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Comparative efficiency analysis of major international airlines using Data Envelopment Analysis: Exploring effects of alliance membership and other operational efficiency determinants

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ABSTRACT

The establishment of alliance groups during the end of 1990s has marked the beginning of an era that is characterized by increased consolidation among Full-Service Network Carriers (FSNCs). In the context of increased competition, membership in a global airline alliance group has served as the main avenue for FSNCs to maintain or increase market share and attain economic viability. Although previous literature has repeatedly stressed the enhancement of operational efficiency as a major incentive for airline alliance membership, existing research related to the assessment of comparative efficiency between allied and non-allied airlines and among alliance groups is fairly scarce. In the current paper, an integrated methodological framework employing Data Envelopment Analysis (DEA) with super-efficiency and intertemporal approach is implemented to assess the effect of alliance group membership on 30 major international airlines regarding period 2012–2016. Primary findings suggest that alliance group membership is not associated with superior airline efficiency. In addition, airlines with high freight traffic revenue share are found to be more efficient than airlines demonstrating lower freight traffic revenue share. Finally, a statistically significant superior efficiency of Asian and European air carriers over American air carriers is substantiated.

1. Introduction

Airlines around the world have developed various cooperation forms, commonly referred to as alliances, in order to overcome various regulatory and financial obstacles. In general, airline alliances comprise any collaborative arrangement between two or more carriers involving joint operations, with the declared intention of improving competitiveness and thereby enhancing overall performance (Morrish and Hamilton, 2002). The consolidation of global airline industry has subsequently led to the formation of alliance groups. These are in essence multilateral, formal networks of airlines which have established sets of alliances with each other or with the group itself (Kleymann and Seristö, 2004).

Especially during the last two decades, the three global alliance groups (i.e. Star, SkyTeam, Oneworld) have become dominant stakeholders of the global airline industry, thus shaping its modern structure. The pace by which the aforementioned global alliance groups have expanded is truly astonishing. More specifically, from five airlines initially forming Star alliance group in 1997, currently there are in total 62 airlines participating in the three global alliance groups. Another striking figure in regard to the global alliance groups is the fact that between 2012 and 2016, they have consistently accounted for over 60 percent of the total global passenger traffic (Flight Airline Business, September 2017).

Apart from becoming standard practice in the global airline industry, airline alliances have constituted a major research topic for several scholars and practitioners. Research efforts related to the specific field of study have gained a really critical mass, thus covering an immense spectrum of facets like air transport networks (Bissessur and Alamdari, 1998; Dennis, 2000; US DOT, 2000; Dennis, 2005; Gillen, 2005; Iatrou and Oretti, 2007), airline economics (Oum et al., 2000; Brueckner, 2001; Kleymann and Seristö, 2004; Vinod, 2005; EC and US DOT, 2010), airline operations (Oum and Park, 1997; Oum and Zhang, 2001; Brueckner and Pels, 2005; Button, 2009) etc. In this context, the impact of airline alliances with respect to various aspects within or outside the airline industry has been a special focus among researchers. Though, the quantification of those impacts has comprised a serious challenge for the researchers, which has been conducted through the

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implementation of various methodological approaches.

A quite controversial topic related to airline alliances and airline industry in general, is the one pertinent to performance evaluation. The most widely used measure of performance in the airline industry is financial performance, which is usually measured by indicators like net profit margin, return on equity and investment, cash flow etc. Another essential measure of performance is operational performance, which is often referred to as productivity. Subsequently, airline productivity has diverse partial measures with the most prominent being labor productivity (on a per employee basis) and aircraft utilization (e.g., load factor) (Kleymann and Seristö, 2004).

As far as concerning the performance measurement methods implemented by airlines, Francis et al. (2005) designated benchmarking as the most widely adopted. Several researchers dealing with the assessment of airline performance have also implemented benchmarking by implementing a wide array of relevant methodologies. Among the various benchmarking methodologies implemented for airline performance assessment, Data Envelopment Analysis (DEA) has gained an elevated significance in the course of time. As a matter of fact, the number of research efforts dealing with airline performance using the methodological approach of DEA is steadily increasing, thus highlighting the emerging interest over the particular special topic.

The research efforts conducted in the framework of assessing airline performance implementing DEA, have primarily focused on operational productivity, which is otherwise referred to as efficiency. Although previous relevant research has investigated the effects of a wide array of financial and operational aspects on airline efficiency using DEA, the potential impact of alliance membership on airline efficiency has not been sufficiently addressed in existing literature. In this context, the current paper primarily aims to investigate the impact of alliance membership on the efficiency of major international airlines. Additionally, airline efficiency is further explored with respect to freight traffic revenue share and the continent to which air carriers belong (America, Europe, Asia, Oceania). The research contribution of the current paper is threefold, thus reported as follows:

- Evaluate the effect of airline alliance membership on airline efficiency, albeit implementing a differentiated DEA methodological approach and a more recent timeframe compared to the research of Min and Joo (2016) which involved the same topic.
- Assess the effect of freight traffic revenue share on airline efficiency, thus attempting to verify the findings of the research effort of Hong and Zhang (2010).
- Compare the efficiencies of air carriers belonging to different continents, for the purpose of identifying statistically significant differences in a similar way to Joo and Fowler (2014).

