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An analysis of Asian airlines efficiency with two-stage TOPSIS and MCMC generalized linear mixed models

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ABSTRACT

This study reports on the performance assessment of the Asian airlines using TOPSIS – a multi-criteria decision making technique – as the cornerstone method to compute efficiency scores. Subsequently, and observing indicators frequently found in literature, TOPSIS results on efficiency levels are combined with GLMM-MCMC methods to assess the impact of contextual variables on performance. The results reveal significant impacts of cost structure, ownership type, market positioning, and mileage program offered on efficiency levels. Findings also suggest that gains in efficiency level were stagnated over the period analyzed, implying the inexistence of a learning curve.

1. Introduction

This research focuses on the efficiency of Asian airlines by using Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) as the cornerstone method to compute efficiency. Previous research on airlines have 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 Data Envelopment Analysis (DEA) models (Merkert and Hensher, 2011; Barros et al., 2013; Barros and Peypoch, 2009; Barros and Couto, 2013). All these papers analyzed airlines from USA (Barros et al., 2013; Greer, 2008; Sjögren and Söderberg, 2011), Canadia (Bauer, 1990; Assaf, 2009), Europe (Distexhe and Perelman, 1994; Greer, 2008; Barros and Peypoch, 2009) and Asia (Baltagi et al., 1995).

More recently, Barros and Wanke (2015) assessed the efficiency of African airlines using a two-stage TOPSIS-neural network analysis. The authors showed that TOPSIS scores increases the discriminatory power of the analysis against the efficient frontier, when compared to those derived from traditional DEA models. Besides, the authors also advised in favor of the combination of several predictive modeling techniques to effectively explore the impact of contextual variables on efficiency measurement using TOPSIS. Therefore, this paper innovates in this context first by undertaking a review of Asian airlines and, second, by adopting as a research tool TOPSIS combined with Markov Chain Monte Carlo Generalized Linear Mixed Models (GLMM-MCMC) in a two-stage approach, differently from Barros and Wanke (2015), who used neural networks in the second stage. Typically, contextual variables related to major business characteristics are used in fuzzy Analytical Hierarchy Process (AHP) techniques for determining the criteria weights and are subsequently incorporated into TOPSIS (Seçme et al., 2009; Shaverdi et al., 2011). In this research, however, although these contextual variables are used as explanatory variables in GLMM-MCMC models to assess their impact on efficiency levels, sensitivity analyses on the weighting criteria are also performed by means of the weighted linear optimization model proposed by Ng (2007).

The motivations for the present research follow. First, Asia is the most dynamic growth area in terms of population and gross domestic product in the early part of the present century and this dynamism propagates to airline traffic, justifying the present research. Second, this paper builds upon previous studies related to airline efficiency, evaluating the relative efficiency among Asian airlines. To the best of our knowledge, this is the first time Asian airlines have been analyzed as a whole, differing from country-based level analysis. Third, the present analysis enables a ranking of the relative efficiency of the Asian airlines, while assessing the impact of different contextual variables related to cost structure, ownership type, market positioning, quality of the services provided, and mileage program offered on their efficiency levels.

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Therefore, the purpose of this study is to assess the determinants of airline efficiency in Asia 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: TOPSIS is performed first, followed then by GLMM-MCMC, since Bayesian econometrics methods aim to render prediction of performance more flexible and informative than traditional statistical methods (Verhofen, 2005; Ruppert, 2011; Sarkis and Dhavale, 2014). The paper is structured as follows: after this introduction, the contextual setting is presented, including a description of the Asian airlines. The literature survey is then presented, followed by the methodology section where the two stage TOPSIS/GLMM-MCMC is further discussed. Section 5 presents the data, followed by the discussion of the results and the conclusion in Section 6.

