Airport Performance: A Summary of the 2003 ATRS Global Airport Benchmarking Report

Tae Hoon Oum,

UPS Foundation Professor, University of British Columbia, Canada
And President, Air Transport Research Society (ATRS)
2053 Main Mall, Vancouver, BC, Canada, V6T 1Z2
Phone: (604) 822-8320
E-mails: tae.oum@sauder.ubc.ca
www.atrsworld.org

and

Chunyan Yu

Centre for Transportation Studies,
University of British Columbia, Canada
2053 Main Mall, Vancouver, BC, Canada, V6T 1Z2
Phone: (604) 822-9416
E-mails: chunyan.yu@sauder.ubc.ca

In cooperation with
The Global Airport Benchmarking Task Force
of Air Transport Research Society (ATRS)
North America: David Gillen, Bijan Vasigh;
Asia Pacific: Peter Forsyth, Yuichiro Yoshida, Yeong-Heok Lee;
Europe: Jaap de Wit, Eric Pels, Keith Mason, Nicole Adler,

Airport Performance:
A Summary of the 2003 ATRS Global Airport Benchmarking Report

by
Tae Hoon Oum and Chunyan Yu
University of British Columbia

In cooperation with
The Global Airport Benchmarking Task Force
of Air Transport Research Society (ATRS)
North America: David Gillen, Bijan Vasigh;
Asia Pacific: Peter Forsyth, Yuichiro Yoshida, Yeong-Heok Lee;
Europe: Jaap de Wit, Eric Pels, Keith Mason, Nicole Adler

Abstract

This paper provides a partial summary of the 2003 ATRS Global Airport Benchmarking Report which uses year 2000-2001 data. The objective of the ATRS benchmarking report is to measure and compare the performance of several important aspects of airport operation: **productivity and efficiency, unit costs and cost competitiveness, financial results.** The report also examines the relationships between various performance measures and airport characteristics in order to better understand the observed differences in airport performance. This particular paper extracted from the benchmarking report focuses on the productivity and efficiency performance of the airports. In particular, the paper presents the results on the airports' Variable factor Productivities (VFP). It further examines the effects of various factors influencing airport's variable input productivity, and computes a 'residual' VFP index to provide an indicator for airports' operations efficiency.

Airport Performance:
A Summary of the 2003 ATRS Global Airport Benchmarking Report

The growing trend of commercializing and privatizing airports is challenging airport managers worldwide to provide the best possible services in the most efficient manner. To do this, airports need to know the best practices over various dimensions of airport operations within the industry, and how their performance compare to the best industry practices. Air Transport Research Society (ATRS), a worldwide research network, embarked on an annual endeavour in 2001 in the form of global airport benchmarking, in order to provide a meaningful global comparison of airport performance, and to investigate the relationships between the performance measures and airport characteristics and management strategies in order to provide a better understanding of the observed differences in airport performance. The 2003 ATRS Global Airport Benchmarking Report is the second report, and it presents the results on various measures of airport productivity and efficiency, unit costs and cost competitiveness, and financial performance, for up to 90 airports of various sizes and ownership forms in North America, Europe and Asia Pacific.

The objective of this paper is to provide a summary of the airports' productivity and efficiency performance, and to investigate the relationships between the productivity measures and airport characteristics and management strategies in order to better understand the observed differences in airport performance.

The paper is organized as follows: section 2 discusses the diverse and heterogeneous characteristics of airport operations and their implications in airport productivity measurement, and provides a brief review of previous airport performance studies; section 3 describes the sample airports and some key statistics; section 4 presents empirical results. Section 5 examines the factors that may explain the observed differences in airport productivity; and summary and concluding remarks are given section 6.

Airport Performance Measurement

Airports provide a wide range of services and facilities to passengers, shippers, airlines, and others, including runway services, apron services, loading and unloading of baggage/freight hold, passenger services, concessions, office rentals, car parking, etc. The airport industry is very diverse and heterogeneous with a high degree of quality differentiation, different ownership and regulatory structures, different mixes of services and operating characteristics, as well as external constraints such as location and environmental factors. Therefore, measuring and comparing the performance of airports is a tricky business. At some airports, such as Frankfurt, most of the airport service activities are carried out directly by the airport operator, whereas at others, such as Vancouver International Airport, many services, such as terminal operation, are contracted out to airlines and independent companies. The extent of an airport operator's direct involvement in the various activities at the airport will affect the cost and revenue structure of each airport, and thus must be taken into account in assessing and comparing airports.

