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Efficiency decomposition approach: A cross-country airline analysis

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ABSTRACT

In this paper a two-phase data envelopment analysis approach is proposed in order to examine in a separated way the operational and financial performances for airlines. Empirical results are based on panel data from Brazilian and American airlines, using data from 34 observations (within the period from 1997 to 2006), and shows that for the emergent market, operational performance is always much better than the financial one, showing that the resources optimization has been the main concern for these companies. Also, results for this market show that improving the operational efficiency does not necessarily generate an improvement in financial efficiency. Future research should ascertain whether or not these results replicate in companies other than airlines.

1. Introduction

The airline sector has been greatly affected by economic challenges, mainly by the recent world-wide financial crisis of 2008 and 2009. During this period, even the most lucrative companies lost money and, even now with the sector recovering, the current margins in the Brazilian airline sector are still very low, 2% on average. Due to the current financial climate, performance measurement studies have given the sector an opportunity to identify and enhance their economic indicators.

The economic indicators that authors usually consider in evaluating the overall performance of airlines can be obtained by operational and/or financial measures. But, especially in this sector, some attention must be taken when choosing the information that reflects the financial performance. Schefczyk (1993) explained the difficulty in using financial information of international airlines, since different accounting and taxation rules in various countries result in different impacts of leased assets on profit and balance-sheet information. After that, Scheraga (2004), using the model from Schefczyk (1993), investigated the structural drivers of operation efficiency as well as the financial posture of airlines on the eve of September 11th. They also found that relative operational efficiency did not inherently imply superior financial mobility, i.e., airlines that had chosen relatively efficient operational strategies also suffered the consequences of the post-September 11th environment.

Other authors investigated airline performance, for example, Feng and Wang (2000) showed that performance evaluation for airlines can be more comprehensive if financial ratios are considered. Wang (2008) applied a fuzzy multi-criteria decision-making (FMCDM) method using financial indicators and evaluated financial performance of airlines. More recent, Barros and Peypoch (2009) analyzed the operational performance of a sample of AEA from 2000 to 2005, combining operational and financial variables.

But, as can be noted, operational and financial variables are frequently used in conjunction, even in the airline sector where both indicators are of concern.

The aim of this paper consists of analyzing operational and financial efficiencies in a separate way, i.e., using only operational variables to evaluate the operational efficiency and only using financial variables to find the financial efficiency. In this way, the contribution of this paper consists of: (i) modeling a two-phase data envelopment analysis approach separating the operational and financial indicators, but taking into account that reducing the costs (operational performance) leads to an increase in the results (financial performance); (ii) place side by side the results of operational and financial performances for airlines in a data panel; and (iii) verify the efficiency and advantages of decomposition methodology.

The rest of the paper is organized as follows. The next section presents a recent literature review of the uses of a two-phase data envelopment analysis approach. After that, we present the data set and variables used in the proposed model. Section 4 shows the methodology applied, followed by the empirical results. Finally, we present some concluding remarks.

2. The two-phase DEA approach: A literature review

Francis, Humphreys, and Fry (2005) have investigated performance measurement practices within the airline industry with a focus on operational and financial measures. The paper showed that the most used technique for performance improvement for

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airlines is *benchmarking* followed by *quality management systems*. None of them mentioned the data envelopment analysis (DEA) technique, although its application for airlines was reported in literature by various previous papers, as with Behn and Riley (1999), Feng and Wang (2000), Schefczyk (1993), Scheraga (2004), etc.

More recently, some studies have pointed to a two-stage DEA model using the first stage inputs to generate outputs which become the inputs for the second stage. But this can be used only in circumstances where the output of the first stage can be converted into the input for the second stage (Wang & Chin, 2010).

In this way, some authors define the overall efficiency as the product of the efficiencies of the two stages (Kao & Hwang, 2008), or as the weighted sum of the efficiencies of the two stages (Chen, Cook, LI, & Zhu, 2009), or as the weighted harmonic mean of the efficiencies of the individual stages (Wang & Chin, 2010). Table 1 describes the inputs and outputs of stages 1 and 2 for some papers that used this methodology.

In this paper, we also propose a two-phase data envelopment analysis approach, but if we use the output of the first phase as an input for the second phase we will also use both, operational and financial variables, in order to evaluate the overall performance.

