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Evaluating airline efficiency: An application of Virtual Frontier Network SBM

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ABSTRACT

In this paper, airline efficiency is divided into three stages: Operations Stage, Services Stage and Sales Stage. The new three-stage strategic operating framework of airline efficiency is a modification of existing models. A new model, Virtual Frontier Network SBM, is proposed to evaluate the efficiency of 22 international airlines from 2008 to 2012. The results demonstrate the following: 1. The new model can apply to a new benchmarking airline such as Scandinavian Airlines. 2. Although passenger traffic, cargo traffic and revenue decreased from 2008 to 2009, most airlines' overall efficiency increased in the period.

1. Introduction

Airlines are an important component of the transportation system and have a strong effect on the development of modern society. Conversely, the development of airlines suffers greatly from the overall economic situation. Since 2008, the global airline industry has been greatly influenced by the weak global economy and the changing oil price. The changing situation of profit, revenue, Revenue Passenger Kilometers and Flight Tonne Kilometers is shown in Fig. 1. The data come from the annual reviews of the International Air Transport Association (IATA, 2014).

As shown in Fig. 1, in 2008, global airlines were affected by an unprecedented spike in oil prices and by a precipitous drop in revenues. The revenue drop was caused by the collapse in world trade. Freight Tonne Kilometers and Revenue Passenger Kilometers of 2008 had collapsed 22% and 4.6% below 2007, respectively. In 2009, airlines lost $4.6 billion, Revenue Passenger Kilometers fell 2.1% and Freight Tonne Kilometers dropped 9.8%. Industry revenues fell 15% to $479 billion. However, in 2010, airlines made $19.2 billion in profits and recovered to $554 billion in revenues in 2010. Revenue Passenger Kilometers improved by 6.1%. In 2011, Revenue Passenger Kilometers flown grew 5.9% to a new high of 5.2 trillion. However, despite the passenger demand increase, airlines struggled to make profits. The profits of global airlines in 2011 fell by almost half compared with 2010, to $8.8 billion. In 2012, the profits of global airlines continued to fall to $7.6 billion, whereas Revenue Passenger Kilometers had increased by 5.3% from the previous year.

The increasing Revenue Passenger Kilometers and the fluctuating profit indicate that airlines have low efficiency in controlling operating costs. The profits per Revenue Passenger Kilometers of global airlines from 2008 to 2012 were −6.64 cents in 2008, −1.23 cents in 2009, 4.80 cents in 2010, 2.01 cents in 2011 and 1.66 cents in 2012. This indicator was very volatile during the period and reflects the efficiency change of airlines in a certain degree. However, airline efficiency is complex, and a single indicator cannot sufficiently illuminate the improvement of airline efficiency (Cui and Li, 2015a). Thus, it is

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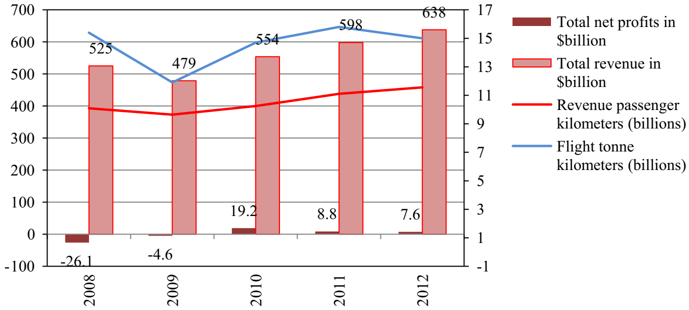

Fig. 1. Changing situation in 2008–2012.

meaningful to measure overall airline efficiency in the changing external environment in 2008–2012. Cui and Li (2015a,b) focused on the energy efficiency and safety efficiency of airlines in this period. However, although these two types of efficiency measures can be used to evaluate airline efficiency from a certain point of view, they do not consider the network structure of airline efficiency, which will be introduced in the following parts. Key questions to be answered include, has the total operating efficiency of global airlines dropped since 2008? How can we measure airline efficiency more comprehensively? By aiming at these questions, this paper focuses on the evaluation of airline efficiency.