The structure of the rest of the current paper is as follows: Section 2 describes the research background and the relevant literature, specifically focusing on DEA methodologies and the selection of inputs and outputs in the framework of the assessment of airline efficiency by previous research. Section 3 deals with the production model of the airlines under investigation, for the purpose of providing a strong theoretical basis for the subsequently adopted DEA model. Section 4 gives a description of the DEA methodological approach, thus providing proper justification with respect to the input and output data and the DEA model that shall be implemented. In addition, Section 4 contains the criteria for selecting the airlines under investigation, along with the sources that relevant input and output data were extracted from. Subsequently, in Section 5, the efficiency results of the implemented DEA model are provided with respective post-hoc analysis related to alliance membership and other relevant aspects. Moreover, in Section 5 results of the post-hoc analysis are discussed, taking into account the conclusions of previous relevant research. Finally, Section 6 summarizes the concluding remarks of the paper and discusses some recommendations for future research.

2. Research background and relevant literature

The research pertinent to transport comprises the fourth most popular research field associated with the application of DEA, for the time period 1978–2010 (Liu et al., 2013). In the current paper, a review of the previous research solely dealing with application of DEA for airline efficiency shall be performed, thus focusing on the aspects of the implemented methodological approaches. Therefore, a comprehensive understanding of previous research efforts shall be developed, subsequently comprising a link to better comprehend the DEA methodological approach implemented in the framework of the current paper.

2.1. DEA models for the assessment of airline efficiency

Previous research concerning the evaluation of airline efficiency using DEA shall be cited in a time sequence context, thus designating its evolution over time. The first research effort involving DEA application for the assessment of airline efficiency is the one conducted by Schefczyk (1993). In the particular research effort, the CCR (Charnes, Cooper, Rhodes) input-oriented basic DEA model is implemented in order to evaluate the efficiency of 15 large international airlines for 1990. The subsequent research of Banker and Johnston (1994) implements the BCC (Banker, Charnes, Cooper) input-oriented basic DEA model to evaluate the efficiency of 12 major US air carriers for the period 1981–1985.

The CCR input-oriented DEA model is also deployed by Good et al. (1995) for the efficiency evaluation of the eight largest European and U.S. airlines for the period 1976–1986. Following a differentiated methodological framework, Sengupta (1999) implements an own-developed Dynamic Efficiency DEA model to evaluate the efficiency of 14 international airlines during the period 1998–1994. Fethi et al. (2000) and Scheraga (2004) also implement the CCR DEA model for the purpose of assessing the efficiency for 17 European and 38 international airlines, respectively. The former deals with time period 1991 to 1995, while the latter deals with years 1995 and 2000. Subsequently, the research of Chiou and Chen (2006) implements both CCR and BCC basic DEA models, attempting to evaluate the efficiency of a single Taiwanese air carrier for various domestic routes during the year 2001. Notable feature of the specific research effort is the assessment of both production and service efficiency utilizing the aforementioned methodologies.

Research conducted by Greer (2006) is deemed quite novel, on the grounds that the super-efficiency methodological approach originally developed by Andersen and Petersen (1993) is implemented along with the CCR input-oriented DEA model, to compare efficiency of seven U.S.-based full-service network carriers (FSNCs) and seven U.S.-based low-cost carriers (LCCs) for the year 2005. Equally notable is the research of Greer (2008), which combines the CCR DEA model with the Malmquist index, for the purpose of evaluating efficiency changes over time for 12 major U.S.-based airlines between years 2000 and 2004.

The BCC DEA model is utilized by Barbot et al. (2008), Barros and Peypoch (2009), and Bhadra (2009) for assessing efficiency of 49 international, 27 European, and 13 U.S.-based airlines, respectively. Though, model orientations differ among the aforementioned research efforts, with Barbot et al. (2008) adopting input orientation and the other two adopting output orientation. On the other hand, the research efforts of Chow (2010) and Hong and Zhang (2010) employ the CCR input-oriented DEA model, for the purpose of evaluating the efficiency of Chinese and international air carriers respectively. Moreover, Lee and Worthington (2010) adopt both CCR and BCC DEA models using input orientation, for the efficiency assessment of 53 international airlines for 2006.

The research effort of Zhu (2011) is considered of high importance, due to the fact that it incorporates the novel own-developed Two-Stage Network DEA model, in order to evaluate 21 international airlines for the period 2007–2008. The aforementioned Two-Stage Network DEA