ANALYSIS OF ROUTES OVERLAPPING EFFECTS ON THE EFFICIENCY GAINS IN AIRLINE MERGERS

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ABSTRACT

Companies from several sectors may experience merger and acquisition initiatives (M&A) seeking improvements in productivity and reduction of costs. In the air transport industry, mergers may occur between companies with different degrees of competition. A suggested measurement of competition is the number of routes that are operated simultaneously by the companies, i.e., the routes overlapping. In order to investigate the effects of routes overlapping in the productivity gains for airlines in a merger process, we assess two pairs of airlines that have carried out a merger process: American Airlines/U.S. Airways and United Airlines/Continental Airlines. Data shows that the first merger involved companies with more routes overlapping than the second one. To compare productivity gains for these companies, a Cobb-Douglas production function relating RPM with ASM, number of employees, and fuel consumption was applied for a period of 12 months before the merger for all mentioned airlines, and for periods of 12, 24 and 36 months after the merger for the resulting companies. The data was obtained from the USA Bureau of Transportation Statistics. The results evidenced that the merger with more competition showed a diminishing return to scale just after the merger. However, in the following periods, there was increasing return to scale. In contrast, the merger with less previous competition showed increasing return to scale after the merger. These results suggest that when there was a merger between airlines that compete more, at the first moment, the resulting company experienced negative effects on its productivity probably due to difficulties to reduce inputs, or to proportionally increase the outputs, and to restructure the new company. The results also show that both resulting companies demonstrated gains in efficiency after the merger in the long run.

Keywords: Airlines merger, Routes overlapping, Theory of production, Cobb-Douglas

1. INTRODUCTION

The theory of production plays a fundamental role in the industry as a tool for the economic management of companies. This function aims to identify how the inputs are combined to generate a product or service most efficiently and what is the weight of each of them within the productive chain.

Productivity in air transport is defined as the relationship between the production, measured by the sum of the total number of transported passengers multiplied by their traveled distance (Revenue Passenger-Miles, RPM), and the inputs necessary for its achievement. The greater the relationship between the quantity produced and the inputs used, the higher the productivity (Barros, 2007).

Empirical studies of this nature can be useful for understanding the production structure of air transport companies. The production function can be a support tool for airlines managers since it helps in planning the allocation of resources (labor, materials, and equipment) to achieve better productivity. These functions can also predict and identify capacity expansion needs and choose strategic operating alternatives (Guterres and Correia, 2007).

Seeking improvements in productivity and reduction of costs, companies from several industrial sectors are experiencing merger and acquisition initiatives (M&A). The difference between a merger and an acquisition is that, in the first case, two or more companies join to create a new one, while an acquisition represents the purchase of one company by another one. Mergers and acquisitions among similar companies are denominated as horizontal mergers, aiming to increase efficiency and synergy through a larger market share and reduced costs. Mergers and acquisitions are alternative forms of exogenous growth. In general, a merger or an acquisition has a positive impact on the efficiency of airlines (Barros, Liang, and Peypoch, 2013).

The variations in infrastructure, staff, market share, among other factors, caused by mergers or acquisitions between airlines drive productivity fluctuations over time. Based on this approach, this study proposes the estimation of a Cobb-Douglas production function for two processes of M&A between airlines in the United States: American Airlines and US Airways, which began in December 2013 and was completed in October 2015 with the resulting company adopting the name of American Airlines; and United Airlines and Continental Airlines, which was consolidated in 2010 and made the United Airlines the largest airline at that moment (Shen, 2017).

Several factors may determine gains in efficiency when firms invest in M&A. According to Yan et al. (2019), airline mergers are expected to bring efficiency gains by aggregating the traffic volumes of the firms involved. Higher traffic volumes allow the use of larger and more efficient aircraft, besides a more intensive utilization of aircraft, airport facilities, and ground equipment with a possible reduction of average costs.

An essential determinant of efficiency gains with M&A is related to the level of competition before the merger, represented by the total quantity of routes simultaneously operated by both companies (routes overlapping). This study analyzes the effect of different levels of competition before the merger in the productivity gains obtained by the merged companies.

2. MERGERS, ACQUISITION, AND EFFICIENCY

The airline industry is known for providing frequent low profits and having a history of bankruptcy. Among the factors that contribute to this scenario are undue government regulation, network-driven structure, high labor cost, fuel and capital prices causing high variable and fixed costs, variation in demand due to seasonality, which results in revenue vulnerability, destructive competition, dependency on weather and other climate conditions, subjection to infrastructure conditions, and uneven competition due to state subsidies in other countries (Ingold 2003). To face this scenario, airlines have explored other sources of revenue such as charging ancillary fees, additional charges for food and beverage for economy passengers, extra fees for preferred seats and checked-in luggage for passengers who have not attained premium frequent flyer status, rebooking and cancellation fees (Manuela and Rhoades, 2014).

The challenges for the air transport industry lead airlines to invest in M&A, seeking to improve their profits since there may be an increase in revenues and improvements in non-labor costs, as pointed out by Hanlon (2007). Two long-term strategic motivations for mergers are growth and improvements in synergy. Firms choose M&A to seize critical opportunities since M&A tend to create synergy by either promoting savings or creating opportunities for revenue enhancement (Manuela and Rhoades, 2014). Reduction in average costs is an important result to be sought in an M&A decision. Ryerson and Kim (2014) point the late 2000s - early 2010s was a period of frequent mergers, partially caused by the rising fuel prices.

