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An Empirical Investigation on the Efficiency, Capacity and Ownership of Italian Airports

by

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An Empirical Investigation on the Efficiency, Capacity and Ownership of Italian Airports

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Abstract

In this paper we study the efficiency of Italian airports applying a DEA model to a sample of 34 airports. We consider two outputs: aircraft movements and passengers. We find that large airports are more efficient that domestic and regional ones, i.e. small airports have spare capacity since they are, on average, more distant from the VRS frontier than large airports. Moreover, the latter are operating under decreasing returns to scale while increasing returns to scale arise in the small ones. These findings imply that further investments to develop large airports will lead to higher average costs. The Tobit regression on the estimated DEA scores shows that efficiency is positively related with the so–called hub premium (i.e. an airline dominates an airport) and with privatization, and it is negatively affected by military activities and season effects. Hence we suggest that airport's privatization, incentives to invest in large airports (which are close to saturation of their capacity) and development plans to improve the activities in domestic and regional airports may form the benchmarks of air transportation policy in Italy at least in the short–run.

JEL classification: L930, L590, L110
Keywords: Airport efficiency, DEA analysis, privatization, capacity.

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1 Introduction

The Italian air transportation sector has shown a robust growth during the last years. In the period 2000–2005 passengers increased at an annual rate of 4.2%, a rate much higher than that of the Italian GDP (1.4%).[1] This is the effect of liberalization: the EU started in 1993 the open skies regime, allowing every European carrier to operate flights from every airport located in country members. New carriers entered the market—especially the low cost airlines—increasing the supply and reducing the price. As stated by Gillen and Lall [1997], the carriers' increased competition has provided a strong stimulus to improve airport performances, since airlines cannot easily pass increases in airport charges to consumers. Moreover, in several European countries governments have started to privatize several airports and have introduced Price Cap regulation to improve their efficiency.

The analysis of airports efficiency is crucial because, as argued by Sarkis and Talluri [2000], it allows airlines to select the more efficient airports, municipalities to understand their capacity to attract business and tourists, and governments to optimally allocate resources to airport improvement programs, rather than being subject to lobbies and political pressures. Finally, benchmarking their airports against comparable ones helps managers to understand their competitiveness. Hence the objective of this paper is to investigate the efficiency of Italian airports, and to analyze the relationships

[1] During the same period the annual growth in France is 1%, in Germany 2.7%, in Great Britain 4.6%, in Spain 5.1%. See ICCSAI [2007] for a comprehensive analysis of the trends in the European countries. Similar trends have been observed for freight: the annual growth rate in Italy is 2.8% during 2000–2005.

between the productivity measures and the airport's ownership (to assess the impact of privatization) and the airport characteristics.

Methods of measuring efficiency can be classified into non–parametric and parametric (Gillen and Lall [1997], Pels *et al.* [2003]). The former includes indexes of partial productivity and Total Factor Productivity (TFP), and Data Envelopment Analysis (DEA). Parametric methods involve the estimation of neoclassical and stochastic cost and/or production functions. Partial productivity measures (such as output per employee) are quite popular since they are easy to compute; however they can be quite misleading, since they do not consider differences in factor prices and depend upon the amount of the other factors involved in production (i.e. they do not take into account of factors' substitutability). TFP measures do not suffer from these drawbacks but taken alone are not very informative about management strategies.[2] The problems with parametric methods are related with the choice of the functional form, which may produce different results.[3] DEA is instead a linear programming technique and requires only information on inputs and outputs (allowing for investigation of multiple outputs firms). It provides a well–defined relation between outputs and inputs, which corresponds to a production function, in which the output is maximal for the indicated level of inputs. Efficiency scores for each firm (i.e. distance from the efficient fron-

[2]As stated by Gillen and Lall [1997], extracting more information from TFP measures requires the estimation of a parametric neo–classical cost or production function, and a richer data set including information on prices.

[3]Parametric methods need to pre–specify the functional form and are therefore open to specification bias. As argued by Parker [1998] this is important since when investigating airports each may have different output and input characteristics.

tier) are computed with DEA and then they may be regressed against some explanatory variables to extract information about the impact of government decisions (e.g. privatization) or management strategies (e.g. making the airport the hub of an airline, opening it to low cost carriers, etc.). This study applies the DEA model to estimate the efficiency of Italian airports.

Several contributions have investigated the productivity measures of airports using the DEA model. Gillen and Lall [1997] provide the most influential paper, pointing out the advantages of the DEA method when studying the efficiency of airports and setting a model of airport management based on two outputs: terminal services (i.e. passengers) and aircraft movements. They investigate a dataset composed by 21 US airports (out of the 30 top US airports).[4] Other studies on the efficiency of US airports are provided by Sarkis and Talluri [2004] and by Oum and Yu [2004].[5] Pels *et al.* [2003] study the efficiency on a sample of 33 European airports, adopting a model of airport activities similar to that of Gillen and Lall [1997], based on two outputs: aircraft movements and passengers. They show that many airports can improve efficiency and that there are no region–specific effects on efficiency.

[4]They show that, concerning aircraft movements, having hub airlines and expanding the number of gates increase the efficiency; terminal efficiency is instead improved by (again) increasing the number of gates and by managing them in order to ensure their effective utilization.

[5]Sarkis and Talluri perform a benchmarking analysis based on DEA and clustering over a sample of 44 US airports. Oum and Yu compute factors productivity for airports included in the 2003 ATRS (Air Transport Research Society) Global Airport Benchmarking Report, which covers 37 US airports, 6 North American airports, 26 European airports, and 21 of the Asian countries. They show that both the airport size and capacity constraints (which create costs paid by airlines and passengers) improve airports' productivity.

Several papers analyze efficiency on single countries, as the present one. Parker [1999] investigates the impact of privatization on a sample of 22 British airports, to find that it has no impact on their efficiency. Yoshida [2004] and Yoshida and Fujimoto [2004] explore the efficiency of Japanese airports and focus on regional airports, which seem to be less efficient because suffering of political pressure.[6] Australian airports have been investigated by Hooper and Hensher [1997] and Abbott and Wu [2002], showing again that privatization has no impact on efficiency. Fernandes and Pacheco [2002] and Pacheco and Fernandes [2003] analyze the case of Brazilian airports, focusing on the performances of domestic airports, accomplishing a benchmark analysis. Barros and Sampaio [2004] examine a sample of 10 Portuguese airports, providing benchmarks and determinants of economic efficiency, arguing that Portuguese airports should be privatized. Murillo–Melchor [1999] studies the efficiency of 33 Spanish airports, showing that large size airports have decreasing returns to scale. To the best of our knowledge this paper is the first attempt to investigate the efficiency of Italian airports.