Different airport performance measures and methodologies have been developed and applied over time (Francis, Humphreys and Fry, 2002, and Humphreys and Francis, 2002). For example, Martin and Roman (2001) apply DEA (Data Envelopment Analysis) to evaluate the performance of 37 Spanish airports. They include three outputs (aircraft movements, number of passengers and tons of cargo) and three inputs (labour, capital and materials – all expressed in terms of expenditures). Martin-Cejas (2002) estimates a translog cost function to examine the productive efficiency of 40 Spanish airports. "Units of traffic transported" is used as the single output variable, whereas labour and capital are the only two inputs considered. It is not clear how input prices are determined. Parker (1999) analyzed the performance of BAA before and after privatization using DEA as well. Labour, capital stock, non-labor and capital costs are used as inputs and number of passengers and cargo and mail handled as outputs. Abbott and Wu (2002) investigate the efficiency and productivity of 12 Australian airports for the period 1990-2000 using Malmquist total factor productivity (TFP) index and DEA. The study considers two outputs and three inputs; the two outputs being the number of passengers and the amount of freight cargo in tonnes passing through an airport. The three inputs are the number of staff employed by the airport, the capital stock in constant dollar terms constructed using the perpetual inventory method, and the runway length of an airport. Sarkis (2000) evaluated the operational efficiency of U.S. airports using DEA. The input set included operational costs, number of airport employees, gates and runways and the outputs included operational revenue, number of passengers, aircraft movements and cargo. Hooper and Hensher (1997) examine the performance of six Australian airports over a 4-year period using the TFP method. A deflated revenue index is used as an output measure, and three inputs are considered: labor, capital, and other. Nyshadham and Rao (2000) use TFP to evaluate the efficiency performance of 24 European airports and examine the relationship between the computed TFP index and several partial measures of airport productivity. Similar to Hooper and Hensher, they use revenue and expenses as output and input variables in computing the TFP index. Gillen and Lall (1997) and Pels, Nijkamp and Rietveld (2001) separate airport operation into landside and airside, and develop separate DEA models to evaluate the productive efficiency of landside and airside operations, respectively.

The aforementioned studies tend to simplify the problem by focusing on certain aspects of airport operation or certain group of airports with similar operating environments because of the complex nature of the airport operation. This paper attempts to provide an overall assessment of airport productivity performance across 76 airports worldwide, explicitly taking into account of the diverse nature of airport operation and market environments. The paper also examines how various factors, including airport characteristics and service quality level, affect the measured airport performance. As some of these factors are beyond control of airport operators, and the observed performance may not reflect an airport's true efficiency level, a residual (net) productivity performance indicator is measured and compared after removing the effects of such factors.

Sample Airports and Output and Input Variables

Our sample includes 76 airports[1], representing different sizes and ownership structures and located in Asia Pacific, Europe, and North America. Selected airport characteristics are listed in Table 1. The data is compiled from various sources including the International Civil Aviation Organization (ICAO), Airport Council International (ACI), the U.S. Federal Aviation Authority (FAA), International Air Transport Association (IATA), airport annual reports and direct communication with airports.

To measure airport productivity, one must first identify outputs that an airport produces and the inputs it uses in producing these outputs. In this study, the following four output categories are considered: (1) number of passengers handled; (2) air cargo tonnes handled; (3) number of aircraft movements handled; and (4) the amount of non-aeronautical service outputs, including concessions and other rental revenues, car parking, and numerous other services from which airports generates revenues, but are not directly related to aeronautical activities in a traditional sense. These activities are becoming increasingly more important for airports around the world. A non-aeronautical (commercial) output index is constructed by deflating the commercial or non-aeronautical revenues by Purchasing Power Parity (PPP). Inclusion of the non-aeronautical services output allows us to examine the efficiency implication of airports' revenue diversification strategies.

On the input side, two inputs are considered as we choose to focus variable factor productivity: labor and the so-called soft cost input (ATRS, 2003)[2]. Labor is measured by the number of employees who work directly for an airport operator on a full-time basis; Soft costs input is a catch-all input other than labor and capital costs, including costs of outsourced services, consultant services, utility costs, travel expenses, non-labor building and equipment maintenance expenses, and repair costs. There is no direct quantitative measure for the soft cost input, thus a soft cost input index is constructed by deflating all soft cost expenses by PPP. Soft cost expenses include all expenses not directly related to capital and personnel, and is considered to partly reflect the extent of an airport's outsourcing activities. Inclusion of the soft cost input allows us explicitly to take into account of the effects of airports' strategy with respects to outsourcing activities on productivity. Exclusion of the soft cost input would bias productivity comparisons significantly in favor of the airports that outsource much of their services.