Mergers are widely studied in the literature. Manuela and Rhoades (2014) examined the announcement and post-merger effects of three US airlines mergers: America West and US Airways (2005), Delta and Northwest (2008), and United and Continental (2010), and found that there was even an increase (United, America West, Continental) and decrease (Delta and Northwest) in the share prices of these companies. However, factors related to the economic scenario when the mergers were revealed may have influenced the effects of the announcement on the companies' share prices.

By looking at an operational aspect of the companies involved in a merger process, Ryerson and Kim (2014) investigated how fuel costs may be reduced with mergers. The authors noted that after the merger, companies might reorganize their network structure, allowing them to transfer flows at the same time costs are reduced due to economies of scale. In this way, operations are consolidated while the companies' connectivity is maintained. Ryerson and Kim (2014) found that reduction of the fuel consumption by the companies overcame possible degradation in the passenger service level.

Several studies have been carried out to determine if M&A results in airline productivity improvements. By analyzing the merger of Chinese airlines, Yan et al. (2019) found that the mergers increased the productivity of the involved companies. For Johnston and Ozment (2013), major US airlines experienced increasing returns to scale with this process. On the other hand, some studies identify mergers that do not result in gains in productivity. Fregnani et al. (2019) encountered diseconomies of scale in the acquisition of Webjet Linhas Aéreas by GOL Linhas Aéreas, suggesting increasing costs due to the duplication of administrative features of the two companies in the years right after the merger. Similarly, Gudmundsson et al. (2017), by analyzing 19 M&A processes, concluded that mergers might have caused increasing in costs when they involved airlines with a large difference in their size.

Regarding the complementary of routes, Shaw and Ivy (1994) studied the effects of mergers in the network strategy and identified three classifications for the merged networks: single carrier dominant, overlapping, or complementary. The single carrier dominant pattern results when the cities of a merged network are overwhelmingly dominated by only one of the two carriers. Complementary networks are those in which the main attended cities of the individual carriers contribute equally to the main cities list for the merged network. Overlapping networks happen when the hubs for the individual carriers are somewhat similar. Shaw and Ivy (1994) conclude that no merger pattern is clearly best under all circumstances and that other factors such as financial position, congestion, employee relations, etc., also play a role in the subsequent decisions on the adjustments of hubs and linkages.

Studies of the effects of competition in mergers are frequent; however, the focus of the majority is on price formation. Shen (2017) demonstrated that after the United and Continental merger occurred, the resulting company increased airfares significantly in nonstop markets where they previously competed, despite the US Department of Justice (DOJ) had approved the merger expecting that the small number of overlap routes between these airlines would generate significant efficiency gains for consumers. On the other hand, Luo (2014) concluded that the prices for airport pairs where Delta and Northwest competed before the merger did not increase much following the merger.

Different from the focus of Shen (2017) and Luo (2014), this paper intends, through a study case, to analyze the effects of different levels of previous routes overlapping in

productivity gains after the merger by calculating the production functions of the involved companies before and after the merger' conclusion. This study considers the mergers of American Airlines and US Airways (2015) and United Airlines and Continental Airlines (2010), using monthly data from three years before and after each merger.

3. METHODOLOGY

3.1. The Cobb-Douglas Function

The Cobb-Douglas production function represents the relationship between an output and the various inputs. It is possible to analytically estimate the production function through an exponential model that allows the analysis of the theory of marginal productivity simply and efficiently. Equation (1) expresses the Cobb-Douglas production function in its simplest format.

$$Q = AK^{\beta 1}L^{\beta 2} \quad (1)$$

Where Q represents the production (output), K and L represent the inputs, A is the constant number of the function, and β_1 and β_2 are the elasticity parameters. In Equation (1), the relation between production and the two inputs is not linear. However, a logarithmic transformation is made in this model according to Equation (2).

$$ln\,(Q) = \alpha + \beta_1 \ln(K) + \beta_2 \ln(L) \quad (2)$$

Equation (2) is the linear format of the production function. It allows the application of the ordinary least squares method using a set of historical data for the output and the selected inputs to estimate the elasticity parameters β_1 and β_2.

An important property of this function is that if all inputs are multiplied by a factor μ, the Q function will be multiplied by μr where $r = \Sigma_i^n \beta_i$ represents the returns to scale (or factor of homogeneity). When r = 1, the returns to scale are constant. When r < 1, there is a diminishing return to scale, and when r > 1 represents an increasing return to scale (Fregnani et al., 2019). From the traditional economics perspective, returns to scale are a characteristic of a particular production function. They describe the impact of scaling all inputs up or down in constant proportions on the output. Increasing return to scale refers to a more than proportional change in output for a given change in inputs, diminishing return to scale refers to a less than proportional change in output for a given change in inputs, and constant return to scale refers to a proportional change in output for a given change in inputs (Johnston and Ozment, 2013).

3.2. Research Approach

This section presents the proposed methodology to analyze the production of the airlines before and after the merger. The study analyzed two mergers two mergers involving companies with different levels of routes competition, or overlapping, with the intent of verifying how the merger impacted their productivity gains, *ceteris paribus*.

3.2.1. Data

The literature review and the available public data allowed selecting the variables to compose the proposed production function. RPM (Revenue Passenger Mile) was selected to represent the output, and ASM (Available Seat Miles), Employees, and Fuel Consumption were selected to represent the inputs that influence the production results. These are:

RPM (Revenue Passenger-Miles): refers to the number of passengers and the distance flown, i.e., the sum of the product between the number of passengers and the distance of all ranges flown. It is a dependent variable used as output in the function, representing the production.

ASM (Available Seat-Miles): refers to the number of seats and the distance flown, i.e., the sum of the product between the number of seats offered and the distance of all ranges flown. It is an independent variable used as input in the function.

