Journal of Air Transport Management xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Journal of Air Transport Management

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

Short communication

The analysis of the cost-revenue production cycle efficiency of the Italian airports: A NSBM DEA approach

Corrado lo Storto

Department of Industrial Engineering, University of Naples Federico II, Piazzale V. Tecchio n. 80, 80125 Naples, Italy

ARTICLE INFO

Keywords:
Airport
Italy
Efficiency
Cost-revenue production cycle
Business models
NSBM DEA

ABSTRACT

This paper measures the efficiency of Italian airports using Data Envelopment Analysis (DEA). Particularly, the efficiency of an airport is evaluated at three different stages of its cost-revenue production cycle, i.e. cost-operations-revenue stages, while network-slack based measure DEA (NSBM-DEA) is adopted to generate efficiency measurements for the airports at each stage. Results show that the suggested modeling approach has a better discrimination capability than the traditional black-box DEA model and provides important insights for policy makers and airport concessionaires useful for improving industry performance and airport management.

1. Introduction

After the deregulation of the air transport market in the 80s, all over the world airports have transformed from being infrastructure assets owned and/or managed by various bodies belonging to public sector into business-oriented firms that provide air transport and other services. Because airport operators must finance investment and operating costs of the infrastructure, they were forced to increase their revenues relying on a variety of other sources including space leasing for commercial activities, car parking and retail and not only on the traditional aviation revenues. Non-aviation revenues have become an important component of the airport economics in many airports as they generally yield higher profit margins in comparison with the traditional aviation revenues. However, recent statistics have showed that several airports are unable to achieve financial sustainability (ACI, 2016). Indeed, even though in the last years airport concessionaires have improved how they manage operations to increase efficiency and better meet passenger and airline needs, total operating costs have risen due to new imposed safety and security regulatory burden. Evaluating the capability of airports to generate revenues efficiently along the cost-revenue production cycle and uncovering causes of scarce performance is therefore an important topic to focus on.

Since time Data Envelopment Analysis (DEA) has been extensively utilized in several fields to assess the performance of homogeneous units that are denominated decision-making units (DMUs). Particularly, literature reports a big number of empirical studies in which scholars have implemented DEA to measure efficiency and conduct benchmarking analysis to compare airports with the aim to investigate the factors that negatively affect their efficiency (Barros and Dieke, 2007; Fasone and Zapata-Aguirre, 2016). Most of these studies consider airports under evaluation as DMUs that utilize a single production process which converts a set of inputs into another set of outputs adopting a "black-box" approach. In the black-box approach the airport specific activities and sub-processes remain aggregated and the interactions between them are not considered in the efficiency analysis.

Whereas the black-box approach of traditional DEA provides useful insights to identify causes of inefficiencies when DMUs are simple systems, it may be useless or even misleading when the inner structure of the production process of the DMUs becomes very complex as in the case of airports. Airports are complex systems in which several production processes are performed (Liu, 2016). As a system, the goal of an airport is to move aircraft, passengers, freight and baggage to a certain place at the planned time. Several organizations provide different services along the customer-supplier value chain contributing to achieve such a goal, i.e. the airport operating company, the airlines, the ground handling operators, the aircraft servicing operators, the aviation safety authority, shops and restaurants in the terminal area, etc. To provide these services, some facilities are available to these organizations - facilities to store and maintain the aircraft, a control tower, the landing and take-off areas with the airport aprons, taxiway bridges and runways, the terminals with the check-in and control areas, and the passenger facilities such as restaurants and lounges, parking lots, customs and emergency services. Thus, the airport operational efficiency is critically affected by the interaction of several activities and processes (Adler et al., 2013a). In such a context, a traditional DEA approach can be not useful. Rather a network-DEA approach provides a more accurate measurement of efficiencies and indications for management (Färe and Grosskopf, 2000; Lewis and Sexton, 2004).

E-mail address: corrado.lostorto@unina.it.

https://doi.org/10.1016/j.jairtraman.2018.05.010
Received 3 January 2018; Received in revised form 22 April 2018; Accepted 29 May 2018

This study evaluates the efficiency of Italian airports by adopting a non-parametric method. Specifically, the efficiency of an airport is measured along its cost-revenue production cycle (CRPC) by implementing network-slack based measure DEA (NSBM-DEA) (Tone and Tsutsui, 2009). The impacts on efficiency of the airport business and management model and airport size are also explored. The remainder of the paper is organized as follows. Section 2 illustrates details of the modeling approach focusing on the airport cost-revenue production cycle concept and the network slacks-based measure model. Section 3 provides information about the sample of Italian airports and variables used to model the airport cost-revenue production model, and presents results of the empirical study. Particularly, the approach is applied to investigate the influence that the business and management model and size may have on efficiency. Finally, Section 4 concludes and presents recommendations for further research.

