CAN WE LEARN FROM BENCHMARKING STUDIES OF AIRPORTS AND WHERE DO WE WANT TO GO FROM HERE?

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In the last 15 years privatisation and commercialization of an increasing number airports have contributed to a substantial number of benchmarking studies. So far, the majority of studies focus on a national level. International studies commonly conclude that German airports are financially inefficient in comparison to other airports in Europe and in particular to Non-European countries. In the following paper, the authors analyse what factors could have caused the poor performances of German airports based on benchmarking studies of ATRS and TRL. The high degree of vertical integration was identified as a potential reason for the low performance of German airports. The paper closes with an outlook of the authors' own research project, German Airport Performance (GAP) which will address changes of ownership structure, competition, and economic regulation on the performance of German airports.

Keywords: Benchmarking, Airports, Vertical Integration

1. INTRODUCTION

What is the motivation and importance for doing airport benchmarking and who is interested in the results of such studies? Generally speaking, airport benchmarking aims to provide objective data of capacity utilization or financial performance and compares the data. Consequently, it identifies best practice standards for facilities and services. Such studies are very useful for different groups of stakeholders and users of airports. For instance, there are airlines that are concerned with the relative performance of the airports they use. As well, there are the economic communities related to the airport, and also local regulators, who would like to know more about the performance of the local infrastructure.

Another motivating factor for airport benchmarking is the need for better public policy analysis in the ongoing process of commercialisation and privatization activities of airports. The question '*do privatized airports operate more efficiently than publicly owned airports?*' is often raised in this context. With competition intensifying in the European airline market, it

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has become more important for airports to provide high quality services in the most efficient manner and over all dimensions of airport operations. Benchmarking allows the possibility of measuring airports or airport groups against the best practices in the industry. As a consequence, airport operators, airlines, government regulators and financial analysts show an increasing interest in this type of information.

Airport benchmarking is also attractive for planners. It helps them to identify the gaps in their projects by comparing them to world-class standards. It therefore leads to a better understanding of transport problems and observed differences in airport performance.

Airport benchmarking is challenging because of the so-called 'uniqueness' of airports, as the operation of every airport slightly differs from the other.

Perhaps for this simple reason, there have only been a limited number of studies that have measured the performance of German airports. Studies that do exist are based on a national or international level, whereas ATRS and ATRL who publish *Airport Benchmarking* and the *Airport Performance Indicators*, respectively, benchmark airports on an annual basis and focus on airports of different sizes and ownerships worldwide. Please see Tab. 5 (in App.) below for examples of various studies.

The methodology of the studies varies from the measurement of partial performance indicators to analyses with aggregated data using Total Factor Productivity (TFP) or Data Envelopment Analysis (DEA).

This paper assesses the financial performance and relative efficiency of German airports, based on a literature review of available benchmarking studies. In the first section, the relevant studies are discussed. According to these studies, German airports are financially inefficient compared to other airports in Europe and in particular to Non-European airports. In the second section, we attempt to analyze the reasons for the weak performance of German airports. The paper closes with an outlook of our own research project, GAP, and addresses how we aim to answer some of the questions related to airport benchmarking.

2. THE PERFORMANCE OF GERMAN AIRPORTS IN PUBLISHED BENCHMARKING STUDIES

First, we will compare the benchmarking reports of ATRS and TRL, as they have used similar performance indicators and have overlapping time frames. In addition, we include some aspects of the study by Doganis et al (1995) and Pels et al (2003). In the next section, the four studies will be briefly introduced, followed by a discussion of the results and a short summary.

2.1 Introduction to the Selected Studies

a) Doganis et al (1995): The Economic performance of European Airports

Doganis et al (1995) measured the economic performance of 25 European airports of different sizes and ownership structures for the financial year 1993. The study covers large hub airports like London Heathrow, which is Europe's largest airport with more than 48 million passengers in 1993. It also looks at small airports like Vigo in Spain, which has less than 376,000 passengers per year. The German airports that have been included in the study are Frankfurt with 32 million passengers and Düsseldorf with 13 million passengers.

As airports differ in terms of the services supplied, a straightforward comparison with raw data might produce misleading results. Some operate ground handling by themselves; other airports outsource this service to third parties and merely provide the core facilities at the airport and receive concession fees for the rest. Therefore, Doganis et al (1995) have defined core activities at the airport and adjusted the overall data accordingly[3]. Hence, the following services have been excluded from the cost and revenue figures as well as from the staff numbers:

- Air Traffic Control
- Security
- Ground Handling
- Commercial Activities, e.g. Duty-Free, Retail, Catering
- Car Park
- Terminal Cleaning
- Recharges from water and electricity
- Head Office Functions

To measure the airports' output, seven descriptive measures were used such as passenger volume, cargo, Work Load Unit (WLU)[4] and aircraft movements. Furthermore, 21 performance indicators were defined to calculate partial productivities. The overall profitability of the airport is also benchmarked, as well as for the revenues generated on the aeronautical and on the commercial side. Next, the factors that had a significant effect on the airport performance were identified via multiple regression analysis. This calculation can identify if the relationship between a dependant variable (e.g. unit costs or revenues) and some independent factors such as WLU (indicating the airport size) are statistically significant.

b) Air Transport Research Society: Airport Benchmarking Report

The ATRS-study is already in its fifth year. The purpose of the ATRS study is to benchmark airports worldwide and to categorize them into three different geographic regions. These regions consist of North America, Europe and the Asia-Pacific Region. The ATRS studies measure productivity and efficiency; unit cost and cost competitiveness; and financial performance, i.e. revenue generation and profitability. Productivity calculations of partial performances such as labour or capital productivity are carried out, as well as aggregating inputs and outputs to measure Total Factor Productivity (TFP).

Measurements of Factor Productivity (variable and total) include some factors that are beyond managerial control and also influence productivity and efficiency measurements. Some authors therefore differentiate between Gross and Residual Factor Productivity. ATRS for example, undertakes a regression analysis to differentiate between the two factor productivities. By adding this additional step to their process, certain external factors can be identified and removed from the data set. This allows for the residual productivity (again either variable or total) to be measured. External factors that are likely to have such an effect on the measurements are the shares of international traffic or the capacity constraint indicator.

[3] While the need to focus comparisons on core activities by removing all measurable effects of other activities seems logical, published information does not always allow this to be done. Even if it is possible on the revenue side, adjustments to costs, where joint or common costs are involved, are difficult to carry out. To the extent that airports differ in their commercial activities' there may also be differences in the scale of joint and common costs.

[4] A Work Load Unit (WLU) is defined as one passenger or 100kg cargo

In our paper, we review the ATRS studies that have been published in 2003 and 2005, which cover the financial years 2000/2001 and 2003 respectively. The 2003 publication includes 90 airports and 8 authorities[5]; the 2005 publication covers 116 airports and 15 airport authorities. In both studies Cologne-Bonn[6] (6.3; 5.7; 7.8), Düsseldorf (16.0; 15.4; 14.3), Frankfurt (49.4; 48.7; 48.4), Hamburg (9.9; 9.4; 9.5) and Munich (23.2; 23.6; 24.2) are the German airports included. In the 2005 publication, Berlin is included twice (i.e. Berlin-Tegel; 11.1, and the whole Berlin Group (including Tegel, Tempelhof and Schönefeld; 12.1) and Fraport (70.6) are also included.

The output variables used in both studies are

- Number of passengers
- Amount of cargo (in Tons)
- Number of air transport movements
- Revenues received from airport charges and non-aeronautical operations

As inputs, the study included:

- Number of employees
- Expenses in purchased goods and materials as well as purchased services
- Capital inputs
    - Number of runways
    - Total terminal size
    - Number of gates (ATRS 2005).

c) Transport Research Laboratory: Airport Performance Indicators

TRL has been publishing its reports annually since 1999. The data collection is based on financial and traffic data from annual reports. To be able to compare ‘like with like’, TRL and Doganis et al. (1995) use the same methodology to isolate core activities. They both adjust their data to reduce the airport operations to specifically defined core activities of an airport. These core activities are, as already mentioned, the provision and operation of the terminal as well as the provision of airside facilities and the space within the terminal. Thus, non-core activities like ground handling, car park operations, Air Traffic Control (ATC), catering services and hotel operations are extracted from the raw data.

The worldwide comparisons made by TRL cover airports of different sizes and ownerships. The sample ranges over the years from 33 to 47 airports and airport groups and all are covered in a single analysis. The German airports in these publications were Frankfurt, Munich and the Berlin Airport Group. We consider the reports for the years from 1997 to 2002 (published from 1999 to 2004).

As well as Doganis et al (1995), TRL uses different performance indicators to measure e.g. labour productivity, cost performance, revenue generation or the profitability of an airport.

[5] Airport Authorities have been analysed separately.
[6] The passenger volume in million of both periods is given in brackets.

The following outputs have been used to calculate these indicators:

- Total Passengers
- Cargo/Mail (in Tons)
- Total WLU
- Number of Air Transport Movements
- Aeronautical, Commercial and Other Revenue

The inputs in this study cover

- Number of Employees
- Operating and Personnel Expenditure
- Depreciation and Tax

Further variables and the net interests are from an annual balance sheet data.

In order to assess the overall performance of an airport, TRL uses the multi-attribute assessment approach, which is based on a weighted sum. In a further step, the airports that obtained similar scores and characteristics are formed into a joint group or block. If an airport significantly differs from any other airport it is called a singleton.

d) Pels et al (2003): Inefficiencies and Scale Economics of European Airport Operations

Pels et al (2001, 2003) measure the relative efficiency of 34 European airports in the period 1995 to 1997. They published two papers using the same airport sample but different data in 2001 and in 2003. In our paper, we mainly use the latest article and the PhD thesis of Eric Pels (2000). Their focus is different to the other studies, because there is more attention given to technical efficiency rather than financial performance.

The methodology used in their study, consists of Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA). Both studies include the German airports in Berlin-Schönefeld (1.9), Frankfurt (40.1), Hamburg (8.5), Hanover (4.7), Munich (17.6) and Nuremberg (2.4). These airports are compared to European airports of different sizes and ownerships. Pels et al (2003) have separated the airports into two operational areas, namely the airside and the terminal side.

For the terminal side, output is measured by the number of passengers. Inputs are the size of the terminal, the number of aircraft parking positions at the terminal and the available remote stands, the number of check-in-desks and the number of baggage belts. For the airside, output is indicated by the number of aircraft movements; inputs are the total airport area, the total length of runways, the number of parking positions at the terminal and at remote parking positions.

2.2 Results of the Studies

In the following section, we will compare some of the results from the benchmarking studies with respect to labour productivity, the cost performance and some aggregated scores. These results were primarily obtained from the ATRS and TRL studies[7]. Furthermore, we will briefly compare the financial performance of the airports with some of the results obtained

[7] Note that the data from TRL and Doganis et al (1995) have been converted from Standard Drawing Rate (SDR) and ECU respectively to US$ based on conversion rates from the mid-year of the corresponding financial year.

from the study on technical efficiency of Pels et al (2003). Our focus is on comparing the German airports covered in these studies with respect to the European average and the Best Practice airports in the sample. This is to show:

1) how the German airports perform in an international comparison and
2) that this type of comparison can be misleading due to different airport structures and operation.