We apply a DEA model to a sample of 34 Italian airports, considering two typical outputs of the air transportation sector: aircraft movements and passengers. These outputs have been collected for 2005 and 2006, and are investigated taking into account of physical inputs (e.g. runways, terminal surface, etc.). The sample covers 98% of movements and 97% of passengers. Our findings are the following ones: First, we find that many airports can improve their efficiency on both types of output. By splitting airports according

[6] Regional Japanese airports exhibit over capacity because local politicians direct more investments in their region, in order to gain consensus.

to the standard EU classification and by studying—for each category—the average distance from the VRS frontier of the inefficient airports, we get that efficiency is positively related to airports' size. This means that the "Great European Airports" (with more than 10 millions passengers) and "National Airports" (less than 10 millions but more than 5 millions) are more efficient than the domestic and regional ones.[7] Since an airport close to the physical efficiency frontier (or on the frontier itself) it is heading for saturation in its capacity to offer airport services (Pacheco and Fernandes [2003]), these results imply that large Italian airports are operating at full capacity while the small and regional airports have spare capacity.

Second, large airports are mainly working under decreasing returns to scale; on the contrary, increasing returns to scale prevail in domestic and regional Italian airports. Hence, from a cost perspective, large airports should decrease their scale of operation to enjoy a reduction in average costs. As just mentioned, these airports are close to capacity saturation. Hence in case of an increase of the large Italian airports' activities (e.g. Rome Fiumicino and Milan Malpensa), the combination of these two factors (capacity saturation and decreasing returns to scale), on the one hand, will require further investments (to overcome capacity saturation), on the other hand will lead to higher unit costs (due to decreasing returns to scale). Small airports should instead increase their capacity utilization, while an increase in their scale of operation will produce a reduction in average costs (thanks to increasing

[7]See EU classification. Airports with less than 5 millions but more than 1 million passengers are classified as "Great Regional Airports", while those with less than 1 million are classified as "Small Regional Airports".

returns to scale).

Third, we have compute the Malmquist indeces relating to productivity scores between the two years considered in this study and we obtain that the average change in efficiency in the Italian airport sector is positive for both outputs but higher for passengers. Fourth, we have performed an econometric analysis on the estimated efficiency scores on a set of airport–specific explanatory variables and we have identified that airports are closer to an optimal inputs' utilization if one airline dominates the airport (a confirmation of the hub premium effect), if the airport is private (for aircraft movements), while military activities and season effects operate as barriers towards efficiency.

Hence our policy recommendations for the Italian airport sector, at least in the short–run, consist of three benchmarks: privatization, incentive schemes to invest in large airports (which are close at saturation in their capacity) and the design of development plans to improve the activities in domestic and regional airports, where there is over capacity.

The paper proceeds as follows. In Section 2 we describe the main features of the Italian airports sector, while in Section 3 we present the DEA model and the productivity measures adopted in this paper. In Section 4 we describe our data set and show some summary statistics about Italian airports. Our estimated results about the production frontier and productivity performances are reported in Section 5, while concluding comments are highlighted in Section 6.

2 The Italian airports sector

The sector is composed by 101 airports, under the supervision of a regulator, ENAC (Ente Nazionale Aviazione Civile).[8] Among them, 45 airports are classified by ENAC as international (i.e. they can have scheduled international flights), while the remaining 56 are labeled as domestic (they can only offer scheduled domestic flights). The airports operating with a commercial goal are 54, while 4 airports are run only for military purposes (Capua, Frosinone, Latina and Palermo Boccadifalco).[9] 17 are classified as military airports but with the possibility to supply commercial scheduled flights[10], while 2 airports (Cagliari and Rome Ciampino) are considered as mixed commercial–military, since the airport's infrastructures belong to the state properties but are run both by militaries and civilians, and they offer scheduled flights. The airports operating as flying clubs are 24.[11]

Among the 45 airports classified as international by ENAC, only two airports—Lampedusa and Pantelleria—are managed directly by the government, through ENAC itself. The other 43 airports are run by independent companies: 31 of them are controlled by local governments (regions and municipalities) and 12 by private agents. These companies operate at the different airports through a long run license[12], which is not uniform across airports:

[8] Another important public agency in Italy is ENAV (Ente Nazionale per l'Assistenza al Volo), who is in charge of air traffic control.

[9] The last three airports can be authorize to operate commercial flights under exceptional circumstances.

[10] Among them the more important ones are Ancona, Brescia–Montichiari, Brindisi, Napoli, Pisa, Rimini, Trapani, Treviso and Verona.

[11] One airport—Pontedera—is not operating at the moment.

[12] Biella airport is an exception, since the company running the service is also the owner

18 companies have a "total" license (i.e. the company gets all the airport's charges and is responsible for the infrastructures)[13], 10 have a "partial" license (the license—and, consequently, the airport's charges collected—is only for the infrastructure concerning passengers and freight terminals and does not include the runways and parking positions, whose airport's charges go to the government)[14], while 14 companies have a "precarium" license (they are waiting for a new license and can again manage only the passengers/freight terminals, but they cannot collect any airport's charge, since their revenues are only given by the commercial activities inside the terminals)[15].

The standard EU classification split airports, according to their size, into four categories: A (Great European Airports), with yearly passengers above 10 millions, B (National Airports), with total passengers between 5 and 10 millions, C (Great Regional Airports), between 1 and 5 millions, and D (Small Regional Airports), with total passengers lower than 1 million. Table 1 reports the distribution of the 45 Italian international airports according to the EU classification.

The airport's charges applied at the various Italian airports are regulated by ENAC.[16] At the present time these charges are not set according to incentive methods, such as the price cap regulation which is applied to airports in

of the land and infrastructures.

[13]Rome Fiumicino and Ciampino, Milan Malpensa and Linate, Venice, Naples, Bergamo, Bologna and Turin belong to this category.

[14]Among them Catania, Palermo, Cagliari, Pisa and Verona.

[15]It is worth mentioning, in this group, Alghero, Ancona, Bolzano, Brescia, Lamezia Terme, Pescara, Reggio Calabria and Trapani.

[16]Charges regard passengers, baggage security, aircraft movements, and parking. The source is ENAV [2006], Charges for aerodromes and air navigation services.

Category	Airports
A	2 Rome Fiumicino, Milan Malpensa
B	5 Milan Linate, Venice, Catania, Bergamo, Naples
C	14 Rome Ciampino, Palermo, Bologna, Turin, Pisa, Verona, Cagliari, Bari, Olbia, Florence, Lamezia T., Treviso, Genoa, Alghero
D	24 Brindisi, Trieste, Forlì, Reggio C., Ancona, Pescara Rimini, Trapani, Brescia, Parma, Lampedusa, Pantelleria Crotone, Bolzano, Perugia, Marina di C., Cuneo, Albenga Aosta, Foggia, Vicenza, Siena, Taranto, Biella

Table 1: Italian airports by size

several countries, but on a non–transparent cost–plus approach. The charges applied to aircraft movements depend on the type of connection: domestic and European flights versus international flights (i.e. not in country members of the EU). The average charge for domestic and European flights is Euro 1.22/ton for the first 25 tons, and Euro 1.86/ton for each further one: the most expensive airport is Treviso (Euro 2.15/ton for the first 25 tons and Euro 2.69/ton for each further ton), the cheapest Bari (Euro 0.81/ton and Euro 1.21/ton respectively). The two largest airports, Rome Fiumicino and Milan Malpensa, charge, respectively, Euro 1.26/ton (Euro 1.92/ton for each ton after the first 25 tons) and Euro 1.63/ton (Euro 2.14/ton). The charge for international flights is uniform across airports and equal to Euro 2.15/ton for the first 25 tons and to Euro 2.65/ton for each further one.