To demonstrate the objective of this paper in investigating the estimation of the separated efficiencies, we use an efficiency variable, evaluated as the result of the first phase, as an input for the second phase, i.e., the first phase uses just operational variables, generating an operational efficiency. Then, the second phase uses financial variables generating an economic efficiency. And, to link the two phases, the second phase uses as an input the score efficiency obtained by the first phase.

3. Data set and variables

Our analysis includes four large airlines, two Brazilian (BR1 and BR2) and two American (USA1 and USA2). Data is collected from annual reports over the period as presented in Table 2, generating 34 observations. The size of the companies is illustrated by the available seats km (or mile for the American airlines) and the national market share that also follows in Table 2.

Next we define the variables used in the two-phase DEA model. First we will define the operational variables, for phase I, and then we will define the financial variables, for the second phase of the model.

Table 1
The two-stage approach.

Author(s)	Company type	Stage 1	Stage 2
Seiford and Zhu (1999)	Commercial banks	*Inputs:* Employees, assets, stockholder's equity	*Inputs:* **Revenues, profits**
		Outputs: **Revenues, profits**	*Outputs:* Market value, total return to investors, earnings per share
		Performance measured: in generating profit	*Performance measured:* in generating market value
Kao and Hwang (2008)	Non-life insurance	*Inputs:* Operational expenses, insurance expenses	*Inputs:* **Direct written premiums, reinsurance premiums**
Chen, Cook, LI, and Zhu (2009)		*Outputs:* **Direct written premiums, reinsurance premiums**	*Outputs:* Underwriting profit, investment profit
Wang and Chin (2010)		*Performance measured:* in marketing	*Performance measured:* in generating profit from the premiums

Table 2
National market share.

	Brazilian companies*		American companies**	
	BR1	BR2	USA1	USA2
Data period	1997–2006	2001–2006***	1997–2006	1998–2000 and 2002–2006****
Available seat km or mile (in millions – 2006)	34,750	19,443	174,021	116,133
National market share (2009–2010)	42.4%	39.5%	13.8%	14.8%

* *Source:* http://www.anac.gov.br.
** *Source:* http://www.transtats.bts.gov/.
*** This company was found in 2001.
**** The data for aircraft fuel from 1997 and 2001 were not found.

3.1. Phase I – operational performance

In the study of Francis et al. (2005), they also presented that the *available seats*, *load factor*, *revenue passenger mile* and *cost/seat mile* were used as operational performance measures by 93%, 100%, 95% and 90% of managers (from the 43 companies that completed the questionnaire). The last one was also the measure seen as most useful to managers.

In this study, we include all these variables plus the *aircraft fuel, wages, salaries and benefits*, since it also could reflect significantly on the operational efficiency. Table 3 shows the inputs and output used in phase I. As we will be using DEA, there is a limitation for the number of variables used, for the output we use the variable $\frac{\text{Load Factor}}{\text{Available Seat Mile}}$, which means exactly the Revenue Passenger Mile.

3.2. Phase II – financial performance

As previously mentioned, the operational efficiency is reflected in the financial performance, we just do not know how much. So in order to have the model capture this correlation, we used the *score efficiency* obtained in phase I as an input for phase II. It is expected that the better the *score efficiency* from phase I, the better the financial efficiency (from phase II).

Observe that the *score efficiency* input is anti-isotonic, since input variables are desired to be minimized, however, we want to maximize the *score efficiency*. To overcome this challenge, Dyson et al. (2001) suggested to invert this variable, as $\frac{1}{\text{Score Efficiency}}$, so the input of phase II becomes isotonic.

As previously mentioned, the impacts of leased assets on financial performance differ according to country-specific accounting and taxation laws, so the variables such as purchasing or sales indicators are not used (Schefczyk, 1993). Thus the output will be measured by two financial variables: the flight revenue and the flight income. It is relevant to mention that the flight income can decrease even if the flight revenue increases (because of the reduction of rates, promotional rates, etc.). Table 4 resumes the input and outputs used in phase 2.

As the flight income is negative during some years for some companies (mainly after 2001), and DEA does not permit the usage of negative numbers, we sum up the flight income for each year as: (minimum flight income in all years for Brazilian airlines + 1) in order to rearrange this data for Brazilian airlines. The same was done for American airlines. The descriptive statistics are shown in Tables 5 and 6.

4. Methodology

The data envelopment analysis (DEA) is a non-parametric technique used to measure the relative efficiency of decision making