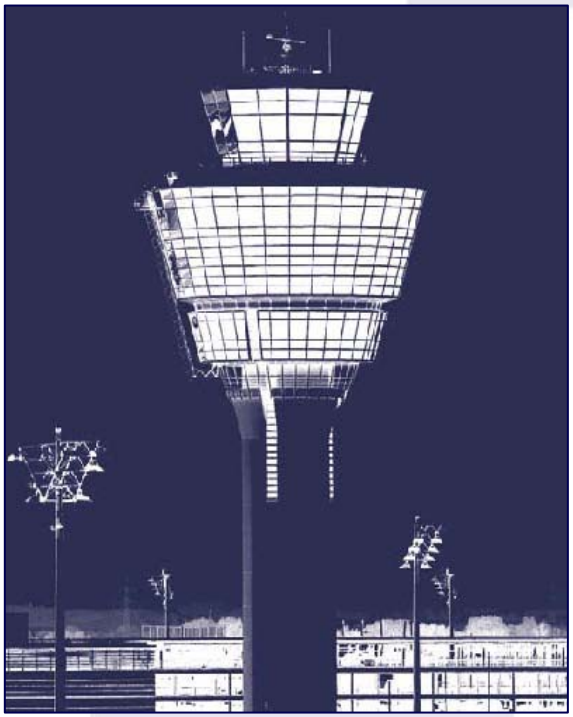
The Measurement of Technical Efficiency at German Airports-

An Empirical Research with Data Envelopment Analysis
and Stochastic Frontier Analysis



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Outline

1. Introduction
2. Methodology and Data
3. Results
    1. DEA
    2. SFA
    3. Second Stage Regression
4. Conclusion and Future Research

1. Introduction

Who benchmarks airports?

- ✈ Tool for regulators
  - yardstick competition
- ✈ Benchmarking studies by consultancies, e.g
  - ATRS, TRL, Booz Allen Hamilton
- ✈ Benchmarking amongst airports, e.g.
  - European Benchmarking Club (EBC)
- ✈ Academic Benchmarking studies, e.g.
  - Gillen and Lall (1997, 2001)
  - Pels et al (2001, 2003)

1. Introduction

Benchmarking of German airports

- ✈ Aims of this paper
  - Presentation of DEA and SFA results on technical efficiency of German airports
  - Recommendations for future research

2. *Methodology* and Data

Data Envelopment Analysis (DEA)