2.2.1 Labour Productivity

a) The Performance of the German Airports

The ratio of 'passengers per employee' is a common measure for labour productivity.[8] But the measure has to be treated with caution, as the Irish Commission for Aviation Regulation writes when trying to assess the performance of Dublin airport:

"*The interpretation of partial measure of productivity – such as passenger per employee – is made more difficult by two considerations. First, the measures are partial, and therefore may not capture the way in which a company chooses to substitute one input for another. Second, airports with different managerial arrangements, in particular with regard to outsourcing versus direct service provision, may give different performance measures.*" (Commission for Aviation Regulation 2005, p.14)

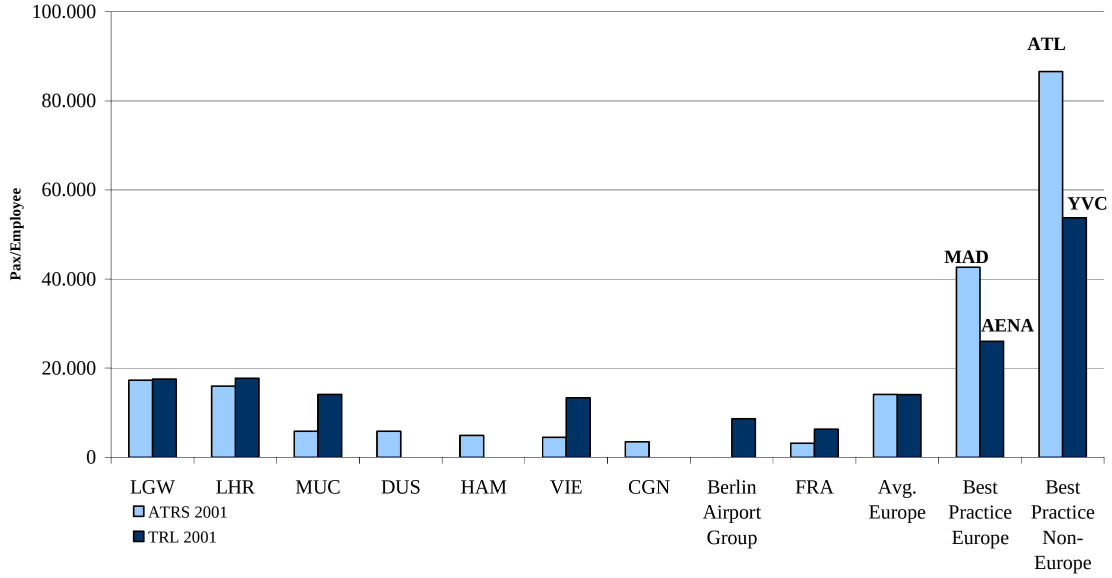

Fig. 1: Labour Productivity (Differences between ATRS and TRL Data)

As indicated in Fig.1[9], nearly all German airports performed below average in the ATRS and TRL studies, some with a difference of around 40% to the European mean. TRL as well as ATRS calculated a European average of around 15,000 passengers per employee for individual airports. In the ATRS data from 2000/2001[10], the German airports were ranked the last seven out of 23 European airports, with a labour productivity of less than 6,000

[8] Note that the results of TRL are based on adjusted data. Therefore the labour productivity of adjusted airports will be higher than ATRS' results.
[9] The European average represents the mean of individual airports.
[10] In the following, the years always refer to the financial years rather than the year when the report has been published. For further information on the results of ATRS and TRL please refer to the corresponding studies.

passengers per employee. Frankfurt had a productivity ratio of less than 4,000 passengers per employee throughout the whole period and was ranked last in Europe.

The higher labour productivity for Frankfurt and Fraport[11] in the TRL-study (with a ratio between 5,000 and 8,000 passengers per employee) is due to a data adjustment, namely the removal of the labour intensive ground handling operations, which is considered a non-core activity. Nevertheless, all airports in Germany achieved low rankings in the TRL studies, just as we saw from ATRS. German airports were among the last ten in all rankings.

On the other hand, in the TRL study Munich is a surprise with a large increase in labour productivity between 1999 and 2000. Labour productivity rises from 7,000 to 18,000 passengers per employee. This seems to be an unrealistic increase and will be looked at further in section c) of this chapter.

Obviously the weak performance of German airports in the results of ATRS might be caused by the low degree of outsourcing. All airports in the sample operate ground handling and other in-house operations, like the operation of the car park, by themselves. This leads to higher staff numbers per passenger volume in comparison to other airports that have outsourced these operations.

Berlin-Tegel is the only German airport with above average labour productivity. ATRS calculated a ratio of 17,700 passengers per employee in 2003 (compared to a European average of 14,300 in the same year). Data related to revenues, expenditures and employment figures for ground handling are not included in Berlin-Tegel's financial statement, because these services are outsourced to another company (Globe Ground Berlin GmbH). Hence, when comparing the labour productivity of ATRS and TRL regarding the Berlin Airport Group, both indicate the same productivity ratios of approximately 8,000 passengers per employee in 2002/03. However, the removal of ground handling figures cannot fully explain such a low ranking, as even with TRL's adjusted data, the German airports still perform badly.

A comparison with the Vienna airport is interesting, as it also operates ground handling on its own. But TRL reports a higher labour productivity for the Vienna airport (with on average 13,500 passengers per employee) compared to the German airports. The effect of having adjusted the data for ground handling seems to be greater for Vienna than for the German airports. The labour productivity calculated by ATRS (which does not adjust down to core activities) for Vienna substantially deviates from TRL´s data, with a score of less than 5,000 passengers per employee in both periods. This figure is as low as the one we found for German airports in ATRS.

b) German Airports in an International Comparison

In comparison to Non-European airports, both ATRS and TRL show substantial differences in relation to the German airports (see Fig.1).

The best airport over the whole period in the ATRS study is Atlanta with almost 100,000 passengers per employee in 2003[12]. This airport handles more than 75 million passengers per year and employs less than 500 people for the core activities at the airport, indicating a high degree of outsourcing. Indeed, the terminals in North America are usually not operated and maintained by the airport, but rather by the airlines or a management company.

[11] TRL has officially switched from Frankfurt to Fraport in the 2004 publication.
[12] Data for Melbourne was not available in this study.

In the TRL study, Calgary with more than 60,000 passengers per employee between 1997 and 2001 and Melbourne with nearly 120,000 in 2002 are identified as the most labour productive airports worldwide. Even in this TRL study, which has already removed the staff data from non-core activities, only Non-European airports and especially airports in Australia and North America yielded high labour productivity levels. This seems to indicate that European airports and especially the airports in Germany are more labour intensive in the operation of their core airport activities.

The fully privatized airports in London also do not achieve substantially higher productivity ratios than the European average; both yielded around 17,000 passengers per employee in 2001 and 2002. In the TRL report, the best European airport from 1997 to 2000 was Stockholm, followed by AENA from 2001 to 2002. The same results were obtained in the ATRS studies; here Madrid and Barcelona had the highest labour productivity and Stockholm was also ranked high in this area.

c) Productivity Changes at German Airports

Some of the trends that were measured can be misleading. The airports in Munich, Frankfurt and Hamburg show big increases in labour productivity that cannot purely arise from passenger increases or decreasing staff numbers[13].

As already mentioned above, TRL, (see Tab 1), for example, shows a high increase from 7000 to more than 18,000 passengers per employee, in Munich between 1999 and 2000. One reason for this large increase in productivity could be that TRL has adjusted the data related to ground handling from 2000 onwards. The increase observed might therefore be due to measurement errors rather than a productivity increase.

Labour Productivity	*Passengers per Employee*					
	1997	**1998**	**1999**	**2000**	**2001**	**2002**
FRA	7.697	7.190	7.697	8.050	**6.276**	**5.020**
MUC	8.377	6.473	**6.941**	**18.032**	14.126	12.609
Berlin Airport Group	6.135	6.780	8.632	9.199	8.653	8.372
VIE	10.631	14.036	14.959	14.632	13.363	13.753
AMS	17.345	18.304	21.498	23.531	20.898	21.087
LHR	13.252	15.676	16.949	19.066	17.702	17.019
LGW	12.865	15.161	16.221	18.092	17.543	16.207
Average Europe	13.196	13.585	13.568	15.575	14.092	14.995
Average Total	19.965	23.318	22.670	25.063	22.283	27.034
Best Practice Europe	24.594	23.102	25.642	26.241	26.037	25.664
	ARN	ARN	ARN	ARN	AENA	AENA
Best Practice Non-Europe	66.372	65.044	55.717	61.759	53.755	118.874
	YVC	YVC	YVC	YVC	YVC	MEL

Tab. 1: Labour Productivity (TRL)

Similar measurement effects can be observed when one looks at the results for Frankfurt. The slight decrease in labour productivity from financial year 2001 to 2002 is probably due to the full consolidation of ICTS in 2002, a Dutch security service provider[14]. On the other hand, until 2001, the traffic data for Frankfurt airport was consolidated with the financial data for the whole Fraport group. This led to an '*increase*' in 20 million passengers from 2001 to 2002, which was not due to a real passenger increase. In fact, passenger volume for Frankfurt slightly decreased by 0.2% from 48.6 to 48.5 million passengers during this time frame.

[13] The passenger decreases due to 9/11 or SARS do not show substantial effects on the passenger volume. This aspect is not considered as a reason for the changes in productivity.

[14] In total the staff numbers for Fraport have increased by 38% from 15,500 to 21,400 between 2001 and 2002.

In Hamburg, ATRS (see Tab. 2) indicated an increase from 5,000 to more than 12,000 passengers per employee from 2001 to 2003. What could be the reason? Since October 2002 the airport has outsourced the IT-Department Airsys, thereby reducing the number of employees by 48. This increase in productivity cannot be due to such a small decrease in staff numbers and only a slight increase of 0.42% in passengers.

Again, a measurement error may have caused the observed productivity increase. This possible measurement error is likely due to the fact that the whole group was used as the basis for the analysis in 2000 and 2001, whereas subsidiaries and their staff numbers were excluded from the data in 2003 and onwards. If one correctly accounts for these changes, then the productivity increase between 2001 and 2003 is only 4.5% (instead of 150%) and 1.3% from 2000 to 2001.

Corrected productivity ratios based on the 2003 annual report are: 11,715 (2000), 11,731 (2001), 12,265 (2003). This would leave Hamburg with a higher labour productivity than other German airports when measuring with raw data. Overall, this result seems clear, because in 1999, the handling of ground services was outsourced to “Groundstars”, a 100% subsidiary of the Flughafen Hamburg GmbH.

Labour Productivity	*Passengers per Employee*		
	2000	**2001**	**2003**
CGN	3.837	**3.479**	**4.147**
DUS	5.850	5.837	5.963
FRA	3.459	3.128	3.718
HAM	5.329	**4.909**	**12.265**
MUC	5.714	5.846	4.951
TXL	n/a	n/a	17.710
VIE	4.879	4.514	4.381
Berlin Airport Group	n/a	n/a	7.487
Fraport	n/a	n/a	3.021
AMS	20.270	19.387	17.911
LHR	17.002	15.985	16.065
LGW	17.814	17.323	15.029
Avg. Europe	14.428	14.119	14.382
Avg. North America	43.803	40.875	40.025
Best Practice Europe	41.271	42.640	44.993
	MAD	MAD	BCN
Best Practice Non-Europe	91.510	86.586	99.983
	ATL	ATL	ATL

Tab. 2: Labour Productivity (ATRS)

Only for the Cologne-Bonn airport were there substantial increases in labour productivity, which can be explained by an increase in passengers. In the study by ATRS, the number of passengers rose from 5.7 million to 7.8 million from 2001 to 2003. The cause of this large increase is due to the development of the low cost segment. Here mostly Hapag-Lloyd Express and germanwings are responsible for the increase as they are the main low cost carriers at the airport.

d) Ranking Differences between ATRS and TRL

When looking at the differences in the airport ranking between ATRS and TRL in Tab.3, Munich and Vienna show large differences in the European sample[15] [16]. Again, we notice the substantially higher productivity of Munich measured by TRL of 18,000 passengers per employee compared to 5,000 in the ATRS study in financial year 2000. This indicates that removing ground handling from the data can substantially improve the productivity when comparing to other European airports. It should also be noted, that the ATRS calculation uses 4000 employees, whereas TRL uses only 1300 core employees. In the European ranking, Munich was in 7th place (out of 12 European airports that were investigated in both studies) in the TRL table and in 10th place in the ATRS results. Munich therefore achieved a higher productivity level than Manchester, Copenhagen and Geneva in the TRL study[17].

