

GARS Workshop November 10<sup>th</sup> and 11<sup>th</sup> 2006  
“Liberalization of Air Transport, Airport Regulation and Benchmarking”

**An application of robust nonparametric methods to measure  
the efficiency of Italian airports after privatization**

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## ➤ The Motivation

*To carry out a deep research of the Italian Airports Industry after privatization*

in a research network jointed with Professor Jurgen Müller

*This paper is a first step of the more complex analysis we will carry out in the future.*

# Summary

- The Main Aims and Contributions
- The Main Aspects of the Italian Airport Industry
- Data
- The Methodological Approach
- Empirical evidences
- Concluding remarks

## ➤ The Main Aims

*To study the technological efficiency of 17 Italian Airports*

*To highlight the weakness of non parametric DEA models  
(even if in partial way: no robust method for scale efficiency)*

## ➤ The Main Contribution

Summary of past studies on Italian Airports Industry

- Bergamini, Gitto and Mancuso (GARS Workshop, July 2006);

*The sample of airports has been enlarged. We have considered additional airports: Bologna, Napoli, Torino, Trapani and Venezia*

*A different methodology has been applied*

## ➤ The Main Aspects of the Italian Airports Industry

*The Italian Airport Industry is undergoing several changes:*

- ✓ law n. 537/93 has had impacts on capital compositions;
- ✓ law n.351/95 joined with European Directive 96/67/CE have had impacts on the liberalization of the handling services

*Law n.351/95 has uniformed the concession agreements: complete concession.*

Before law n.351/95:

Genova, Milano Linate, Milano Malpensa,  
Roma Ciampino, Roma Fiumicino  
Torino

# ➤ The Main Aspects of the Italian Airports Industry



## **Sample:**

Total Airports: 101

Significant Airports : 45

Airports considered: 17

## **Data Coverage:**

Number of passengers: 89.9%

Number of cargos: 95.6%

Number of movements: 83.6%

**Time period:** 2000-2004

## **Sources:**

Balance sheets

Annual Statistics of ENAC  
(Ente Nazionale Aviazione  
Civile)

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# ➤ The Main Aspects of the Italian Airports Industry

Airports	IATA code	passengers (%)	cargos (%)	movements (%)
Alghero Fertilia	AHO	0.9	0.2	0.9
Ancona Falconara	AOI	0.6	0.7	1.6
Bergamo Orio al Serio	BGY	2.2	14.2	3.4
Bologna Borgo Panigale	BLQ	3.9	3.1	4.6
Catania Fontanarossa	CTA	5.0	1.4	4.2
Genova Sestri	GOA	1.2	0.8	2.3
Lamezia Terme	SUF	1.1	0.3	1.0
Milano Linate	LIN	8.9	3.2	9.1
Milano Malpensa	MLP	21.4	41.7	19.0
Napoli Capodichino	NAP	5.0	1.1	5.2
Palermo Punta Raisi	PMO	4.0	0.7	3.6
Pescara Pasquale Liberi	PSR	0.3	0.3	0.8
Pisa San Giusto	PSA	1.9	1.4	2.4
Roma Ciampino	CIA	1.6	2.4	2.8
Roma Fiumicino	FCO	30.3	22.7	24.5
Torino Caselle	TRN	3.3	2.2	5.0
Trapani Birgi	TPS	0.2	0.0	0.3
Venezia Tessera	VCE	5.5	2.3	5.9
Verona Villafranca	VRN	2.7	1.4	3.2
Sample Total		89.9	95.6	83.6

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## ➤ The Main Aspects of the Italian Airports Industry

<b>Codice</b>	<b>WLU</b>	<b>Naz./Int</b>	<b>ROI</b>
AHO	1.010.811	1,369	neg.
AOI	587.225	0,707	neg.
BGY	4.647.411	0,141	0,073
BLQ	3.119.331	0,451	0,026
CTA	5.208.652	4,283	0,088
GOA	1.138.371	1,610	0,008
SUF	1.302.027	5,352	0,126
LIN	9.203.875	2,465	0,093
MXP	22.167.244	0,231	
NAP	4.716.420	1,262	0,146
PMO	3.833.491	4,853	0,033
PSR	356.308	0,367	neg.
PSA	2.152.780	0,310	0,123
CIA	2.773.346	0,001	0,163
FCO	29.870.537	0,831	
TRN	3.301.828	1,307	0,090
TPS	411.388	20,076	neg.
VCE	6.094.975	0,519	0,059
VRN	2.815.155	0,525	0,077

*The airports of Milano and Roma concentrate more than 50% of the Italian Traffic volumes*

*The smaller airports have difficulty in recovering capital investment (negative ROI)*