- Non-Parametric Function
- Linear Programming Method

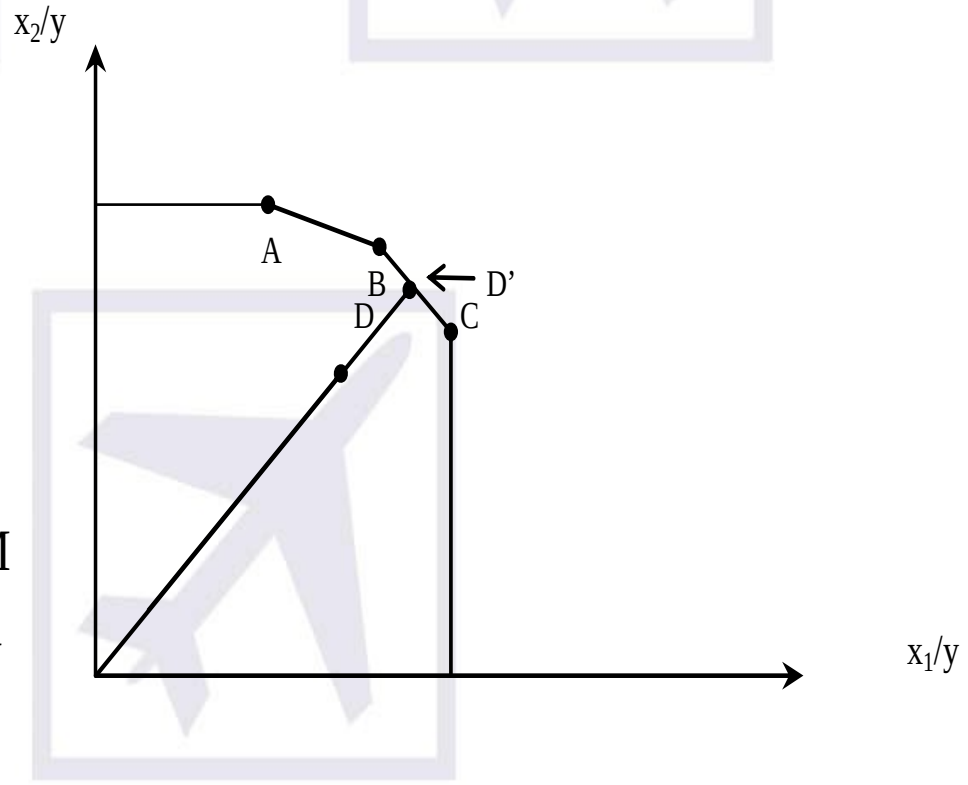
$$\max \theta^{k'}$$

s.t.

$$\sum_{k=1}^{K} z^k y_m^k \geq \theta^{k'} y_m^{k'}, \quad m=1,\ldots,M$$

$$\sum_{k=1}^{K} z^k x_n^k \leq x_n^{k'}, \quad n=1,\ldots,N$$

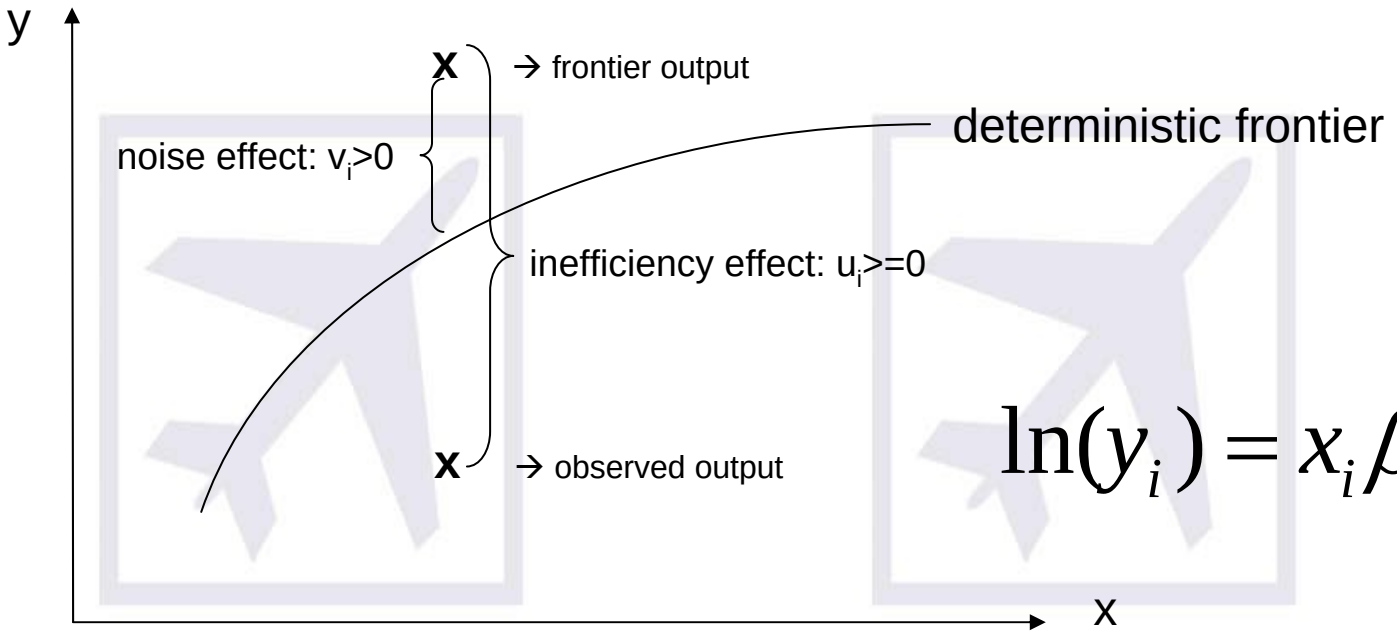
$$z^k \geq 0$$



2. *Methodology* and Data

Stochastic Frontier Analysis (SFA)