		ATRS 2000	TRL 2000		
1	ARN	26.352	26.241	ARN	**1**
2	OSL	22.955	23.531	AMS	**2**
3	ZRH	22.249	22.627	ZRH	**3**
4	AMS	20.270	22.447	OSL	**4**
5	LGW	17.814	19.066	LHR	**5**
6	LHR	17.002	18.092	LGW	**6**
7	GVA	16.008	**18.032**	**MUC**	**7**
8	CPH	12.617	17.979	GVA	**8**
9	MAN	7.067	**14.632**	**VIE**	**9**
10	**MUC**	**5.714**	13.174	CPH	**10**
11	**VIE**	**4.879**	10.692	MAN	**11**
12	**FRA**	**3.459**	**8.050**	**FRA**	**12**

Tab. 3: Labour Productivity in Passenger per Employee (Ranking Differences)

In Vienna, the labour productivity changed from less than 5,000 in ATRS to nearly 15,000 in TRL. As with Munich, the reason for the difference in calculations was due to the removal of ground handling activities from their data, which made the airport better in relation to the other European airports. Indeed, the staff number in Vienna is 2,400 in ATRS and 816 in TRL for the financial year 2000. In the European ranking, Vienna was in 9th place in the TRL table and in 11th place in the ATRS results. Hence, Vienna achieved a higher productivity level in the TRL study, than Manchester and Copenhagen.

For Frankfurt as well, we observe a difference in labour productivity of 4,500 passengers per employee for the two studies, with 3,500 passengers in ATRS and 8,000 passengers in the TRL data for the financial year 2000; it resulted in low labour productivity in both studies. No relative improvement to other airports was observed, which supports the view of low labour productivity at Frankfurt Airport.

Different to Germany, the airports in North America and Asia-Pacific do not show significant changes in the order of their ranking in ATRS and TRL. This also indicates that airports in Germany are more heterogeneous in terms of the services provided. The list of the adjusted airports in the TRL study supports this hypothesis, as in their publications only European

[15] Passenger movements are not, of course, the only output of an airport. Output may be measured more broadly by an aggregate of passenger, plus Air Transport Movements (ATMs), plus non-aero output (that is appropriately aggregated) and then compared to the labour input in order to give an overall labour productivity measure. We will return to this issue below.

[16] Only airports that have been included in ATRS and TRL studies have been considered.

[17] The differences in the productivity ratio of ATRS and TRL in Copenhagen, Geneva and Manchester are not as high as in Munich and Vienna.

airports[18] are taking care of their own ground handling services. Of all non-core activities, this service is the most labour intensive. Therefore, the effects of data adjustments will have a greater effect on changes in the ranking between European airports compared to North America or the Asia-Pacific Region.

2.2.2 Cost Performance

Using only labour productivity as measurement is not a good method for determining an airport's performance. This is particularly true for Germany, where the airports tend to produce more in-house operations, which result in higher staff numbers in comparison to the passenger volume. In a case like Germany's, it is also important to look at the more general indicators, like cost performance and to aggregate the measures to be able to estimate Variable and Total Factor Productivity. Cost performance is investigated under several aspects in the literature. In the next section we primarily looked at the ratio of labour costs and non-capital costs per passenger, as both ratios were used in the ATRS and TRL benchmarks.

a) Labour Costs and Labour Cost Shares

When looking at labour costs per passenger in Fig. 2, the ATRS and TRL results indicate a negative correlation with labour productivity. Frankfurt has extremely high labour costs per passenger of $10.00 to $15.00, as measured by ATRS. This is around twice the average in Europe (with $4.00 to $6.00 per passenger between 2000 and 2003). Again, the lower amount in the TRL study of around $7.00 per passenger in Frankfurt is especially due to the removal of ground handling.

Similar to the findings on labour productivity, the data adjustment related to ground handling in Munich in 2000, is the cause for the substantial decrease in staff costs per passenger from $7.30 to $2.80 in the TRL study. This decrease in staff costs are likely not due to an increase in passengers.

When ranking the German airports, the ATRS study indicates that Frankfurt has higher staff costs per passenger than any other German airport. Hamburg performs the best with staff expenses per passenger, which are three times lower than at Frankfurt. TRL does not show these large differences: although Frankfurt has higher staff costs than Munich and the Berlin Airport Group, the magnitude of these costs is not as high in the ATRS publication. This seems to indicate that airports have high staff costs when ground handling is included, since the high labour costs in that segment of the value added chain receives more weight in the calculation of the labour costs per passenger.

[18] The airports in the sample that operate their own ground handling services are in Paris and Rome, Budapest, Frankfurt, Manchester, Munich, the Swedish airports and Vienna (based on the sample in the 2002 edition).

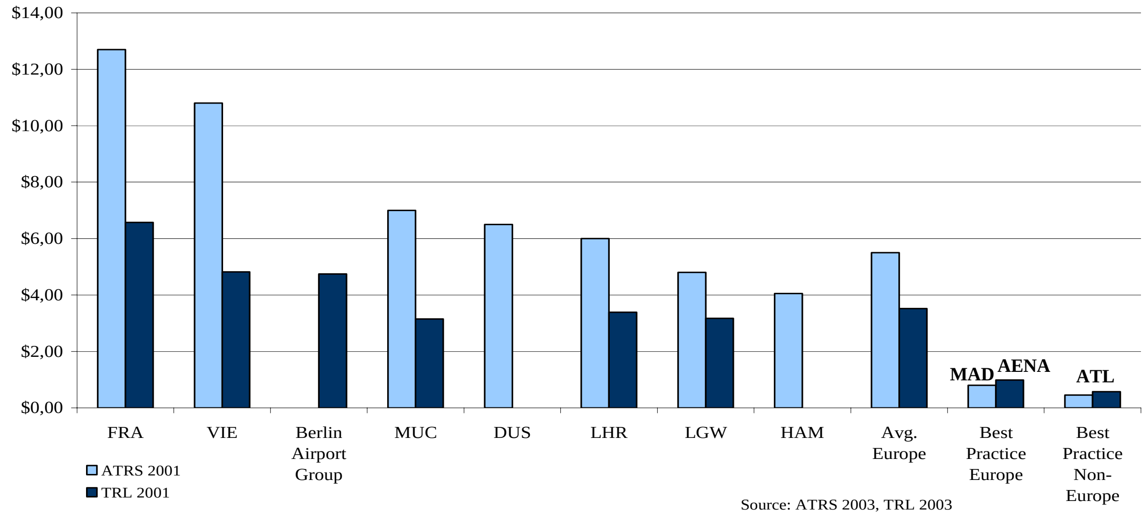

Fig. 2: Labour Costs per Passenger

The average labour costs in North America, as measured by ATRS, are much lower than in Europe, with $1.50 to $2.00 per passenger. In the TRL study, North American (Atlanta) and Australian (Brisbane and Melbourne) airports lead the ranking with expenses per passenger of less than $1.00, which is in line with the results derived from the analysis of labour productivity above.

However, the high staff costs per passenger do not necessarily arise due to the low passenger-to-employee ratio, but rather because of higher wages. When multiplying the labour productivity with the staff costs per passenger, it is shown in Fig. 3 that Heathrow and Gatwick have higher staff costs than any German airport. Also, the previous results indicate that Gatwick and Heathrow have an average European labour productivity. This is inherently not surprising as London is one of the world's most expensive cities to live. Furthermore, large airport groups usually pay higher salaries than small individual airports. Whereas the average annual wages at German airports are in the range of around $35,000 to $50,000 (with the exception of $60,000 in Hamburg in 2003), the airports in London had annual staff costs of more than $64,000 in 2003. Vienna also has higher wage levels than airports in Germany. In 2003 their average staff costs of $56,000 were around $10,000 higher than those of Fraport.

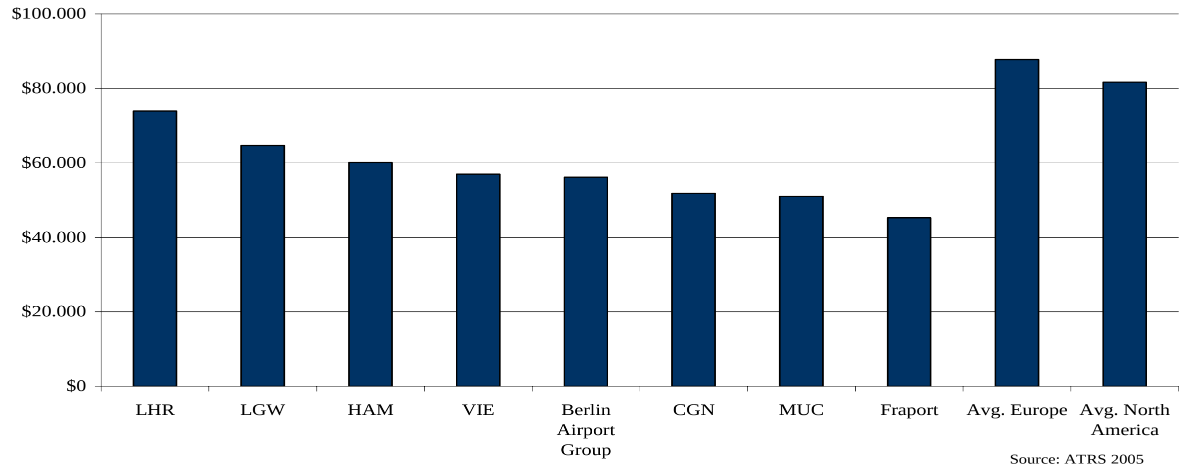

Fig. 3: Staff Cost Level ATRS (2003)

The differences in the European ranking of ATRS and TRL (as done in section c) of 2.2.1) for labour productivity costs per passenger indicate the same improvement in the ranking for

Munich, because the airport moved from 3rd place in ATRS's study (indicating the 3rd highest staff costs per passenger) to seventh place (out of 13 airports). Furthermore, London-Heathrow improved its position from rank seven to nine. Indeed, the staff expenditures for Heathrow in the ATRS study are $6.00 per passenger and $3.40 by TRL's estimation. Data adjustments that were made for the BAA airports included the World Duty Free operation and the Head Office staff. Vienna and Frankfurt show high differences in staff costs, but as these costs are substantially higher than anywhere else, these 2 airports still remain on top of the rankings in terms of labour cost shares in both studies.

A close look at labour cost share also indicates that staff costs in Germany are an essential part of expenditures. TRL and ATRS used the same measure to determine the labour cost share by calculating the labour costs as a share of non-capital expenses. Having adjusted the data for ground handling and the other non-core services, TRL ranks Frankfurt with the highest share of labour costs in Europe with more than 70% (exception in financial year 2000). The highest labour cost shares at Non-European airports[19] are only around 50% to 60% (see Fig. 4).

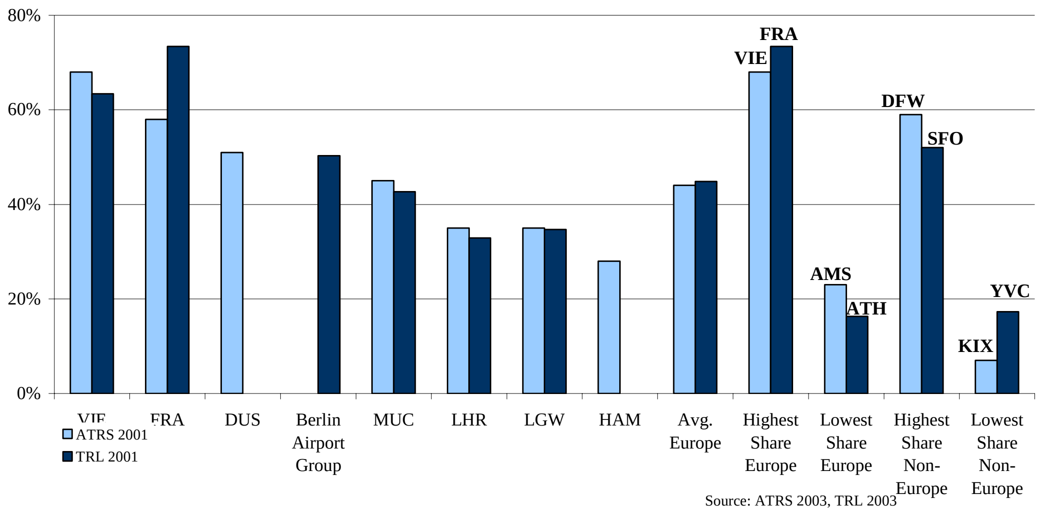

Fig. 4: Labour Cost Share (of Variable Costs)

In the ATRS study, Frankfurt again has the highest labour cost shares of 58% and 65% in 2001 and 2003[20], compared to the European average of less than 50%. The Berlin Airport Group and Munich have average shares of 40% and 36%, respectively, in 2003; with labour cost shares of 60% and 80% lower than Fraport. Also, Düsseldorf and Cologne-Bonn are around the European average in the ATRS study of 2003. The value for Hamburg seems quite low in relation to the other German airports, with less than 30% in both periods.