*Traffic composition does not affect airports returns.*

*Different policies in two airport Systems:*

*Malpensa: International traffic  
Linate: National traffic*

*Fiumicino: both traffic  
Ciampino: International low cost companies*

## ➤ Data

**Time period:** 2000-2004

<b>INPUTS</b>	Mean	Max	Min	St. Dev.
Labor costs	223519	2283731	3278.936	431246.5
Other costs	252248.1	1765921	2751.525	410522.4
Dimension of runways	230451.4	891004	108000	208000.7
<b>OUTPUTS</b>				
Number of movements	70081.89	353921	1715	97544.93
Number of passengers	5109245	306756	28312	8194862
Amount of cargo	47318.01	3872425	0	97544.93

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## ➤ The Methodological Approach

Two Steps in Measurement of Technical Efficiency (*Daraio, Simar 2006*)

*First Step: Measure of Technical Efficiency Score*  
(*Farrell 1957, Debreu and Koopmans 1951*)

Formulation: DEA VRS model – output oriented

Let  $TE_i$  the technical efficiency associated to each firm  $TE_i = z_i \quad 1 \leq TE_i \leq \infty \quad i = 1, \dots, n$

$$\max_{\phi, \lambda} z_i = \phi$$

s.t.

$$- \phi y_i + Y \lambda \geq 0;$$

$$x_i - X \lambda \geq 0;$$

$$N \mathbf{1}' \lambda = 1$$

$$\lambda \geq 0$$

where:

$\Phi$ : scalar greater than 1

$\lambda$ : vector of weight  $n \times 1$

$Y$ : output matrix

$X$ : input matrix

$N \mathbf{1}'$ : vector  $N \times 1$  of one

$n$ : numbers of observations

## ➤ The Methodological Approach

Two Steps in Measurement of Technical Efficiency (*Daraio, Simar 2006*)

*Second Step: Sensitivity Analysis of Efficiency Scores*

*(Simar and Wilson 1998, Daraio and Simar 2006)*

Bootstrap Algorithm (First phase: generation of pseudo-efficiencies)

1. Transform the input-output vectors using the Original Efficiency Scores;
2. Generate smoothed re-sample pseudo-efficiencies;
3. Transform the data obtained in 1.;
4. Estimate the bootstrap efficiencies using the pseudo-data and the usual linear program
5. Repeat steps (2)-(4) B times to create a set of B firm specific bootstrapped efficiency estimates.

## ➤ The Methodological Approach

Two Steps in Measurement of Technical Efficiency (*Daraio, Simar 2006*)

*Second Step: Measure of Bootstrapped Technical Efficiency Scores*  
(*Simar and Wilson 1998, Daraio and Simar 2006*)

Bootstrap algorithm (second phase: bias and inference)

1. Estimate the bias  $Bias_i^* = \frac{1}{B} \sum_{b=1}^B \phi_{in}^{*b} - \phi_{in} \quad i = 1, \dots, n$
2. Estimate the confidence interval for the true value of technical efficiency scores through the percentile method (Mooney and Duval, 1993; Hall 1998; Simar and Wilson 1998)

If the ratio of the estimated bias to the standard error exceeds 0.25,  
the bias is significant (Efron, 1982);  
thus the bias corrected bootstrap efficiency scores provide better valuation

## ➤ Empirical evidences

Descriptive statistics of the aggregate original and bootstrap efficiency estimates