The passengers' charges are again split between domestic and European flights and intercontinental ones: for the former the average charge is Euro 5.27/passenger. The most expensive airport is again Treviso (Euro 8.21/passenger), the cheapest Reggio Calabria (Euro 3.72/passenger). Rome Fiumicino charges Euro 5.63/passenger, Milan Malpensa Euro 6.25/passenger. In case of international flights the charge is uniform across airports and equal to Euro 8.25/passenger. The charges for freight, passengers—hand baggage security control and aircraft parking are uniform too: the former is equal to Euro 0.02/kilo, the latter to Euro 0.08/ton (the first two hours of parking are free of charge). The charge for passenger—hand baggage security control is Euro 1.81/passenger. The charge for baggage control (loaded on the aircraft's hold) differs between airports: the average is Euro 1.76/passenger, the most expensive airport is Rimini (Euro 2.33/passenger) while the cheapest is Verona (Euro 1.10/passenger). Rome Fiumicino charges Euro 2.05/passenger, Milan Malpensa Euro 2.07/passenger.

ENAC started a revision of the regulatory approach in 2000 which is not effective yet.[17] The new scheme is based on a price cap model, so that each airport charge will be modified, over a five years period, according to the $RPI - x$ formula, where the x–factor represents the efficiency target required by the regulator to each specific airport. Price cap regulation is applied to

[17]The first resolution, "Delibera CIPE 86/2000", has been partially applied to new deals between ENAC and some airports. However no agreements have been concluded yet, due to both the regulator's length to start the new process and the several modifications on airports' regulation introduced later by the government, due to political pressure to deal with the poor performances of Alitalia (e.g. Legge 248/2005).

airport's charges in several countries, European and worldwide.[18] This new incentive scheme requires a deep knowledge about the actual efficiency of each airport. This paper may provide some information.

3 The DEA model and productivity measures

The determination of the efficiency in the management of an airport involves the estimation of a production frontier, so that inefficiency is measured as the distance of an airport from that frontier. We adopt a DEA model where a sequence of linear programming problems creates a piecewise linear frontier, implicitly assuming that outputs can be fully explained from the inputs.[19] We focus on a input oriented DEA model, since we assume that the decisions concerning the output levels are out of control of the airports' management (Gillen and Lall [1997] and Pels *et al.*).

The DEA approach has two models: a Constant Return to Scale (CRS) model and a Variable Return to Scale (VRS) model, which allow to distinguish between Technical Efficiency (TE) and Scale Efficiency (SE).[20] The model implies solving the following constrained minimization problem for each airport included in the sample:

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[18] For instance in Australia, the average x-factor applied by the regulator to Australian airports during the 1990s is 3.3%, with a maximum of 5.5% and a minimum of 1%.

[19] Under this approach, the efficiency of an airport is estimated relative to the performance of other airports.

[20] See Charnes *et al.* [1978], Coelli [1996] and Färe *et al.* [1994] for a discussion on DEA model.

$$
\begin{aligned}
&Min_{h,\lambda} && h_0 \\
&s.t. && \textstyle\sum_{l=1}^{L} \lambda_l y_{i,l} \geq y_{i,0}; \quad i = 1, ..., m \\
& && h_0 x_{j,0} - \textstyle\sum_{l=1}^{L} \lambda_l x_{j,l} \geq 0; \quad j = 1, ..., n \\
& && \textstyle\sum_{l=1}^{L} \lambda_l = 1 \\
& && h_0, \lambda_l \geq 0
\end{aligned} \tag{1}
$$

where L is the total number of airports, m is the number of outputs considered and n is the number of inputs. The variables h and λ represents the weights to be determined by solving the programming model. The constraint $\sum_{l=1}^{L} \lambda_l = 1$ is included to distinguish between TE and SE. An intuition of this result is displayed in Figure 1. TE is given by the horizontal segment between the location of the generic airport A and the closest segment on the VRS frontier. The latter coincides with h_0 in problem (1). SE is instead equal to the horizontal segment between the linear combination on the VRS frontier corresponding to airport A, and the same linear combination on the CRS frontier. This combination is obtained as the solution of a problem similar to (1), and identifies only one efficient airport. The idea is that under the CRS model each unit varies all the inputs, while some of them are constrained under the VRS model. If SE $= 1$ the unit is efficient, since it is on the CRS frontier. If instead SE < 1 then we know that VRS are prevailing, but not the direction of these returns. The latter are identified by running another program with the following constraint: $\sum_{l=1}^{L} \lambda_l \leq 1$ (instead than $\sum_{l=1}^{L} \lambda_l = 1$). Then if this new estimate of SE is lower than 1 and h_0 from this new program is equal to (lower than) h_0 under program (1), we have decreasing (increasing) returns to scale.

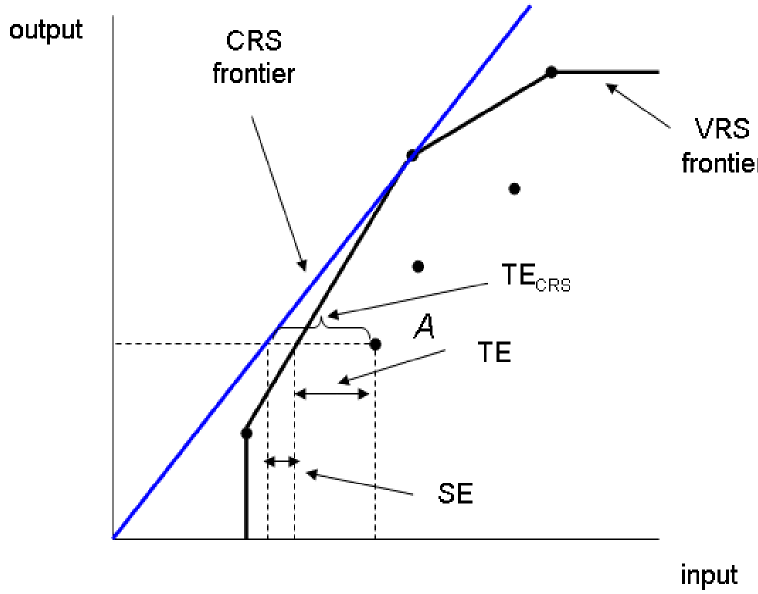

Figure 1: DEA input oriented, TE *vs* SE

Moreover, we can adopt the DEA approach to compute the Malmquist input oriented total productivity index (Färe *et al.* [1994]), which can be employed to identify whether an airport has reduced or increased its distance from a production frontier that can vary over time. Indeed, the Malmquist DEA approach derives an efficiency measure from one year relative to the prior year, while allowing the best practice frontier to shift (due to technological progress). A total factor productivity index between period t and period $t+1$ is then as follows:

$$M(y_{t+1}, x_{t+1}, y_t, x_t) = \left[\frac{h_0^t(y_{t+1}, x_{t+1})}{h_0^t(y_t, x_t)} \times \frac{h_0^{t+1}(y_{t+1}, x_{t+1})}{h_0^{t+1}(y_t, x_t)}\right]^{1/2} \qquad (2)$$

where M is the input oriented total factor productivity index and $h_0^t(.)$ is an input distance function relative to a VRS frontier computed at period t and at period $t+1$. An equivalent way of writing the Malmquist index, useful to specify that the total factor productivity change has two components, i.e. the Efficiency Change (EC) and the Technical Change (TC), is as follows:

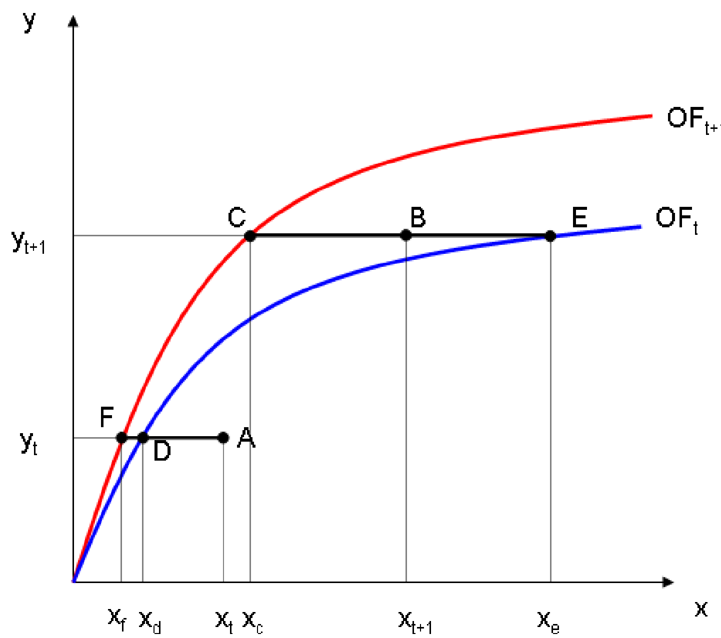

Figure 2: Total Factor Productivity and EC vs TC

$$M(y_{t+1}, x_{t+1}, y_t, x_t) = \frac{h_0^{t+1}(y_{t+1}, x_{t+1})}{h_0^t(y_t, x_t)} \times \left[\frac{h_0^t(y_{t+1}, x_{t+1})}{h_0^{t+1}(y_{t+1}, x_{t+1})} \times \frac{h_0^t(y_t, x_t)}{h_0^{t+1}(y_t, x_t)} \right]^{1/2} \tag{3}$$

where

$$EC = \frac{h_0^{t+1}(y_{t+1}, x_{t+1})}{h_0^t(y_t, x_t)} \tag{4}$$

$$TC = \left[\frac{h_0^t(y_{t+1}, x_{t+1})}{h_0^{t+1}(y_{t+1}, x_{t+1})} \times \frac{h_0^t(y_t, x_t)}{h_0^{t+1}(y_t, x_t)} \right]^{1/2} \tag{5}$$

Hence the Total Factor Productivity Change (TFPC) can be written as: $TFPC = EC \times TC$. The intuition underlying the Malmquist index and the two components given by EC and TC can be provided using Figure 2. Suppose that the production of a single output y involves a unique input x, and that there are two observations, at period t and $t+1$. The two frontiers are given by OF_t and OF_{t+1}, so that there is a shift in the production frontier over time. We also assume that the generic airport we are considering is inefficient at both periods, given that is located at points A (at time t)

and B (at time $t+1$). This implies that the change of this airport over time depends on both its position relative to the corresponding frontier (i.e. the technical inefficiency or efficiency change EC) and the position change in the frontier itself (the technological change TC). By applying expression (4) we obtain that $h_0^{t+1}(y_{t+1}, x_{t+1}) = CB, h_0^t(y_t, x_t) = DA$. Hence $EC = \frac{CB}{DA}$. This implies that if $EC = 1$ the airport has not recovered efficiency during the observed period, while if $EC < 1$ ($EC > 1$) it has improved (decreased) its efficiency. Furthermore, from (5) we get: $h_0^t(y_{t+1}, x_{t+1}) = BE, h_0^{t+1}(y_{t+1}, x_{t+1}) = CB, h_0^t(y_t, x_t) = DA, h_0^{t+1}(y_t, x_t) = AF$. Hence $TC = \left(\frac{BE}{CB} \times \frac{DA}{AF}\right)^{1/2}$. Again, if $TC = 1$ the distance between the two frontiers at t, computed taking point A as reference, is equal to the distance between the two frontiers at $t+1$, taking point B as reference. If instead $TC < 1$ ($TC > 1$) the distance between the two frontiers at t is greater (lower) than the distance between the two frontiers at $t+1$. If $TC > 1$ the airport has exploited the (exogenous) technical progress.

We adopt the Gillen and Lall [1997] and the Pels *et al.* [2003] model of airport activities, such that an airport can be regarded as an interface between airlines and the passengers. Hence we need to consider both Air Transport Movements (ATM) and Air Passenger Movements (APM) and to treat ATM both as an output (for aircrafts movements) and as an input (for passenger movements).[21] This means that we can estimate both an efficiency in ATM (without considering APM) and also an efficiency in APM (where ATM is treated as an input).

[21] ATM can be considered as an intermediate good that is produced by the airport and consumed in the production of APM.

4 The data

The data set used in this contribution is composed of information from collected statistics regarding a sample of 34 Italian airports for the period 2005–2006. The sample covers 97.6% of Italian passenger movements and 96.7% of aircraft movements in this period. Since we need data on inputs, such as the number of parking positions or the lines of baggage claims, we had to contact directly each airport's management and to build a new data set. We run a direct investigation covering 37 airports, but only 34 (92%) provided the necessary information. For each airport we have information on the two output variables: the yearly number of aircraft movements (ATM) and the yearly number of passenger movements (APM). When dealing with the ATM frontier we consider the following inputs: the entire area of the airport (AREA), the total length of the runways (RUNWAYS), the total number of the aircraft parking positions (PARKING). The analysis of the APM frontier involves instead the following inputs: the yearly number of aircraft movements (ATM), the terminal surface (TERMINAL), the number of check–in desks (CHECK), the number of the aircraft parking positions (PARKING) and the number of lines for baggage claim (CLAIM). Table 2 presents descriptive statistics for each output and input variable in the sample data.