Employees (Full-Time Equivalent Employees): refers to the number of Employees FTEE (count two part-time employees as one full-time employee) of the airlines. It is an independent variable used as input in the function.

Fuel consumption: refers to the fuel consumption (in gallons) by the total scheduled service, considering domestic and international aviation. It is an independent variable used as input in the function.

The data were obtained through the Bureau of Transportation Statistics - BTS, which publishes data related to transportation in the United States. The collected data were extracted from the BTS website without the need for any specific treatment. The data for the variables are monthly reported ranging from 36 months before and after each merger. The same data range was adopted for both periods before and after the merger to keep the symmetry of the analysis. The 36-month period was chosen so as not to bias the result due to factors other than the merger itself.

The data for the routes overlapping analysis were collected from the Bureau of Transportation Statistics – BTS website for domestic flights, considering the last quarter before the two processes of merger present in this analysis.

3.2.2. Proposed Model

Two mergers with different levels of routes overlapping are analyzed. For each one, to estimate the impact of the merger in the production of air transport units (expressed in terms of RPM), it is proposed the analysis of the variation of the multi-linear regression parameters (production elasticity parameters) through Equation (3). The results obtained by this model to the elasticities βi are considered in a *ceteris paribus* hypothesis.

$$\ln(RPM) = \alpha + \beta_1 \ln(ASM) + \beta_2 \ln(FTEE) + \beta_3 \ln(FUEL) \quad (3)$$

where:
RPM: Revenue Passenger-Miles.
ASM: Available Seat-Miles.
FTEE: Full-Time Equivalent Employees.
FUEL: Fuel consumption in gallons.

3.2.2.1.US Airways and American Airlines

For the analysis over time, one scenario for US Airways, currently a non-existent company, was established, which investigates how the firm performed 36 months before the conclusion of the merger, that is, from July 2012 to June 2015. For American Airlines, it was established four scenarios. The first one analyses how it performed 36 months preceding the merger; the second one analyzes how it was from the merger up to 12 months ahead; the third one analyzes its performance from the merger up to 24 months ahead, and the last scenario analyzes how was its performance from the merger up to 36 months after it.

3.2.2.2.United Airlines and Continental Airlines

Similarly, as performed in the analysis of the US Airways and American Airlines merger, in the case of Continental, the analysis was performed with data from 36 months before the merger. For United Airlines, there were four scenarios: the first one contained data from 36 months before the merger, the second analyzes 12 months after the merger; the third looks at 24 months after the merger; and the fourth, 36 months after the merger.

4. RESULTS AND DISCUSSIONS

This section presents a descriptive statistical analysis of the dataset and the results of applying the Cobb-Douglas production function.

4.1. Routes Overlapping

Table 1 shows the statistics of routes overlapping for the two mergers in analysis. It is possible to see that the merger between American Airlines and US Airways involved a greater overlapping of routes (56%) than the merger between United Airlines and Continental (31%).

Table 1 Routes Overlapping Statistics during the last quarter before the merger

American Airlines routes	905
American Airlines routes in common with US Airways	505
Routes Overlapping	56%
United Airlines routes	1203
United Airlines routes in common with Continental	368
Routes Overlapping	31%

As observed by Chen e Gayle (2018), even before the merger, United and Continental were seen as complementary companies since both had similar fleets and explored different geographical regions, with United Airlines more present in the west of the United States and Continental more present in the east. This behavior can be observed in 3 and Figure 4. These figures show the routes departing from the five main hubs before the merger, which were identified according to the number of destinations. Figure 1 and Figure 2 show the same information for American Airlines and US Airways, respectively. One can see that the geographical regions explored coincide more than the Continental and United Airlines routes.

