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The impact of airport competition on technical efficiency: A stochastic frontier analysis applied to Italian airport

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A B S T R A C T

We investigate how the intensity of competition among airports affects their technical efficiency by computing airports' markets on the basis of a potential demand approach. We find that the intensity of competition has a negative impact on airports' efficiency in Italy from 2005 to 2008. This implies that airports belonging to a local air transportation system where competition is strong exploit their inputs less intensively than do airports with local monopoly power. Further, we find that public airports are more efficient than private and mixed ones. Hence, policy makers should provide incentives to implement airports' specialization in local systems where competition is strong and monitor the inputs' utilization rate even when private investors are involved.

1. Introduction

One effect of the liberalization process in the EU air transportation market has been the growth in the European network. European airlines can now provide intra-European connections (i.e., flights having an origin and a destination in airports within the EU 25) without restrictions provided there is slot availability. As a result, if we consider all the 460 airports of the 18 countries that belonged to the European Common Aviation Area (ECAA[1]) in 1997, the total number of connections among these airports rose from 3410 in 1997 to 4612 in 2008. This implies a compounded annual growth rate of 2.78%, with the number of connecting flights increasing from 4,102,484 to 5,228,688.

The network expansion has increased the intensity of competition between airports, as they compete both directly for airlines and indirectly for passengers and freights, and as airline new business models have emerged, notably low cost carries (LCC). Further, travelers may now choose their travel suppliers from different airlines at the same airport (direct competition) or from ones operating at nearby ones (indirect competition).

Here we investigate the impact of competition between airports and ownership on their technical efficiency. The latter impacts on both airport charges and services provided to passengers (e.g., shorter waiting times). For our empirical analysis we develop a potential demand approach and a multi-output stochastic frontier model. They are applied to 38 Italian airports between 2005 and 2008.

2. The Italian airport system

Before 1990, Italian airports were, as in many other European countries, controlled by the national government; although sometimes management was delegated to a public agency. The first important development was Act n. 537/93, which introduced changes in Italy's airports' ownership. First, it established that airports would no longer be under the control of the national government. Second, the management of airports was delegated to companies that may involve private agents, region or county governments, municipalities and chambers of commerce. Third, at least 20% of the shares in a company managing the airport had not to be in the hands of private agents. As a consequence, many local governments entered in the airports' ownership, taking control in the vast majority of cases. In 1997, Act 521/97 eliminated the 20% minimum stake for local public and created a national public authority. Ente Nazionale per l'Aviazione Civile (ENAC) in charge of the sector's regulation. ENAC directly manages Lampedusa and Pantelleria airports, facilities serving two small islands in the Mediterranean Sea.

These reforms created the conditions for the gradual entry of private capitals into airport ownership. The first privatization took place in 1995 in Naples, where the British Airports Authority (BAA) got the majority of shares of the company managing the airport. Privatization occurred also in 2000 for ADR (that controls Rome Fiumicino and Rome Ciampino). Other airports with private ownership are Florence (year 2003), Venice (year 2005), Treviso (year 2007), Parma (second half 2008) and Olbia (since the beginning 1974). The majority of Italian airports are still, however, under the control of local public authorities or entail public or mixed ownership.

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[1] 15 EU members plus Iceland, Norway, and Switzerland.

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The Italian system consists of 45 airports open to commercial aviation. Rome Fiumicino and Milan Malpensa are the most important intercontinental airports, with further long haul European and domestic connections provided by 12 regional medium sized airports. The remaining 31 airports can be classified as regional with a limited number of European and domestic connections. All these airports have benefited from the EU liberalization of air transportation, with the average number of destinations served rising from 20 in 1997 to 37 in 2008, and with this has come increased competition between them.

3. Methodology

3.1. The stochastic distance function econometric model

We use stochastic frontier analysis to disentangle random shocks from on-going technical inefficiency (Aigner et al., 1977). Further, we incorporate exogenous variables, which are neither inputs to the production process nor outputs of it, but which nonetheless exert an influence on producers' performance (Kumbhakar and Lovell, 2000).

In terms of inputs, since our data set does not include monetary variables but only physical inputs and outputs, our aim is to measure technical efficiency – i.e., an airport management's ability to achieve efficient input utilization. This means that we do not identify the input combination yielding the minimum cost. Moreover since airports are typically multi-product firms, an appropriate multi-output framework for estimating technical efficiency is required. As shown by Coelli and Perelman (2000), this implies the estimation of a stochastic distance function. Last we need to choose between input and output orientation. The former identifies the inputs' reduction required to reach the efficient frontier. Given that in airport operation many inputs are indivisible, at least in the short run, an output oriented stochastic distance function seems to be appropriate, especially in a context where airports are in competition.

In this framework we define $P(x)$ as the airports' production possibility set – i.e., the output vector $y \in R_{+}^{M}$ that can be obtained using the input vector $x \in R_{+}^{K}$. That is: $P(x) = \{y \in R_{+}^{M} : x \text{ can produce } y\}$. By assuming that $P(x)$ satisfies the axioms listed in Fare et al. (1994), we introduce Shephard (1970) output oriented distance function:

$$D_O(x,y) = \min\{\theta : (y/\theta) \in P(x)\},$$

where $\theta \le 1$. Lovell et al. (1994) shows that the distance function is nondecreasing, positively linearly homogeneous, and convex in y, and decreasing in x. $D_O(x,y) = 1$ means that y is located on the outer boundary of the production possibility set – i.e., $D_O(x,y) = 1$ if $y \in IsoqP(x) = \{y : y \in P(x),\ \omega y \notin P(x),\ \omega > 1\}$. If instead $D_O(x,y) < 1$, y is located below the frontier; in this case, the distance represents the gap between the observed output and the maximum feasible output.