	2005				2006			
	mean	st.dev.	min	max	mean	st.dev.	min	max
APM (num.)	3.276.157	5.803.283	7.709	28.683.456	3.547.784	6.218.459	8.226	30.176.760
ATM (num.)	43.151	63.543	2.468	308.284	45.392	66.693	2.031	315.627
TERMINAL (Sqm)	33.323	71.468	998	329.000	35.668	71.219	1.200	329.000
PARKING (num.)	23,6	23,6	3,0	115,0	24,7	23,5	3,0	115,0
CHECK (num.)	36,3	60,2	2,0	267,0	38,9	60,2	2,0	267,0
CLAIM (num.)	3,7	2,7	1,0	14,0	4,0	2,8	1,0	14,0
AREA (hectares)	286,9	303,9	40,0	1.605,0	289,2	303,2	40,0	1.605,0
RUNWAYS (met.)	3.361	2.400	1.596	14.895	3.376	2.391	1.596	14.895

Table 2: Descriptive statistics for Italian airports

The average number of passengers increases from 2005 to 2006, but also its variability across airports, measured by its standard deviation. The same observations hold for the average number of aircraft movements. Among inputs, the average figures increased too: hence the capacity of the representative Italian airport increased between 2005 and 2006. RUNWAYS, TERMINAL, PARKING and AREA show a decrease in standard deviation, i.e. the differences between Italian airports concerning these inputs decreased. In 2006 the typical Italian airport has a terminal surface of 35.668 Sqm, about 25 aircraft parking positions, 39 check–in desks, 4 lines of baggage claims and it covers an area of 290 hectares. The runway length is 3.376 m.

5 Results

Table 3 shows the DEA efficiency scores regarding the Italian airports relating the ATM model. In 2006 there are 9 airports on the VRS frontier, i.e. with $TE = 1$: both the A category airports, only Milan Linate among those in category B, Cagliari and Florence in category C and Crotone, Foggia, Parma and Reggio Calabria among the smallest airports. The category distance from the frontier, measured as the average distance from the VRS frontier of those airports with $TE < 1$, is as follows: 0,26 for category B, 0,27 for category C and 0,31 for category D.[22] The average inefficiency increases the smaller are the airports considered, when aircraft movements are taken into account. Since we know that being close to the physical frontier is a signal of capacity saturation, this result implies that large Italian airports are working either at full capacity or close to it, while there is spare capacity in small and regional airports.

Concerning the returns to scale, in 2006 both the two largest airports exhibit decreasing returns to scale, signaling that, from a cost perspective, they will get lower average costs by decreasing their scale of operation. The evidence is mixed for the 5 category B airports: 3 of them (Bergamo, Catania and Naples) show increasing returns to scale, one (Milan Linate) has an optimal scale since it has constant returns to scale, while Venice needs further capacity, since it is experiencing decreasing returns to scale. Among the 13 category C airports, 1 (Cagliari) has an optimal size (i.e. constant returns to scale), one (Palermo) has decreasing returns to scale, while all the others have increasing returns to scale. All the category D airports have increasing returns to scale. Hence there is evidence that small size Italian airports may benefit of a reduction in average costs if they can increase their scale of

[22]Taking, for each category, only the airports not on the frontier avoids the distortion that large airports, which are less than small ones, may be closer to the frontier only because just one of them (out of two or of 5) is efficient. The limited number of airports in Category A and B does not allow to perform tests on the difference between the averages.

	2005				2006			
Airport	CRS	VRS(TE)	CRS/VRS(SE)	RS	CRS	VRS(TE)	CRS/VRS(SE)	RS
Alghero	0,43	0,72	0,60	Inc.	0,42	0,73	0,57	Inc.
Ancona	0,35	0,66	0,53	Inc.	0,28	0,66	0,42	Inc.
Bari	0,35	0,68	0,51	Inc.	0,40	0,73	0,56	Inc.
Bergamo	0,47	0,61	0,77	Inc.	0,47	0,63	0,75	Inc.
Bologna	0,66	0,72	0,92	Inc.	0,73	0,80	0,91	Inc.
Brescia	0,27	0,64	0,43	Inc.	0,26	0,66	0,39	Inc.
Brindisi	0,23	0,48	0,48	Inc.	0,24	0,50	0,48	Inc.
Cagliari	1,00	1,00	1,00	Con.	1,00	1,00	1,00	Con.
Catania	0,89	0,95	0,94	Inc.	0,71	0,82	0,87	Inc.
Crotone	0,21	1,00	0,21	Inc.	0,18	1,00	0,18	Inc.
Cuneo	0,17	0,85	0,21	Inc.	0,13	0,79	0,16	Inc.
Florence	0,81	1,00	0,81	Inc.	0,64	1,00	0,64	Inc.
Foggia	0,21	1,00	0,21	Inc.	0,24	1,00	0,24	Inc.
Forlì	0,16	0,71	0,22	Inc.	0,16	0,72	0,22	Inc.
Genoa	0,41	0,59	0,70	Inc.	0,43	0,62	0,69	Inc.
Lamezia T.	0,24	0,69	0,35	Inc.	0,26	0,70	0,37	Inc.
Milan LIN	1,00	1,00	1,00	Con.	1,00	1,00	1,00	Con.
Milan MXP	0,59	1,00	0,59	Dec.	0,59	1,00	0,59	Dec.
Naples	1,00	1,00	1,00	Con.	0,74	0,83	0,90	Inc.
Olbia	0,50	0,69	0,73	Inc.	0,50	0,71	0,70	Inc.
Palermo	0,70	0,74	0,94	Dec.	0,76	0,76	1,00	Dec.
Parma	0,57	1,00	0,57	Inc.	0,54	1,00	0,54	Inc.
Perugia	0,13	0,89	0,14	Inc.	0,14	0,74	0,19	Inc.
Pescara	0,27	0,78	0,34	Inc.	0,32	0,82	0,39	Inc.
Reggio Cal.	0,49	1,00	0,49	Inc.	0,76	1,00	0,76	Inc.
Rimini	0,16	0,57	0,28	Inc.	0,17	0,57	0,29	Inc.
Rome CIA	0,84	0,92	0,91	Inc.	0,86	0,99	0,86	Inc.
Rome FCO	0,85	1,00	0,85	Dec.	0,88	1,00	0,88	Dec.
Turin	0,58	0,63	0,92	Inc.	0,59	0,66	0,89	Inc.
Trapani	0,25	0,90	0,28	Inc.	0,24	0,90	0,27	Inc.
Treviso	0,40	0,75	0,54	Inc.	0,39	0,77	0,50	Inc.
Trieste	0,20	0,56	0,37	Inc.	0,20	0,56	0,36	Inc.
Venice	0,69	0,72	0,96	Dec.	0,69	0,70	0,99	Dec.
Verona	0,40	0,57	0,70	Inc.	0,41	0,60	0,68	Inc.

Table 3: DEA scores for aircraft movements

operation, i.e. the volume of aircraft movements.

The increase in airports' productivity between the two years considered, i.e. the individual Malmquist indices, always regarding the aircraft movements, is presented in Table 4. The average change in efficiency (EC) between 2005 and 2006 is equal to 0.4%: large increases in efficiency have been obtained by Alghero (+8%), Bari (+7%), Genoa (+6%), Rome Ciampino (+8%) and Turin (+6%). The sector has instead a worse performance if we consider the capacity to exploit the technical progress: the average of TC is indeed -0.5%. Important exceptions are the two largest airports (above all Milan Malpensa with +18%, while Rome Fiumicino has only +2%), and two of the largest category B airports (Milan Linate +11% and Venice + 8%) and Palermo (+4%). We then observe an higher ability of largest airports to exploit the technical progress. The average change in TFPC is positive and equal to 0.1%.[23] The productivity has increase in 15 airports during the period considered, while it has decreased in 11 airports.

