



**German Aviation Research Society**

**Airport Competition and the Role of Airport Benchmarking**

**Vienna Airport on 24th/25th November 2005**

**Questions to Airport Benchmarkers –  
Some Theoretical and Practical Aspects Learned from  
Benchmarking Other Industries**

**Christian von Hirschhausen and Astrid Cullmann**

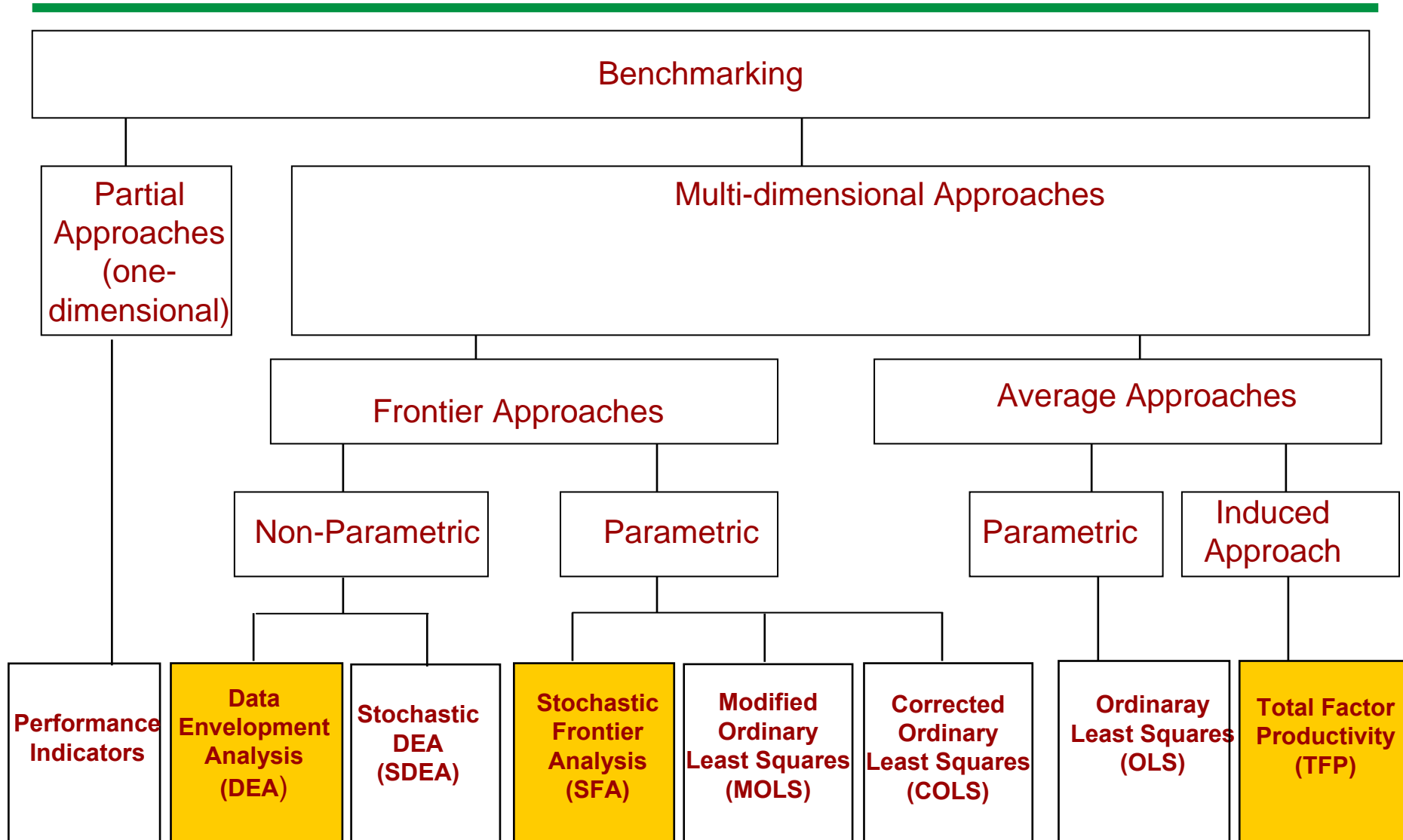
**Chair of Energy Economics and Public Sector Management, Dresden  
University of Technology, and DIW Berlin**

