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The influence of fleet mix, ownership and LCCs on airports' technical/environmental efficiency

Gianmaria Martini [a], Alessandro Manello [b], Davide Scotti [a,*]

[a] University of Bergamo, Department of Economics and Technology Management, Viale Marconi 5, 24044 Dalmine, BG, Italy
[b] University of Bergamo & CNR-Ceris, Via Real Collegio 30, 10024 Moncalieri, TO, Italy

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A B S T R A C T

This paper analyses the efficiency of 33 Italian airports for the period 2005–2008. In addition to conventional outputs, differently from previous contributions, two environmental externalities are considered: noise and local air pollution. We perform a two-stage analysis. First, we implement a directional distance function (DDF) model and get airports' efficiency scores. Then, we study the factors affecting efficiency using a bootstrapping procedure. We find that the fleet mix significantly affects technical/environmental efficiency. Moreover, we provide evidence that public airports have higher efficiency scores. Last, LCCs have no effect on technical/environmental efficiency.

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1. Introduction

Aircraft emissions of air pollutants (produced by aircraft engines) and noise nuisance are the two main environmental concerns related to the aviation sector in the area surrounding an airport. Although noise is currently the primary environmental concern for airport operations, many airports also take air quality issues into account (GAO, 2000). Furthermore, while the connection between noise and human health is still somewhat unclear, emissions are known to have a direct impact on population health (Daley, 2010), especially on those people living near airports. Hence, it is necessary to integrate emissions and noise into productivity measures in order to design polices providing to airlines the necessary incentives for moving towards a greener fleet. Few contributions are available on this issue: Yu (2004) and Yu et al. (2008) consider only the impact of noise on airports' efficiency. To the best of our knowledge, no efficiency studies consider both emissions and noise. Furthermore, no previous contributions have investigated which factors affect airports' technical/environmental efficiency. Hence, our goals are threefold. First, our aim is to assess airport productivity by taking into account both desirable (i.e., passengers, aircraft movements, and freights) and undesirable (i.e., noise and local air pollution) outputs. Second, we want to compare these productivity levels with those obtained when only desierable outputs are considered, in order to outline the possible distortions arising on airports' benchmarking. Finally, we want to investigate the determinants of airports' efficiency scores, such as their fleet mix, ownership, size, presence of low-cost carriers (LCCs), and airlines' market power. We investigate a sample of 33 Italian airports over the period 2005–2008.

The remainder of this paper is organized as follows. Section 2 reviews the relevant literature, Section 3 presents the empirical model, and Section 4 shows the methodology adopted to measure the environmental outcomes produced at the airports' level. Section 5 describes the database for the empirical analysis. Our results are presented in Section 6, and conclusions and policy implications are drawn in Section 7.

* Corresponding author. Tel.: +39 0352052026; fax: +39 0352052310.
E-mail address: davide.scotti@unibg.it (D. Scotti).

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2. Literature review

Our contribution is mainly linked with two different streams of literature: (1) papers analyzing the impact of some possible determinants of airport technical efficiency levels and (2) contributions investigating the effect of undesirable outputs on airport efficiency assessment.

Regarding the determinants of airport technical efficiency, several papers focus on some airport characteristics such as size, hub/non-hub status and ownership. A positive impact of airport size has been identified by Oum and Yu (2004), Yoshida and Fujimoto (2004) and Barros and Dieke (2007). Gillen and Lall (1997) were the first to find that hubs tend to be more technically efficient than non-hubs, a result replicated, among others, by Sarkis (2000), Barros and Diecke (2008) and Fung et al. (2008). Concerning ownership, the evidence is mixed. Parker (1999) and Abbott and Wu (2002) do not find that private for-profit airports are significantly more efficient than airports of other ownership types. Oum et al. (2008), Barros and Diecke (2008), Fung et al. (2008) and Chi-Lok and Zhang (2009) identify instead a positive effect of private for-profit airports on efficiency. Curi et al. (2010) provide evidence that public airports are more efficient than private ones in Italy.