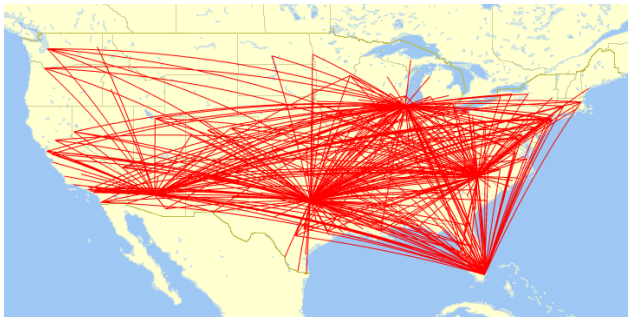

Figure 1 American Airlines' routes from five main hubs

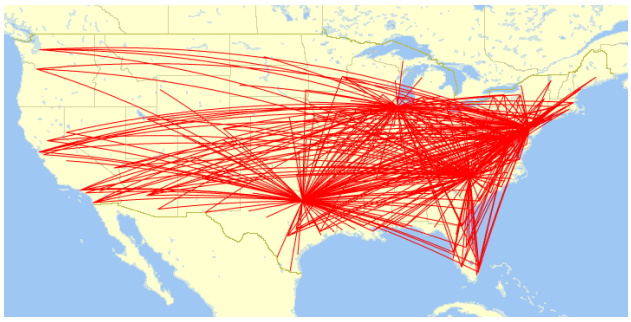

Figure 2 US Airways' routes from five main hubs

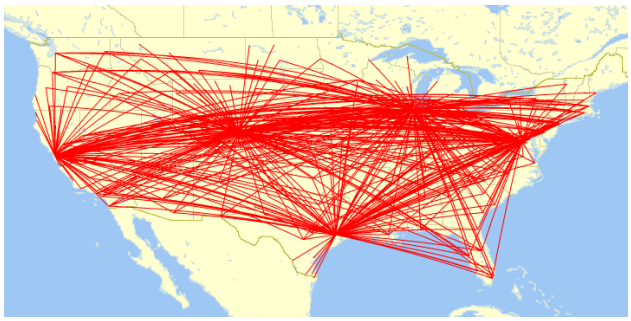

Figure 3 United Airlines' routes from five main hubs

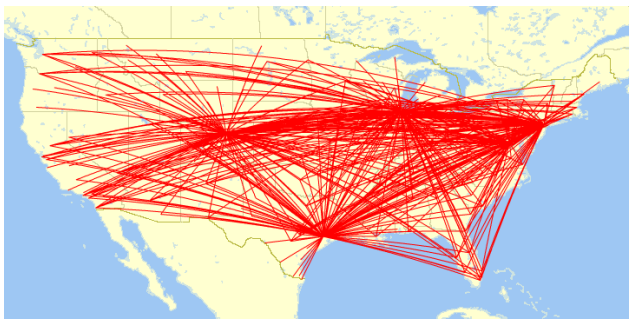

Figure 4 Continental's routes from five main hubs

The routes exhibited on maps of Figure 1 to Figure 4 represent, respectively, 32%, 29%, 26% and 29%, of total number of routes for American Airlines, US Airways, United Airlines and Continental.

4.2. Database Statistics for American Airlines and US Airways Merger

Figure 5 and Figure 6 show, respectively, graphics of RPM evolution and the number of employees for American Airlines and US Airways, before and after the merger. By analyzing the evolution of RPM in the last cycle of 12 months before the merger, both companies showed stability in the level of production compared to the previous year. Regarding the number of Employees, both companies showed an increase in their number one year before the merger.

Figure 7 shows the relation between the RPM and the number of employees for American Airlines before and after the merger. It is possible to see that the trend line is stable before the merger and with a positive slope after the merger. Two factors are potential justifications for this frame presented by the companies. The first is that they were already adapting to the merger before it was effectively completed; the other is that the companies no longer presented very interesting financial results. According to Peterman (2014), the unfavorable financial health was one of the justifications for the companies effectively to conclude the merger since this transaction would create the largest airline in the United States, which left regulators worried as this could potentially harm the sector's competitiveness.

Figure 8 shows the relationship between ASM and RPM, and Fuel Consumption and RPM for American Airlines, before and after the merger.

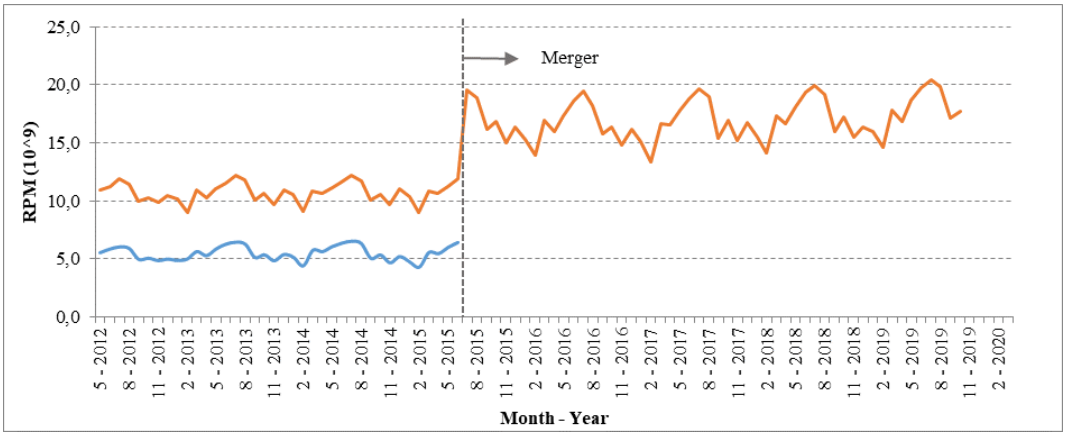

Figure 5 American Airlines and US Airways' RPM evolution

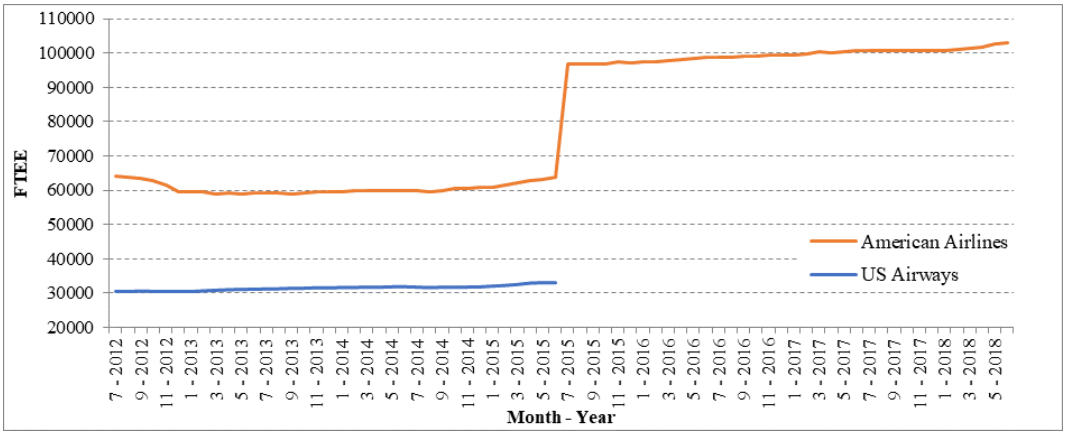

Figure 6 American Airlines and US Airways' employees' number evolution.