- ✈ Parametric Function
- ✈ Estimation of the Production Frontier



$$\ln(y_i) = x_i\beta + v_i - u_i$$

2. Methodology and *Data*

Dataset

- 16 international airports in Germany
- Time Period 1998-2004
- Traffic Data and Physical Data since Financial Data is not available yet
- Measurement of Technical Efficiency
- Variables:
  - One-output-case: passenger volume
  - Inputs: runways, check-in-counters, gates, airport size, parking positions

3. Results- DEA

Output Maximization and VRS

Data Envelopment Analysis										
	Pax '04 (in million)		**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**Mean**
Bremen	1.7	BRE	0.944	0.929	0.892	1.000	1.000	1.000	1.000	0.966
Dresden	1.6	DRS	0.879	0.897	1.000	0.903	0.869	0.870	0.916	0.905
Dortmund	1.2	DTM	1.000	1.000	1.000	0.681	0.681	0.680	0.830	0.839
Düsseldorf	15.2	DUS	1.000	1.000	1.000	1.000	1.000	0.984	1.000	0.998
Münster-Osnabrück	1.5	FMO	0.908	1.000	1.000	1.000	1.000	1.000	0.991	0.986
Frankfurt	50.1	FRA	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Hannover	5.2	HAJ	0.732	0.713	0.717	0.691	0.632	0.634	0.650	0.681
Hamburg	9.8	HAM	0.807	0.781	0.771	0.758	0.714	0.850	0.840	0.789
Leipzig	1.9	LEJ	0.936	0.957	0.761	1.000	1.000	0.567	0.570	0.827
Munich	26.7	MUC	0.895	0.921	0.958	1.000	1.000	0.864	0.897	0.934
Nuremberg	3.6	NUE	0.763	0.778	0.822	0.926	0.969	0.961	1.000	0.888
Saarbrücken	0.4	SCN	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Stuttgart	8.7	STR	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Berlin-Schönefeld	3.3	SXF	0.375	0.340	0.363	0.440	0.393	0.427	0.842	0.454
Berlin-Tempelhof	0.4	THF	0.313	0.256	0.224	0.667	0.542	0.367	0.360	0.390
Berlin-Tegel	11.0	TXL	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Mean	**8.9**	∅	**0.938**	**0.942**	**0.934**	**0.947**	**0.941**	**0.917**	**0.948**	**0.938**