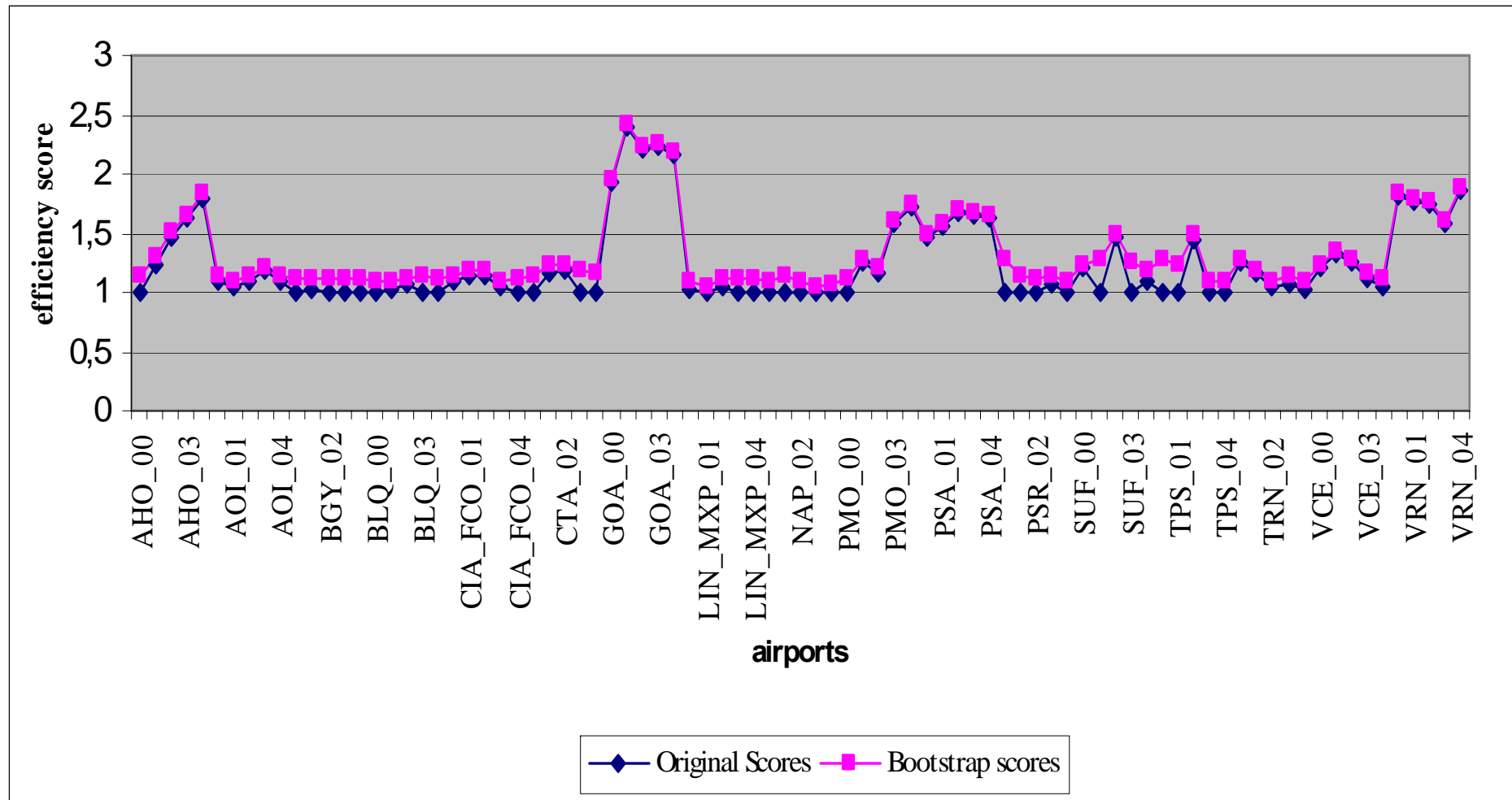
Estimate	Mean	Standard Deviation	Minimum	Maximum
Original estimate	1.243	0.344	1.000	2.398
Bootstrap estimate	1.319	0.316	1.053	2.416

- ✓ *The bias corrected bootstrap efficiency scores are different from the original*
- ✓ *Mean, Min and Max of bootstrap estimators are higher than the others;*
- ✓ *The ratio of the estimated bias to the standard errors of the bootstrap estimates exceed 0.25 (Efron, 1982)*

The bootstrap estimators provide a better indication of Italian Airport Industry  
The average technical inefficiency of Italian airports is about 32%

## ➤ Empirical evidences

Mean levels of the original and bias-corrected bootstrap efficiency scores



The original Dea efficiency scores are biased downwards.

# ➤ Empirical evidences

## Airports Ranking

Airport Code	2000		2001		2002		2003		2004	
	Original DEA	Boot.	Original DEA	Boot.	Original DEA	Boot.	Original DEA	Boot.	Original DEA	Boot.
AHO	1	9	11	12	14	14	15	15	15	15
AOI	11	7	7	3	7	7	12	11	11	10
BGY	1	5	5	4	1	6	1	5	1	9
BLQ	1	3	12	2	6	5	1	8	1	7
CTA	1	6	13	10	10	10	1	10	1	11
GOA	17	17	17	17	17	17	17	17	17	17
SUF	1	12	14	14	11	11	1	12	12	12
LIN_MXP	10	1	1	1	5	3	1	4	1	8
NAP	1	2	1	6	1	2	1	1	1	1
PMO	1	4	9	11	9	9	14	14	14	14
PSR	1	11	1	5	1	4	9	7	1	4
PSA	15	15	15	15	15	15	16	16	13	13
CIA_FCO	12	8	8	7	8	8	8	3	1	5
TRN	14	14	6	8	4	1	10	6	9	3
TPS	1	13	1	9	13	13	1	2	1	2
VCE	13	10	10	13	12	12	11	9	10	6
VRN	16	16	16	16	16	16	13	13	16	16

## ➤ Empirical evidences

### The “Best Performer”

- ✓ The airport of Napoli is the best performer.

It is the first Italian airport owned by a private majority

- ✓ The airports of Pescara, Trapani and Milano follow the airport of Napoli.