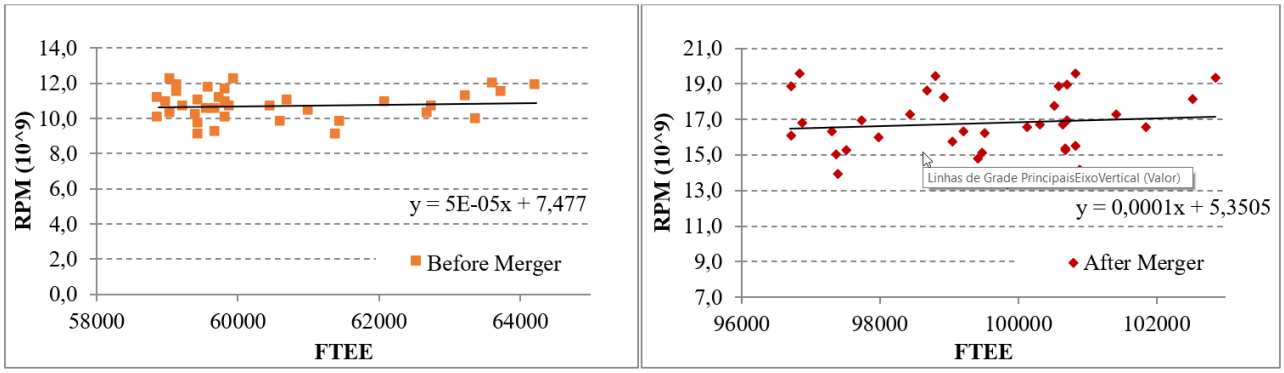

Figure 7 Relationship of FTEE and RPM before and after the merger (American Airlines)

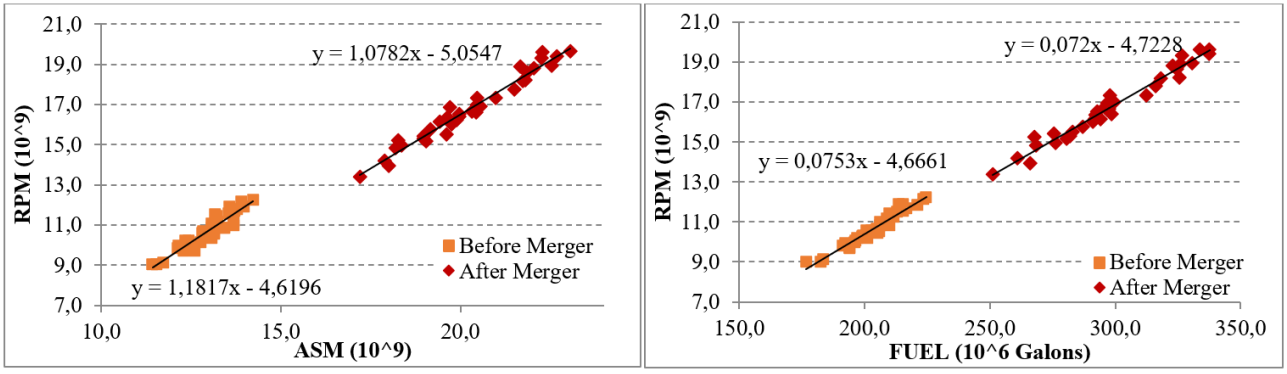

Figure 8 Relationship of ASM and RPM and of Fuel and RPM before and after the merger (American Airlines)

4.3. Database Statistics for United Airlines and Continental Airlines Merger

Figure 9 shows the evolution of RPM for United Airlines and Continental before and after the merger, and Figure 10 depicts the evolution of the number of employees for both companies, also before and after the merger. The curve for United indicates a decreasing trend in the number of employees from the merger until 36 months after it.

Figure 12 shows the effects of variation of the considered inputs over the RPM before and after the merger. On the left, one can observe the evolution of the indicator of production RPM in relation to ASM. The graph on the right indicates the evolution of RPM in relation to fuel consumption.