# Agenda

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- 1. The Issue: Efficiency Measurement of Airports**
- 2. Options in Nonparametric Approaches**
- 3. Recent Developments in Parametric Approaches**
- 4. Conclusions**

# Overview of Benchmarking Techniques



## How Should we measure airport efficiency? Model specification - Pels (2000)

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ATM MODEL		APM MODEL	
OUTPUT	INPUT	OUTPUT	INPUT
<b>Air Transport Movement</b>	<b>Number of runways</b>	<b>Air Passenger Movement</b>	<b>Check in Desks</b>
	<b>Aircraft parking positions</b>		<b>Baggage Claim</b>
	<b>Number of remote aircraft parking positions</b>		<b>ATM</b>
	<b>Airport surface area</b>		

# Stochastic Frontier Analysis

(Pels (2000), 41)

PARAMETES ATM		PARAMETERS APM	
$\alpha_{\text{constant}}$	0.713 (0.083)*	$\beta_{\text{constant}}$	0.213 (0.061)*
$\alpha_{96}$	0.670 (0.032)*	$\beta_{96}$	0.016 (0.041)
$\alpha_{97}$	0.154 (0.061)*	$\beta_{97}$	0.050 (0,051)
$\alpha_{\text{area}}$	0.403 (0.059)*	$\beta_{\text{ATM}}$	<b>0.848 (0.096)*</b>
$\alpha_{\text{runways}}$	0.002 (0.115)	$\beta_{\text{check-in desks}}$	<b>0.490 (0.160)*</b>
$\alpha_{\text{positions}}$	<b>0.268 (0.211)*</b>	$\beta_{\text{baggage claims}}$	-0.129 (0.191)
$\alpha_{\text{remote}}$	<b>0.280 (0.055)*</b>	$\beta^2_{\text{ATM}}$	-0.586 (0.162)*
$\alpha^2_{\text{area}}$	-2.207 (0.458)	$\beta^2_{\text{check-ins}}$	-0.851 (0.722)
$\alpha^2_{\text{runways}}$	<b>-0.456 (0.077)*</b>	$\beta^2_{\text{baggage claims}}$	<b>-0.905 (0.268)*</b>
$\alpha^2_{\text{positions}}$	-0.606 (0.130)*	$\beta_{\text{ATM*check-ins}}$	0.353 (0.477)
$\alpha^2_{\text{remote}}$	-0.308 (0.137)*	$\beta_{\text{ATM*bag.claims}}$	0.209 (0.469)
$\alpha_{\text{area*runways}}$	0.591 (0.068)*	$\beta_{\text{check-ins*bag.cl}}$	0.436 (0.561)
$\alpha_{\text{area*positions}}$	1.208 (0.043)*	$\delta_{\text{constant}}$	0.815 (0.562)
$\alpha_{\text{area*remote}}$	-0.090 (0.012)*	$\delta_{\text{time restriction}}$	<b>-0.592 (0.222)*</b>
$\alpha_{\text{runways*position}}$	-0.218 (0.157)	$\delta_{\text{load factors}}$	-1.454 (0.199)*
$\alpha_{\text{runways*remote}}$	-0.286 (0.128)*	$\sigma^2$	0.377 (0.064)*
$\alpha_{\text{positions*remote}}$	0.343 (0.152)*	$\gamma$	0.999(0.5E-7)*
$\delta_{\text{slot coordination}}$	<b>-0.278 (0.726)</b>		
$\delta_{\text{time restriction}}$	<b>-2.363 (1.447)</b>		
$\sigma^2_U + \sigma^2_V$	0.734 (0.106)*		
$\gamma = \sigma^2_U / (\sigma^2_U + \sigma^2_V)$	0.999 (0.6 E-05)*		

-Translog Production function

- Battese and Coelli Specificitation (1995), the inefficiency effects are expressed as an explicit function of a vector of firm specific variables and a random error

# Data Envelopment Analysis: A Variety of Results

(Pels (2000), 52-53)

