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OPERATIONAL EFFICIENCY AND MARKET CONCENTRATION: A COMPARATIVE ANALYSIS OF BRAZILIAN AIR PASSENGER TRANSPORT COMPANIES

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ABSTRACT

The airlines constitute the central element of the air transport production chain. Brazil has been consolidating as one of the main markets of the sector in the world, with rising annual growth rates of passengers since the beginning of the 21st century. Despite this positive scenario of market growth and the country's great experience in the commercial airline sector, there is a turbulent environment in this industry, with bankruptcies, consolidations and acquisitions of companies. The goal of this article is to analyze the efficiency of this industry, through the data envelope analysis (DEA), in view of the market share currently possessed by airline companies. As a result, we observed that the largest companies in the sector are not operating on the efficiency edge, and so we suggest an increase in this aspect to make them more attractive and competitive in their market area.

Keywords: Brazilian Airlines; DEA; Concentration

1. INTRODUCTION

The relevance of the airline sector to the world economy and to each country in particular is unquestionable. The international air transport association (IATA, 2008) states that the global economic impact of aviation, that is, the effects from direct, indirect, induced and/or catalytic events reach around US$ 3,560 billion, an equivalent to 7.5% of the world's Gross Domestic Product (GDP).

The aviation sector in Brazilian territory contributes with R$32 billion for the formation of GDP, according to the Oxford Economics (2011). This accounts for 1.0% of the country's GDP. This expressed total comprises R$ 13.3 billion from the direct aviation sector, namely, airlines, airports, and services offered in soil and airspace; R$ 11.5 billion as indirect contribution through the supply chain of the sector; and R$ 7.3 billion from the expenses of aviation employees and their supply chain. In addition, tourism brings approximately R$ 9.9 billion in benefits to this economic activity.

Air transport is a sector with international characteristics, with stakeholders in several countries, where the expansion of economic relations and globalization are elements that affect it in an expressive way. Thus, we perceive that this economic activity generates many outputs to the society as a whole and has great relevance in the logistics of the companies of all the sectors of the economy. However, in spite of the great aeronautical tradition of Brazil, air transport still has a percentage of contribution to the formation of GDP below of that observed worldwide.

According to IATA (2011), the air transport market and the airline industry underwent many changes over the last 40 years. The number of passengers increased 10-fold and cargo volume grew 14-fold, despite repeated shocks from recessions, terrorism and diseases. Demand is volatile but the trend is the return to rapid growth. Supply has also changed significantly, having been a highly regulated sector during the first three decades of the postwar period. But access to the market is increasingly less regulated, starting with US

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domestic markets in the late 1970s, followed by US "open skies" policy in international markets since the early 1990s, And the single European aviation market in the mid-1990s.

According to Brazilian National Civil Aviation Agency (ANAC) (2014), the number of people transported reached 107.2 million passengers, an increase of 188% over the last 10 years. Thus, we can observe the growth the sector has experienced over time. However, although Brazil has experienced a substantial growth of the sector, and is currently following the same steps of liberalization of the air transport market when compared to other parts of the world, financial outcomes of the national airlines have been negative, unlike what happens in companies of this branch in other parts of the world, a fact that emphasizes the relevance in investigating the reasons for this discrepancy.

In this context, the quest for minimizing the mismatch between passenger demand and air infrastructure makes the concern with the management of the elements that integrate this sector gain importance. The productivity of air transport becomes imperative in this scenario, which presents the airlines as one of its fundamental elements. Brazilian airlines suffer from the instability of the sector, which, in turn, depends on the macroeconomic scenario that the world economy experiences. This contributed to the fact that the Brazilian passenger air transport industry has experienced troubled times and to the restructuring of some elements of this productive chain, either by regulation or by market mechanisms.

This way, the present study aims to perform a comparative analysis of the operational efficiency of Brazilian passenger airlines in operational terms in 2013 with their market concentration. The expected result is the construction of a relationship between the efficiency of these companies and the market power they hold.

The present article is divided as follows: section 1 presents the introduction, contextualizing the study with respect to the subject studied. Section 2 presents a review of the literature on the main topics needed to understand the work. In section 3 we demonstrate the applied methodology, as well as the main concepts related to it. Section 4 presents the results obtained by applying the methodology presented in the previous topic. Finally, section 5 addresses the main conclusions found by the study.

2. LITERATURE REVIEW

The aviation production chain encompasses a number of elements, including airlines. According to Tretheway et Markhvida (2014), they occupy the central element of the aviation value chain. This consists of some interlinked activities that can be divided upstream and downstream.

Figure 1 illustrates the above.