The highest labour cost shares in Europe are reported for Frankfurt (and Fraport in 2003 data), together with Vienna and Copenhagen. As with Frankfurt, Vienna also has a high cost share due to the large share in ground handling. But this does not hold for Copenhagen, since it has already outsourced ground handling. Instead, this result seems to be more related to high staff cost levels. Furthermore, high labour cost shares can also be seen for airport groups with small airports like in Sweden and Hawaii. TRL argued that this is due to diseconomies of scale (TRL 2003).

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[19] These non-European airports include: the Hawaiian airports in 1997/98 and 2000, Capetown in 1999, San Francisco in 2001 and Ontario in 2002.

[20] The 2003 figures are for Fraport.

The study of Doganis et al (1995) shows cost shares of the airport before data adjustment, with the expenses separated into staff costs, services/equipment and supplies, maintenance, other operating expenses and capital charges (see Fig. 5). The data in this table supports some previously mentioned rankings. Frankfurt and Vienna both show high labour cost shares of 45% and 48%, respectively. Düsseldorf's cost share of 39% also comes close to the average structure of 37%. In comparison, the airports at Heathrow and Gatwick spend merely 30% of total costs on salaries and pensions; even so, we saw earlier that their average annual salaries are among the highest in Europe

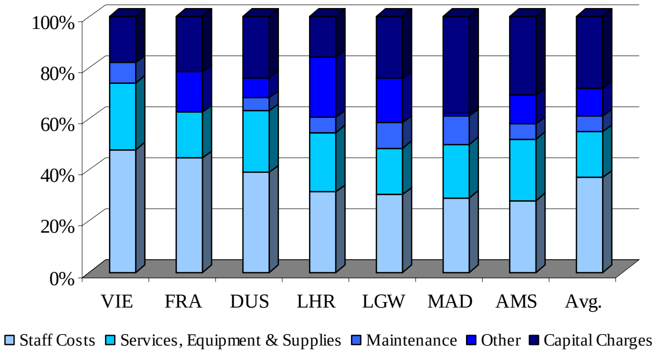

Fig. 5: Cost Structure (Doganis et al 1995)

Overall, the results are reciprocal to the earlier observations on labour productivity. They point to a relationship between a high ranking in labour productivity and a low labour cost share. Where this is not the case and high labour cost shares correlate with a relatively high labour productivity ratio, the wage levels might be high at these airports. Besides Heathrow and Gatwick, this is also the case for Copenhagen and Geneva, according to the latest publications of ATRS and TRL.

b) Non-Capital Expenditures

Another indication of the high costs at German airports is the measurement of variable costs per passenger as measured by ATRS and operating costs per passenger calculated by TRL.

When looking at variable costs per passenger in Fig. 6, the cost for Frankfurt is more than $20.00 per passenger, which is higher than the European average (between $9.00 and $14.00) during the period of examination. This is basically due to the high staff costs that were identified before. The other airports in Germany are also above the average European costs.

In general, ATRS has ranked the German airports among the most costly. In 2003, Cologne and Munich reported even higher variable expenses per passenger than Fraport of $29.00 and $23.00 per passenger, respectively, with Cologne being the most expensive in the sample. These high costs indicate higher operating costs because staff costs per passenger are higher in Frankfurt. Furthermore, ATRS shows a high increase of variable costs per passenger from 2001 to 2003 in Hamburg and Munich, but these costs could also arise from a decline in passengers during that time.

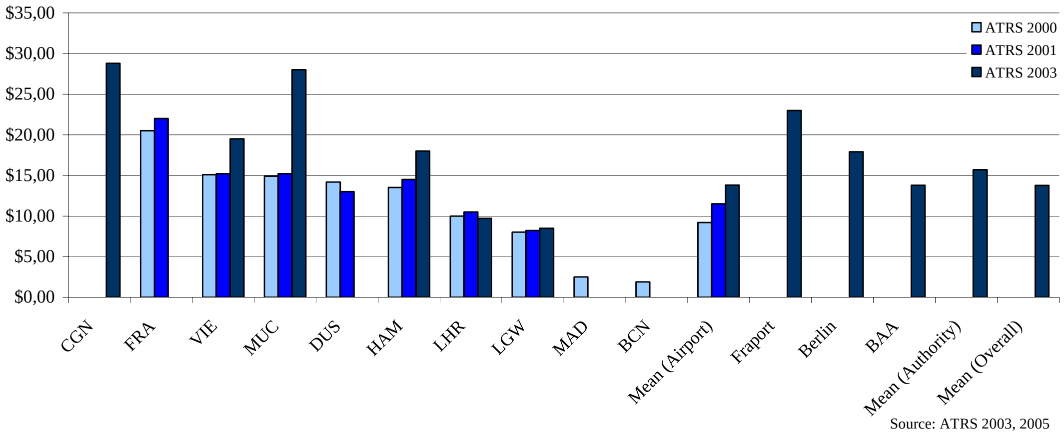

Fig. 6: Variable Costs per Passenger (Europe)

In the Asia-Pacific Region too, the Japanese airports seem to have extremely high variable costs of more than $20.00 per passenger. Hong Kong, with variable costs per passenger (that is staff costs plus operating costs) of less than $13.00 is ranked in third place. This is not surprising, as the Japanese airports are well-known for having high expenditures[21].

When looking at operating costs per passenger[22] as reported by TRL, it is worth mentioning that Frankfurt reported average operating costs per passenger of between $2.00 and $3.00, due to the adjustment in data for non-core activities (see Fig. 7). This is now below the European average of $4.00 to $5.00 per passenger. These figures seem to be much lower than what was measured in Munich and Berlin. Both airports reported above average costs, Berlin had operating costs per passenger between $5.00 and $6.00 and Munich between $5.00 and $8.50. The wide range in the Munich results is due to the reduction of expenses related to ground handling in the 2000 data. Also, in comparison to Heathrow and Gatwick, Frankfurt had lower operating expenses; the airports in London were above average with about $6.00. The reason for Frankfurt's lower operating costs could be because staff costs are not included in operating expenses.

Does that mean that staff costs have an especially negative impact on the financial performance in Frankfurt? Further, we find operating costs per passenger still lower outside Europe. The best airports over the period with less than $1.00 per passenger were Capetown, Melbourne and Atlanta.

[21] The same result can be observed in the TRL study, where the airports in Osaka Kansai and Tokyo Narita have been included from the 2002 edition onwards. In the three studies published since then, both airports listed operating costs per passenger of nearly $20.00 per passenger, more than 100% higher than for the next Non-Japanese airport. When comparing these expenses to the German airports it appears, that the operating costs are particularly high in Japan. Whereas the variable costs per passenger amount to $25.56 in Osaka and $29.00 in Cologne-Bonn, only $2.30 are staff costs per passenger in Osaka, but account for more than $12.00 in Cologne.

[22] Note, that expenses related to staff costs are not included.

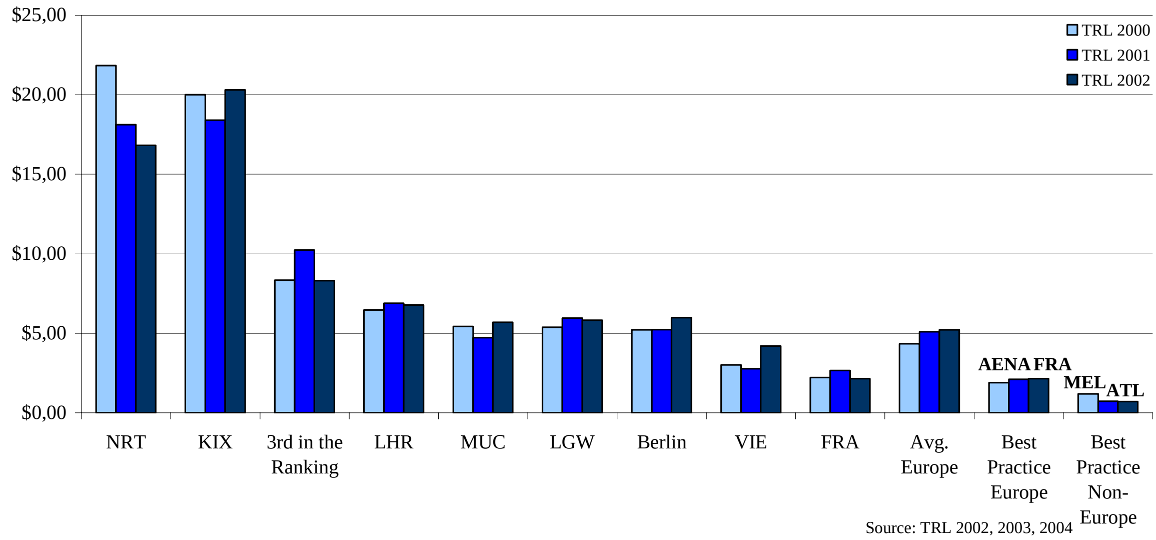

Fig. 7: Operating Costs per Passenger

2.2.3 Gross versus Residual Factor Productivity – An aggregated approach

Besides the partial productivity measures, we also briefly examined the aggregate results obtained from the ATRS study. The question is '*how have the German airports performed on an aggregated level and how do factors which are beyond managerial control influence their performance?*'. To help provide an answer for this question, the two ATRS editions considered here, have formed an output and an input index. The output index contains the number of air transport movements, the number of passengers, the amount of cargo (in tonnes) and a quantity index for non-aviation related revenue. The input index is made up of labour and soft cost[23] data (weighted by the variable cost shares) as short and medium term variables, and can be used for the determination of the Variable Factor Productivity (VFP)[24].

By assumption, capital input is held constant. In other words, the VFP statistic measures the efficiency with which the airport utilises its variable inputs for a given level of capital infrastructure. The VFP estimate is reported gross, or unadjusted, as well as net, after excluding the estimated contribution to productivity of factors outside the airport's control.

They are then able to calculate Total Factor Productivity (TFP) as long term performances, by additionally including further capital variables, namely the number of runways, the terminal size and the number of air bridges in the input index[25]. For both productivity measures (i.e. VFP and TFP), a multilateral translog index has been used, which combines the cost shares of the input variables as weights for the aggregation (ATRS 2005).

Note, that the scores for European airports have been normalized at Vancouver Airport = 1.0 of financial year 2000 for 2000/01 data and at Copenhagen = 1.0 for 2003 data.

[23] Non-capital and non-personnel data are considered as soft cost input.
[24] This productivity measure has been calculated in both editions.
[25] The calculation of the Total Factor Productivity has only been done in the 2003 edition.

a) Variable and Total Factor Productivity

Looking at the results for the 2000/01 data in Fig.8, all German airports recorded a low VFP, with Düsseldorf and Hamburg having the lowest VFP level of 0.15.