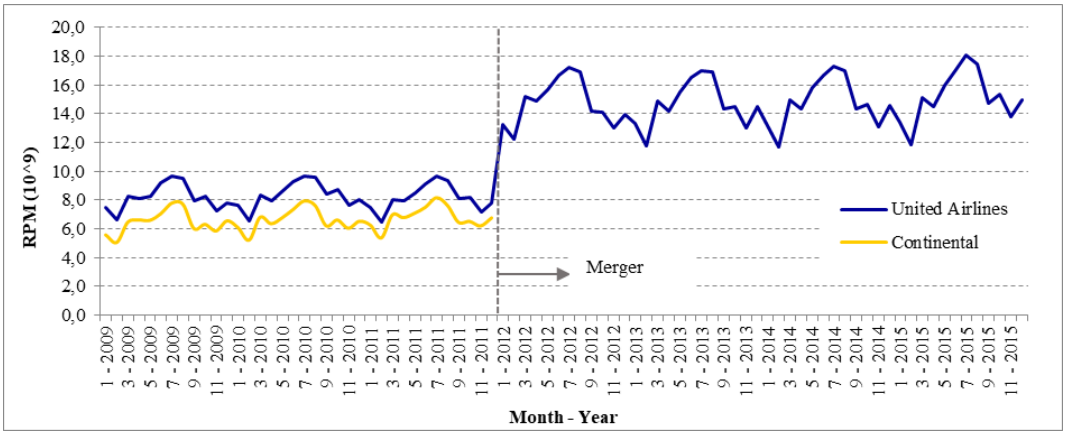

Figure 9 United Airlines and Continental RPM evolution

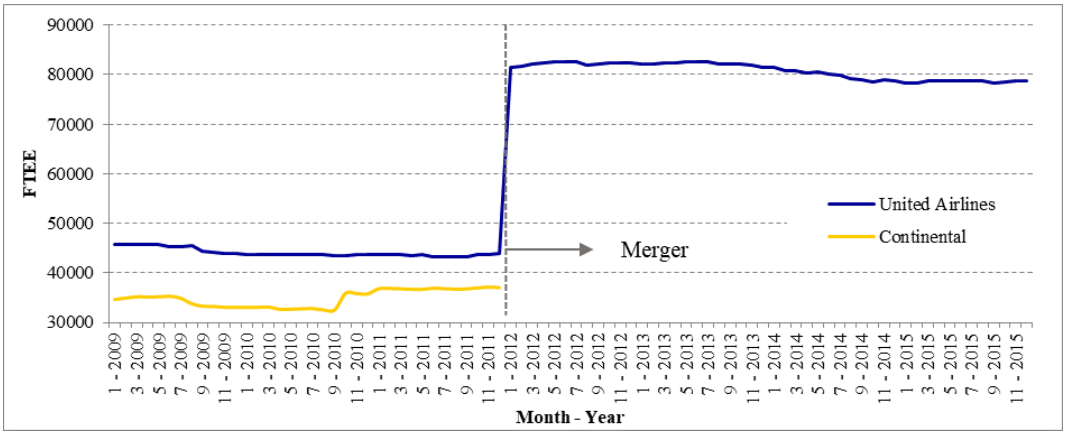

Figure 10 United Airlines and Continental employees number evolution.

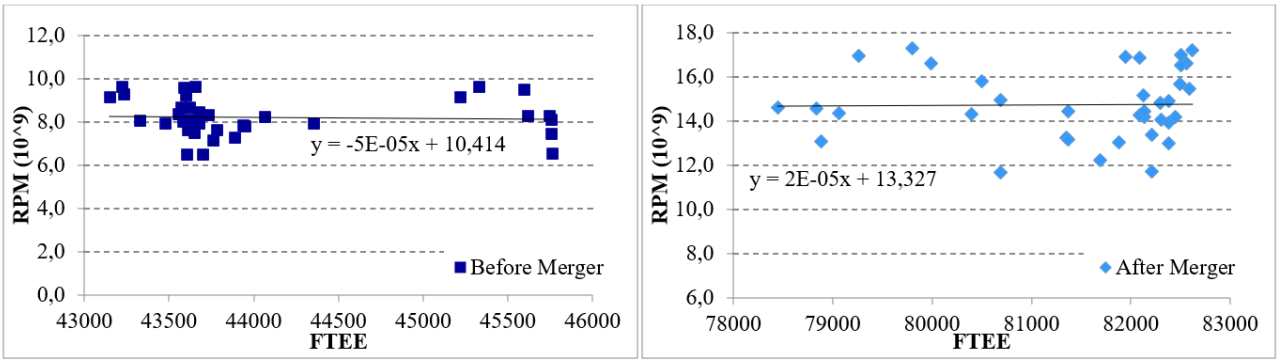

Figure 11 Relationship of FTEE and RPM before and after the merger (United Airlines)

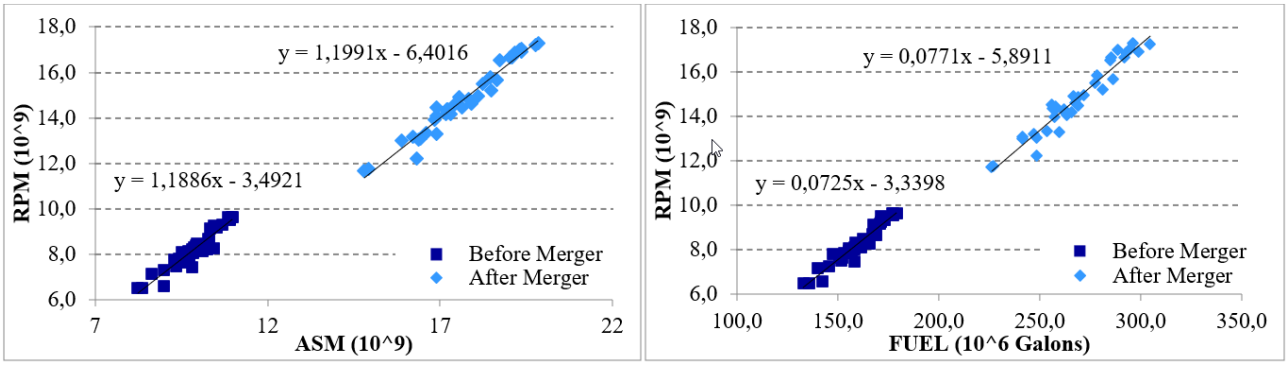

Figure 12 Relationship between ASM and RPM and between Fuel and RPM before and after the merger (United Airlines)

4.4. Application of the Cobb-Douglas Production Function

The hypothesis of the study is that the incorporation of fixed and variable inputs caused by the merger of the two companies directly affects the production of the companies before and/or after the merger. This factor should be observed by the behavior of the RPM (Revenue Passenger-Miles) in function of the Available Seats-Miles (ASM), Fuel Consumption, and Employees through the regression base on the Cobb-Douglas proposed model on a time scale that includes the periods before and after the merger. The variation in productivity caused by the merger can be affected by many variables, including the overlapping proportion of the routes from both companies before the merger.

This study proposes the application of a production function for the companies before and after the merger to investigate the impact of the merger on productivity and to understand the effect of the overlapping *ceteris paribus*. In the case of US Airways and Continental Airlines, the application of the production function was performed only for the period before the merger.