2. Modeling approach

2.1. Background

Since the 90s, DEA has been used to measure airports efficiency in several studies (Gillen and Lall, 1997). In some of these studies, scholars computed airports efficiency relatively to specific years (Barros and Dieke, 2007; Sarkis, 2000); in other studies, researchers evaluated efficiency changes and productivity in a period of time (Ahn and Min, 2014; De Nicola et al., 2013); finally, a number of studies investigated the impact on efficiency of certain factors, i.e. size (Adler et al., 2013b; Lam et al., 2009; Martín and Román, 2008), ownership (Adler and Liebert, 2014; lo Storto, 2018; Oum et al., 2008), business and management model (Ferreira et al., 2016), competition and market regulation (Curi et al., 2010; D'Alfonso et al., 2015), country development and wealth (Tsui et al., 2014).

Generally, scholars that used a DEA-based model to measure airport efficiency considered the production system of an airport as a *black box* performing a single production process. However, as Lewis and Sexton (2004) emphasize, the black-box modeling approach is unable to provide accurate information about inefficiency of the production system as it does not consider the various interrelated production processes performed by the system. Since the first paper by Färe and Grosskopf (2000), several network DEA (NDEA) modeling frameworks have been proposed to account for the internal structure of the production system to measure both its overall efficiency and the efficiency of the underlying processes. Particularly, NDEA models have been employed in the transportation industry (Yu and Lin, 2008; Yu, 2008; Tavassoli et al., 2014, 2015; Zhu, 2011), banking and financial sector (Avkiran, 2009; Kao and Hwang, 2008; Yang and Liu, 2012), and utilities (Tone and Tsutsui, 2009).

A few studies applied NDEA to evaluate airport efficiency. Yu (2010) measured the efficiency of a sample of domestic airports in Taiwan adopting a slacks-based measure network data envelopment analysis (SBM-NDEA) approach. In his model the airport operations are decomposed into a sequence of production and service operations. Service operations are further decomposed into airside and landside operations which are connected in parallel. Lozano et al. (2013) developed a NDEA model to compare efficiencies of Spanish airports operations. Their model includes two stages, the first one modeling aircraft movement operations, the second one modeling aircraft loading operations. They use a directional distance approach to account for undesirable outputs. Adler et al. (2013a) adopted a comprehensive NDEA based method to benchmarking airports from a managerial perspective. Such method conceptualizes the airport as a production system that transforms some inputs (capital, labor, materials and outsourced services) to produce traffic volume as intermediate output and different types of revenue as final output. Their methodology is used to evaluate the efficiency of 43 European airports located in 13 different countries over 10 years. Maghbouli et al. (2014) proposed a two-stage NDEA model to measure the efficiency of 39 Spanish Airports in 2008. Their model allows consider weak disposability and undesirable products, either as intermediate links or final outputs. Both cooperative and non-cooperative game assumptions are used in their study.

In all the proposed models, researchers generally decomposed the black-box production system into a two-stage production process in which the outputs from the first stage are the inputs to the second stage. Splitting the airport production system into more than two stages allows having a more refined understanding of determinants of inefficiencies and measurement of the overall efficiency. Additionally, NDEA modeling was not yet employed by scholars to measure airports efficiency in Italy. Filling these gaps is the aim of this study.

2.2. The airport cost-revenue production cycle (CRPC) model

To have a more accurate efficiency measurement and effective understanding of what are the determinants of scarce performance, the analysis should consider both financial and operational issues of the airport at the same time and in an integrated view. As recent literature suggests "[…] a broader perspective that takes into account financial and operational issues is necessary to capture relevant aspects of airport efficiency" (lo Storto, 2018, p. 183). Henceforth, in this study a multiple-perspective view of airport efficiency is used and the production process of the airport is modeled combining the cost-revenue production cycle (CRPC) concept and the network DEA (NDEA) approach.

Adopting the CRPC conceptualization allows having a more comprehensive and in-depth view of how different types of resources (i.e., financial and physical) are sequentially utilized and transformed to produce necessary outputs in an airport. In the CRPC model the production process starts when a certain amount of financial resources is used to make available the hard and soft infrastructure assets (i.e., runways, apron, people, etc.) necessary to carry on the airport operations. Cost data provide a measure of the economic value of such financial resources. At the next stage of the CRPC, the infrastructure assets are utilized to deliver typical airport services, i.e. airfield operations and maintenance, passenger and cargo terminal management, operations and maintenance, ground handling and aircraft fueling, etc. The cycle ends with the generation of financial resources after selling - either directly or indirectly - services both to passengers, airlines, and commercial businesses.

The CRPC is split into three stages, modeling three interlinked sub-production functions that capture the same number of different

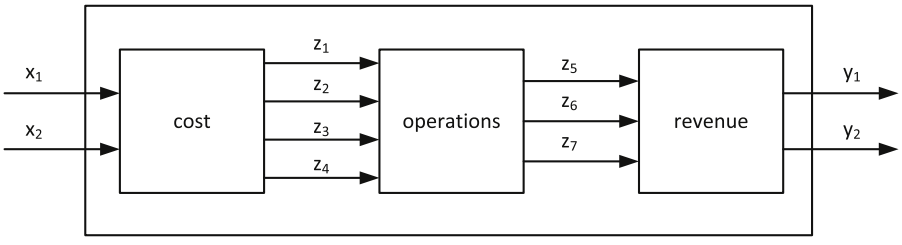

Fig. 1. The airport cost-revenue production cycle.