Table 1 Airport Characteristics and Service Quality

[1] Actually, our sample includes about 90 airports. However, not all of the 90 airports have complete data requirement for the productivity analysis. Therefore, only the airports with consistent data are included.
[2] ATRS (2003) also reports on total factor productivity (TFP) results. However, we focus on variable factor productivity (VFP) here because of problems with capital input measures.

Airport	Total Passengers (000's)		Passengers/ Movement		% International Passengers		% Aeronautical Revenues		Customer Satisfaction*	
	2,000	2,001	2,000	2,001	2,000	2,001	2,000	2,001	2,000	2,001
ATL	80,162	75,849	88	85	7%	7%	48%	42%	3.92	3.68
BOS	26,973	24,200	62	53	16%	24%	46%	45%	3.44	3.44
CVG	22,538	17,270	47	44	4%	4%	57%	61%	4.13	4.13
DFW	51,349	55,151	73	70	8%	8%	52%	55%	3.85	3.51
DTW	35,535	32,294	64	62	11%	10%	54%	55%	3.23	2.98
EWR	34,188	30,500	76	70	25%	23%	70%	70%	3.63	3.28
HNL	23,017	21,096	67	65	22%	21%	29%	34%	3.44	3.44
IAD	20,661	17,860	43	45	18%	22%	61%	59%	3.55	3.35
IAH	35,251	34,975	73	74	16%	16%	46%	53%	3.88	3.56
JFK	32,856	29,400	95	101	57%	57%	72%	72%	3.32	3.13
LAX	67,303	61,025	86	83	26%	26%	41%	41%	3.39	3.15
MCO	30,485	28,167	85	88	8%	7%	36%	39%	3.89	3.89
MIA	33,621	31,668	65	67	48%	48%	38%	49%	3.44	3.23
MSP	36,752	35,171	70	70	5%	4%	48%	52%	3.97	3.84
ORD	72,144	66,805	79	73	15%	14%	60%	66%	3.73	3.44
PDX	13,823	12,704	43	46	4%	2%	43%	49%	3.74	3.74
PHL	24,918	23,927	51	51	11%	12%	63%	65%	n/a	3.31
SEA	28,409	27,036	64	68	9%	9%	52%	52%	3.91	3.67
SFO	40,980	34,627	93	89	20%	22%	51%	52%	3.55	3.19
YUL	8,493	8,157	41	42	51%	51%	33%	31%	3.64	3.41
YVR	16,247	15,622	48	50	47%	49%	30%	32%	4.25	3.91
YYC	8,090	8,300	48	37	29%	29%	36%	37%	3.91	3.91
YYZ	28,930	28,043	68	69	57%	56%	62%	55%	3.67	3.36
Mean	33,597	31,298	66	65	22%	23%	49%	51%	3.70	3.50
Europe										
AMS	39,607	39,531	92	92	99%	99%	49%	48%	4.05	3.80
BRU	21,595	19,636	66	64	100%	99%	62%	62%	3.83	3.83
CDG	48,246	47,996	97	92	71%	90%	31%	33%	3.36	3.36
CPH	18,294	18,136	60	63	88%	90%	60%	60%	4.35	4.08
DUS	16,030	15,393	83	80	75%	76%	72%	72%	3.58	3.32
FCO	27,118	25,566	87	90	52%	52%	64%	65%	3.54	3.36
FRA	49,360	48,569	108	107	82%	83%	73%	70%	3.59	3.36
GVA	7,764	7,488	45	46	85%	86%	49%	48%	n/a	3.40
HEL	10,004	9,972	60	60	69%	70%	69%	68%	4.28	4.05
LGW	32,066	31,182	123	124	91%	90%	46%	46%	n/a	3.58
LHR	64,607	60,743	138	131	88%	89%	48%	48%	3.64	3.40
MAN	18,820	19,555	95	99	82%	83%	50%	52%	4.18	3.93
MUC	23,153	23,647	73	70	63%	64%	60%	59%	3.82	3.82
MXP	20,717	18,570	83	78	73%	76%	71%	71%	3.43	3.27
OSL	14,232	13,993	70	71	47%	48%	54%	52%	3.98	3.76
VIE	11,940	11,853	58	58	95%	95%	78%	77%	n/a	3.64
ZRH	22,627	21,013	69	68	94%	94%	53%	52%	3.99	3.72
Mean	26,246	25,461	83	82	80%	81%	58%	58%	3.83	3.63
Asia Pacific										
BKK	23,534	30,624	166	152	69%	70%	44%	44%	3.60	3.46
HKG	29,610	32,553	175	157	100%	100%	62%	60%	4.03	3.92
KIX	20,576	19,342	166	157	57%	55%	47%	44%	3.87	3.87
KUL	14,733	14,539	134	128	70%	69%	58%	58%	4.16	4.16
PEK	21,691	24,176	116	109	26%	25%	61%	61%	2.99	2.99
SEL	36,727	22,062	155	136	49%	19%	31%	29%	3.09	3.09
SIN	28,618	28,094	155	148	100%	100%	42%	41%	4.31	4.16
SYD	23,800	24,303	78	83	33%	34%	33%	35%	3.82	3.87
TPE	18,681	18,461	161	149	100%	100%	65%	66%	3.27	3.35
Mean	24,219	23,795	145	135	67%	64%	49%	49%	3.68	3.65