3. Results- DEA

Weak Performers

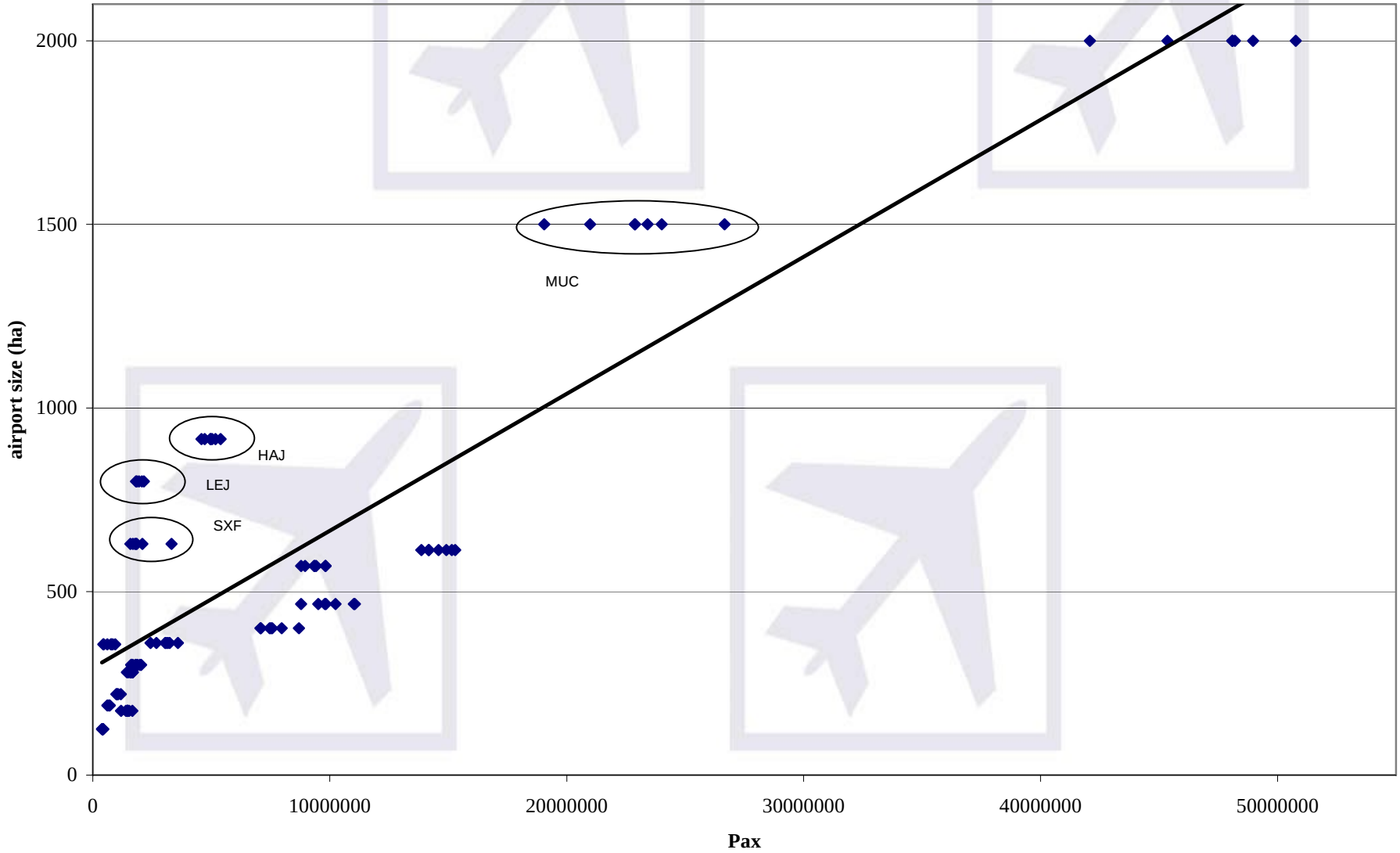
- Hannover
  - Third largest airport size in the sample
- Berlin-Schönefeld
  - Large airport size relative to airports with similar passenger volume

3. Results-DEA

Growth Potential

	2003		Δ		2004		Δ
BRE	1.60	1.60	0.0%		1.65	1.65	0.0%
DRS	1.50	1.70	13.33%		1.60	1.70	6.25%
DTM	1.00	1.50	50.00%		1.20	1.40	16.67%
DUS	14.20	14.40	1.41%		15.15	15.15	0.0%
FMO	1.50	1.50	0.0%		1.46	1.46	0.0%
FRA	48.11	48.11	0.0%		50.77	50.77	0.0%
HAJ	4.90	7.80	59.18%		5.20	7.90	51.92%
HAM	9.40	11.10	18.09%		9.80	11.70	19.39%
LEJ	**1.90**	**3.30**	**73.68%**		**1.90**	**3.40**	**78.95%**
MUC	24.00	27.80	15.83%		26.70	29.70	11.24%
NUE	3.20	3.40	6.25%		3.59	3.59	0.0%
SCN	0.41	0.41	0.0%		0.41	0.41	0.0%
STR	7.46	7.46	0.0%		8.70	8.70	0.0%
SXF	**1.70**	**3.90**	**129.41%**		**3.30**	**3.90**	**18.18%**
THF	**0.45**	**1.20**	**166.67%**		**0.44**	**1.20**	**172.73%**
TXL	11.06	11.06	0.0%		11.01	11.01	0.0%

3. Results-DEA



3. Results-SFA

- Cobb-Douglas Production Function

Stochastic Frontier Analysis			
Parameter	**Coefficient**	**SD**	**t-ratio**
β_0 constant	-0.103	0.036	-2.829
check-in counter	0.540	0.072	7.474
aircraft positions	0.928	0.087	10.640
δ_0 constant	-1.042	0.972	-1.072
Gates	-1.008	0.221	-4.554
airport size	-0.086	0.176	-0.488
runways	2.366	0.791	2.991
σ^2	0.216	0.035	6.177
γ	0.798	0.041	19.324