Table 5 shows the category–airport's productivity between 2005 and 2006. The largest airports (category A) and the great regional airports (category C) exhibit an increase in productivity (much higher for the largest airports). The national airports (category B) report a 4% decrease in productivity between 2005 and 2006: exceptions are Milan Linate (+11%), Venice (+5%) and Bergamo (+2%). This category suffers for the very low performances of Catania (-19%) and Naples (-24%), and it is the only one with a robust decrease in efficiency change. The small regional airports (category D) present

[23]Unfortunately it is not possible a comparison with the productivity score of the whole Italian economy, since the latest score reported by the OECD is for 2004.

Airport	TE(2005)	TE(2006)	EC	TC	TFPC
Alghero	0,72	0,73	1,01	0,97	0,99
Ancona	0,66	0,66	1,00	0,95	0,96
Bari	0,68	0,73	1,07	0,96	1,03
Bergamo	0,61	0,63	1,03	0,99	1,02
Bologna	0,72	0,80	1,11	1,00	1,11
Brescia	0,64	0,66	1,03	0,97	0,99
Brindisi	0,48	0,50	1,03	0,97	1,00
Cagliari	1,00	1,00	1,00	0,95	0,95
Catania	0,95	0,82	0,87	0,95	0,83
Crotone	1,00	1,00	1,00	0,99	0,99
Cuneo	0,85	0,79	0,94	0,99	0,93
Florence	1,00	1,00	1,00	0,94	0,94
Foggia	1,00	1,00	1,00	1,00	1,00
Forlì	0,71	0,72	1,01	0,99	1,00
Genoa	0,59	0,62	1,06	0,96	1,02
Lamezia T.	0,69	0,70	1,01	0,99	1,00
Milan LIN	1,00	1,00	1,00	1,11	1,11
Milan MXP	1,00	1,00	1,00	1,18	1,18
Naples	1,00	0,83	0,83	0,95	0,78
Olbia	0,69	0,71	1,04	0,97	1,01
Palermo	0,74	0,76	1,04	1,04	1,08
Parma	1,00	1,00	1,00	0,98	0,98
Perugia	0,89	0,74	0,83	0,99	0,83
Pescara	0,78	0,82	1,04	0,97	1,02
Reggio Cal.	1,00	1,00	1,00	1,10	1,10
Rimini	0,57	0,57	1,00	1,00	1,00
Rome CIA	0,92	0,99	1,08	0,97	1,05
Rome FCO	1,00	1,00	1,00	1,02	1,02
Turin	0,63	0,66	1,06	0,98	1,04
Trapani	0,90	0,90	1,00	1,00	1,00
Treviso	0,75	0,77	1,03	0,97	1,00
Trieste	0,56	0,56	1,00	1,00	1,00
Venice	0,72	0,70	0,97	1,08	1,05
Verona	0,57	0,60	1,05	0,96	1,01

Table 4: Total factor productivity changes for aircraft movements

Airport Category	EC	TC	TFPC
A	1,00	1,10	1,10
B	0,94	1,02	0,96
C	1,04	0,97	1,02
D	0,99	0,99	0,99

Table 5: Average airport category productivity for aircraft movements

a 1% decrease in productivity. Hence the smallest Italian airports do not seem to have adopted plans to reduce their spare capacities at the moment.

Now we examine the other airport's output considered in this paper, i.e. passengers (APM). The results concerning the efficiency scores obtained with the DEA model are shown in Table 6. On average the 34 airports have a technical efficiency in 2005 equal to 0,84 (they are at about 16% distance from the VRS frontier), and to 0,76 if we take scale efficiency into account. The corresponding average TE and SE for the ATM output are, respectively, 0,79 and 0,60 (for 2005). The average TE for APM in 2006 is 0,84, while SE is equal to 0,77 in the same year. These averages are again higher than those obtained for ATM in 2006. Hence we can say that Italian airports seem to be more efficient in managing passengers rather than aircraft movements. The number of efficient airports in 2005 if we consider a VRS frontier is equal to 10, which increases to 14 in 2006. If we observe SE, only 5 airports are on the frontier in 2005, while they increase to 6 in 2006.

Rome Fiumicino is the unique A category airport on the frontier in 2006. Bergamo and Catania are the efficient airports among those classified in category B, Alghero, Lamezia Terme, Palermo and Rome Ciampino in category C, Crotone, Cuneo, Foggia, Forlì, Parma, Perugia and Reggio Calabria in

	2005				2006			
Airport	CRS	VRS(TE)	CRS/VRS(SE)	RS	CRS	VRS(TE)	CRS/VRS(SE)	RS
Alghero	0,96	1,00	0,96	Inc.	0,97	1,00	0,97	Inc.
Ancona	0,27	0,54	0,50	Inc.	0,33	0,54	0,61	Inc.
Bari	0,75	0,76	0,98	Inc.	0,72	0,76	0,95	Inc.
Bergamo	0,97	0,98	0,99	Inc.	1,00	1,00	1,00	Con.
Bologna	0,71	0,71	1,00	Inc.	0,63	0,64	0,99	Inc.
Brescia	0,40	0,61	0,66	Inc.	0,24	0,48	0,50	Inc.
Brindisi	0,77	0,92	0,84	Inc.	0,77	0,92	0,83	Inc.
Cagliari	0,88	0,93	0,95	Inc.	0,80	0,81	0,99	Inc.
Catania	1,00	1,00	1,00	Con.	1,00	1,00	1,00	Con.
Crotone	0,36	1,00	0,36	Inc.	0,51	1,00	0,51	Inc.
Cuneo	0,02	1,00	0,02	Inc.	0,05	1,00	0,05	Inc.
Florence	0,61	0,75	0,81	Inc.	0,61	0,69	0,90	Inc.
Foggia	0,02	1,00	0,02	Inc.	0,03	1,00	0,03	Inc.
Forlì	0,69	0,95	0,72	Inc.	0,78	1,00	0,78	Inc.
Genoa	0,42	0,52	0,80	Inc.	0,44	0,53	0,84	Inc.
Lamezia T.	0,88	0,96	0,92	Inc.	0,96	1,00	0,96	Inc.
Milan LIN	0,80	0,92	0,87	Dec.	0,96	0,97	0,99	Inc.
Milan MXP	0,90	0,92	0,97	Dec.	0,90	0,92	0,99	Dec.
Naples	0,96	0,98	0,98	Inc.	0,97	0,97	1,00	Inc.
Olbia	0,56	0,57	0,98	Inc.	0,55	0,57	0,98	Inc.
Palermo	0,91	0,92	0,98	Inc.	1,00	1,00	1,00	Con.
Parma	0,10	1,00	0,10	Inc.	0,15	1,00	0,15	Inc.
Perugia	0,13	1,00	0,13	Inc.	0,08	1,00	0,08	Inc.
Pescara	0,35	0,61	0,58	Inc.	0,30	0,54	0,56	Inc.
Reggio Cal.	0,55	0,95	0,58	Inc.	0,65	1,00	0,65	Inc.
Rimini	0,43	0,62	0,68	Inc.	0,46	0,58	0,79	Inc.
Rome CIA	1,00	1,00	1,00	Con.	1,00	1,00	1,00	Con.
Rome FCO	1,00	1,00	1,00	Con.	1,00	1,00	1,00	Con.
Turin	0,58	0,58	0,99	Inc.	0,53	0,54	0,99	Inc.
Trapani	0,59	0,94	0,63	Inc.	0,49	0,87	0,57	Inc.
Treviso	1,00	1,00	1,00	Con.	0,79	0,87	0,90	Inc.
Trieste	0,39	0,51	0,75	Inc.	0,41	0,53	0,77	Inc.
Venice	0,77	0,81	0,95	Dec.	0,89	0,95	0,94	Dec.
Verona	0,72	0,73	0,98	Inc.	0,79	0,81	0,98	Inc.