Comment [PS1]: Still need European % Aeronautical Revenues; however, I don't have these figures in my Excel files, maybe take a look at yours. I do have some airport's aeronautical revenues, but not their operational revenues and vice-versa; thus, I can't compute their % Aeronautical revenues

* IATA Global Airport Monitor

Productivity Measurement and Empirical results

As discussed earlier, airports produce multiple outputs using multiple inputs, which causes difficulty in defining a consistent overall performance measure. Thus, partial measures of productivity are commonly used by trade and popular press, industry, and academics to assess differences in performance. These partial productivity measures generally relate a particular output to a single input factor. For example, passengers per employee is a labor-based partial productivity measure. A large variety of “performance ratios” have been used to assess the performance of airports. These measures are easy to compute, require only limited data, and are intuitively easy to understand. However, the productivity of one particular input factor (such as labour) depends on the level of other inputs (such as outsourcing) being used; high productivity performance in one input may come at the expense of low productivity of other inputs. Therefore, there is a need to construct an aggregate measure of productivity for all inputs airports use. In the short to medium term, airports make managerial and operational decisions within the given state of their capital infrastructure and facilities. In general, airport managers have nearly total control of their operating costs, i.e., labor and soft-cost input costs, but may not have complete control of capital costs. Therefore, an aggregate productivity measure in the short to medium term would include all non-capital or variable inputs. Because of lack of detailed data and information, we consider two general categories of non-capital or variable inputs: labor and soft cost input. Variable Factor Productivity (VFP) is computed by aggregating labor productivity and soft cost input productivity using variable cost shares as the weights.

Variable Factor Productivity (VFP) measures the performance of an airport in utilizing variable input factors for given level of capital infrastructure and facilities. Table 2 presents the gross VFP estimates for 2000 and 2001. On the basis of VFP, Christchurch, Sydney, Auckland and Singapore are the high performers in Asia Pacific, whereas Tokyo-Narita, Kansai, Peking, and Kuala Lumpur are the low performers; In Europe, Copenhagen, Heathrow, Zurich, Amsterdam, Barcelona, Madrid and Arlanda are the high performers, whereas Dusseldorf, Hamburg, Vienna, and Manchester are the low performers; In North America, Atlanta, Raleigh-Durham, Charlotte, Indianapolis, Memphis, Phoenix, and Minneapolis/St. Paul are the high performers, whereas Washington National, JFK, LaGuardia, Chicago-Midway, Edmonton, and Ottawa are the low performers.