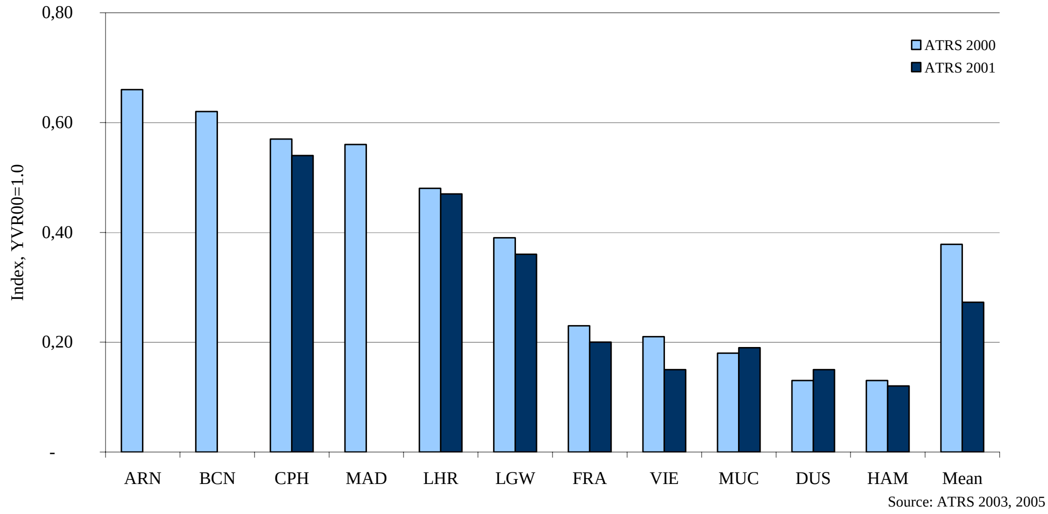

Fig. 8: Variable Factor Productivity (Europe) I

The German airports as well as Vienna airport performed far below average (0.38 in 2000 and 0.3 in 2001), which is not a surprise when comparing this with the results derived from the partial productivity measures above. The best European airports in this sample are again, a Scandinavian and Spanish airport, a result, which is in line with the previous analysis.

Comparing the results of the European airports with North America, we again find higher VFP values. As expected, Atlanta is by far the 'most productive' airport in this sample due to high labour productivity and low expenses. It obtained a productivity score of more than 2.0 (also normalized at YVR = 1.0) in both years.

When looking at 2003 data in Fig. 9, the ranking in the chart does not significantly change (Stockholm, Barcelona, Madrid and Frankfurt as individual airports are not included in this publication). For both, individual airports and airports groups or authorities, we find Germany has low rankings: Berlin, Fraport, Cologne and Munich are far below the European average of 0.62 for individual airports and 0.54 for airport groups and authorities. Only Vienna and Hamburg did slightly better, reporting a score of nearly below average. For Hamburg this might be due to the measurement error in 2003 that we mentioned already above. For Vienna, this good performance with respect to VFP is quite surprising as the airport had been identified above with low labour productivity and high costs, analogue to Frankfurt's position in 2000/01.

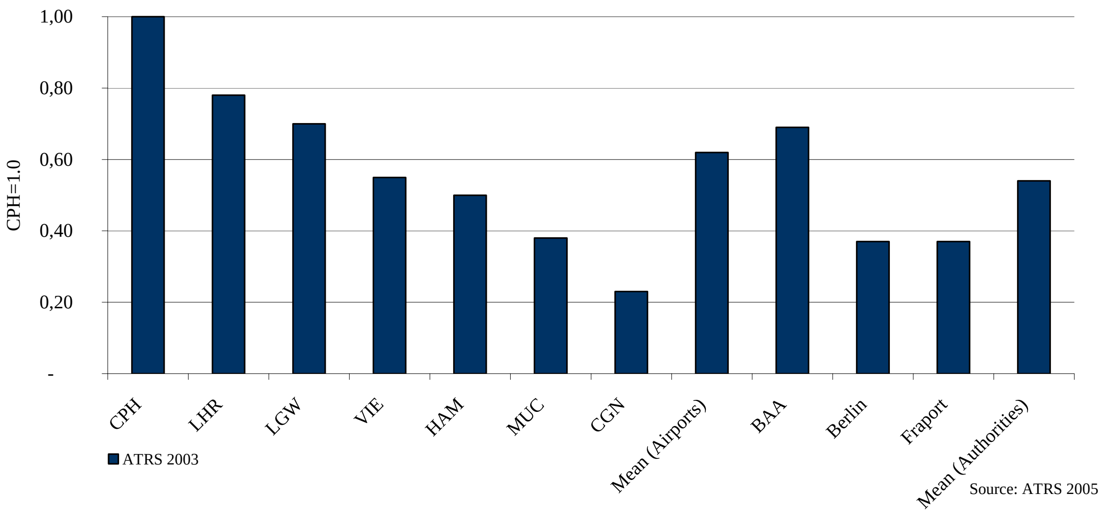

Fig. 9: Variable Factor Productivity (Europe) II

When looking at the TFP for 2000 and 2001 in Fig. 10, the values estimated for German airports exhibit similar rankings as we have seen for VFP. Again, all German airports are ranked below average (0.85 in 2000 and 0.77 in 2001); Düsseldorf with a TFP of less than 0.3 in last place. The airport in Vienna could improve its ranking relative to the one achieved in the VFP analysis. This might indicate a better productivity regarding the long-term view, i.e. once capital expenditures are included in the analysis. This is also true for the airports Heathrow and Gatwick. The best European airports achieved TFP values of 1.0, which is nearly on the level of the most productive airports in North America.

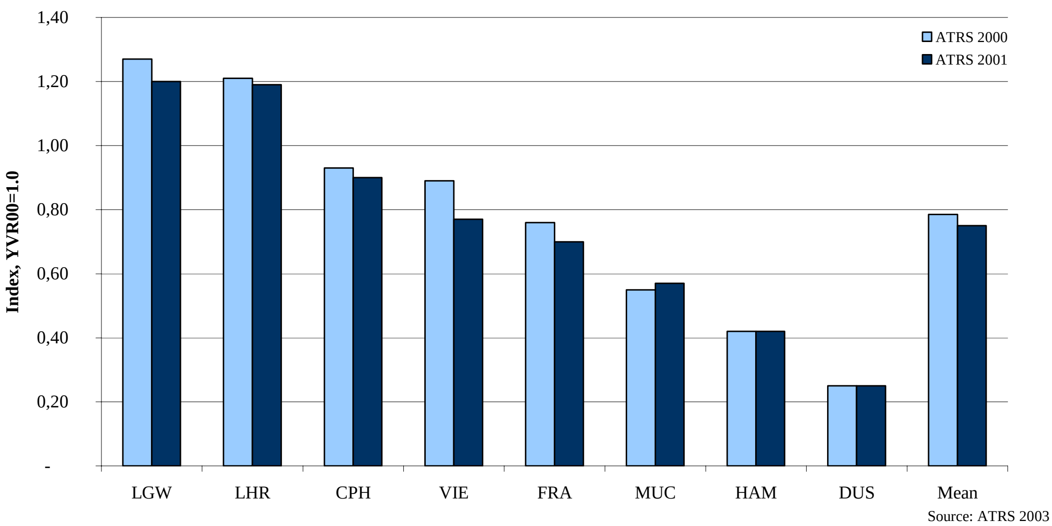

Fig. 10: Total Factor Productivity (Europe)

b) Residual Variable and Total Factor Productivity

To estimate gross VFP and TFP is only part of the exercise. The next step is to see how the differences in productivity can be explained by a regression analysis for both VFP and TFP. The results indicate, that airport size, the share of cargo and non-aviation activities, the type of terminal operator (public, mixed, or private) and an indicator of capacity constraints are statistically significant explanatory variables, thus indicating that these factors lead to higher productivity levels. For the VFP analysis, the share of international traffic was found to be statistically significant with a negative coefficient, but looking at the results for the TFP analysis, the coefficient was not significant. The same lack of significance for both measures was found with respect to average aircraft size and overall passenger satisfaction (ATRS 2003).

The airport size, the amount of international traffic and cargo as well as the capacity constraint indicator, represent factors that are beyond managerial control. As a consequence, in a second step these factors were removed from the data, and new productivity indices for both the residual VFP and TFP were calculated. Overall, there haven't been significant changes in 2000 and 2001 after having adjusted the data in this way (see Fig. 11 and 12): all four German airports from the ATRS sample still remain on the bottom of the ranking.

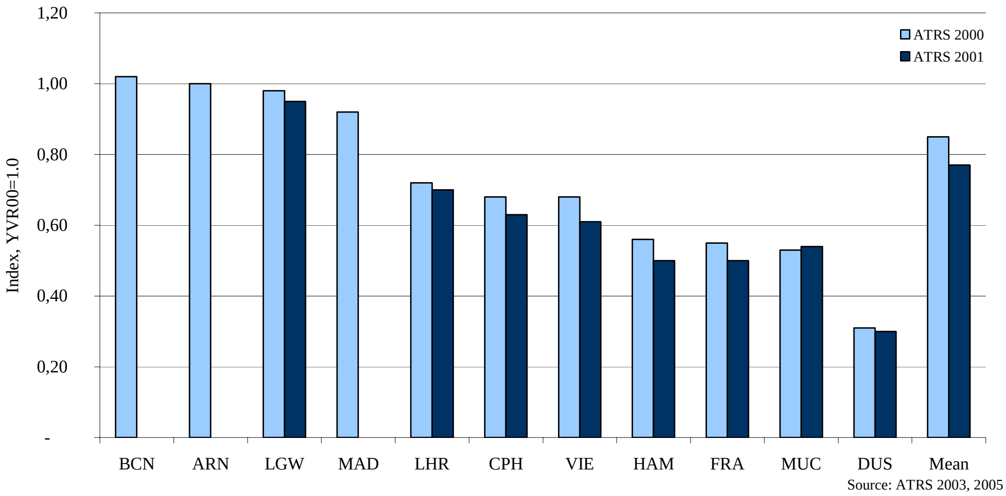

Fig. 11: Residual Total Factor Productivity (Europe)

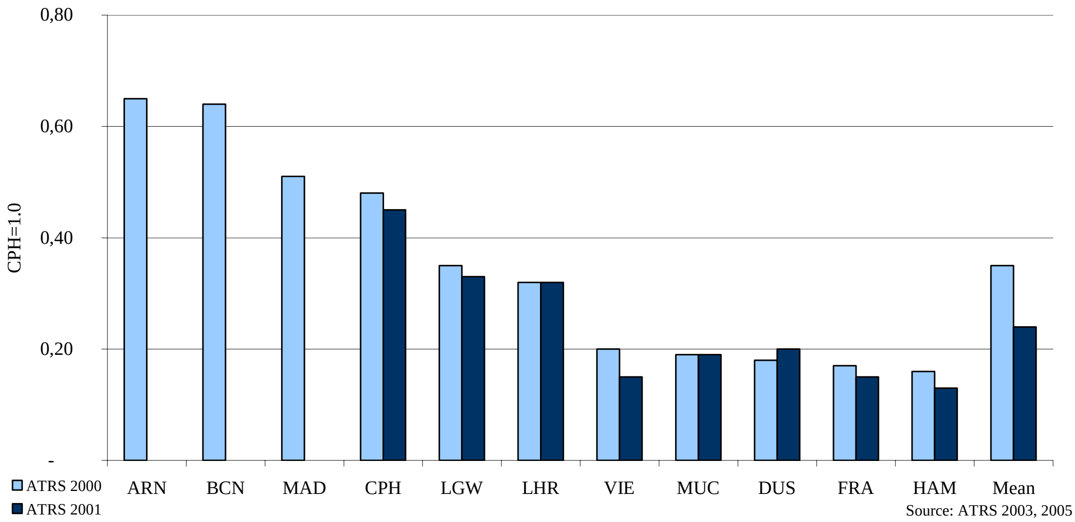

Fig. 12: Residual Variable Factor Productivity (Europe) I

The 2003 data analysis, which merely presents the residual VFP, also indicates no significant changes to the values of gross VFP (see Fig. 13). Having removed the fraction of international traffic, cargo and connecting traffic as well as the capacity constraint indicator[26] the German airports are still left in the last places and Vienna in the middle, but slightly below average (0.594).

[26] The airport size has not been considered in the regression analysis. The reason is that a recent study found that in airports in the US, economies of scale are levied out at a passenger volume of 2.5 to 5 million passengers.

