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Airport efficiency in Pakistan - A Data Envelopment Analysis with weight restrictions

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ABSTRACT

This paper investigates 12 major airports in Pakistan for potential cost inefficiencies. We identify inefficiencies by benchmarking the productive performance of airports using Data Envelopment Analysis (DEA) and data for 2012. To improve the ability of DEA to differentiate performance levels, we impose restrictions on the possible weights of inputs and outputs in the DEA procedure. The definition of these weight restrictions is based on additional information on feasible production trade-offs and relative input prices. To the best of our knowledge, this paper provides the first application of predefined weight restrictions in a DEA analysis of airport efficiency. The results suggest that there are cost inefficiencies at several airports, which are mainly caused by overstaffing and overinvestment in capacity. Furthermore, we find that the operational scale of most airports is inefficiently small, so that increases in traffic will result in declining unit costs.

1. Introduction

Competition between airports is often limited as there are several sources of market power (see e.g. Starkie, 2002). The lack of competitive pressure may lead to inefficiencies in the provision of airport services. At state-owned airports, incentives for efficient operation can be particularly weak if losses may be covered by public funds. Therefore, performance benchmarking is an important tool for both public and private airport operators. Comparing the performance among airports helps in identifying excess use of resources and potential areas for improvement. Besides airport operators, regulators also apply performance benchmarking (Marques and Brochado, 2008). Regulators using price-cap regulation need to estimate the productivity growth in the industry over time, in order to determine appropriate price caps.

To compare productive performance, airport managers generally use partial measures of performance (Francis et al., 2002). Partial performance measures, such as the number of passengers handled per employee, consider only selected inputs and outputs. However, comparisons based on partial performance measures may be misleading, if relevant inputs and outputs are ignored. For example, the indicator passengers per employee disregards activities that are not directly related to passenger handling, but are performed by employees, such as the facilitation of aircraft operations. Total performance measures take all inputs and outputs into account. Data Envelopment Analysis (DEA) is a technique that enables considering multiple inputs and outputs and is widely applied by academics to measure airport efficiency (see e.g. Gillen and Lall, 1997; Parker, 1999; Pels et al., 2003; Ferreira et al., 2016). DEA assigns each evaluated decision-making unit (DMU) a relative efficiency score ranging between zero and one, with one indicating efficiency. However, a common problem in DEA applications is that the performance of the DMUs cannot be differentiated sufficiently. DEA may rank most DMUs as efficient even though their performance differs. This is particularly likely to occur when the number of inputs and outputs is high in comparison to the number of observed DMUs.

To improve the ability of DEA to differentiate performance levels, restrictions can be imposed on the possible weights of inputs and outputs in the DEA procedure (Podinovski and Thanassoulis, 2007). Kuosmanen and Post (2001) demonstrate that even a simple weight restriction can have a strong impact on DEA efficiency scores. For illustration, they assess the cost efficiency of commercial banks. From economic theory, they derive that equity capital should be a more expensive input for banks than debt capital, and therefore enforce a higher DEA weight for equity than for debt capital.

This paper uses DEA to investigate the airports in Pakistan for potential cost inefficiencies. To improve the differentiation of performance, we restrict the possible weights of inputs and outputs on the basis of additional information on feasible production trade-offs and relative input prices. To the best of our knowledge, this paper provides the first application of predefined weight restrictions in a DEA analysis of airport efficiency and is also the first study of airport efficiency in

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Pakistan.

Our results show that there are cost inefficiencies at airports in Pakistan. The inefficiencies found in the employment of labor have direct implications for airport management; increases in labor productivity are possible and would enable the reduction of staff numbers without changing the level of operation. In contrast, the inefficiencies identified in the use of capital cannot or can only minimally be decreased by management, as investments in airport infrastructure like runways and terminal buildings are irreversible. Only a significant growth in traffic in the future may better utilize existing capacity and increase efficiency. Thus, the measured capital efficiencies indicate rather where investment in airport infrastructure has been efficient in the past, and allow conclusions to be drawn on how future expansion plans should be designed. We also identify scale efficiencies and find that the operational scale of most airports is inefficiently small. Rising traffic levels would lead to a decline in unit costs at these airports, which has implications for airport charges and airport development.

The remainder of the paper is structured as follows: Section 2 introduces the DEA method, and discusses factors that need to be considered in a DEA analysis of airport efficiency. Section 3 explains our DEA methodology. Section 4 describes the data, and Section 5 presents and interprets the efficiency results. Finally, Section 6 concludes.

2. Measuring airport efficiency with DEA

DEA is a technique for measuring relative efficiency. In DEA, a production frontier is constructed from a set of comparable DMUs and data on their input and output quantities. The efficiency of each DMU is defined by its relative distance from the production frontier. DEA is often used because of its attractive properties. That is, it is a nonparametric technique and therefore does not require assuming a parametric form of the production frontier. In addition, no information on input and output prices is needed.