Table 2
Gross Variable Factor Productivity
(Base: Vancouver YVR, 2000=1.0)

	2000	2001
	North America	
ATL	2.540	2.583
BOS	0.716	0.643
BWI	0.698	0.650
CLE	0.678	0.469
CLT	1.424	1.401
CVG	1.242	0.955
DCA	0.326	0.284
DEN	0.610	0.519
DFW	1.126	0.981
DTW	0.714	0.696
EWR	0.569	0.552
FLL	0.808	0.704
HNL	0.869	0.936
IAD	0.696	0.666
IAH	1.077	0.885
IND	1.509	1.276
JFK	0.438	0.400
LAS	0.812	0.694
LAX	0.873	0.690
LGA	0.367	0.399
MCI	0.698	0.612
MCO	0.628	0.515
MDW	0.384	0.355
MEM	1.307	1.241
MIA	0.568	0.524
MSP	1.344	1.040
ORD	0.935	0.817
PDX	0.795	0.768
PHL	0.679	0.640
PHX	1.037	1.047
PIT	0.380	0.414
RDU	1.515	1.456
SEA	0.625	0.571
SFO	0.644	0.459
SLC	0.873	0.869
STL	0.786	0.719
TPA	0.698	0.650
YEG	0.405	0.367
YOW	0.391	0.372
YUL	0.408	0.419
YVR	1.000	0.929
YYC	0.793	0.745
YYZ	0.639	0.538
Mean	0.828	0.755

Source: Air Transport Research Society (2003)

Table 2 (cont.)
Gross Variable Factor Productivity
(Base: Vancouver, YVR, 2000=1.0)

	2000	2001
	Europe	
ADP	0.417	0.396
AMS	0.506	0.443
ARN	0.663	N/A
BCN	0.620	N/A
BRU	0.451	0.368
CPH	0.573	0.532
DUS	0.127	0.146
FRA	0.226	0.204
GVA	0.271	0.240
HAM	0.121	0.118
HEL	0.285	N/A
LGW	0.388	0.364
LHR	0.479	0.470
MAD	0.563	N/A
MAN	0.163	0.151
MUC	0.185	0.191
OSL	0.361	0.315
VIE	0.212	0.157
ZRH	0.547	0.454
Mean	0.377	0.279
	Asia Pacific	
AKL	0.715	0.695
BKK	0.422	N/A
CHC	0.527	0.552
HKG	0.283	0.326
ICN	N/A	0.242
KIX	0.186	0.162
KUL	0.175	N/A
NRT	0.139	0.110
PEK	0.163	0.170
PEN	0.339	N/A
SEL	0.604	0.304
SIN	0.487	0.445
SYD	0.866	0.844
Thai-AAT	0.370	0.469
Mean	0.411	0.428

Source: Air Transport Research Society (2003)

Factors influencing productivity performance and VFP Regressions

are affected by a number of factors, including airport characteristics, service quality level, etc. Some of these factors can not be controlled by airport operators, and thus the gross VFP and TFP levels (computed from observed data) may not reflect an airport's true efficiency level.

The Gross VFP levels are affected by many factors, including airport characteristics, service quality level, etc. Some of these factors are beyond the managerial control of airport operators. Thus, the gross VFP provides an indicator of the observed productivity performance, which may not reflect an airport's true efficiency level. Therefore, one should refrain from making inferences on productive efficiency using these gross VFP estimates. For this reason, we use regression analysis to decompose VFP differentials into various sources. Such regression analysis has two objectives: to identify the potential effects of various factors on gross VFP and to compute residual VFP index after removing the effects of these variables on gross VFP. The following factors are likely to influence gross VFP:

- **Airport Size (Output):** If there are economies of scale in airport operations, a larger airport is expected to achieve lower cost and higher VFP than a smaller airport, other things being equal.
- **Average Aircraft Size:** An airport which mostly handles large aircraft is expected to have higher productivity than an airport handling a large number of small aircraft.
- **Percentage of International Traffic**: An airport with higher percentage of its passenger being international passengers is expected to have lower productivity than a comparable airport with lower international passenger proportion.
- **Percentage of Air Cargo in Total Traffic**: An airport with a higher percentage of its traffic being air cargo is expected to have higher productivity than a comparable airport with lower cargo proportion.
- **Capacity Constraint:** Many airports are operating under runway and terminal capacity constraints for various reasons. Most of these reasons are beyond current management's ability to control, such as constraints imposed by regulatory, environmental, and investment funding concerns. However, runway and terminal capacity shortages have effects on productivity and quality of service to users of airport services (delays and inconvenience of

airliners, passengers and shippers). These capacity shortages would increase productivity of capital input while reducing service quality to airlines and other users of airport services.