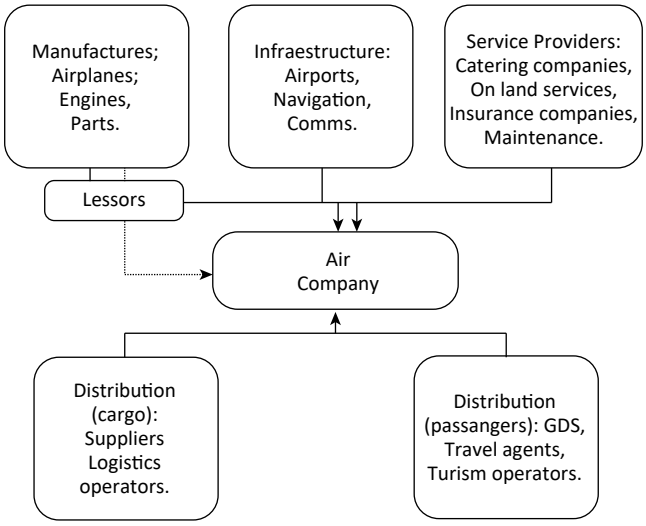

Figure 1. The commercial aviation value chain
Source: Based on Tretheway et Markhvida's research (2014)

The figure shows that the upstream activities are related to: the aircraft, engine and component manufacturers that are intermediated by their lessors; Infrastructure for airports, air navigation and air communication providers; And other service providers, such as fuel suppliers, insurance and on-land service companies, and others.

In relation, the activities for passenger transport listed downstream, they encompass aspects related to distribution, i.e., tour operators, travel agents and global distribution systems.

The aviation supply chain is characterized by a high degree of vertical disintegration. As a general rule, airlines have little or no participation in other sectors of the value chain. Over the years, airlines have been trying to uncouple their share in various sectors of the aviation value chain, either as a result of changes in national laws, regulatory interventions, or as decisions to improve business competitiveness and financial performance (Tretheway et Markhvida, 2014).

Due to the importance that this activity plays in the aviation production system, what is expected is that it stands out compared to the others in terms of performance. However, what is observed during its existence are troubled moments that result in bankruptcies of some or acquisitions and mergers of others.

Fernandes et Pires (2012) state that airlines require substantial financial investment, especially in new aircrafts, fleet maintenance and information systems, in order to establish air transport operations and growth in the industry. To meet passenger demand, the system must balance these and

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other factors, such as operating costs and expenses, fleet adequacy for each route, and company profitability.

According to a recent study by IATA (2014), airline profit margins are still small compared to the costs and revenues they have. Figure 2 below shows the forecast of the results of these companies, in 2014, per passenger.

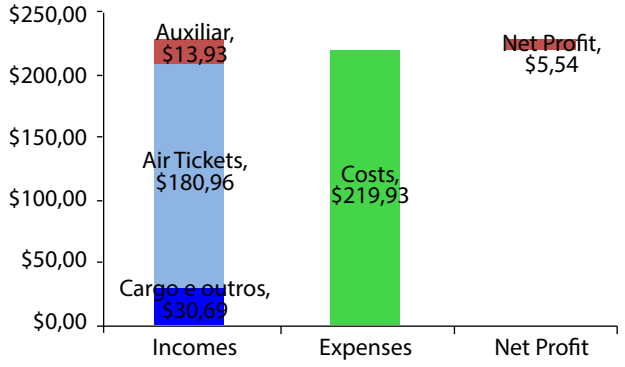

Figure 2. Forecast of airline companies results in 2014
Source: Based on IATA reports, 2014

The civil aviation sector has the characteristic of having a high risk related to it and great maintenance costs. In addition, local companies have a greater challenge than the global ones, considering that revenues are in Reais and part of their costs and operating expenses have to paid in dollars (Camargos et Minadeo, 2007), decreasing their profitability once That, historically, the foreign currency is more valued than the national one.

Therefore, among other reasons, Brazilian passenger transport companies have obtained a lower net profit than the other companies operating in the global market. According to data from ANAC (2013), the two main Brazilian companies, GOL and TAM, have been receiving negative results since 2011. In addition, the aviation sector passed through a scenario of lower economic growth in 2013 Brazilian currency, increase of prices of the oil barrel and US currency compared to Real. These facts affected the demand for air tickets.

Increasing competitiveness in the aviation industry, in order to provide a quality service that meets the demand, is a subject of great prominence and complexity, because many are the factors that define its performance.