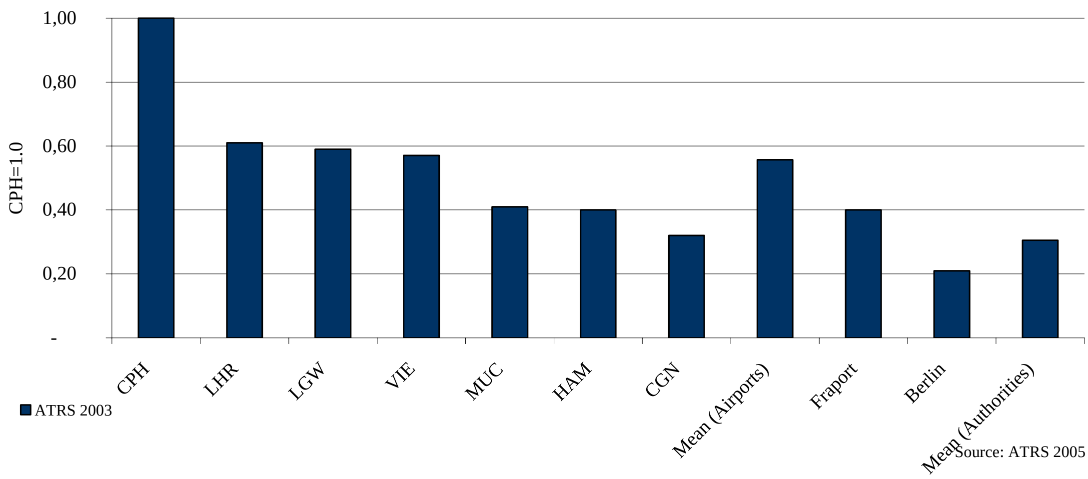

Fig. 13: Residual Variable Factor Productivity (Europe) II

In summary, the aggregated estimates of Gross and Residual Factor Productivity also show poor productivity outcomes for German airports. This result was already expected from the partial productivity measures, where the German airports performed weakly in nearly all areas. After having removed the effects that are beyond managerial control, the ranking has not changed.

2.2.4 The Technical Efficiency at German Airports

Another way to do benchmarking is to look at technical efficiency scores. Here, we rely on the results of Pels et al (2003) who have included physical instead of financial data in their analysis. It is interesting to see, that compared to the financial performance, the scores for technical efficiency are much better for the German airports. In general, the efficiency scores for all European airports are relatively high on both operational sides (with a mean value of 84% on the terminal side and a value of 82% on the airside).

a) The Technical Efficiency on the Airside

For the airside, Frankfurt obtained an efficiency score of 100% in 1997, which is surprising as it was one of the worst performers in the previous analysis[27] (see Fig.14). The same results can be found for Munich, Nuremberg and Stuttgart. Only the Berlin airports in Schönefeld and Tegel have attained low scores of around 50%. Hanover performed average and Hamburg came off weak with a score of only 65% technical efficiency.

These results are not very surprising for most of the German airports: Frankfurt is an airport that suffers under severe capacity constraints, which leads to high capacity utilization and thereby to a higher level of technical efficiency. On the contrary, the airport in Berlin Schönefeld, has a lot of excess capacity, especially on the airside and thus recorded low technical efficiency performances.

The authors then attempt to explain these differences and have investigated the correlation between the scale efficiency[28] and airport size. Although the coefficient is only 0.18, the larger airports such as Frankfurt and Munich are operating with near constant returns to scale

[27] Only scores for 1997 have been published.

[28] "Scale Efficiency recognizes that economy of scale cannot be attained at all scales of production, and that there is one most productive scale size, where the scale efficiency is maximum at 100 per cent." (Ramanathan 2003, p. 78)

or slight decreasing returns to scale, whereas small airports like Nuremberg and Berlin-Schönefeld show increasing returns to scale.

Besides Frankfurt and Munich, the other airports operating with high technical and scale efficiency are the larger airports in the study, namely Copenhagen, Gatwick, Heathrow, Paris Charles de Gaulles and Zurich. The airport in Milan-Linate, as a medium-sized airport has also obtained a high ranking, as it was a highly congested airport. From 2000 onwards, Milan-Malpensa took over most of the traffic because it still had capacities to expand and relieved the airport in Linate.

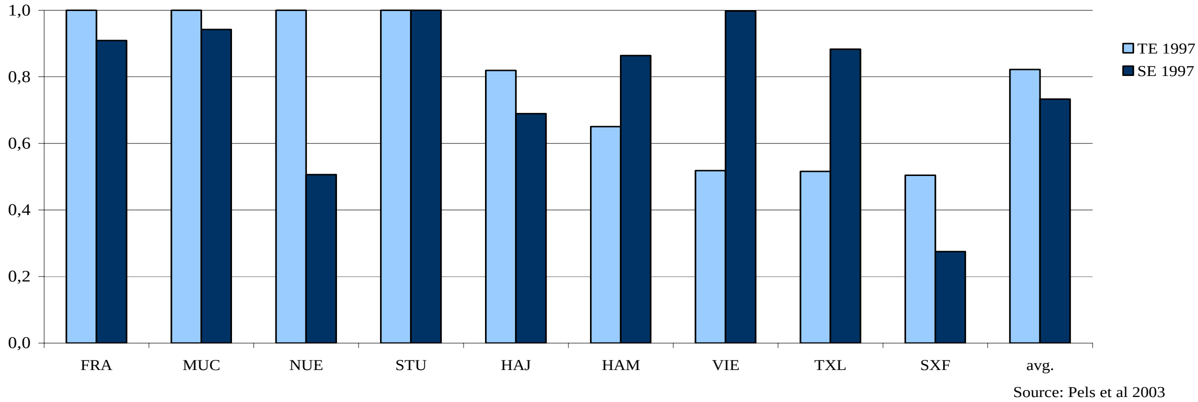

Fig. 14: Technical and Scale Efficiency (Airside)

b) <u>The Technical Efficiency on the Terminal Side</u>

The analysis of technical efficiency on the terminal side exhibits nearly the same average score as on the airside, but finds fewer technically efficient airports, but also few airports with low efficiency scores. Here, all German airports operate relatively well; with technical efficiency scores of more than 60% (see Fig.15). One reason for this may be that during the time period under investigation (1995-1997), no major airport capacity expansion took place in Germany, which would have led to lower efficiency scores. The most technically efficient airport in Germany on the terminal side is Schönefeld, which is quite interesting, as it achieved low scores on the airside. Nevertheless the scale efficiency of Schönefeld is quite low with 50%, indicating increasing returns to scale.

The correlation between the scale efficiency and airport size on the terminal side is much higher, with a value of 0.53, but still indicates a weak effect. As on the airside, Frankfurt and Munich, as the larger airports in Germany, operate under slight decreasing returns to scale, whereas Schönefeld und Nuremberg operate under increasing returns to scale and could increase their airport operations to improve performance.

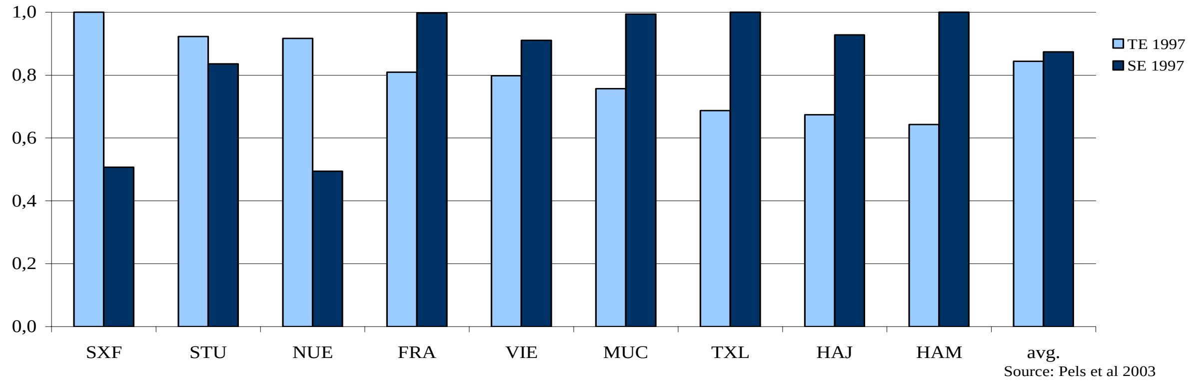

Fig. 15: Technical and Scale Efficiency (Terminal Side)

3. Some Shortcomings and points of further research

From the benchmarking studies emerges the picture of German Airports as relatively strong, vertically integrated, with relatively low labour productivity, high labour costs, but high technical efficiency. This immediately raises the question if this picture is true for all German airports, a question which we will try to answer with our GAP project. Furthermore, it raises the question, what are the causes for this rather poor performance? Do the results clearly show the inefficiency of German airports or might the results also reflect efficient behaviour? The studies do not answer these questions, but have more or less confirmed themselves to stating the performance differences.

We will confine ourselves to two important factors, which from our point of view; deserve further attention and which we intend to study in our GAP project.

3.1 Economies of scale and scope

Benchmarking airports of different size raises the question of how to eliminate the effects of size for a multi- product firm 'airports'. In particular, differences in scale and scope lead to the following questions:

- Is the weak performance of the German airports partially due to size effects?
- Does size matter for the GAP project? How important is it for the sample of German and international airports?

In order to answer these questions, we will first define economies of scale and scope, thereafter discuss the results of empirical studies and then provide a preliminary answer to the two questions.

The concept of economies of scale and scope belongs to the long run theory of production. It is assumed that all factors are variable and a profit maximizing firm will find a cost efficient combination of outputs with given factor and output prices. If long run average costs decrease with the scale of production, the airport operates under economies of scale. The long run average cost curve represents the minimum of the short run average cost curves. It is important to note that economies of density - that is lower average costs due to an increase in output with given capacity- is a short-term phenomenon (Gillen and Lall, 1997). Also, diseconomies due to congestion belong to the short term (Janic and Stough, 2003). When a firm produces more than one product; economies of scope are reaped if the firm saves costs by producing two or more products jointly, rather than separately.

There are surprisingly few studies on the long-run cost function of airports, given the fact that airports might be regarded as natural monopolies, which presupposes knowledge about the shape of the average cost function. We have so far been able to review the following studies:[29]

[29] We have yet to look at the study of Jeong (2005). According to Jeong, US airports have decreasing average costs up to a threshold of 2.5 to 5 million passengers and constant costs in a range of 40 million passengers.

Study	Observed period	Sample of Airports	Output	Method	Results
Doganis Thompson (1973)	1969-70	18 UK airports	WLU	Regression Analysis	L-shape cost curve with decreasing average costs up to three million.
Doganis (1995)	1993	25 airports thereof 12 European airports	WLU	Regression Analysis	L-shape cost curve with decreasing average costs up to five million
Salazar de la Cruz (1999)	1993-95	16 Spanish airports	Passenger	DEA	Decreasing average costs up to 3,5 million passengers, increasing from 12,5 million
Pels (2000)	1997	35 European airports	Air traffic movements (ATM) and Air Passenger Movements (APM)	DEA	Average airport with 12.5 Mio. APM passengers and 150000 APM operates under constant returns to scale for ATM and increasing returns for PTM.
Main, Lever and Crook (2003)	1988 –2001	27 UK airports	WLU and passengers	Regression Analysis	Sharp decreasing costs up to 4 million passengers and 5 million WLU and weak decreasing costs up to 64 million and 80 million passengers.
Main, Lever and Crook (2003)	1998- 2001	44 airports of TRL data set	WLU	Regression Analysis	L-shape cost curve with decreasing average costs up to 90 million WLU
Vogel (2005)	1990 to 1999	47 European airports	Passenger	DEA	Increasing economies of scale of up to 4 million terminal passengers

Tab. 4: Studies on Economies of Scale at Airports

The standard interpretation of the empirical results would lead us to interpret these results as an L-shaped average cost curve. After the airport reaches the size of about 3 to 5 million passengers, economies of scale effects flatten out, so that for benchmarking of medium and large sized airport size does not matter (for e.g. Graham 2004, Oum 2005).

