Journal of Air Transport Management 54 (2016) 93–103

Contents lists available at ScienceDirect

Journal of Air Transport Management

journal homepage: www.elsevier.com/locate/jairtraman

Efficiency in Latin American airlines: A two-stage approach combining Virtual Frontier Dynamic DEA and Simplex Regression

Peter Wanke [a, *], C.P. Barros [b]

[a] COPPEAD Graduate Business School, Federal University of Rio de Janeiro, Rua Paschoal Lemme, 355, 21949-900 Rio de Janeiro, Brazil
[b] ISEG – Lisbon School of Economics and Management, ULisboa and CEsA - Research Centre on African, Asian and Latin American Studies, Rua Miguel Lupi, 20, 1249-078, Lisboa, Portugal

ARTICLE INFO

Article history:
Received 1 March 2016
Received in revised form
5 April 2016
Accepted 6 April 2016
Available online 18 April 2016

Keywords:
Airlines
Latin America
VDRAM
Two-stage
Simplex regression

ABSTRACT

This paper presents an efficiency assessment of Latin American airlines, using VDRAM-DEA (Virtual Frontier Dynamic Range Adjusted Model - Data Envelopment Analysis). In VDRAM, the reference and DMU evaluation sets are different, thus allowing higher discrimination of scoring. In this research, the VDRAM model is used first in a two-stage approach. In the second stage, Simplex Regression is adopted to handle skewed and asymmetrical efficiency scores. The results corroborate previous studies and reveal that the impact of fleet mix and public ownership cannot be overlooked in Latin American airlines, which seem to be affected by insufficient load factors and hub and spoke systems. For the same reasons, although low cost carriers are an emerging trend in the region, it was not possible to confirm their higher efficiency levels. Besides, to some extent, these findings also show the absence of a learning curve in Latin American airlines.

1. Introduction

This research focuses on the efficiency of Latin American airlines by using the VDRAM-DEA, presented in Li et al. (2016), as the cornerstone method to compute efficiency. Previous research on airlines has adopted several methods, such as the factor productivity approach (Bauer, 1990; Oum and Yu, 1995; Barbot et al., 2008); Stochastic Frontier Analysis or SFA (Good et al., 1993; Baltagi et al., 1995); the Turnquist total factor productivity index (Coelli et al., 2003; Barbot et al., 2008); and DEA (Data Envelopment Analysis) models (Merkert and Hensher, 2011; Barros et al., 2013; Barros and Peypoch, 2009; Barros and Couto, 2013). Papers have variously focused on US airlines (Barros et al., 2013; Greer, 2008; Sjögren and Söderberg, 2011), Canadian airlines (Bauer, 1990; Assaf, 2009), European airlines (Distexhe and Perelman, 1994; Greer, 2008; Barros and Peypoch, 2009), Asian airlines (Baltagi et al., 1995; Wanke et al., 2015), and African airlines (Barros and Wanke, 2015). Except for Melo Filho et al. (2014), who focused on wages in Brazilian airlines; and Oliveira and Huse (2009), who focused on Brazilian airlines' price reactions to market entry, thus far, to the best of our knowledge, few papers have focused on Latin American airlines. Therefore, this paper innovates by focusing on a comprehensive set of Latin American airlines.

Recently, Wanke et al. (2015) and Barros and Wanke (2015) showed the importance of using efficiency methods with high discriminatory power towards the efficiency frontier – that is lower efficiency scores in contrast to traditional DEA models – when assessing, respectively, the efficiency of Asian and African airlines. Additionally, the authors advocate the combining of different predictive modelling techniques to explore effectively the impact of contextual variables on efficiency measurement. Therefore, this paper innovates in this context first by undertaking a review of Latin American airlines and, second, by adopting as a research tool the newly VDRAM, presented in Li et al. (2016), combined with Simplex Regression in a two-stage approach. To the best of our knowledge, this is the first time such approach is used to analyze airline efficiency in light of different contextual variables, simultaneously tackling two major problems in efficiency measurement: score discrimination and asymmetry.

The motivations for the present research follow. First, Latin America is one of the regions in the world most favored by the commodity price boom in the last ten years, with clear reflexes on airline traffic, justifying the present research. Second, this paper builds upon previous studies related to airline efficiency by

* Corresponding author.
E-mail addresses: peter@coppead.ufrj.br (P. Wanke), cbarros@iseg.utl.pt (C.P. Barros).

http://dx.doi.org/10.1016/j.jairtraman.2016.04.001
0969-6997/

evaluating relative efficiency among Latin American airlines. To the best of our knowledge, this is the first time Latin American airlines have been analyzed as a whole, thus differing from country-based level analysis. Third, the present analysis enables a ranking of the relative efficiency of the Latin American airlines using the newly developed VDRAM (Li et al., 2016), while assessing the impact of different contextual variables related to cargo type, ownership type, and fleet mix on their efficiency levels.

Therefore, the purpose of this study is to assess the determinants of airline efficiency in Latin America based on business related variables commonly found in the literature. In order to achieve this objective, an efficiency analysis is developed in a two-stage approach: VDRAM DEA model efficiency estimates are computed first, observing the prescriptions in Li et al. (2016), followed by Simplex regression. Researchers frequently face situations where they are interested in modelling proportions, percentages or values, such as efficiency scores, within the open interval (0; 1), according to one or several covariates, within the architecture of the regression. For this type of variable, the normal assumption is not supported, thus invalidating conclusions that might otherwise be obtained from these results. Asymmetry of the response variable and multicollinearity are two of the most frequent problems that the normal model cannot accommodate. In this situation, several alternatives have been developed, such as Beta regression, which leverages the advantages the general linear model, and simplex distribution, which is part of a more general class of models, i.e., dispersion models (López, 2013). The paper is structured as follows: after this introduction, the literature survey is presented. The methodology section, in which the two-stage VDRAM-Simplex regression is further discussed, follows next. Section 4 presents the data and the contextual setting, followed by the discussion of the results in Section 5 and the conclusions in Section 6.