According to Correia et Soares de Mello (2008):

> "The Data Envelopment Analysis (DEA) method is a mathematical tool that measures the relative efficiency of the DMU's (Decision Making Units). It compares what has been produced (outputs), given the available inputs, with what could have been produced with the same resources. In addition, it sets efficiency goals, through the identification of benchmarks for units below the efficiency border."

Several studies have applied the DEA in order to evaluate the performance of airlines, as shown in Table 1 below.

Distexhe et Perelman (1994) developed a study using DEA in three different periods in order to evaluate if there was an increase in the efficiency of airlines after the deregulation of the sector in 1978 in the USA. In this same sense, Good et al. (1995) analyzed the performance of American and European companies in a total of 16 companies during the period 1976 to 1986, to evaluate how much liberalization of the sector has impacted on the efficiency of airlines.

In 2008, Greer (2008) used DEA to analyze the productivity changes of the main American passenger airlines from 2000 to 2004, with a total of 7 companies; While Barbot et al. (2008) adopted DEA as methodology to verify the efficiency of 49 companies worldwide in 2005.

The research carried out by Merkert et Morrel (2012) used the DEA methodology in a sample of 66 airlines worldwide in two different periods, in order to verify if the efficiency of these companies improved over time.

The study developed by Barros et Couto (2013) evaluated the changes in productivity of European airlines, that is, 23 companies, combining operational and financial variables of the years 2000 and 2010.

Also, Tavassoli et al. (2014) proposed in 2014 a model to evaluate both the technical efficiency and the effectiveness of the services provided by the airlines. In this case, 11 Iranian airlines were assessed using data from 2010.

Although Li et al. (2015) have made a study in three stages, as operational, services and sales analyzes, the most relevant for this research is the operational one. The case previously evaluated used 22 airlines for the period from 2008 to 2012.

Finally, an analysis of strategic alliances was made by Min et Joo (2016) using data from the year 2010 for 8 members of Sky Team, 27 of Star Alliance, 9 of One World; and 15 which were not part of any alliance.

3. METHODOLOGY

In order to meet the goal proposed in this article, we used the data envelopment analysis, also known as DEA, as methodology. This is a nonparametric linear programming tech-

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Table 1. Studies using DEA in the airline industry

Year	Authors	Title	Inputs	Outputs
1994	Distexhe and Perelman	Technical efficiency and productivity growth in an era of deregulation: the case of airlines	Takeoffs	RTK (cargo)
			Airplanes	Passengers
			Crew onboard	RTK (cargo)
1995	Good, Roller and Sickles	Airline efficiency differences between European and the US: implications on for the pace of EC integration and domestic regulation.	Work	Cargo services
			Energy and other material	Passenger services
			Air fleet	Eventual services
2008	Greer	Nothing focuses the mind on the productivity quite like the fear of liquidation: changes in airline productivity in the United States	Work	Seats (capacity)
			Fuel	ASM
2008	Barbot, Costa and Sochirca	Airlines performance in the new market context: A comparative productivity and efficiency analysis	Fleet	ASK
			Work	RPK
			Fuel	RTK (cargo)
2008	Correia and Soares de Mello	Avaliação da eficiência das companhias aéreas brasileiras com modelo DEA nebuloso	Takeoff maximum weight	RPK
				RTK (cargo)
2012	Merket and Morrel	Mergers and acquisitions in aviation – Management and economic perspectives on the size of airlines	ATK	RPK
			Work	RTK (cargo)
				Income
2013	Barros and Couto	Productivity analysis of European airlines, 2000–2011	Employees	RPK
			Operational costs	RTK (cargo)
			Available seats	
2014	Tavassoli, Faramarzi and Saen	Efficiency and effectiveness in airlines performance using a SBM-NDEA model in the presence of shared input	Planes (passengers)	Passenger * Km
			Planes (cargo)	Ton * Km
			Employees	
2015	Li, Wang and Cui	Evaluating airline efficiency: An application of Virtual Frontier Network SBM	Employees	ATK
			Fuel	ASK
2016	Min and Joo	A comparative performance analysis of airline strategic alliances using data envelopment analysis	Operational costs	Operation income
			Underutilization	Passengers
				RPK

Source: Authors' study

nique that offers some advantages over parametric methods to estimate the efficiency border. It builds the efficiency border based on the observation units, DMUs (decision making units, the airlines in this case), and the inputs and outputs related to them. In order to carry out the evaluation of the efficiency, we made use of the SIAD program (Angulo Meza et al., 2005).

The methodology was proposed by Charnes et al. (1978) and Banker et al. (1984), with the following most used two models: the CCR and the BCC. The first one deals with the construction of a non-parametric efficiency frontier with constant returns of scale, while the latter considers variable returns of scale, so the relation between inputs and outputs is no longer proportional.