2. Contextual setting

Asia is the world region with higher population and GDP growth in present century. This social and economic characteristics combined with a dynamic industrialization results in higher airline traffic when compared to other industrialized regions such as EU and USA. Therefore in recent decades, the Asian airline sector has been prosperous (Chin and Tay, 2001). According to the Global Market Forecast 2013–2033 by Airbus, passenger traffic RPK for civil aviation is expected to see rapid growth and bigger market share when comparing to the rest of world. This significant potential growth is likely determined by multiple factors. Firstly, Asia is the most populated region in the world. During the period 1950–2010, the world's population almost tripled, and now totals more than seven billion people. Asia has been the biggest contributor, accounting for about 60% of global population growth (Airbus, 2014). Furthermore, this advantage, which stands for the potential market demand, will be one of most significant drivers to promote the development of the Asian airline industry. Secondly, Asia has witnessed the remarkable economic miracles represented by Japan to the highly populated China, and the Four Asian Dragons/Tigers[3] to India (Oki et al., 1997). As such, the cited populations have enjoyed a better standard of living and can afford to travel by plane, despite the fact that, currently, the average trips per capita in Asian are less than half the corresponding level in Europe or North America (Airbus, 2014). Moreover, international trade in East and South Asia as well as the massive oil production and export in West Asia both improve the globalization and integration of Asia into the world. Moreover, these economic activities have stimulated the demand for air transportation (Cline, 1982; Wang et al., 2014b). Therefore GDP—Gross Domestic Product is high in Asia compared with other world regions. Thirdly, the airline industry of Asia has experienced significant deregulation in the last decade. State-owned carriers have been privatized; new carriers have been allowed to enter domestic and international markets; and government controls over such dimensions of airline competition, such as choice of equipment, fares, and route selection have been eased (Bowen and Leinbach, 1995; Sadi and Henderson, 2000; Adler et al., 2014).

The present research aims to provide an assessment of the various airlines of Asia since competition among airlines in Asia is rampant. For example, Singapore Air's passenger count has fallen 12% since 2008—the biggest drop among 12 major full-service Asia-Pacific carriers in 2012, thanks to belt-tightening by business travelers and the rapid growth of Middle Eastern airlines intent on offering even more in-cabin luxury. Air China overtook Singapore Air in 2009 to become the world's most valuable airline by stock value, based on the highest market growth among Asian airlines. Cathay Pacific also saw a satisfactory market rise, as did Qantas Airways. In light of the above, the present research aims to analyze efficiency levels and their determinants in Asian airlines.

[3] Four Asian Dragons or Four Asian Tigers is a term used in reference to the economies of Hong Kong, Singapore, South Korea, and Taiwan. These nations and areas were notable for maintaining exceptionally high growth rates (in excess of 7% a year).

3. Literature review

Research in airline frontier models encompasses several scientific methods to analyze efficiency quantitatively. First, 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, the total factor productivity approach of Bauer (1990) adopted by Oum and Yu (1995) and Barbot et al. (2008). And, finally, the contemporary stochastic econometric frontier models (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 11 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 the US and the non-US airlines over the period 1970–1983. Schmidt and Sickles (1984) analyzed the efficiency of the 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 the US airlines. Bauer (1990) assessed the efficiency and returns to scale of 12 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 the 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 the US and European airlines.

Recent papers maintain this focus. Barbot et al. (2008) compared the efficiency of the 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 the US airlines with a Bayesian frontier model. Barros and Wanke (2015) introduced the use of TOPSIS in airline efficiency measurement by focusing on the African case.

A literature review synthesis 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. Taking a closer look within each paper, one can easily note that the most common inputs are the labor, capital, and materials or capacity; while the most frequent outputs encompass revenues, profits, movements, and passengers. Therefore, in this research, as the inputs (or the TOPSIS criteria with negative impact on efficiency levels), we use the number of employees, the total number of planes, the operating costs, the total amount of salaries paid, the asset depreciation, the total assets, and the fixed assets. The outputs (or the TOPSIS criteria with positive impact on efficiency levels) used involves the revenue per passenger-kilometer, the earnings before interest and taxes, the total number of