2. Literature review

Research in airline frontier models encompasses several scientific methods to analyze efficiency quantitatively. First was the early tradition based on cost models (e.g., Caves et al., 1981, 1984; Windle, 1991; Baltagi et al., 1995; Oum and Yu, 1998; Liu and Lynk, 1999; Fritzsche et al., 2014). Second was the total factor productivity approach of Bauer (1990) adopted by Oum and Yu (1995) and Barbot et al. (2008). More recently, the contemporary stochastic econometric frontier models have gained popularity (e.g., Cornwell et al., 1990; Good et al., 1993; Sickles, 1985; Sickles et al., 1986; Captain and Sickles, 1997; Coelli et al., 1999; Inglada et al., 2006) and the DEA models (e.g., Distexhe and Perelman, 1994; Good et al., 1995; Adler and Golany, 2001; Fethi et al., 2001; Scheraga, 2004; Greer, 2008; Bhadra, 2009; Gitto and Mancuso, 2012).

Caves et al. (1981) assessed the productivity of eleven US airlines for the period 1972–1977. Caves et al. (1984) analyzed the impact of network size on the performance of US airlines. Caves et al. (1984) compared the productivity performance of a sample of US and non-US airlines over the period 1970–1983. Schmidt and Sickles (1984) analyzed the efficiency of US airlines. Gillen et al. (1990) compared the productivity of seven Canadian airlines over the period 1964–1981. Sickles (1985) analyzed the impact of deregulation on the performance of US airlines. Bauer (1990) assessed the efficiency and returns to scale of twelve US airlines over the period 1971–1981. Good et al. (1993) compared the performance of large European and US airlines over the period 1976–1986, and Oum and Yu (1995) compared the performance of European and US airlines over the period 1986–1993. Ehrlich et al. (1994) analyzed the impact of ownership on the productivity of European airlines. Captain and Sickles (1997) analyzed the impact of average stage length, network size, and percentage of the work force on the performance of European airlines. Coelli et al. (1999) analyzed the impact of stage length, load factor, and network size on the performance of US and European airlines.

Several issues have been addressed by these studies within these countries or regions. Besides, for example, rankings of efficiency and comparisons of slack, the impacts of network size, ownership, and regulatory measures on the performance of the airline industry have also been assessed, by incorporating contextual variables in a two-stage approach (Barros et al., 2013). Indeed, recent papers maintain this focus. For example, Barbot et al. (2008) compared the efficiency of US, European, and Asian airlines with a DEA model. Barros and Peypoch (2009) analyzed European airline efficiency with a DEA two-stage model, applying the results of Simar and Wilson (1998). Assaf and Josiassen (2012) analyzed the efficiency of European and US airlines with a Bayesian frontier model. Wanke et al. (2015) and Barros and Wanke (2015) introduced the use of TOPSIS in airline efficiency measurement by focusing on the Asian and African cases, respectively. It is interesting to note, however, that despite the emergence of the phenomenon of low cost airlines (Pearson et al., 2015 and Yu et al., 2016), this is still a relatively understudied topic under the lenses of operational efficiency between them and the traditional full services carriers.

A summary of the literature review is presented in Table 1, which enumerates the objects of analysis and the models used in each paper over the last three decades of studies on airline efficiency. This paper builds upon this body of knowledge not only by revisiting and confirming in a relatively unexplored geographic region several findings related to the contextual variables, but also by offering additional insights on new contextual variables and methodological approaches where the discriminatory power of the efficiency models and the asymmetry of their computed scores are handled simultaneously.

Additionally, taking a closer look within each paper, it is clear that the most common inputs are labor, capital, and materials or capacity, while the most frequent outputs encompass revenues, profits, movements, and passengers. Therefore, in this study, as the input, we use the number of employees, and, as the dynamic factor, the total number of aircraft. The outputs used involves the number of domestic, world, and Latin and Caribbean flights. Additionally, it appears that although there has been, thus far, only one application of virtual frontiers in the airline industry (Li et al., 2015), no paper has adopted simultaneously VDRAM DEA and Simplex regression in a two-stage approach. Furthermore, as an additional innovation of this paper, no earlier work has analyzed Latin American airlines in isolation.

3. Virtual Frontier Dynamic Range Adjusted Model (VDRAM)

DEA is a non-parametric model first introduced by Charnes et al. (1978). Based on linear programming (LP), it is used to address the problem of calculating relative efficiency for a group of DMUs by using a weighted measure of multiples inputs and outputs (Wanke, 2012). Consider a set of n observations on the DMUs (Decision Making Units). Each observation, DMU_j ($j = 1, \ldots, n$) uses m inputs x_{ij} ($i = 1, \ldots, m$) to produce s outputs y_{rj} ($r = 1, \ldots, s$). DMU_o represents one of the n DMUs under evaluation, and x_{io} and y_{ro} are the i^{th} input and r^{th} output for DMU_o, respectively. Model (1) presents the envelopment modelling for the variable return-to-scale frontier types, where ε is a non-Archimedian element and s_i^- and s_r^+ account, respectively, for the input and output slack variables (Zhu, 2003; Bazargan and Vasigh, 2003).