In DEA analyses of airport efficiency, physical as well as financial measures of inputs and outputs are employed. Liebert and Niemeier (2010, 2013) review studies assessing the productivity and efficiency of airports. According to the list of DEA studies in Liebert and Niemeier (2010), commonly used inputs are the number of employees, number of runways, airport area, terminal area, staff costs, other operating costs and capital stock. Typically considered outputs are the number of passengers, number of aircraft movements, tonnes of cargo, aeronautical revenue and non-aeronautical revenue.

One of the main challenges in DEA is to ensure comparability between DMUs. Differences in the range and quality of inputs and outputs, factors not under the control of decision-makers, and variations in data-reporting methods complicate the analysis. To account for these circumstances, two strategies are pursued. First, the analysis can be restricted to a group of similar DMUs or to a comparable activity of DMUs. Second, dissimilarities can be allowed for in a DEA model, if suitable data are available to control for the respective factors. In the following, we discuss differences between airports and in airport data that are most challenging in benchmarking, and review some applications of the two approaches. In doing so, we also refer to studies that use other productivity measurement methods, but whose approach is transferable to DEA.

2.1. Factors out of control of airport operators

The transport demand at an airport is strongly influenced by population size and economic activity in the catchment area, and by nearby competing airports (Liu et al., 2006). The specific level of demand limits the influence of management on airport outputs like traffic volumes and revenues. One approach to accounting for this uncontrollable factor in DEA is to take outputs as given, by using the input-orientation and to measure outputs physically in terms of traffic numbers (see e.g. Pels et al., 2001). Thereby it is analyzed to what extent inputs, and therefore costs, could be reduced, while serving the same traffic volumes. Another procedure in DEA applied by Yu (2010) is to use the output-orientation in combination with a measure of demand as an uncontrollable input. In general, output-oriented DEA models evaluate to what extent outputs could be increased, while employing the same amount of inputs. Yu uses the population in the region surrounding the airport as a proxy for demand, and includes it as an uncontrollable input, which puts upper limits on the traffic numbers that efficient airports can achieve.

Demand also affects airport size, which has an impact on operating cost. There is considerable evidence that increasing economies of scale prevail at airports, at least to some point (see e.g. Tolofari et al., 1990; Pels et al., 2003; Martín and Voltes-Dorta, 2008). This means that airports with higher traffic volumes usually have lower unit costs. Average costs appear to decline most significantly up to a level of about three to five million passengers annually (Doganis and Thompson, 1973; Doganis et al., 1995; Main et al., 2003). In airport DEA studies, the variable returns to scale (VRS) model is often used, which was developed by Banker et al. (1984). The VRS model is an extension of the constant returns to scale (CRS) model introduced by Charnes et al. (1978). The shape of the production frontier of the VRS model incorporates the possibility that returns to scale increase at low output levels and decrease at high output levels. Thus, potential scale inefficiencies at smaller and larger airports are treated as beyond managerial control.

Furthermore, the type of passenger traffic depends on demand and affects the level of costs. A large share of international passengers results in higher unit costs, as more employees and terminal space are needed for immigration, customs and lounge areas (Graham, 2008, p. 77).

Besides demand, input prices also differ by geographical location, in particular wages and land prices. Therefore, instead of considering costs and asset values as inputs, physical measures such as the number of employees and the size of the airport area are often used in DEA applications (see e.g. Gillen and Lall, 1997).

Other factors that limit airport performance and are beyond the control of management include governmental noise regulations, such as restrictions on the number of aircraft movements and night curfews. In addition, climatic and topographic conditions of the airport location play a role. Strong winds from varying directions may require additional runways with different orientations. Snow falls necessitate snow removal and de-icing equipment and further personnel. High altitudes and high temperatures make longer runways necessary, because less dense air reduces the lift of aircraft wings and increases the required takeoff speed.

2.2. Factors under control of airport operators

The range of offered services belongs to the factors on which airport management can decide. Airport services can be classified as either aeronautical or non-aeronautical. Aeronautical activities are directly related to airport traffic and include the provision of runways, terminal buildings, air traffic control, security, fire services, and the handling of passengers, aircrafts and cargo. The non-aeronautical services of an airport include the granting of concessions for food and beverage outlets, retail shops, car parks, and car rentals, as well as the renting out of land, terminal area and advertising space. Different levels of involvement of airports in these activities make comparisons difficult. For example, at most airports worldwide, passenger, aircraft, and cargo handling is done by external handling agents or airlines. But some airports, particularly in Europe, offer handling services themselves and are in part heavily engaged in these activities (Graham, 2008, p. 73). Doganis et al. (1995) and the Transport Research Laboratory (TRL) (1999) account for diversity in the range of airport services by limiting their performance assessment to core aeronautical services that all studied airports provide exclusively by themselves. Non-core activities