Table 6: DEA scores for passenger movements

category D. The category distance from the VRS frontier is as follows: 0,08 for category A, 0,04 for category B, 0,31 for category C and 0,36 for category D. Again we observe a lot of inefficiencies in the small domestic and regional airports when passengers are considered, and that large airports are close to saturation while small ones have spare capacity.

When we analyze returns to scale, we get that in 2006 Rome Fiumicino has constant returns to scale, while Milan Malpensa has decreasing returns to scale. The latter prevails also at Venice airport, which belongs to category B but it is the fourth Italian airport in terms of passengers. Bergamo and Catania have constant returns to scale, while Milan Linate and Naples exhibit increasing returns to scale. This implies that, in general, further investments to increase the number of passengers in the large Italian airports, which are close to full capacity utilization being at a low distance from the physical frontier, will not lead to an increase in average costs. They should remain constant or decrease (Milan Malpensa may be an exception). The regional airports (category C) have increasing returns to scale, with the exceptions of Palermo and Rome Ciampino, which have constant returns to scale. The small regional airports (category D) have all increasing returns to scale. These airports, being not too close to the physical frontier, should first improve their capacity utilization by increasing the number of passengers. After this they may increase their scale of operation and then benefit of lower average costs. The latter is immediately possible for the C and D airports already on the frontier. The number of airports with constant returns to scale is higher under APM (5 airports in 2006) than ATM (only 2 airports): this is a confirmation that it is easier to reach the optimal size in managing passengers rather than aircraft movements.

The productivity scores, i.e. the Malmquist Indeces for APM, are reported in Table 7. On average the Italian airports show a decrease in efficiency (EC) between 2005 and 2006 equal to -1,1%. Large increase in efficiency are observed for Venice (+18%), Verona (+12%) and Palermo (+8%). The mean TC is instead positive: +1.8%. Hence if we consider passengers, Italian airports seem to be able to exploit the technical progress: we observed the opposite when aircraft movements were analyzed. Rimini (+16%), Crotone (+14%) and Bergamo (+13%) realize the best performances. The average performance regarding the total factor productivity change TFPC is equal to 0.7%, i.e. higher than for the aircraft movements. Hence the airports productivity is greater for passengers rather than for aircraft movements. Remarkable productivity performances are reported for Venice (+21%), Bergamo (+16%), Crotone (+14%), Reggio Calabria (+11%), Rimini and Verona (+9%), Lamezia Terme (+8%), Milan Linate (+7%) and Forlì (+6%).

If we examine each airport individually, we can observe the following important results: (1) 6 airports report an increase in efficiency, since EC is higher than 1. Among them two–digits percentage increases are for Venice (+16%) and Verona (+12%). (2) 8 airports score a decrease in efficiency, given that $EC < 1$. Among them it is worth mentioning Cagliari (-14%). (3) The results for the TFPC highlight that 13 Italian airports have improved their productivity between 2005 and 2006: relevant results have to be remarked for Rome Ciampino (+27%), Venice (+21%) and Bergamo (+11%). (4) There are 9 airports marking a decrease in productivity between the two years considered: among them two–digits percentage reductions are observed

Airport	TE(2005)	TE(2006)	EC	TC	TFPC
Alghero	1,00	1,00	1,00	1,04	1,04
Ancona	0,54	0,54	0,99	1,00	1,00
Bari	0,76	0,76	0,99	1,03	1,01
Bergamo	0,98	1,00	1,02	1,13	1,16
Bologna	0,71	0,64	0,90	1,03	0,93
Brescia	0,61	0,48	0,79	1,02	0,81
Brindisi	0,92	0,92	1,00	1,01	1,02
Cagliari	0,93	0,81	0,87	0,99	0,87
Catania	1,00	1,00	1,00	0,89	0,89
Crotone	1,00	1,00	1,00	1,14	1,14
Cuneo	1,00	1,00	1,00	1,00	1,00
Florence	0,75	0,69	0,92	1,01	0,93
Foggia	1,00	1,00	1,00	0,97	0,97
Forlì	0,95	1,00	1,05	1,01	1,06
Genoa	0,52	0,53	1,01	0,98	0,98
Lamezia T.	0,96	1,00	1,04	1,04	1,08
Milan LIN	0,92	0,97	1,05	1,02	1,07
Milan MXP	0,92	0,92	0,99	1,03	1,02
Naples	0,98	0,97	0,99	0,90	0,89
Olbia	0,57	0,57	0,99	1,05	1,04
Palermo	0,92	1,00	1,08	0,97	1,05
Parma	1,00	1,00	1,00	0,92	0,92
Perugia	1,00	1,00	1,00	0,93	0,93
Pescara	0,61	0,54	0,90	0,99	0,88
Reggio Cal.	0,95	1,00	1,05	1,05	1,11
Rimini	0,62	0,58	0,94	1,16	1,09
Rome CIA	1,00	1,00	1,00	1,30	1,30
Rome FCO	1,00	1,00	1,00	1,04	1,04
Turin	0,58	0,54	0,93	1,02	0,94
Trapani	0,94	0,87	0,93	1,01	0,94
Treviso	1,00	0,87	0,87	0,91	0,80
Trieste	0,51	0,53	1,03	1,00	1,04
Venice	0,81	0,95	1,17	1,03	1,21
Verona	0,73	0,81	1,12	0,98	1,09

Table 7: Total factor productivity changes for passengers

Airport Category	EC	TC	TFPC
A	1,00	1,04	1,03
B	1,05	0,99	1,04
C	0,98	1,03	1,00
D	0,98	1,02	0,99

Table 8: Average airport category productivity for passengers

for Treviso (-33%), Florence (-14%), Naples and Cagliari (-13%) and Catania (-11%).

Table 8 shows the category–airport's productivity when passengers are considered between 2005 and 2006. The largest airports (category A) and the national airports (category B) have an increase in productivity. Again the small regional airports (category D) present a 1% decrease in productivity.