- **Passenger service levels in and round the airport.** Airlines may incur additional resources and costs to provide better services. Therefore, passenger and other user service levels beyond the congestion delays is likely to influence gross VFP.
- **Non-Aeronautical Business.** Proactive management tends to try to diversify an airport's revenue base by expanding its commercial, and other non-aeronautical business opportunities. Since such business require resource input, it is important to factor into these outputs and inputs in the VFP as was done in our case. It is also important to know what effects, if any, such diversification strategy will have on overall productivity performance of an airport. The share of Non-Aeronautical revenue is used as an indicator of the extent of airports' business diversification.
- **Airline or Independent Company Operated Terminals.** Many airports, especially in the United States and Asia, contract out or lease out the operations of certain terminals to airlines or independent terminal operators. It would be useful to know what effects, if any, such business strategy will have on overall productivity of these airports. A dummy variable is used to indicate these airports.

Since airport size, average aircraft size using an airport, percentage of international traffic, proportion of air cargo in total traffic handled, and capacity constraints are in large part beyond the control of the current airport management, it is fair to remove the effects of these factors on gross VFP measures in order to derive a true indicator for efficiency performance. This calls for computation of the so-called "Residual VFP".

Regression analysis was conducted to examine the effects of these factors on productivity performance, including both controllable and un-controllable factors. The results are presented in Table 3. Note that both the dependent variable (gross TFP1) and all of the explanatory variables, except dummy variables, are transformed into natural logarithm

Table 3 VFP Regression Results

Dependent variable: LVFP = LN(VFP)

	Coefficients	*T-Value*
Intercept	0.035	0.173
Airport Size	0.159	3.264
%International	-0.142	-6.137
%NonAviation	0.413	4.714
Terminal Operators	0.308	3.302
%Cargo	0.151	3.103
Capacity Constraints	0.177	2.816
R Square	0.380	
Observations	196	

*All variables, except the terminal operator dummy, are in logarithmic form.

The results are discussed as follows:

- ***Airport size*** is significant with a positive coefficient, indicating that large airports are expected to have higher 'gross' VFP level..
- ***% International*** has a statistically significant negative coefficient. This implies that the airports with heavy reliance on international passengers are expected to have lower 'gross' VFPs than the average airports. This result is expected because, international traffic requires more services and resources than domestic traffic.
- ***%Cargo*** is statistically significant with a positive coefficient. That is, airports with larger proportion of cargo traffic are expected to have higher VFP, confirming our hypothesis.
- ***%NonAviation*** has a significant positive coefficient, indicating airports with higher share of non-aeronautical revenue achieves higher VFP. This implies that airports with proactive development of commercial opportunities related airport activities appears to be more efficiently manage its productivity than airports who rely heavily on their aeronautical revenue base.
- ***Terminal Operators*** has a significant positive coefficient, indicating that airports would be able to improve their VFP by contracting out or lease out their terminal operations to efficient operators.
- ***Capacity Constraints*** has a significant positive coefficient, indicating that congested airports are likely to have higher VFP.
- ***Average aircraft size*** was originally in the regression, but was found to be statistically insignificant. Thus it was not included in the final regression.

- ***Overall passenger satisfaction***, as measured by IATA's Global Airport Monitor, does not have a statistically significant effect on VFP, implying that improving passenger satisfaction does not necessarily cost the airport more resources. Some perceived improvement of passenger services may be achieved just by taking some proactive steps with the existing staff and resource input.

Residual Variable Factor Productivity

As discussed earlier, the VFP measures reported in Table 2 are observed or gross productivity and are influenced by many factors, thus they may not reflect the true efficiency of an airport. In order to compare productive efficiency of the airports, a 'residual' VFP index is computed, using the regression results in Table 3, after removing the effects of uncontrollable variables (airport size, %international, capacity constraints, and %cargo) from the 'gross' VFP values. Figure 1 reports on the residual VFP. As expected there are smaller variations across the airports when comparing residual VFPs than the variations observed in gross VFPs. This is because some of the gross VFP differentials have been explained away by the variables in the VFP regression. The residual VFP results indicate that Auckland, Christchurch, Sydney are the high performers in Asia Pacific; Copenhagen, Amsterdam, Oslo, and Zurich, Gatwick are the high performers in Europe; and Atlanta, Charlotte, Raleigh-Durham, Vancouver are the high performers in North America.

