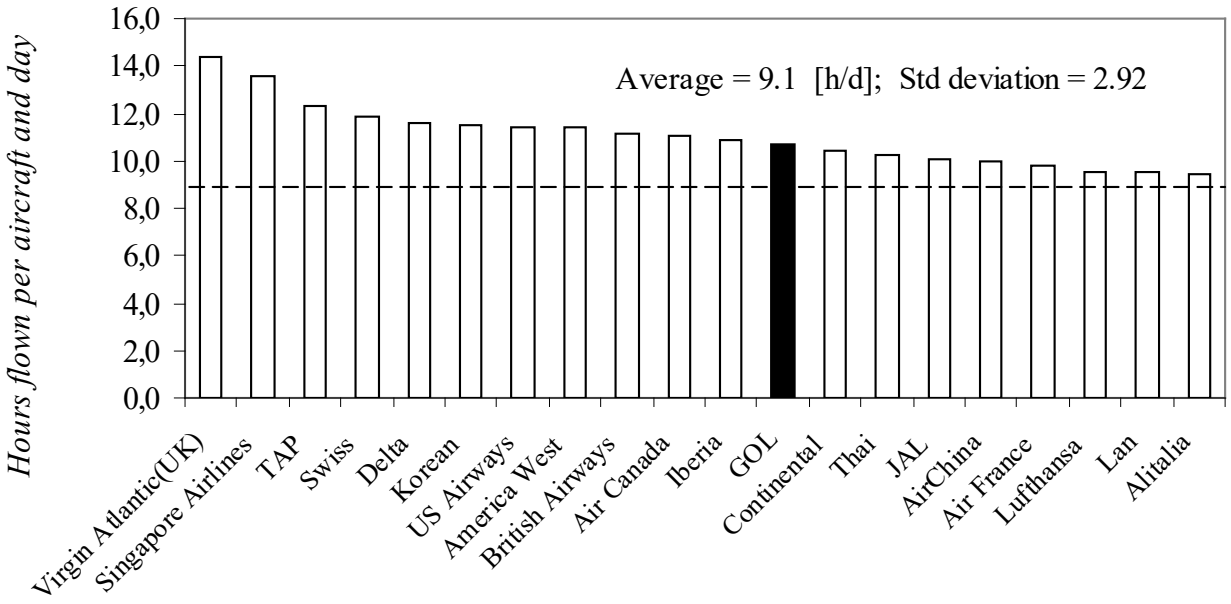


Source: the author.

6.4 DAILY FLIGHT HOURS PER AIRCRAFT

Low-cost/low-fare companies (LCC) and airlines with a significant presence in continental flights demonstrated the most efficient utilization of aircraft in terms of hours flown. Virgin Atlantic and Singapore Airlines held the top positions in this metric. The average aircraft usage across the sample was 9.1 hours per day, with a small standard deviation of 2.92. In 2005, Virgin Atlantic and Singapore Airlines flew an average of 14.4 and 13.6 hours per day, respectively. It is important to note that the number of hours flown may be underestimated as the IATA figures only consider scheduled operations.

Figure 6 | Daily flight hours per aircraft in 2005.



Source: the author.

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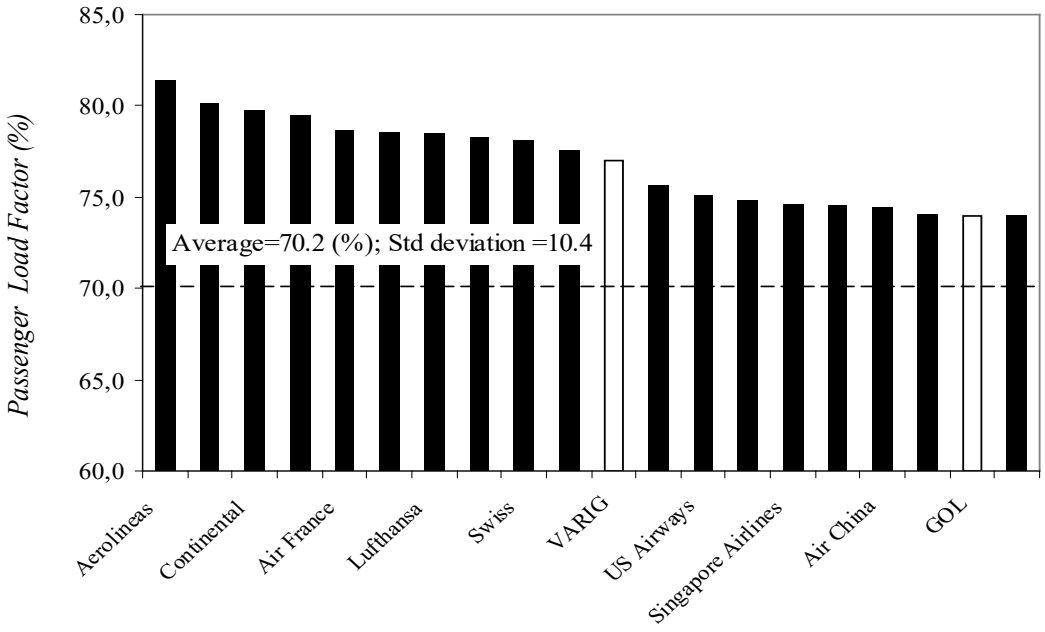
6.5 PASSENGER LOAD FACTOR

Regarding the passenger load factor in 2005, Aerolineas and Air Canada exhibited the highest performance within the sample of 45 airlines. On average, their fleets achieved load factors of 81.4% and 80.1%, respectively. Varig, influenced by its economic situation and significant tariff reductions, attained the highest passenger load factor among Brazilian airlines at 77%, followed by GOL at 74% and TAM at 73%.

Figure 7 | Passenger load factor in 2005.



Source: the author.

CONCLUSION

The deregulation and market opening in the early 2000s exposed Brazilian carriers to competition, compelling them to reduce prices in order to maintain or expand their market share. This strategy had an impact on demand. Similar improvements in productivity were observed among Brazilian airlines, as well as American and European carriers, following deregulation, as reported in the literature. This study highlights the productivity advantage of Low-Cost Carriers (LCC) over Full-Service Carriers (FSCs) and regional airlines.

Comparing productivity growth among airline classes, low cost companies demonstrated the best performance with an annual increase of 4.4%, followed by full service companies with 3.0% and foreign regionals with 1.9% per year.

Brazilian companies operating domestically exhibited productivity growth above the sample average at 7.7% per year. On the other hand, Brazilian regionals underperformed compared to the overall productivity average of the sample, experiencing a decline of 1.8% per year. This was attributed to low demand density on routes and underutilization of their fleet.

In general, low cost companies exhibited superior operational performance compared to

full service and regional airlines, as evidenced by higher passengers transported per employee and Revenue Seat Kilometers (RSK) per employee. This can be attributed to the better utilization of their aircraft, with an average of 14 hours flown per airplane day in 2005, compared to the overall sample average of 9.25 hours flown per day. The study also revealed a significant statistical correlation between productivity growth, hours flown per aircraft, and the passenger load factor.

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