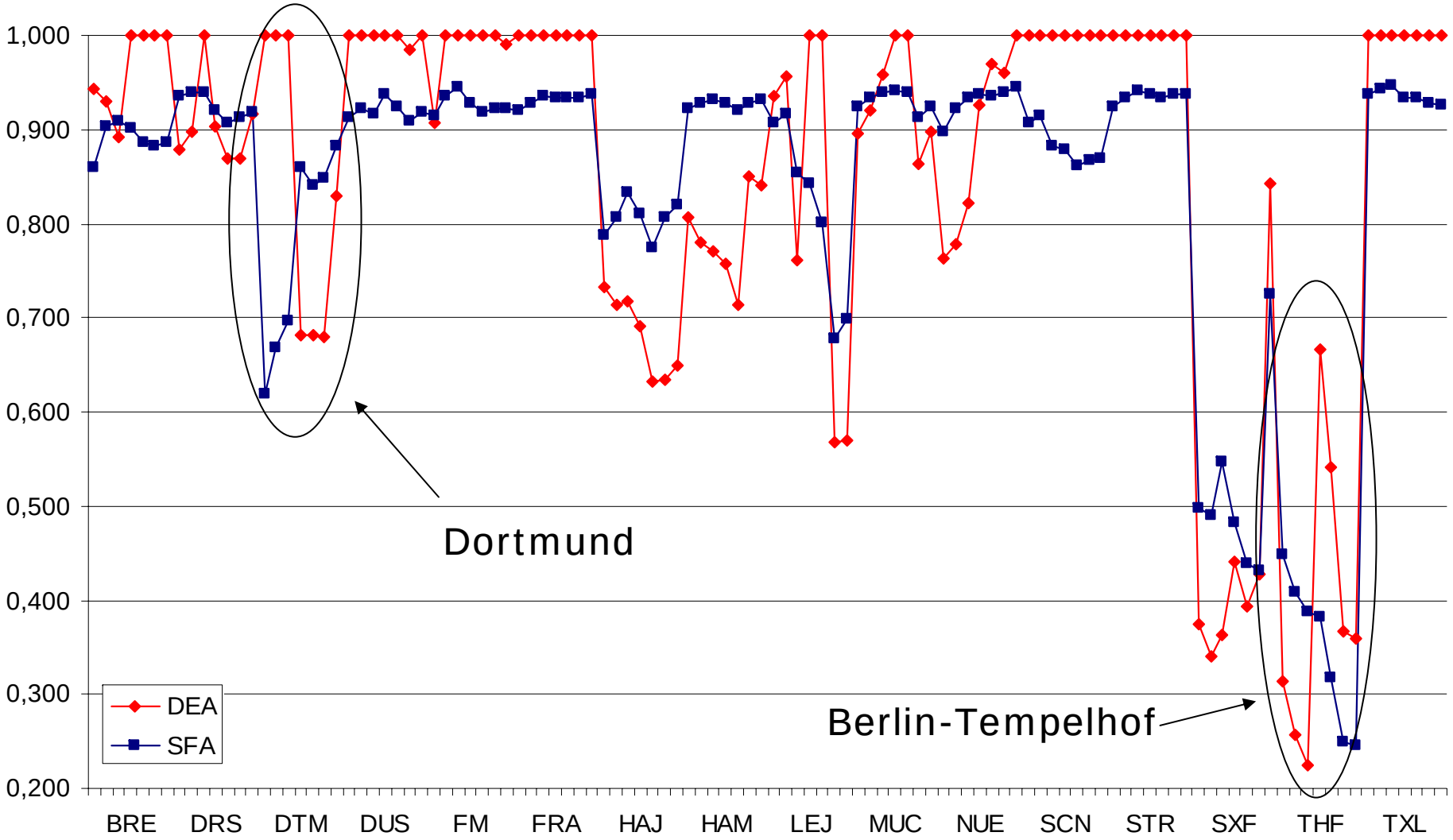
3. Results-SFA

		Stochastic Frontier Analysis							
		1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**Mean**
Bremen	BRE	0.859	0.903	0.908	0.901	0.886	0.882	0.886	0.889
Dresden	DRS	0.936	0.938	0.939	0.920	0.907	0.913	0.919	0.925
Dortmund	DTM	0.618	0.668	0.697	0.859	0.841	0.849	0.883	0.774
Düsseldorf	DUS	0.913	0.922	0.916	0.937	0.924	0.909	0.918	0.920
Münster-Osnabrück	FMO	0.915	0.936	0.945	0.928	0.918	0.923	0.922	0.927
Frankfurt	FRA	0.921	0.928	0.935	0.934	0.934	0.934	0.938	0.932
Hannover	HAJ	0.787	0.807	0.834	0.811	0.775	0.806	0.821	0.806
Hamburg	HAM	0.923	0.927	0.932	0.928	0.921	0.928	0.932	0.927
Leipzig	LEJ	0.908	0.916	0.854	0.843	0.801	0.677	0.698	0.814
Munich	MUC	0.924	0.933	0.940	0.941	0.940	0.913	0.925	0.931
Nuremberg	NUE	0.897	0.921	0.934	0.937	0.935	0.938	0.945	0.930
Saarbrücken	SCN	0.907	0.916	0.882	0.879	0.861	0.867	0.869	0.883
Stuttgart	STR	0.925	0.935	0.942	0.938	0.933	0.937	0.938	0.935
Berlin-Schönefeld	SXF	0.497	0.490	0.548	0.482	0.438	0.432	0.726	0.516
Berlin-Tempelhof	THF	0.448	0.408	0.388	0.382	0.317	0.249	0.245	0.348
Berlin-Tegel	TXL	0.937	0.942	0.947	0.933	0.933	0.927	0.927	0.935
mean	∅	**0.857**	**0.899**	**0.949**	**0.933**	**0.864**	**0.868**	**0.945**	**0.902**

3. Results-Differences

- DEA provides higher average results
  - DEA: 93.8%
  - SFA: 90.2%
- Highest differences between DEA and SFA
  - Dortmund
  - Berlin Tempelhof

3. Results-Differences



3. Results-Second Stage Regression

Second Stage Regression		
	Coefficients	*t-ratio*
constant	3.706	5.870
Density Index	0,000	-3,391
Nearby airports	-0,121	-1,122
Ownership	-0,221	-0,681
Regulation	0,095	0,252
Hub airport	0,565	1,733