From our point of view, it seems more appropriate to say that we do not know very much about the long run average cost curve. In particular we don't understand well enough:[30]

1) - The shape of the curve, that is, how fast small airports can benefit from higher traffic volumes.

2) - The stability over time, that is, how technical progress and innovative business concepts of terminal and traffic management might shift the curve and to what extent.

3) - The role of diseconomies of scale, that is, from what range onwards large airports experience higher long run average costs.

4) - In addition, we seem not to really understand the sources of economies and diseconomies of scale and scope. We think that a joint effort of econometric analysis and management theory is necessary to address the sources of economies and diseconomies of scale and scope of airports.

In order to illustrate these points, we outline a description of the sources of economies and diseconomies of scale, as well as sources in general, and ask if these factors are working in the airport industry. Following Besanko et al. (2003), the following factors in general might determine the long run cost curve:

[30] Although benchmarking project *construction* costs might be useful in this connection, the more fundamental issues of whether an airport is faced with increasing or decreasing long-run average costs is possibly addressed better by the use of alternative empirical approaches.

- *Economies of scale.* Real economies of scale are caused by indivisibilities and the spreading of fixed costs. A starting and landing system of an airport is a prominent example of indivisibilities, but it is not clear from which size such economies of scale cease to operate or which investments in capacity are marginal and which are incremental. The same is true for terminals and the non-aviation business, but their indivisibilities and the spreading of fixed costs are less important. Baggage systems for ground handling might be a good example for product specific costs which lead to falling average costs as the fixed costs can be spread out over larger output.
- *Cube square rule and physical properties*. These physical rules seem not to work for larger landing and starting systems but might be relevant for terminal and car parking.
- *Specialisation and the extent of the market*. The division of labour is limited by the extent of the market. The demand for air services in hub markets leads to additional scale effect. Airports like London, Paris and Frankfurt are more than double the size of medium sized markets like Amsterdam, Munich and Zurich. Secondary hub markets like Hamburg, Düsseldorf, Berlin and Vienna can also be ten times larger than regional markets for airports like Bremen, Nuremberg or Saarbrücken. To our knowledge there is no study on the effect of specialisation of firms and labour in this industry.
- *Inventories.* As firms with higher output can maintain a relatively lower ratio of inventory to sales, average costs could therefore decrease. For traditional airports this might not be very relevant, but it might become relevant for non-aviation business activities.
- *Purchasing and advertising*. Discounts for volume purchasers and lower advertising costs per consumer might lead to lower average costs. How relevant this is for airports is not clear, as small airports cooperate with one another in purchasing inputs and thereby receive lower prices. As airports are increasingly addressing passengers directly, marketing and advertising may become a source of economies of scale.
- *Research and development.* R&D seems to be more relevant for the producing industry than for service-oriented airports.
- *Economies of Scope.* Economies of Scope can occur in the airline industry and also in the airport industry. Airports are not only producing “movements” and “passengers” but a variety of products and services. Cost complementarities might result from producing both freight and passengers, as well as aviation and non-aviation services. To our knowledge the relevant elasticities are not known.
- *Diseconomies of scale*. As industries are usually not governed by a few giant companies, there must be some internal limits to growth. Labour cost and firm size, as well as *bureaucracy and incentives*, might be the most relevant factors. Larger firms usually pay higher wages because of higher unionisation and they also draw workers from farther distances (see the BAA airports in our results). It seems very plausible that wages are higher at Frankfurt airport than at Saarbrücken airport even allowing for differences in productivity. However these effects have not been studied. Furthermore, larger firms find it increasingly difficult to set incentives and monitor workers and managers. This seems to be relevant for airports with different vertical and horizontal boundaries. The fact that airports are being commercialised and privatised adds another dimension to this source of diseconomy.

Moreover, it might become increasingly more expensive to get the necessary inputs for large airports. *Land* is becoming more expensive and most large airports are located in populated areas, which means, airports have to go through expensive planning and permission processes. However, it might be also the case that lands becomes cheap once an airport has expanded and additional land has been granted by the planning authorities. An expanding airport might go through waves of expensive and cheap land.

Coming back to our initial two questions, it is clear that size might matter, but probably not so much for the typical medium-sized airports like Cologne, Düsseldorf, Hamburg, Munich and Berlin-Tegel. These medium-sized airports seem to operate more or less in the range of constant economies of scale and scope. However, Frankfurt might be of a size in which diseconomies of scale start to play an important role. Prima facie relatively high labour costs and scarcity of cheap land might be relevant and explain part of the poor performance of Frankfurt.

For the GAP project, size will play an important factor, as most of the German airports should operate with falling average costs and airports like Munich, might grow so fast that diseconomies of size become inevitable.

3.2 Product differentiation and strategic positioning of airports

The last few years have seen a number of changes in the German and European airport scene. Most important has been the development of low-cost carriers (LCC), who already made up more than 40% of all passengers in the UK in 2003. The European share of LLCs in 2003 was 15% and is quickly growing (John, 2005, p.11). The increasing significance of air freight and the emergence of airports that will concentrate on freight services, like Cologne-Bonn has done in the past and Leipzig will do in the future, is important.

We have argued above, that in the long run, airports could be perfectly adjusted according to local demand volume and product orientation. That would imply, that the airports are in the long run like flexible units and can be adjusted to local conditions. However, we have also seen that airports themselves, through specific marketing, pricing and inter linkage strategies can affect their demand and market conditions, especially over time. In order to reach a new equilibrium, these adjustments are clearly not achieved instantaneously. It takes time for capacity and service adjustment to be fully optimized to local conditions. As a consequence, airport capacity and output orientation may not always be in an equilibrium position, but in a continuous disequilibrium while trying to adjust to new conditions.

Let us first look at the case of repositioning due to changes in demand. This might well be illustrated by the case of the Cologne-Bonn airport. Originally it was conceived as a regional airport, which could also serve transport functions linked to the previous German capital Bonn. With the move of the capital from Bonn to Berlin in the mid-90s, the airport found itself with significantly underused capacity. To reorient the airport strategy towards freight and later on to LCCs was thus a logical step. Over the last few years and as already indicated in our empirical results, the volume for freight and passengers has increased significantly, resulting also in improved financial performance and in better productivity measures. The provision of a new rail link will increase the catchment area by adding extra demand for the airport. However, these effects will only be observed gradually in the near future.

Presumably as a new equilibrium is reached, still better capacity utilization will be realized, given local demand conditions and competition from other airports. This example illustrates, that as the airport repositions itself for a new product specialization, its measured productivity may be affected. However, we find that no adjustment has been made for such developments in typical benchmarking exercises.

The other case to look at is that of the repositioning of an airport because of changes in airport or intermodal competition, leading to lower capacity utilization. The airport may have been in an equilibrium position before with respect to capacity and product orientation, but such changes find it in a position where it has to adjust to the new environment. Obviously such shifts, which usually cannot be controlled by management, will lead to a drop in productivity measures, even if some managers adapt a forward-looking approach in order try to reach a new equilibrium.

As a consequence, if benchmarking is to be used in the typical disequilibrium environment, an informed debate about measures of capital and measures of capacity are needed. This implies not only looking at investment decisions, or at incremental costs, or the nature of the underlying cost function (i.e. whether there are constant or non-constant returns to scale), but to also consider the lumpy nature of investment and the fact that different airport investment cycles might distort comparisons. The theory of real options would suggest that this could even lead to adjusting downwards the inputs needed to the actual airport output (CAA 2000, p.27).

This issue of lumpy investment points to a number of problems associated with the measurement of airport capital, especially if trying to estimate whether there are returns to scale and what form incremental costs take. Incremental costs will be influenced both by the particular physical location and by the constraints imposed by previous investment. In some instances, the most cost-effective expansion will lead to the premature retirement/replacement of existing assets. Manchester Airport in its reply to the CAA inquiry about benchmarking therefore suggests,"…that the use of benchmarking in terms of comparing airport investment/capacity relationships might be inappropriate" (CAA 2000).

3.3 Difference in the vertical activities of airports and the associated value chain

Airports differ in terms of the services supplied, some operate ground handling by themselves; others outsource this service to third parties and merely provide the core facilities at the airport and receive concession fees from those providing these services. Doganis et al (1995) and TRL have defined the following as <u>non-core activities</u> at airports:

- Air Traffic Control
- Security
- Ground Handling
- Commercial Activities, e.g. Duty-Free, Retail, Catering
- Car Park
- Terminal Cleaning
- Recharges from water and electricity
- Head Office Functions

What we saw from our discussion of the TRL study above, was that the German airports operate many services in the non-core area themselves; especially ground handling, but also commercial activities and car parking. Are differences in the degree of outsourcing important? We have already raised the question if an airport needs to do more than to just concentrate on its core activities (i.e. providing airport facilities). How competitive are some of the individual activity segments, so that outsourcing can take place effectively? How crucial is it for the operators to control a certain activity segment themselves in order to maintain efficiency and customer loyalty? Is the expectation of better service quality one of the reasons? Or does the degree of vertical integration also depend on the objective function of the owner/management? We will try to identify a few of these issues that we hope to analyze in more depth during our GAP project.

a) Balancing Technical and Agency Efficiencies

The organization of the vertical chain in airports is a matter of choice. They can organize around their core activities - the supply of services via arm's-length market transactions or they can organize these services internally, that is, they can vertically integrate. Besanko et al, in following Williamson use the "Notion of Economizing", which is when a firm chooses between technical versus agency efficiency. Technical efficiency indicates whether the firm is using the least-cost production process and agency efficiency refers to the process of exchange, i.e. to the extent to which the vertical chain has been organized to minimize the coordination, agency, and transactions costs. The airports must choose an appropriate vertical organization of production, which must balance technical and agency efficiencies.

Following Besanko, this balancing act between "the relative efficiency of market exchange versus vertical integration is mainly determined by the trade off with respect to

- scale economies
- incentives and
- the transactions costs of market exchange."

We already discussed the issue of *scale economies* above. A firm gains less from vertical integration the more the outside market specialists can take advantage of economies of scale and scope relative to the firm itself. This is certainly the case for ATC, and perhaps also for commercial activities.

The extent to which scale effects can be realized is also related to market scale and growth: A firm can take greater advantage of economies of scale and scope through vertical integration the larger the market in which it operates. Small airports will certainly outsource activities in which scale economies are important. Larger ones have an option to vertically integrate such services. Large, dense catchments areas and better inter- and intra-modal linkages will have such effects.

Incentives are a particularly important issue in labour-intensive services, where organized labour plays a big issue. If the internal monitoring costs are high, and external labour markets function better, services purchased via the market may be cheaper for the airport.

b) Hold-up Problems and the Role of the Legal Environment

Transactions costs refer to the costs of organizing and transacting exchanges between autonomous parties, which are governed by contract law (Besanko et al 2003). Firms will outsource their activities, if the internal costs of production are higher than the cost of purchasing these services, plus the associated transaction cost. The legal environment in the form of contract law plays a very important role here. Contract law makes it possible for transactions to occur more smoothly when contracts are incomplete, which, as we see below is often the case. If a market for non-core airport activities exists, airports now have the chance to outsource in different ways, i.e. through long-term contracts or strategic alliances.

What makes this decision so complicated is the so-called *hold up problem* as a result of investment in relation specific assets. Relation specific investments refer to an investment made by either the buyer or the seller to support a planned service. Once these investments have been sunk, the two parties to the transaction cannot without cost, switch partners, unless the investment can be easily switched to an alternative use. Now the terms of the exchange are determined by bilateral bargaining. The party that has sunk more into the specific investment is in a weaker bargaining position and could be held up in subsequent negotiation by threats from the other party. It will therefore try to protect itself against such a situation by defining in a legal contract the rights and responsibilities of each contract partner. The more complete such a contract, the better the protection against such a hold up.

In practice, such contracts are seldom complete and may require contract renegotiations. The vulnerability of the partner is related to the degree, to which such relation specific investments lead to sunk cost. Besanko et al (2003) talk about four different forms of asset specificity

- “Site specificity (location of assets)
- Physical asset specificity (physical or engineering properties are specifically tailored)
- Dedicated assets (investment in plant and machinery to satisfy a particular buyer)
- Human asset specificity (a worker's acquired skills that are more valuable inside a particular transaction than outside of it)“.