	ATM	ATM	APM	APM		ATM	ATM	APM	APM
	Technical	Scale	Technical	Scale		Technical	Scale	Technical	Scale
AMS	0.804	0.767	0.788	1	LYS	0.368	0.768	0.513	0.970
BLL	1	0.515	0.971	0.461	MAN	0.794	0.821	0.774	0.990
BRU	0.755	0.760	1	1	MRS	0.699	0.702	1	0.970
CDG	1	1	0.695	0.991	MUC	1	0.942	0.757	0.994
<b>CPH</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>	MXP	0.955	0.316	0.842	0.771
DUB	0.442	0.830	0.932	0.963	NUE	1	0.506	0.917	0.494
FAO	1	0.294	1	0.996	OTP	0.734	0.199	0.949	0.401
FCO	0.880	0.850	1	0.995	ORY	0.601	0.921	0.927	1
<b>FRA</b>	<b>1</b>	<b>0.909</b>	<b>0.809</b>	<b>0.998</b>	PRG	0.541	0.673	0.672	0.785
GOT	1	0.493	0.972	0.593	STN	0.614	0.595	0.711	0.748
GVA	0.993	0.669	0.448	0.951	STO	0.999	0.821	0.896	0.988
HAJ	0.819	0.689	0.674	0.928	STU	1	1	0.923	0.836
GAM	0.650	0.864	0.643	1	<b>SXF</b>	<b>0.504</b>	<b>0.275</b>	<b>1</b>	<b>0.507</b>
LGW	1	1	0.954	1	TRN	1	0.272	0.750	0.601
<b>LHR</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>TXL</b>	<b>0.516</b>	<b>0.883</b>	<b>0.687</b>	<b>1</b>
<b>LIN</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>VIE</b>	<b>0.518</b>	<b>0.998</b>	<b>0.798</b>	<b>0.911</b>
LIS	0.760	0.612	0.707	0.886	ZRH	1	0.983	0.986	0.988

## Some Empirical Application

	Airports	Methodologies
Gillen and Lall (1999)	22 in USA 1989-1993	Data Envelopment Analysis, Malmquist Indice, Tobit Regression
Tolofari, Ashford and Caves (1990)	7 in UK 1975- 1987	Translog Cost Function
Martin and Roman (2001)	37 in Spain 1997	Static Data Envelopment Analysis
Pels (2000)	34 in Europe	Data Envelopment Analysis, Stochastic Frontier Analysis
Hooper and Henscher (1997)	6 in Australia 1989-1993	Tornqvist Indice
Holvad and Graham (2000)	25 in Europe, 12 in Australia 1993	Data Envelopment Analysis and Free Disposal Hull

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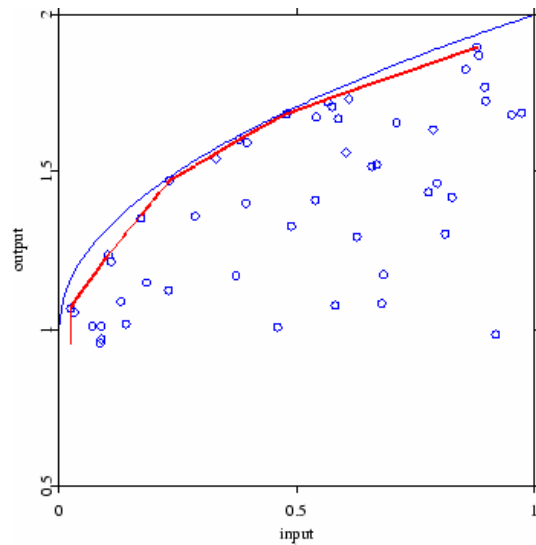
3. Recent Developments in Parametric Approaches