Following Coelli and Perelman (2000), the translog distance function is given by:

$$\ln(D_{Oit}/y_{Mit}) = \alpha_0 + \sum_{m=1}^{M-1}\alpha_m \ln y^{*}_{mit} + \frac{1}{2}\sum_{m=1}^{M-1}\sum_{n=1}^{M-1}\alpha_{mn}\ln y^{*}_{mit}\ln y^{*}_{nit} + \sum_{k=1}^{K}\beta_k \ln x_{kit} + \frac{1}{2}\sum_{k=1}^{K}\sum_{l=1}^{K}\beta_{kl}\ln x_{kit}\ln x_{lit} + \frac{1}{2}\sum_{k=1}^{K} \times \sum_{m=1}^{M-1}\zeta_{km}\ln x_{kit}\ln y^{*}_{mit}, \qquad (1)$$

where M is the number of outputs, K is the number of inputs, D_{Oit} is the output distance from the frontier of firm i in period t and $y^{*}_{mit} = y_{mit}/y_{Mit}$. Eq. (1) can be written as $\ln(D_{Oit}/y_{Mit}) = TL(x_{it}, y_{it}/y_{Mit}, \alpha, \beta, \zeta)$, where TL stands for the translog function. Hence:

$$-\ln(y_{Mit}) = TL(x_{it}, y_{it}/y_{Mit}, \alpha, \beta, \zeta) - \ln(D_{Oit}) \qquad (2)$$

where, $\ln(D_{Oit})$ is non-observable and can be interpreted as an error term in a regression. If we replace it with $(v_{it} - u_{it})$, we get the typical SFA composed error term: v_{it} are random variables that are assumed to be *iid* as $N(0, \sigma^2_v)$ and independent of the u_{it}; the latter are non-negative random variables distributed as $N(m_{it}, \sigma^2_u)$. v_{it} represent the random shocks, while the inefficiency scores are given by u_{it}. Hence, we can now write the translog output oriented stochastic distance function for estimation as

$$-\ln(y_{Mit}) = \alpha_0 + \sum_{m=1}^{M-1}\alpha_m \ln y^{*}_{mit} + \frac{1}{2}\sum_{m=1}^{M-1}\sum_{n=1}^{M-1}\alpha_{mn}\ln y^{*}_{mit}\ln y^{*}_{nit} + \sum_{k=1}^{K}\beta_k \ln x_{kit} + \frac{1}{2}\sum_{k=1}^{K}\sum_{l=1}^{K}\beta_{kl}\ln x_{kit}\ln x_{lit} + \frac{1}{2}\sum_{k=1}^{K} \times \sum_{m=1}^{M-1}\zeta_{km}\ln x_{kit}\ln y^{*}_{mit} + v_{it} - u_{it}. \qquad (3)$$

To investigate the determinants of inefficiency, we apply a single-stage estimation procedure following Coelli (1996) where the technical inefficiency effect, u_{it} in Eq. (3) can be specified as:

$$u_{it} = \delta z_{it} + w_{it}$$

where the random variable w_{it} is defined by the truncation of the normal distribution with zero mean and variance, σ^2, such that the point of truncation is $-\delta z_{it}$; i.e., $w_{it} \ge -\delta z_{it}$. Further, z_{it} is a *px1* vector of exogenous variables that may influence the efficiency of a firm, and δ is a *1xp* column vector of parameters to be estimated.

According to this time-varying specification of airports' inefficiency, the technical efficiency of airport i at period t is defined as follows:

$$TE_{it} = e^{-u_{it}}.$$

3.2. Airport competition index

One approach to defining markets assumes that an airport's relevant geographic market consists roughly of a circle around its location. A fixed-radius technique is usually implemented to define the airport's competitors (Malighetti et al., 2007). The fixed-radius technique, however, does not take into account the distribution of people living in the areas around the airport and neither does it consider the real access time to reach it nor determinants of the demand for airport services in the area (Gosling, 2003).

To deal with these issues, we take into account that any measure based on the determinants of demand cannot be implemented using actual airport choices taken by users; their choices may be influenced by unobservable airport features (McClellan and Kessler, 2000). It is then necessary to compute predicted travelers choices based on exogenous factors. We consider traveling costs as exogenous factors affecting demand and build an airport geographic market (i.e., *CA*) based on this variable. The proxy we adopt is given by passenger traveling time to reach airports. Hence, we assume that individuals are potential passengers of any airport that they can reach in a reasonable time.[2]

Our technique, inspired by Propper et al. (2004, 2008), is composed of several steps. First, we draw a boundary around

[2] As shown by Graham (2008), passengers' demand for flights is function of their preferences regarding (1) the destination, (2) the type of flight (e.g., long/short haul, LCC/traditional, direct/connection flight, etc.) and (3) her/his "type" (e.g., business *versus* leisure). In this contribution we focus on a representative passenger, i.e., a passenger having an average of all the previous characteristics.