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Measurement of airlines' capacity utilization and cost gap: Evidence from low-cost carriers

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ABSTRACT

The aim of this paper is to evaluate the capacity utilization and cost gap between actual and global long-run minimum costs. Based on the data for thirteen low-cost carriers around the world for the year 2010, an input-oriented data envelopment analysis model is used to estimate the physical capacity utilization and cost gap between actual and global long-run minimum costs. The empirical results show that more than half of low-cost carriers should improve their capacity utilization, and all low-cost carriers should enhance their market efficiency and reduce their excess costs. Of the thirteen low-cost carriers, three should improve their technical efficiency, four should re-distribute the mix of variable inputs, all thirteen should pay lower prices for all variable inputs, and ten should enhance the utilization rate of their fixed factors.

1. Introduction

Low-cost carriers (LCCs) have existed in the airline industry for over 30 years. Since the LCCs have cost advantages over traditional airlines, they have grown rapidly. Their growth has promoted competition in the airline industry, and induced a sustained increase in passenger numbers and a larger network in recent decades. According to Airport Council International (2013), the European network had fewer than 6000 routes in 2001, but more than 10,000 in 2013. However, the cost advantages of LCCs are threatened by worsening economic conditions (International Air Transport Association, 2009). Hence, not all LCCs can achieve sustainability. Pearson and Merkert (2014) indicated that there were 27 LCC failures in their samples covering the 1993–2012 period. The International Air Transport Association and other international airline associations have warned that, in the airline industry, higher performance is the only way to achieve sustainability in the tough competitive environment (Assaf & Josiassen, 2012). Therefore, the operational performance assessment of LCCs should be a fundamental management activity. Capacity utilization and the cost gap between actual and global long-run minimum costs can provide useful information on how to improve LCCs' performance. Therefore, this paper aims to analyze capacity utilization, the cost gap between actual and global long-run minimum costs, and their decomposition for LCCs. The results are expected to contribute to improvement in overall management of LCCs.

Since the degree of capacity utilization depends on the ability of firms to utilize their fixed factors in the short run, and cost inefficiency often results from the inability to adjust fixed factors, capacity utilization is an important economic parameter of performance when analyzing firms' behavior (Sahoo & Tone, 2009). Capacity utilization is generically defined as the ratio of actual output to potential output. The potential output can be defined in two alternative ways: physical concept and economic concept. Using the physical concept, the capacity output is defined as the maximum potential output when the variable inputs are fully utilized with existing plants and equipment (Johansen, 1968). In contrast, based on the economic concept, there are three definitions of capacity output. The first definition is the output level at the short-run minimum average cost (Cassel, 1937; Hickman, 1964; Berndt & Morrison, 1981). The second definition is the output level at which the short-run and long-run average cost curves are tangent (Klein, 1960; Segerson & Squires, 1990). The third definition is the output level at the maximum profit (Coelli et al., 2002). The main difference between physical and economic measures is that the physical measure of capacity output does not require information regarding input prices. Since the physical measure can eliminate the effect of input prices, this paper adopts the physical concept of capacity output to measure the capacity utilization. However, we measure physical capacity utilization in terms of

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inputs. In other words, capacity utilization is defined as the ratio of potential fixed input to actual fixed input in this paper, in which the potential fixed input is the minimum fixed input given the current output levels. Furthermore, the effect of input prices is reflected in the measure of market efficiency. Hence, this paper can provide more accurate directions for improvement for managers.

In the field of performance evaluation, few studies have developed frontier-based methods for estimating capacity utilization. Färe et al. (1989) introduced the frontier-based method to define and measure the physical measures of capacity and capacity utilization. Coelli et al. (2002) decomposed capacity utilization into technical efficiency, economic capacity utilization and optimal capacity idleness, and also measured the contribution of the unused capacity of 28 international airline companies. Their results showed that 70% of the profit gap may be attributed to unused capacity. Sahoo and Tone (2009) proposed radial and non-radial methods to assess the physical and economic measures of capacity utilization of the Indian banking industry. Their results indicated that since competition was promoted after the financial sector reforms, efficiency was enhanced and excess capacity was reduced. However, the capacity utilization measured by Färe et al. (1989) results in a downward bias because they consider technical inefficiency and unused capacity to be two mutually exclusive components. Although Coelli et al. (2002) eliminate the aforementioned problem and treat technical inefficiency as a component of unused capacity, they adopt the radial method, which results in an upward bias to the utilization rates when some slacks remain after the full radial projection is achieved. Since the non-radial method proposed by Sahoo and Tone (2009) further solves the problem of slacks and considers technical inefficiency as a component of unused capacity, this paper follows Sahoo and Tone (2009) to use the non-radial input-oriented slack-based measure data envelopment analysis (SBM-DEA) model to measure capacity utilization and its decompositions in the context of LCCs around the world.