The input orientation aims at generating the same quantity of products while minimizing the use of resources. On the other hand, the orientation to output intends to maximize production while keeping a steady amount of resources. This way, the input orientation minimizes inputs, just satisfying the output levels provided. On the other hand, output orientation maximizes outputs without requiring more from any of the observed input values (Cooper et al., 2006).

Following figure 3 demonstrates an example with two outputs and one input. Thus, a frontier of the best results is drawn considering a determined amount of resources. A, D and E DMUs are at the efficiency frontier, while point B is an inefficient DMU which has D and E as efficiency benchmarks

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(Souza et al., 2008). The analysis can be done for both the input and output orientations.

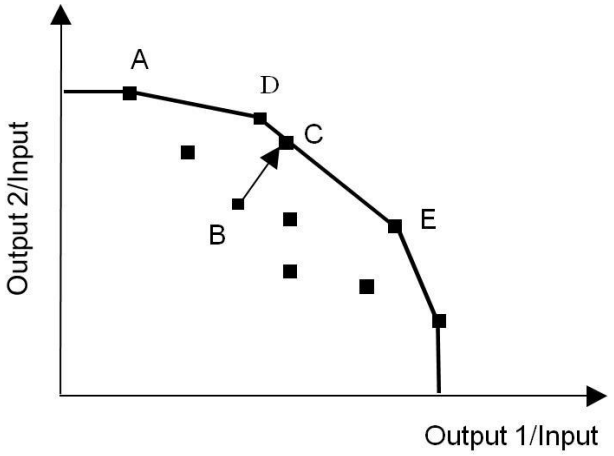

Figure 3. Results-Based Efficiency
Source: Based on studies by Souza *et al.* (2008)

This article analyzed the efficiency of the companies through the two models. However, the one that comes closest to the reality of the chosen variables is the output-oriented CCR. The output-oriented CCR model (Charnes et al., 1978) proved to be the closest to the reality of the chosen variables, since in this work the main interest of the companies would be to glimpse how much they could obtain from passengers given a fixed number of seats, since the companies have a limited quantity of airplanes.

Cooper et al. (2006) determine that, for the case of the BCC-E-O (primal) multipliers model, the following linear programming problem primitives are involved:

$$\begin{aligned} \max_{\eta_B,\mu} \quad & \eta_B \\ Sujeito\ a: \quad & x_o - X \cdot \mu \geq 0 \\ & \eta_B \cdot y_o - Y \cdot \mu \leq 0 \\ & e \cdot \mu = 1 \\ & \mu \geq 0 \end{aligned} \qquad (1)$$

Whereas: η_B = The efficiency of the BCC-E-O model;

μ = Vector of variables related to the reference set;

e = Vector line with all elements equal to 1;

x_o = Vector of observed inputs;

y_o = Vector of observed outputs;

X = inputs matrix;

Y = outputs matrix.

Cooper et al. (2006) define the following variables for the case of an output-oriented CCR-E-O multipliers (primal) model:

$$\begin{aligned} \max_{\eta,\mu} \quad & \eta \\ Sujeito\ a: \quad & x_o - X \cdot \mu \geq 0 \\ & \eta \cdot y_o - Y \cdot \mu \leq 0 \\ & \mu \geq 0 \end{aligned} \qquad (2)$$

Whereas: η = The efficiency of the CCR-E-O model;

μ = Vector of variables related to the reference set;

x_o = Vector of observed inputs;

y_o = Vector of observed outputs;

X = inputs matrix;

Y = outputs matrix.

In this case, x is the input used by the DMUs represented by the total number of seat-kilometers offered (ASK) by the airlines, and y represents the outputs produced by the DMUs, in this case, the passengers per kilometer transported (RPK) and the passengers transported (PAX) by the companies. It should be noted that the data refer to the year 2013.

For the use of the DEA methodology, we took the following steps: first, it was necessary to characterize the problem, then define the performance to be measured and the sample to be studied (DMUs). With this done, the next steps were to choose the relevant variables, then defining and applying the model and finally analyzing the results.

Subsequently, we used the Herfindahl-Hirschman Index, also known as HHI (Hirschman, 1964), to measure the size of companies in relation to the industry and to obtain an indicator of competitiveness among them, according to equation 2 already discussed.

$$HHI = \sum_{i=1}^{n} s_i^2 \qquad (3)$$

Above, Si is the market share related to each airline, and the number of passengers per kilometers carried (RPK) is the measure used to make the calculation. The airlines with international operations had the national and international values added according to the data made available by ANAC (2013).