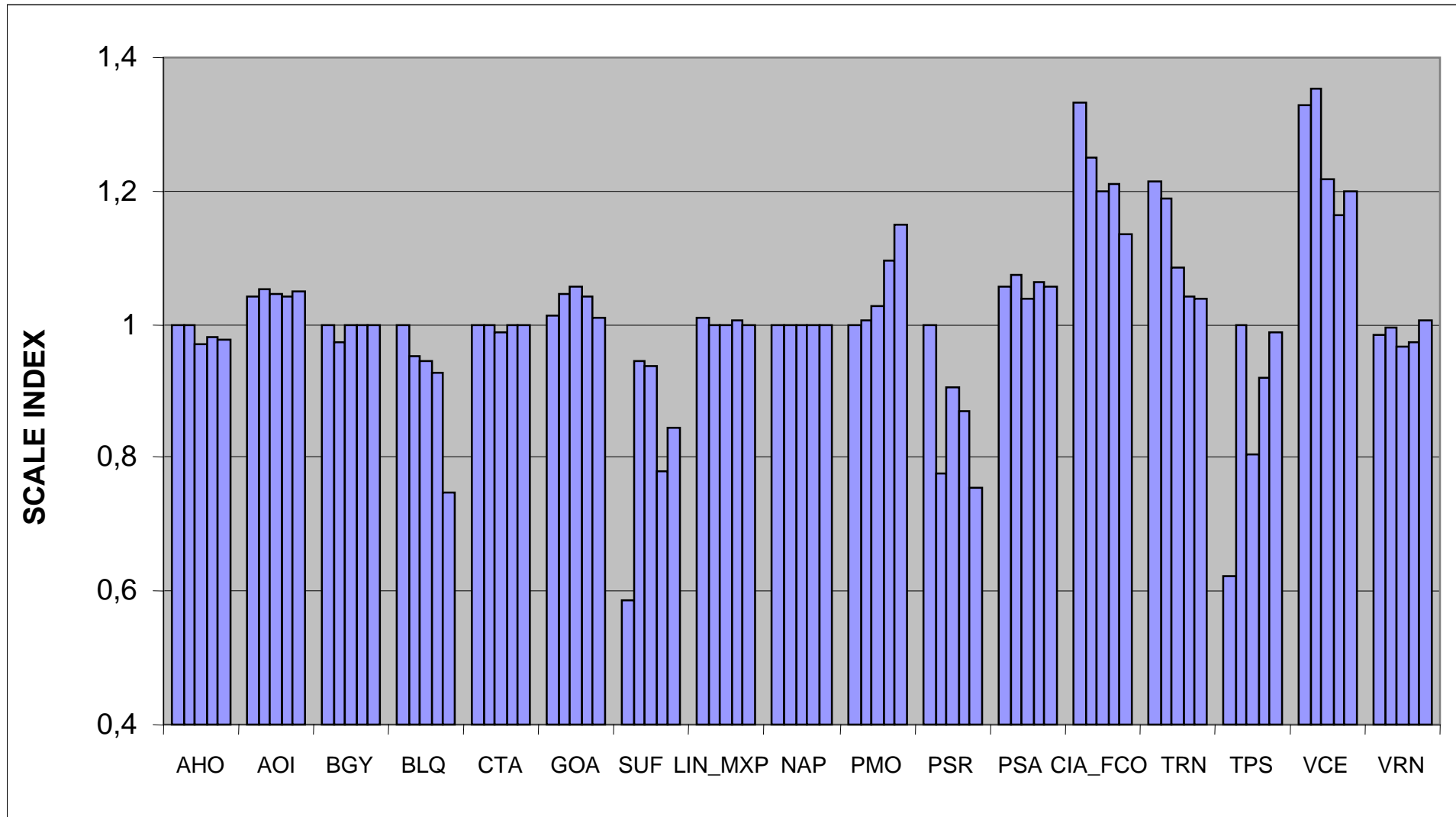
This group is heterogenous both in size than in type

It seems there is not correlation between:

- ✓ dimension and technical efficiency;
- ✓ capital composition and technical efficiency.

## ➤ Empirical evidences

Scale efficiency: Deterministic Approach (Coelli *et al.*, 1998)



## ➤ Concluding remarks

### Methodology

Bootstrap procedure has allowed to estimate bias and confidence intervals for the DEA efficiency scores of 17 Italian Airports.

This methodology has pointed out a different efficiency score ranking among the airports compared with the one identified by the original DEA.

### Policy implication

Absence of any deterministic impact of the dimension on efficiency scores.

Average technical inefficiency of Italian Airport is 32%, and so airport companies should improve the efficiencies of the production process;

Napoli and Milano could incur in a decrease in efficiency as soon as the traffic will increase;

On the contrary, Pescara and Trapani should increase the traffic volumes in order to exploit the increase return to scale and to increase their economical returns.

## ➤ Concluding remarks

### further developments

- Analysis of scale return in a robust setting;
- Analysis of technical efficiency change performing a second-stage Tobit regression.

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