In recent years, many papers have focused on the efficiency measures of airlines, such as operating efficiency addressed by Barbot et al. (2008) and Mallikarjun (2015), energy efficiency or fuel efficiency in Miyoshi and Merkert (2010) and Cui and Li (2015a), and safety efficiency in Cui and Li (2015b). The major studies on evaluating airline efficiency are summarized in Table 1. Table 1 shows the evaluated airlines, the period and the method. Compared with Table 1 in Mallikarjun (2015), some recent and missed studies are added.

These papers can provide references on the topic of this paper, particularly in the selection of inputs, outputs and intermediate products.

As shown in Table 1, many papers employed standard Data Envelopment Analysis (DEA) or its modification as a methodology for airline performance measurement. DEA (Charnes et al., 1978; Cui et al., 2014) is a data-planning method to evaluate the relative efficiency of decision-making units (DMUs) with multi-inputs and multi-outputs. However, it does not consider the internal structure relative to the measures characterizing airline operations performance (Zhu, 2011). Most airlines comprise several divisions, for example, China Southern Airlines contains a few divisions—investment division, capital operation division, safety division, aircraft support division and ticket division, etc. The investment division and capital operation division are for operations, ticket division is for sales, safety division and aircraft support division are for services. For China Southern Airlines, its operation divisions need to fully use the resources (manpower, fuel, etc.) increase its passenger and cargo service capacity, which can be reflected by Available Seat Kilometers (ASK) and Available Tonne Kilometers (ATK). The resources can be treated as the inputs of operation divisions, ASK and ATK can be seen as the outputs. An efficient operation requests the airline to produce as much ASK and ATK as possible when the resources are pre-determined. The service divisions need to satisfy the travel demand of passengers and freights from origins to destinations in a safe, punctual, convenient and comfortable mode. For this purpose, they needs to supply aircrafts, seats and freight loads to produce passenger traffic and freight traffic. The aircrafts, seats and freight loads can be thought as the inputs of airline services and the passenger traffic and freight traffic can be seen as the outputs of airline services. In order to produce efficient services, the service divisions needs to minimize the aircrafts, seats and freight loads when the passenger traffic and freight traffic are certain, or to maximize the passenger traffic and freight traffic when the aircrafts, seats and freight loads are certain. Hence, ASK and ATK can be treated as the linking activities between operation divisions and sale divisions. The sale divisions need to sell airline's services as much as possible to produce revenues, in which the services can be treated as its inputs and the revenues can be seen as its outputs. Certainly, the sales process needs some sale cost. An efficient sale requires the airline to produce most revenues when the services and sale cost are certain, or to minimize the services and sale cost when the revenues are fixed. In this sense, passenger traffic and freight traffic can be treated as the linking activities between service divisions and sale divisions. Therefore, for airlines, divisional efficiency is important when exploring the development of overall airline efficiency. In recent years, DEA models with network structure have become popular for evaluating airline efficiency.

In Chiou and Chen (2006), airline efficiency is divided into cost efficiency and service effectiveness. For cost efficiency, fuel cost, personnel cost and aircraft cost are defined as the inputs, with number of flights and seat-miles as the outputs. For service effectiveness, number of flights and seat-miles are the inputs and passenger-miles and embarkation passengers are the outputs. In Zhu (2011), the performance of airlines is grouped into a two-stage process. In the first stage, cost per Available Seat Mile, salaries per Available Seat Mile, wages per Available Seat Mile, benefits per Available Seat Mile and fuel expense per Available Seat Mile are the inputs to produce load factor and fleet size. In the second stage, load factor and fleet size are the inputs to generate Revenue Passenger Miles. Gramani (2012) divides airline efficiency into two phases, operational performance and financial performance. Aircraft fuel, wages, salaries and benefits and Cost per Available Seat Mile are the inputs