It is obvious from this discussion, that the hold-up problem can raise the cost of transacting via the market exchange in four ways:

1. More difficult and frequent contract negotiations;
2. Reduced investment in relationship-specific assets and thereby a smaller market for the outsourcing of services;
3. Extra investments to improve ex post bargaining positions (e.g. keeping a standby option for a key input as a hedge against a possible hold up);
4. Distrust (Besanko et al 2003).

In the market for non-core services, we can find many relation specific investments, that could lead to such a hold-up problem, especially in the area of ground handling and commercial activities. As a consequence, airports will be looking at vertical integration as an alternative to outsourcing.

c) Market Imperfections as an Additional Reason for Vertical Integration

Market imperfections might drive a firm's decision to vertically integrate, because the structure of the product or service markets of the upstream or downstream firm is imperfectly competitive or because of imperfections in information flows. Vertical integration could help to avoid market foreclosure or to foreclose entry of competitors.

d) Alternatives to Vertical Integration

Instead of vertical integration, firms also have the option of strategic alliances and joint ventures, that fall somewhere between arm's-length market transactions and full vertical integration.

- ”In a strategic alliance, two or more firms agree to collaborate on a project or to share information or productive resources.

- A joint venture is a particular type of strategic alliance where two or more firms jointly create and own a new independent organization” (Besanko et al 2003).

This theoretical framework should help us to look at the role of outsourcing versus vertical integration in more detail, especially as we try to benchmark processes instead of whole airports[31].

4. Conclusions and Outlook for GAP

The benchmarking results of financial performance and technical efficiency show substantial differences for German airports compared to their international peers. Their financial performance is very low by European standards. All airports in Germany are airports with relatively high (staff) costs and low labour productivity. This is particularly the case with Frankfurt airport.

The weak financial performance contrasts with the relatively good performance of the technical efficiency results. Munich and Frankfurt show especially large differences between both types of financial and technical analyses. They are on the bottom ranking in financial performance and labour productivity, but they operate with nearly 100% technical and scale efficiency in the study of Pels et al (2003). They even operate with near constant returns to scale or only slight decreasing returns to scale.

Even when the comparisons are reduced to the core activities of the airport, we do not find significant differences. This makes this sort of benchmarking a very crude tool, but it helps to point to significant differences in performance, which suggest further needed research. Data refinements are certainly necessary to put more thrust into these studies, but further in-depth analysis is also called for, where large differences in performance suggests a deeper underlying problem. It is this issue, which will be returned to next.

What could be the reasons for the low performance of the German airports in these studies?

The reviewed studies do not give a satisfying answer. We have therefore outlined the areas of economies of scale and scope, as well as strategic positioning and outsourcing, which might have caused the poor performance.

Firstly, given the rather weak knowledge about the long-run average cost curve and its determinants, we think that it is necessary to explain in depth the issue of diseconomies of scale for larger airports such as Frankfurt and in the future Munich. Given the fact that small and medium-sized German airports have not outsourced major activities like ground handling, it will be very interesting to benchmark airports of this size and analyze up to what size they are able to operate under increasing returns.

Secondly, we do not know the sources of economies and diseconomies of scale and scope for airports. The benchmarking studies do not deal with them, but obviously it is very important to know from the point of view of management, by which measures such economies could be gained and how to avoid diseconomies.

Thirdly, it is clear that also a better analysis on product differentiation at airports is necessary, when carrying out such studies. The repositioning of Cologne/Bonn has increased passenger numbers and cargo volumes and thus will lead to productivity changes. Also, the change in

[31] In BAA's reply to the CAA Benchmarking inquiry, we found the following quote to support this viewpoint: "BAA's view is that benchmarking's value lies in the extent to which it can be used to inform the company's drive for cost efficiency, focussing on key processes and the opportunities for competitive contracting and outsourcing" CAA APPENDIX 4,Responses to CAA Questions in Paragraph 4 (BAA 2001).

airport strategies regarding non-aviation activities will change the performance measure of an airport, so this topic has to be further considered. How to benchmark airports which are in the long-run process of adapting capacity and product spectrum to changes with airports who have already reached their equilibrium is a methodological challenging question that needs to be answered in order to better interpret benchmark results.

Fourthly, are differences in the degree of outsourcing important? It can be seen from the analysis above, that the German airports operate many in-house services, for example ground handling or the operation of car parks. Can we assume from the ATRS results that these operations are the most labour intensive and the most important cost drivers for an airport? If this is the case, why are German airports taking care of these operations by themselves and are not motivated to outsource them to third parties? Is the market for outsourced services not providing competitive results or might the reason be, that in-house operated ground handling provides better service quality? Generally speaking, is there a correlation between cost and service quality? Or do German airports provide a better service than other airports?

What is the difference in vertical integration among airports and what activities can an airport operate more efficiently then a third party? Obviously, one should investigate not only how competitive the individual activities can be provided, so that outsourcing can take place, but also how crucial it is for operators to control certain segments in order to maintain quality and customer loyalty.

But even when outsourcing is simulated, as indicated by TRL's procedure, which eliminated the effects of ground handling and other non-core activities, the German airports nevertheless reported below average results, especially in labour productivity and staff costs per passenger. In contrast, the operating costs per passenger, which exclude the staff costs, are not very high in a European comparison. This leads to the assumption that was already mentioned, that the staff costs are the crucial cost driver at the German airports and will be further investigated.

Fifthly, a further possibility for the weak performance of German airports in the TRL studies could be that the data adjustment was not very consistent. If an airport operates ground handling and other services, then more employees in central departments are also needed. This would be especially the case for e.g. the Controlling and Finance Department and the Human Resources Department. If these variables were not adjusted properly, could this explain why the German airports in the TRL study still performed relatively poorly after the data had been adjusted? Perhaps the operation of core activities at German airports is essentially performed in an efficient way, but these results could not be seen with the use of the adjusted data. Thus the route of further data refinements mentioned above might shed further light in this analysis.

What follows from that for our GAP research project?

The intention of our benchmarking study is to use unadjusted <u>and</u> properly adjusted data to identify differences between both types of results and to undertake an in-depth analysis regarding the causes of these differences. Furthermore, the project plans not only to incorporate aggregate data to measure the overall performance, but also to use disaggregate data for partial performance measures. With disaggregated data it is possible to identify e.g. the cost driving departments by comparing different individual departments of an airport to one another or to look at individual processes in more detail. On such a basis, one would be in a better position to provide recommendations of how to improve performance in-line with best practice airports[32].

In terms of methodology, the project plans to use different approaches to see if there are strengths and weaknesses with the different instruments and identify the most appropriate approach. For an overall analysis, Total Factor Productivity, Data Envelopment Analysis and Stochastic Frontier Analysis are considered adequate methods. The partial performance measurement will also be based on the calculation of various financial and capacity ratios.

Different to the previous analyses, the project plans to abstain from a challenging worldwide comparison and will instead focus on benchmarking German airports with a restricted sample of international airports, for which we can guarantee a good data quality.

To overcome the shortcomings from formerly disregarded issues like economies of scale and scope, we will also study in detail the degree of outsourcing and product differentiation, which will make up a large part of our benchmarking study. We also aim to provide a more disaggregated, process-oriented approach that has a greater capacity to compare "like with like". Both aspects will be carefully worked out via questionnaires and interviews at the airport.

In our analysis we will also focus on the subsequent causal analysis and the corresponding interpretation of results, after initial benchmarking measurements have been carried out. Similar to the regression analysis of ATRS and Doganis et al (1995), we will try to better identify factors that can significantly influence an airport's performance. The project thus plans not only to run the standard models and give some results but also to find better reasons for the differences. Questions to be addressed are e.g. *is there a difference between privatised and publicly owned airports? How does the type of economic regulation affect the airport's performance?* Further external factors that should be considered in the analysis are: airport size, capacity constraints, noise restrictions, runway configuration, regional economic environments, competition with other airports in the region, state aids, ATC, slot coordination, peakiness of traffic, and the objective function of the airport (profit maximising or otherwise).

All these issues indicate that airports are not unique but complex phenomena, which are worthwhile to study in depth. The ongoing GAP project will provide a platform with which to study these questions in more detail and to analyze the available data with various econometric and basic benchmarking methods, and to use more in-depth case studies. We therefore hope that more answers are soon forthcoming.

[32] . The problem of using such results has also been recognized by the airports in regulatory proceedings. For example, BAA undertook a cost benchmarking exercise as part of the 1991 price review "but there were a number of concerns about the reliability and usefulness of the results. The information was used only to establish in broad terms if there was scope for radical improvements in BAA staff productivity "…." BAA believes that the examination of key processes is likely to be a more fruitful approach to addressing an airport's efficiency than a top down methodology. Material and controllable costs can be identified and in some cases benchmarked. Inefficiencies identified through process examination would provide BAA with clear objectives and lead to quantifiable improvements through a target setting approach". (BAA ,2001, exec. summary p 3)

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6. APPENDIX

Author	Airports	Year Under Review	Methodology
Adler, N. and Berechman, J. (2000)	26 European Airports	-	Data Envelopment Analysis (DEA)
Barros, C.P. and Sampaio, A. (2004)	13 Portuguese Airports	1990 - 2000	DEA
Bazargan, M. and Vasigh, B. (2003)	45 US Airports (15 small, medium, and large hub airports)	1996 - 2000	DEA
Doganis, R., Lobbenberg, A. and Graham, A. (1995)	25 European Airports	1993	Data Adjustments; Productivity Measurement; Regression Analysis
Fernandes, E. and Pacheco, R.R. (2002)	35 Domestic Brazilian Airports	1998	DEA
Gillen, D. and Lall, A. (1997)	23 of the top 30 US Airports	1989 - 1993	DEA/ Tobin Regression
Gillen, D. and Lall, A. (2001)	22 Major US Airports	1989 - 1993	Malmquist-DEA
Graham, A. and Holvad, T. (2000)	25 European and 12 Australian Airports	1993 (Europe), 1992/93 (Australia)	DEA and Free Disposal Hull Analysis (FDH)
Hooper, P.G. and Hensher, D.A. (1997)	6 Australian Airports	1988/89 - 1992/93	Total Factor Productivity (TFP)
Jessop, A. (1999)	32 international airports worldwide	1997 - 2002	DEA and Multiattribute Model; In a 2nd step Cluster Analysis for both models
Martín, J.C. and Román, C. (2001)	37 Spanish Airports (AENA)	1997	DEA
Murillo-Melchor, C. (1999)	33 Spanish civil Airports run by AENA	1992 - 1994	Malmquist-DEA
Pacheco, R.R. and Fernandes, E. (2003)	35 Brazilian Domestic Airports	1998	DEA
Parker, D. (1999)	BAA as a whole, i.e. 32 (22 in a second model) UK Airports	1979/80 - 1995/96 (1988/89 - 1996/97 in a second model)	DEA
Pels, E., Nijkamp, P. and Rietveld, P. (2001)	34 European Airports	1995 - 1997	DEA/ Stochastic Frontier Analysis (SFA)
Pels, E., Nijkamp, P. and Rietveld, P. (2003)	34 European Airports	1995 - 1997	DEA/ SFA (for SFA an production function was estimated)
Sarkis, J. (2000)	44 Major US Airports	1990 - 1994	DEA
Sarkis, J. and Talluri, S. (2004)	44 Major US Airports	1990 - 1994	DEA and clustering method
Vogel, H.-A. (2005)	31 individual and 4 airport systems in Europe	1990-1999	Performance Indicators and Financial Ratios with t-test; DEA (BCC-i-model)
Yoshida, Y. (2003)	30 Japanese Airports	2000	TFP (Endogenous-Weight)
Air Transport Research Society	airports and airport authorities worldwide	published annually	Partial Performance Measurement, TFP
Transport Research Laboratory	airports and airport groups worldwide	published annually	Data Adjustments; Partial Performance Measurement, Multi Attribute Assessment

Tab. 5: Airport Benchmarking Studies