The result of the measure shows whether the market in which the company operates is considered concentrated or not, according to the following metrics, as stated by U.S.

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Table 2. Result of the efficiency of the companies according to DEA

2013	Input 1	Output1	Output 2	CCR	BCC
	ASK	RPK	PAX		
Azul	14478490	11614927	13344740	0,901758	1,000000
Gol	44110363	31218979	34126726	0,795564	1,000000
Avianca Brasil	7679368	6306060	5899693	0,923059	1,000000
MAP	33085	15626	31940	0,552058	0,554306
Passaredo	645819	421006	725850	0,732781	1,000000
TAM	44344748	35182543	36313021	0,891830	1,000000
Sete	65662	43623	79142	0,746790	0,746925
Trip	4427478	3343928	5316660	0,848980	1,000000
Total	80701	71793	24252	0,707828	0,714103
Brava	19593	7553	24252	0,707828	0,714103
Mais	440	335	374	0,855833	1,000000

Source: Authors' study

Department of Justice and The Federal Trade Commission (2010):

- HHI < 0,01, indicates a highly competitive market;
- HHI < 0,15, indicates a not-concentrated market;
- 0,15 < HHI < 0,25, indicates a moderately concentrated market;
- HHI > 0,25, indicates a highly concentrated market.

From that point on, the efficiency results of Brazilian air passenger transport companies were analyzed compared with the market power they hold.

4. RESULTS ANALYSIS

In order to calculate the efficiency of Brazilian passenger airlines, we gathered the data made available by ANAC (2014) regarding 11 companies, air transport yearbook and the demand and supply report from 2013 year base. The results obtained are shown in Table 2 below.

The scores found in Table 2 indicate that the best model to be used in this case is CCR, since there is a proportionality between the input and the outputs chosen. And, according to this model, the only company that could be considered efficient is Total Linhas Aéreas.

Total Linhas Aéreas is currently a company operating specifically in the charter segment. Therefore, it presents a great operational efficiency in its activities, since it's very uncommon that a client requests the chartering of an airplane and leaves several empty seats in it during the service rendering.

When evaluating the companies which are closest to the efficiency frontier and working with regular passenger transport, the study pointed Avianca Brasil and Azul as more efficient companies than TAM and GOL, for example.

Many people believe that there is a relationship between the market power held by the company and the operational efficiency it has developed throughout its operations. To verify this relationship, the HHI was used to confirm if this premise is true. The calculated value resulted in 0.31, a score that reflects the high concentration of the industry. The market share for each company in terms of passengers per kilometer transported, RPK, and the net profit of each company made available by ANAC (2014) are shown in table 3. It is noteworthy that not all companies have their net profit numbers available to the general public.

Table 3. Scores related to market share and net profit of companies

2013	Market Share	Net Profit
Azul	13,16%	R$136.462
Gol	35,39%	-R$709.774
Avianca Brasil	7,15%	-R$36.511
MAP	0,02%	-
Passaredo	0,48%	R$0
TAM	39,88%	-R$1.653.286
Sete	0,05%	-
Trip	3,79%	-R$73.359
Total	0,08%	R$4.052
Brava	0,01%	-
Mais	0,00%	-

Source: Authors' study.

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Table 3 shows that the largest Brazilian passenger airlines are TAM and GOL, the former holding almost 40% of the Brazilian market, followed by GOL, which owns approximately 35% of this market. We highlight that these data only contemplate the national scenario of these companies.

When we analyzed the net profits of the companies that were published, we perceived that the market power does not assure the positive returns resulting from investments made, since in the year of 2013, the largest companies presented losses. It is worth mentioning that the available values are scaled in thousands of Real currency.

5. CONCLUSIONS

Airlines have a key role to play in the value chain of air transport, which in turn has great relevance in the global economy. While carrying out this study about the operational efficiency of Brazilian passenger airlines and the market power they hold, we verified that their efficiency is not directly linked to the market share they own. This fact indicates that a company that has a large percentage of the market is not necessarily an efficient company.

This is also seen in financial terms, as the study shows that the largest Brazilian companies failed to present attractive financial results for investors in 2013 regarding their demand. This fact suggests a need for an increase in the efficiency of companies, in order to make them more attractive and competitive in the market in which they compete.

Thus, we concluded that although many companies adopt the strategy of increasing their respective market share in order to increase their financial results, this attitude may not be the most appropriate for the passenger air transport sector. As we can see throughout the development of this work, the operational efficiency may not be directly linked to the size of the market held by the companies.

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