Time 99	-0,111	-0,375
Time 00	-0,047	-0,158
Time 01	0,164	0,554
Time 02	0,158	0,533
Time 03	-0,097	-0,325
Time 04	0,046	0,155

3. Results-Second Stage Regression

- **Density Index**
  - Significant with slight effect
  - Density in inhabitants per square kilometre ranges from 1,079 to 4,149.
- **Time dummies**
  - Not significant
  - 1998 as base year

3. Results-Second Stage Regression

- **Ownership dummy**
  - Not significant
  - DUS 1996 (50%)
  - HAM 2000 (49%)
  - Fraport 2001 (22.1%)
- **Regulation dummy**
  - Not significant
  - HAM 2000: price-cap regulation
  - FRA 2001 fee-cap regulation
  - DUS 2005 fee-cap regulation

4. Conclusion and Future Research

- **Comparison of DEA and SFA**
  - similar rankings (FRA, STR, TXL vs. HAJ, SXF, THF)
  - lower scores for SFA-results (98.8% vs. 90.2%)
  - Differences:

Attribute	DEA	SFA
Parametric method	No	Yes
Accounts for noise	No	Yes
Need for specification of a functional form	No	Yes
Need of Distributional form for inefficiency term	No	Yes
Possibility of Hypothesis Testing	No	Yes
Sensitive to outliers	Yes	Less

4. Conclusion and Future Research

- **Second Stage Regression**
  - No significant influence for ownership and regulation dummy
- **The problem of airport heterogeneity**
  - Creates difficulties when comparing airports amongst each other
  - Examples:
    - Staff numbers
    - Airport size
    - Cost allocation

4. Conclusion and Future Research

- **Future Research**
  - Consideration of the heterogeneity through adjustments
  - Inclusion of financial data obtained from annual reports
  - Longer time period (from 1990)

The Others !

Us !

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