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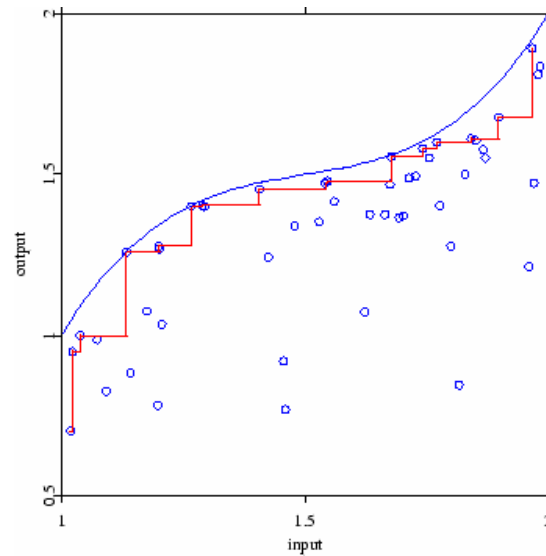
# Free Disposal Hull Estimator

- Deprins et al. (1984) proposed measuring efficiency for a given unit  $(x,y)$  relative to the boundary of the free disposal hull of the sample, the smallest free disposable set.
- Restricts the dominance comparison of the units' inputs and outputs to be with respect to other production units
- FDH excludes linear combinations of production units from the analysis

DEA Frontier



FDH Frontier



# Sensitivity Analysis with Bootstrapping

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- Approximation of the sampling distribution in order to correct for small sample bias and construct confidence intervals

→ Bootstrapping involves the repeated simulation of the data generating process and the application of the original estimator to each simulated sample so that the resulting estimators mimic the sampling distribution of the original estimator

- Practical aspects: Software package FEAR 1.0 (Frontier Efficiency Analysis with R); implementation of the bootstrap methods described by Simar and Wilson (1998, 2000)

- Bootstrap Algorithm:

Simar and Wilson (1998) – restrictive conditional bootstrap

Simar and Wilson (2000) – allow for heterogeneity in the structure of efficiency

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## Greene (2005): Fixed and Random Effects in Stochastic Frontier Models

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- Stochastic frontier models with panel data relied on traditional fixed (Schmidt and Sickles, 1984) and random effects models (Pitt and Lee, 1981)

$$y_{it} = \beta_0 + \delta_0 d_{2t} + \beta_1 x_{it} + a_i + u_{it}$$

### Two problems of the approaches:

- 1) Conventional panel data approaches assume that technical or cost inefficiency is time invariant
- 2) Fixed and random effects estimators force time invariant cross unit heterogeneity into the same term that is being used to capture the inefficiency

### Greene propose extensions of the conventional stochastic frontier models:

- I) The fixed effects model that employs the nonlinear specification
- II) The random effects model, reformulated as a special case of the random parameters model

## Stochastic Frontier Model in a True Fixed and Random Effects Formulation

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I) True Fixed Effect Formulation:  $y_{it} = \alpha_i + \beta' x_{it} + \nu_{it} - Su_{it}$

Retains the distributional assumptions of the stochastic frontier model, allows for freely time varying inefficiency, allows the heterogeneity term to be correlated with the included variables

-Trivial extension of the basic stochastic frontier models: replace the overall constant term with a complete set of firm dummy variables and estimate it by the now conventional means.

II) True Random Effect Formulation  $y_{it} = (\alpha_i + \varpi_i) + \beta' x_{it} + \nu_{it} - Su_{it}$

-Stochastic frontier model with a random (across firms) constant term, retains the essential characteristics of the stochastic frontier model, while relaxing the problematic assumptions discussed earlier

- time invariant term interpreted as firm specific heterogeneity, not inefficiency! Shift all the invariant content of into a heterogeneity term

- Solved Identification Problem

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# Conclusions

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**We just recall two traditional issues in efficiency measurement, to enrich the discussion of how to fill the GAP:**

- 1) Methodology first, what model to use, etc.?**
- 2) Data requirements/availability second, and the ways of going about**

# Literature

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**Deprins, Simar and Tulkens (1984):** Measuring labor inefficiency in post offices, in *The Performance of Public Enterprises: Concepts and measurement* Amsterdam, 243-267.

**Greene W. (2005):** Fixed and Random Effects in Stochastic Frontier Models, *Journal of Productivity Analysis*, 23, 7-23.

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**Simar, L. and P.W. Wilson (1998):** Sensitivity analysis of Efficiency scores: How to bootstrap in non-parametric frontier models, *Management Science*, 44, 49-61.

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