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Incorporating negative externalities into productivity assessments of US airports

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ABSTRACT

This paper analyses the efficiency of 44 US airports for the period 2005–2009. In addition to the conventional outputs (i.e., passengers, flights and cargo), we consider three undesirable externalities of airport activities: delays, noise and local air pollution. We adopt a directional distance function approach and perform a second stage analysis to investigate potential determinants of efficiency. Our base case results with only the positive outputs show that the greater the average aircraft size serving an airport and the larger the dimensions of the airport, the higher the technical efficiency. However, our results are sensitive to the inclusion of the undesirable outputs. The implications are that the inclusion of these externalities into the calculation of efficiency may impact policy decisions.

1. Introduction

As airports have assumed more commercial roles, either as privatized, partially-privatized, or government-sponsored entities, and as airports have vied for traffic from alliance and low-cost carriers, the efficiency of their operations has become increasingly relevant. As a result, there has been an increasing interest in efficiency studies of airport activities (Lozano and Gutiérrez, 2011a). In these studies, airport performance is generally evaluated based on the relationship between combined inputs and outputs.

A technically efficient airport is able to maximize the volumes of passengers, cargo and aircraft movements given the infrastructure and other inputs at its disposal. However, this type of benchmark may not be sufficient. First, there is no consideration of the quality of the services provided by the airport. Along these lines, major concerns of both passengers and airlines are flight delays and their undesirable impact on passenger plans. Hence, it is reasonable to consider delays as negative outputs of an airport production process in order to avoid the risk of overestimating the efficiency of congested airports (Pathomsiri et al., 2008).

Furthermore, airport activities produce negative effects from an environmental point of view, especially for people living near the facility. In this sense, the noise nuisance produced as a byproduct of the activity at the airport is the main concern. However, local air quality is also becoming increasingly relevant, not only for airport neighbors, but also for regulators and airport managers (GAO, 2000). Both noise and local pollutants represent significant undesirable externalities of an airport's

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production process and should be considered when estimating efficiency; that is, airports producing *ceteris paribus* more damaging effects should be penalized when compared to more environmental friendly airports.

To the best of our knowledge this is the first paper that considers, simultaneously, all three of these negative outputs – delays, noise, and local pollution – when assessing airport efficiency. Yu (2004) and Yu et al. (2008) consider only the impact of noise on airport efficiency. Pathomsiri et al. (2008) and Lozano and Gutiérrez (2011b) include the impact of delays in their productivity studies. In this paper, we analyze the efficiency of forty-four US airports for the period 2005–2009 adopting a directional distance function approach (DDF) and considering the three externalities. Furthermore, we perform a second stage analysis to investigate potential determinants of efficiency; notably average aircraft size, airport size, inclusion in a multiple airport system, percentage of both night flights and international flights.

The main contributions of this research are as follows: (1) We highlight possible distortions in the assessment of airport efficiency that arise from ignoring negative externalities; (2) We investigate the role of three key external factors (i.e., delays, noise and local pollution) in influencing airport efficiency, and (3) We examine the impact of various operational characteristics on efficiency measures and determine how these impacts change depending on whether efficiency scores are calculated with or without consideration of the externalities.

The remainder of this paper is organized as follows: Section 2 briefly reviews the relevant literature. Section 3 presents the empirical model and the methodology used to measure the negative outcomes produced at the airports. Section 4 applies this approach to study the production processes of US airports. Section 5 describes the database for the empirical analysis. Finally, results are presented in Section 6, and conclusions drawn in Section 7.

2. Literature review

Technical efficiency is a measure of the ability to maximize outputs from a given input vector or minimize input utilization in the production process of a given output vector (Coelli et al., 2005). As a result, information on the quantities of inputs and outputs are required to describe the structure of production technology (Kumbhakar and Lovell, 2000). Lozano and Gutiérrez (2011a) present a detailed review of the literature on airport productivity analysis. Parametric studies on airport technical efficiency (e.g., Pels et al., 2001, 2003) have been found to be limited in number and to present some relevant drawbacks. First, most of these studies do not consider the multiple outputs produced by airports (e.g., flights, passengers, freight, etc.). To the best of our knowledge, Chow and Fung (2009), Tovar and Martin Cejas (2009) and Scotti et al. (2012) are the only contributions adopting a multi-output parametric approach. Second, undesirable outputs are generally treated as fixed inputs thereby ignoring the jointness in production between desirable and undesirable outputs (e.g., flights cannot be produced without also producing noise and local pollution).[1]

As a result of the drawbacks with the parametric approach, we adopt a non-parametric method for this paper. In particular, we use a Directional Distance Function (DDF) approach (Charnes et al., 1978). With the frontier approach, a best practice production frontier, by which each firm is evaluated, is estimated. In addition, the DDF approach allows us to modify the direction of output changes to reach the efficient frontier (Chambers et al., 1996, 1998; Färe and Grosskopf, 2000). This is an essential property when including both undesirable and desirable outputs since it allows firms to be credited for reducing bad outputs and to be discredited for bad output expansions. Moreover, DDF is an additive model implying that all of the conditions required to identify the best-practice frontier are linear. As a consequence, a standard Data Envelopment Analysis (DEA) procedure can be applied.

Only a few papers include undesirable or bad outputs in their assessment of airport efficiency and DDF is the most common approach used in these papers. Yu (2004) and Yu et al. (2008) includes airport noise as an undesirable output in his estimation of airport efficiency. Yu (2004) analyzes 14 Taiwanese airports for the period 1994–2000 using a DDF model. His results suggest that ignoring noise pollution implies both a higher number of inefficient airports and a greater distance for many airports from the efficient frontier. Yu et al. (2008) analyze the productivity growth of four Taiwanese airports for the period 1995 to 1999, showing a higher average total factor productivity growth when noise is not considered.

Pathomsiri et al. (2008) incorporate congestion (delays) as undesirable outputs and apply a DDF approach to a panel of 56 U.S. airports for the period 2000–2003. Their results show that large but congested airports can be found on the efficient frontier when delays are not included in the analysis. On the contrary, when delays are considered, smaller and less-congested airports recover in terms of efficiency due to the credit provided by the DDF methodology for on-time flights. As a result the efficient frontier includes a more diverse selection of large and small airports when delays are considered in the efficiency estimation.

Lozano and Gutiérrez, 2011b compare the DDF approach with a slack-based method and compute the efficiency of 39 Spanish airports for the period 2006–2007.[2] They also consider delays in their estimation and find that the two methods provide different effects on the efficiency scores when delays are included. Finally, Martini et al. (2013) analyze the efficiency of 33 Italian airports for the period 2005–2008, while including noise and local air pollution as negative outputs of their production function. They find that the inclusion of undesirable outputs increases efficiency scores. Furthermore, a second stage analysis

[1] One possible solution to this second drawback is to specify a hyperbolic distance function as in Cuesta et al. (2009), but this type of approach allows only for equi-proportional reductions in bad outputs with respect to good outputs expansion.

[2] Note that the slack based approach is proved to be only a special case of the more general concept of DDF (Färe and Grosskopf, 2010).