Table 2 US Airways and American Airlines RPM elasticity before the merger.

Regression Coefficients		US Airways 36 months before the merger 07/2012 - 06/2015	American Airlines 36 months before the merger 07/2012 - 06/2015
Intercept	α	0,822	-8,198
ln (ASM)	β_1	1,001	-0,192
ln (FTEE)	β_2	-0,513	0,436
ln (FUEL)	β_3	0,233	1,618
R^2		0,970	0,968
Homogeneity factor		**0,722** Diminishing return of scale	**1,862** Increasing return of scale

Table 3 United Airlines and Continental Airlines RPM elasticity before the merger.

Regression Coefficients		United Airlines 36 months before the merger 01/2009 - 12/2012	Continental 36 months before the merger 01/2009 - 12/2012
Intercept	α	2,548	-3,328
ln (ASM)	β_1	0,937	0,666
ln (FTEE)	β_2	-1,035	-0,390
ln (FUEL)	β_3	0,518	0,800
R^2		0,951	0,938
Homogeneity factor		**0,420** Diminishing return of scale	**1,076** Increasing return of scale

4.4.1. American Airlines and US Airways Before the Merger

The period analyzed for US Airways and American Airlines is from July 2012 to June 2015, 36 months before the merger. The results are shown in the Table 2.

The regression shows that, *ceteris paribus*, the elasticities of the inputs presented in order of importance and module, were the ASM, employees and fuel consumption for US Airways, and fuel consumption, employees, and ASM for American Airlines. Also, the chosen model for production presented R^2 greater than 0.96 for both companies.

Another result presented by the regression is that US Airways showed a diminishing return to scale before the merger, while American Airlines presented an increasing return to scale.

4.4.2. United Airlines and Continental Before the Merger

Considering the results from data of 36 months before the merger, the *ceteris paribus* results presented in Table 3 indicate that for United Airlines, there was a diminishing return to scale. For Continental, there was an increasing return to scale.

Table 4 American Airlines RPM elasticity effects after the merger.

Regression Coefficients		12 months after the merger 07/2015 - 06/2016	24 months after the merger 07/2015 - 06/2017	36 months after the merger 07/2015 - 06/2018
Intercept	α	9,358	-3,256	-5,856
ln (ASM)	β_1	0,600	0,375	0,236
ln (FTEE)	β_2	-1,445	-0,060	0,286
ln (FUEL)	β_3	0,847	0,953	1,051
R^2		0,987	0.978	0.974
Homogeneity factor		**0,003** Diminishing return to scale	**1.268** Increasing return to scale	**1.573** Increasing return to scale

Table 5 United Airlines RPM elasticity effects after the merger.

Regression Coefficients		12 months after the merger 01/2012 - 12/2012	24 months after the merger 01/2012 - 12/2013	36 months after the merger 01/2012 - 12/2014
Intercept	α	-56,736	-29,947	-8,618
ln (ASM)	β_1	0,262	1,089	1,357
ln (FTEE)	β_2	4,700	1,891	-0,123
ln (FUEL)	β_3	1,070	0,323	0,072
R^2		0,970	0,950	0,959
Homogeneity factor		**6,032** Increasing return to scale	**3,303** Increasing return to scale	**1,307** Increasing return to scale

4.4.3. American Airlines and Us Airways After the Merger

For the post-merger period, the study adopted three scenarios so that it was possible to analyze the results through shorter periods (less accurate, but allows the analysis of specific events), and longer periods (more accurate, but not able to identify very specific events).

- The first scenario considered the period from July 2015 to June 2016, equivalent to 12 months after the merger.
- The second scenario considered the period from July 2015 to June 2017, equivalent to 24 months after the merger.

- The third scenario considered the period from July 2015 to June 2018, equivalent to 36 months after the merger.

From Table 4, in the first scenario, the regression showed that, *ceteris paribus*, the elasticities of the inputs, presented in order of importance and module, were employees, fuel consumption, and ASM. The number of employees presented considerable representativeness in the production.

In the 12-month period after the merger, the number of employees continued to grow steadily. However, during the pre-merger period, the two companies increased their staff while productivity fell. These results suggest that the number of employees had a significant and negative impact on the productivity of the merged company.

In the second and third scenarios, the regression showed similar elasticities for the inputs, which presented the same order of importance for both: Fuel Consumption, ASM, and Employees.

Regarding the R^2 of the three scenarios, it is possible to observe that the chosen model for production presented R^2 greater than 0.97 in all three considered periods.

The return to scale achieved through the regressions agrees with some previous studies that suggested that when two companies undergo major acquisitions or mergers, the first post-merger period is expected to be accompanied by a decrease in productivity. This is expected since there is a need to reorganize the infrastructure, services, etc. Through these concepts, it can be observed that the first period presented a diminishing return to scale. This trend was also observed by Fregnani et al. (2019). The second period showed an increase, and the third indicated an even bigger increasing return to scale than the second. This result indicates that the company achieved improvements in the efficiency of its inputs over the years after the merger. This result can be compared with Johnston and Ozment (2013), which also indicates that mergers improve firms' productivity in the long run. Figure 13 shows the evolution of productivity graphically. In Figure 13, the dotted line indicates a constant return to scale. All the above points (in green) mean increasing return to scale, and below (in blue) mean diminishing return to scale.