However, the point of full capacity utilization may be not the point of minimum cost. In order to capture the contribution of capacities, the global long-run minimum cost should be computed, and the cost gap between the actual and global long-run cost minimum should be decomposed. The DEA-based cost efficiency model can be used to estimate the long-run minimum cost. However, the traditional cost efficiency measure neglects the presence of price differences between the decision making units (DMUs) (Tone, 2002). Camanho and Dyson (2008) relaxed the common set of prices for all DMUs to develop a new framework for cost efficiency assessments, and used the DEA analysis to account for the conditions of not-fully competitive markets in real life. When considering economic efficiency, they distinguished between market efficiency and Farrell cost efficiency.[1] Based on their interpretation, market efficiency reflected the differential between the minimum cost with the current input prices and the minimum cost potentially attained under the conditions of fully competitive markets as a baseline. This reflected the ability to pay the minimal input prices under the current conditions of their market. In the airline industry, the input price differences across LCCs are not exogenously defined for the DMUs, but can depend on negotiation in real-life markets. The cost efficiency measure should have a baseline under the conditions of fully competitive markets in DEA analysis. Hence, this paper applies the model proposed by Camanho and Dyson (2008) to reflect cost reductions achievable via price adjustments in non-fully competitive LCC markets which are not fully competitive. In addition, an LCC competes not only with other LCCs in the same market, but also with other LCCs in different markets. In order to achieve global cost efficiency, an LCC seeks not only the minimum input prices in its market but also the minimum input prices in the whole world. Hence, in examining global cost efficiency, this paper distinguishes between market efficiency and the current short-run cost efficiency. It also measures the local market efficiency and global market efficiency to capture the extent to which the LCCs succeed in incurring the minimal input prices under the current conditions of their local market or global market as well as the inefficiencies associated with the overpayment of resources.

The contributions of this paper are threefold. First, we explore the capacity utilization of LCCs based on the SBM-DEA model. Second, we consider the input price and market differences to assess the local and global market efficiency of LCCs. Third, we decompose the cost gap between actual and global long-run minimum costs into the cost gaps between actual and technically efficient costs, between technically efficient and short-run minimum costs, between short-run minimum and local short-run minimum costs, between local and global short-run minimum costs, between global short-run minimum and local long-run minimum costs, and between local and global long-run minimum costs. The advantage of our approach in the measurement of LCCs' capacity utilization and cost gap is that it not only provides more information for cost reduction target setting, but also overcomes the shortcomings of the Farrell cost efficiency measure when prices differ between LCCs. The method we propose provides information that is meaningful to managers.

The rest of this paper is organized as follows. Section 2 presents a literature review on airline performance analysis using DEA models. Section 3 describes the methodology. Section 4 examines the capacity utilization and cost gap between the actual and global long-run minimum costs of LCCs, and also explores the market efficiency measure when prices differ between LCCs in markets. Section 5 concludes the paper.

2. The use of DEA in performance analysis of airlines

Although various methods have been adopted to measure the performance of airlines (e.g. ratio indicators; cost models; total factor productivity approach; stochastic frontier approach), contemporary research has applied the DEA methods to evaluate airline performance in recent years. However, most DEA studies of performance evaluation of airlines focused on computing technical efficiency scores or productivity change.

In terms of technical efficiency, Schefczyk (1993), Barbot et al. (2008) and Cheng (2010) used traditional DEA models to measure the efficiency of airlines. Tofallis (1997) did not consider inputs to be substitutes for each other, and proposed a modified DEA approach to study the input efficiencies of 14 major international passenger carriers for the year 1990. Scheraga (2004), Barros and Peypoch (2009), Assaf and Jossiassen (2011), Wu et al. (2013) and Lee and Worthington (2014) applied DEA models to assess technical efficiency of airlines, and used regression models to investigate the impact of environmental variables on the estimated efficiency. Chiou and Chen (2006) used the perspective of cost efficiency, cost effectiveness and service effectiveness to evaluate the performance of 15 domestic air routes in Taiwan by separate DEA models. Jang et al. (2011) used an SBM model to assess the technical efficiency of 15 major US airlines for the period of 2000–2006. Zhu (2011), Gramani (2012), Lu et al. (2012), Lozano and Gutiérrez (2014), Tavassoli et al. (2014), Li et al. (2015) and Mallikarjun (2015) developed various network DEA (NDEA) models to analyze the sub-process and overall efficiencies of airlines. Yu (2012) developed

[1] Farrell cost efficiency measures the ratio of the minimal cost given the current price levels at each DMU to produce the current outputs to the actual cost (Camanho and Dyson, 2008).