Fewer papers study the impact of other possible determinants of airport efficiency. Barros and Sampaio (2004) provide evidence that airport efficiency is higher the larger is the market share of the main airlines operating in it. Oum and Yu (2004) investigate the impact of one characteristic of aircraft fleet (i.e., the average aircraft size) on airport efficiency and find that it has no effect. Last, to the best of our knowledge, no previous contributions have investigated the impact of LCCs on airport efficiency. As stated by Barbot (2006), the growing importance of LCCs in the EU market after the liberalization makes instead interesting to explore whether they have an effect also on airport efficiency.

The second stream of literature is the one related to the few papers that introduce some undesirable outputs in the estimation of airport efficiency. They focus either on noise or on congestion. Yu (2004) and Yu et al. (2008) estimate airport efficiency including noise. Yu (2004) adopts a directional distance function (DDF) approach and shows that ignoring noise increases both the number of inefficient units and their distance from the frontier. Yu et al. (2008) analyze airport total factor productivity growth and find that its average is lower when noise is taken into account. Pathomsiri et al. (2008) and Lozano and Gutiérrez (2011b) consider instead as undesirable output delays (i.e., airport congestion). Pathomsiri et al. apply a DDF approach and show that including delays leads to a higher number of efficient airports, with small, less-congested airports becoming efficient because they compensate lower desirable output/input ratios with lower delays/input ratios. Lozano and Gutiérrez (2011b) is a methodological contribution comparing the DDF approach with a slack-based measure to estimate airport efficiency when undesirable outputs are included in the production function. However, Färe and Grosskopf (2010) have also analyzed the two approaches, showing that DDF has better properties when a variable return-to-scale framework is considered. Hence, since the latter framework is adopted here, we implement a DDF approach.

This paper is then the first attempt to estimate airport efficiency when two undesirable outputs are taken into account: noise and emissions. Furthermore, it is the first paper analyzing the impact of some possible determinants of technical/environmental airport efficiency. We focus on fleet mix, ownership, size, LCCs and airlines dominance. We do not consider hubs since our data set regards only non-hub Italian airports.

3. Technical/environmental efficiency: first-stage DDF model and second-stage bootstrapping

3.1. The DDF model

In this section, we present some assumptions that have been commonly accepted in previous contributions on the production of both desirable and undesirable outputs.

An important issue when desirable outputs are included in technical efficiency analysis is the specification of the empirical model. We choose to estimate a DDF since it avoids the typical problem of the parametric stochastic frontier approach: the necessary specification of the production functional form. Furthermore, it treats undesirable products as outputs, while the estimation of a stochastic distance function requires treating them as inputs.

Chambers et al. (1996, 1998) develop the DDF model, while Färe and Grosskopf (2000) explore its duality features. Under this approach it is possible to modify the directions of output changes to reach the efficient frontier. This is a crucial feature since it credits firms for bad output reductions and instead discredits them for bad output expansions. Moreover, DDF is an additive model; hence all of the conditions to identify the best-practice frontier are linear. A standard Data Envelopment Analysis (DEA) procedure can be applied.[1]

The first step of this approach consists of defining the production possibility set. Let $x = (x_1, \ldots, x_N) \in R_+^N$ be a vector of N inputs, $y = (y_1, \ldots, y_M) \in R_+^M$ a vector of M good outputs, and $b = (b_1, \ldots, b_J) \in R_+^J$ a vector of J bad outputs. Following Chambers et al. (1996), the production possibility set $P(x)$ collects all the combinations of good and bad outputs that could be produced using each particular input vector x. Hence:

$$P(x) = \{(y, b) : x \quad \text{can produce} \quad (y, b)\}, x \in R_+^N. \tag{1}$$

[1] Many DDF applications have been implemented in the environmental field – e.g., Chung et al. (1997) on paper and pulp mills in the US, Boyd et al. (2002) on glass manufacturing in the US, Picazo-Tadeo et al. (2005) and Picazo-Tadeo and Prior (2009) on ceramic industry in Spain, McMullen and Noh (2007) on coach transportation in the US, Färe et al. (2007) and Kumar and Managi (2010a,b) on power generating industry in the US.

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