From the productivity scores it is possible to compute, with a regulation goal, the x–factor to apply at the typical 5–years price cap period. To get the efficiency target it is possible to proceed as follows: First assume that a single airport should guarantee yearly at least the average TFPC (this would mean, using our data, in the ATM case +0.1%). Then consider a second component, based on the assumption that each airport should reduce its inefficiency, i.e. it should catch up the frontier. TE signals the inefficiency that is directly under the control of the airport's management. Hence compute the difference Δ between the efficient frontier and the position of each airport in the last available year, i.e. 2006 in this case. For instance, looking at Table 4, this means for Alghero $\Delta = 0,27$ and for Ancona $\Delta = 0.34$. It is possible to assume that only half of this distance may be recovered during the 5–years regulatory period, and then compute the yearly target, given by $(1+\Delta)^{1/5}-1$.

This maximum level may be reduced since not all of an airport's productivity gap is due to the management: for instance, as remarked by Pels *et al.* [2003], inefficiency may derive from input indivisibility (i.e. a new runway may take time to reach the optimal planned output), from government limitations (e.g. no flights during some hours), from climatic conditions (e.g. foggy or windy days), and to airlines inefficiencies. Moreover, the dataset should cover more years, to rule out short–run effects.

To sum up, the analysis of the efficiency and productivity scores points out that, for both the outputs considered in this contribution (i.e. aircraft movements and passengers), the inefficiency is higher the smaller is the airport. This implies that large airports are close to saturation, since they are operating close to the physical frontier. On the contrary there is spare capacity in small airports. The sector has increased its productivity in the period considered for both outputs considered, with higher performances for passengers. The small airports are an exception, since they report a decrease in productivity. In general the efficiency is higher for passengers, i.e. airports exhibit an higher ability to manage passengers rather than aircraft movements: this may be due to an exogenous shock (the robust increase in the demand for passenger air transportation in Italy), to regulatory constraints (e.g. time limits in aircraft movements) and to lack of competition between airports in attracting carries.

5.1 The impact of ownership on efficiency

The last part of our empirical analysis regards the sources of efficiency differentials among airports, to assess the impact of privatization. By assuming cross–sectional heteroscedasticity (see Abbott and Wu [2002]), DEA efficiency scores are regressed on a number of exogenous variables, covering specific characteristics of airports. Two dependent variables are taken into account: TE_{ATM}^{2006} and TE_{APM}^{2006}, i.e. the airport's distance from the VRS frontier in 2006. These scores are regressed on four explanatory variables: HHI (the Herfindahl–Hirschman Index computed using the ASK—Available Seat Kilometers—supplied by each carrier in the airport considered), MILITARY (a dummy variable equal to 1 if the airport is used also for military activities), PRIVATE (a dummy variable equal to 1 if private agents control the airport, i.e. they own at least the 51% of the outstanding shares) and SEASON (a variable that considers seasonality effects on the single airport, computed as the ratio between the number of aircraft movements in the peak month and the number of average monthly aircraft movements). HHI takes into account the effect on the airport efficiency of the presence of a dominant carrier, while military activities can clearly have an impact on the efficiency. Ownership is important since it allows to identify the effect of privatization on the efficiency, while seasonality is considered to observe the difference in efficiency of airports with a strong influence of touristic seasonal movements. We adopt a Tobit regression as Abbott and Wu [2002] to allow for the truncated distribution of the efficiency scores, that lie between zero and one. The results are reported in Table 9.

The first four columns of Table 9 are the estimated coefficients, standard errors, t–statistics and the corresponding p–values for the regression of DEA TE 2006 scores on the explanatory variables for efficiency in managing aircraft movements. Significance levels at 1%, 5% and 10% are reported for each

	ATM				APM			
Variable	Coefficient	St. error	t–statistics	p–value	Coefficient	St. error	t–statistics	p–value
HHI	$19,6(10)^{-6}$	$11,9(10)^{-6}$	1,65*	0,110	$49,5(10)^{-6}$	$21,9(10)^{-6}$	2,26***	0,031
MILITARY	-0,115	0,0690	-1,67*	0,105	-0,210	0,1068	-1,97**	0,058
PRIVATE	0,195	0,0782	2,50**	0,018	0,140	0,1186	1,18	0,245
SEASON	-0,148	0,1352	-1,10	0,281	-0,376	0,1999	-1,88**	0,069
Constant	0,921	0,1795	5,13***	0,000	1,254	0,2635	4,76***	0,000

* = 10% ** = 5% *** = 1% (sig. level)

Table 9: Determinants of efficiency

explanatory variable. The outcomes are that efficiency is higher for airports with higher level of concentration (HHI), i.e. the more one airline dominates an airport the more efficient is the use of inputs for airside movements, and with private ownership (PRIVATE). Ownership has a bigger impact on efficiency than airline dominance. Moreover, efficiency on this output is lower if the airport has military activities, as expected. The efficiency in managing aircraft movements is not significantly influenced by seasonality effects.

The following four columns in Table 9 report the estimated coefficients, standard errors, t–statistics and p–values for efficiency in managing passengers. In this case the efficiency is higher for airports where an airlines dominates (HHI), while it is lower in the airports where there are military activities (MILITARY) and seasonality effects due to touristic activities (SEASON). When passengers are considered, ownership has no significant effect on efficiency.

Hence efficiency is higher, for both the outputs considered in this study, if an airport has a dominant airline. This result may be interpreted as a confirmation of the so–called hub–premium (Gillen and Lall [1997]), i.e. airports acting as hub for a specific airlines (or where a large portion of the airport activities is devoted to a single airline) increase the efficient use of inputs. Moreover, it is interesting that private airports are more efficient in managing aircraft movements than public airports. Hence this paper suggests that privatization may improve the efficiency of Italian airports at least in airside operations. An efficient utilization of inputs dedicated to passengers (e.g. terminals, check–in, etc.) seems not to be influenced by ownership.

6 Conclusions

This paper has investigated the efficiency of Italian airports, by applying a DEA model to a sample of 34 Italian airports, covering about 98% of aircraft movements and 97% of passengers in the period considered. We find that many airports can improve their efficiency on both types of output. We show that efficiency is related to airports' size, i.e. airports with more than 5 millions passengers are more efficient than the domestic and regional ones. Moreover, further developments in the activities of large airports may lead to an increase in their average costs, since they are mainly operating under decreasing returns to scale. On the contrary, we find that there is spare capacity in domestic and regional Italian airports and that they are operating under increasing returns to scale. The Malmquist indeces relating to productivity scores show that the average change in efficiency between 2005 and 2006 is positive for both aircraft movements and passengers, and that it is higher for the latter.

The econometric analysis on the estimated efficiency scores shows that airports are closer to an optimal inputs' utilization if one airline dominates the airport (a confirmation of the hub premium effect), if the airport is private (for aircraft movements), while military activities and seasonality effects operate as obstacles towards efficiency.

Hence this paper suggests that airport's privatization, incentives to invest in large airports (since they are close to saturation in their capacity) and development plans to improve the activities in domestic and regional airports—where there is spare capacity—may form the benchmarks of air transportation policy in Italy at least in the short–run.

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