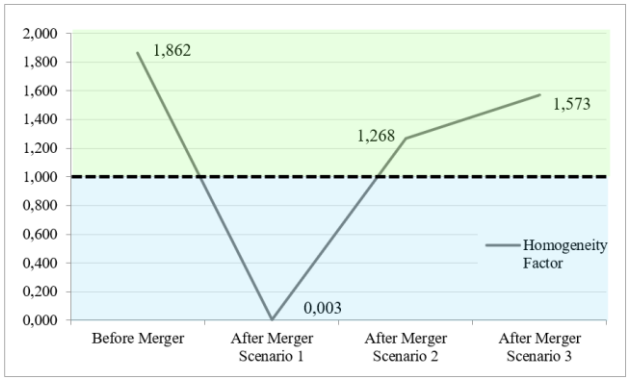

Figure 13 Homogeneity Factor Variation of American Airlines.

4.4.4. United Airlines and Continental Airlines After the Merger

Following the same analysis procedure performed for American Airlines and US Airways, three scenarios representing three different periods after the merger between United Airlines and Continental were analyzed: 12, 24, and 36 months after the merger. Table 5 shows the results (ceteris paribus).

From the results shown in Table 5, it is possible to see that the Employees was the variable with the greatest elasticity in the first scenario, followed by Fuel consumption and ASM. The second scenario also had the Employees as the factor that most contributed to the company's productivity. The third scenario had the ASM as the greatest level of importance in productivity. In all cases, the high values of R^2 indicate a good adjustment of the model to the data.

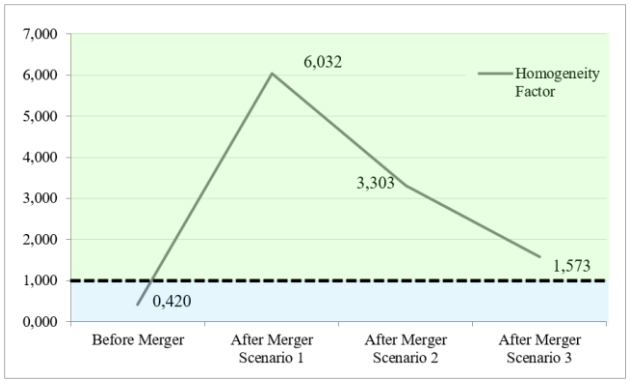

Figure 14 Homogeneity Factor Variation of United Airlines.

Unlike the merger between US Airways and American Airlines, the first scenario here showed an increasing return to scale 12 months after the merger, and the homogeneity factor

showed its greatest value. In the scenarios of 24 and 36 months, the resulting company continued to show increasing return to scale but with decreasing values when comparing each scenario with its previous one. Figure 14 represents the evolution of the homogeneity factor before the merger and in the three periods analyzed after it. The higher values after the merger suggest that it brought benefits in terms of economy of scale in the short and the long run, also aligned with the results of Johnston and Ozment (2013).

4.4.5. Comparison between the two merger results

Through the results presented in the topics above, it is possible to compare both merger processes. The merger of companies with greater competition in terms of routes, i.e., American Airlines and US Airways, presented a diminishing return to scale in the first period analyzed after the merger. However, in the following periods, the homogeneity factor increased, indicating increasing return to scale. On the other hand, the merger with fewer routes overlapping, i.e., United and Continental Airlines, presented an increasing return to scale after the merger, with the highest value obtained for the homogeneity factor in the first 12 months after the merger. This result may be associated with the information presented in Figure 10, which shows that United Airlines initiated a process of reducing its number of employees after the merger, differently from American Airlines, which continued to hire after the merger, as shown in Figure 6. Observing the coefficients obtained through the regressions with data after the mergers, the number of employees was the variable that most contributed to reduce the homogeneity factor for American Airlines. Contrarily, it was the variable that most contributed to increase the homogeneity factor for United Airlines.

The results for the Fuel variable indicate that for the merger with more overlapping routes (American Airlines), the coefficients βi present increasing values over time, suggesting that it contributes more to the increasing values of the respective homogeneity factor. In this sense, a higher level of routes being operated simultaneously by the merged companies provides more space for a reorganization of the network, as indicated by Ryerson and Kim (2014), which, according to the authors, lead to fuel consumption reduction. Indeed, Ryerson and Kim (2014) projected hub structure and consolidation of flows for the American Airlines-US Airways merger and found a potential fuel consumption savings of 23 to 27 percent.

Overall, the application of the Cobb-Douglas production function for these two mergers of companies with different levels of competition showed different results, depending on the period analyzed. When there was more previous competition, the resulting company showed less efficiency at the first moment since the results indicate a diminishing return to scale. A possible explanation is that the total inputs originated from the sum of inputs from both original companies did not propitiate a proportional increase in its production. On the other hand, when fewer routes were overlapping, the resulting company showed an immediate gain in productivity since the production function indicates an increasing return to scale. This increase may be understood since United Airlines became a larger company with more assets and was able to increase its products proportionally.

5. CONCLUSIONS

Estimating a Cobb-Douglas production function of the associated coefficients before and after the merger between two companies has proven to be an effective method for evaluating the effects caused by the merger. This study analyzed two mergers with different levels of previous competition and allowed to compare the results of the production function application for each merger process. The results evidenced that, in the first period after the merger, the one with less previous competition showed an increasing return to scale. In contrast, the other showed a diminishing return to scale, i.e., when there was a merger between airlines that compete more, at the first moment, the resulting company experienced negative effects in its productivity probably due to the difficulties for reducing inputs and structuring the new company. It means that incorporating a new company that is an effective competitor is not easier than incorporating one complementary in the market. The results also show that both resulting companies demonstrated gains in efficiency after

the merger in the long run. Other factors affect production and may not be included in the selected inputs of this study. Future studies may investigate the impact of other inputs to confirm this analysis and analyze different mergers.

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