Summary and Conclusions

This paper measures and compares the productive efficiency of 76 airports in Asia Pacific, Europe and North America, and also examines the effects of various influential factors on airport's productivity performance. The paper chooses to use Variable Factor Productivity (VFP) as an aggregate productivity indicator for the airports for two reasons. First, it is nearly impossible to obtain consistent capital input measures because the airports have different ownership and governance structures, and there is no standardized accounting or reporting system across airports. In addition, airports' capacity expansion and other capital projects are often subsidized, at varying degrees, by various levels of governments. This may distort the measurement of total factor productivity. On the other hand, data on variable input factors can be compiled with reasonable accuracy. Second, in many cases long term investment decisions for capacity expansion are generally beyond airports' managerial control, even for private airports.

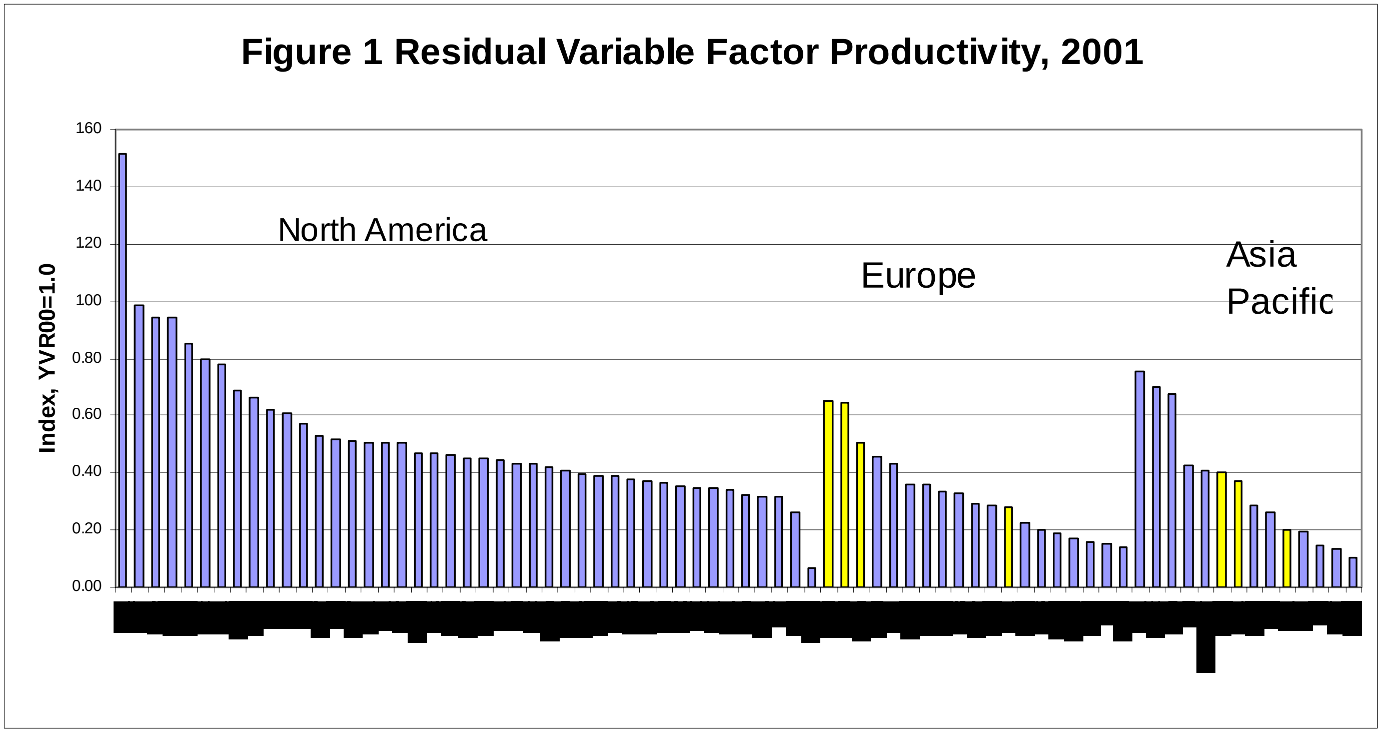

Figure 1 Residual Variable Factor Productivity, 2001

Note that [yellow] indicates 2000 data.

The main results of our research are summarized below.

(a) Larger airports are expected to achieve higher VFP because of the economies of scale in airport operations (Morrison, 1983), not necessarily because they are more efficient than smaller airports;

(b) Airports with a larger percentage of international traffic are expected to have lower 'gross' VFP levels than comparable airports with a lower percentage of international passengers;

(c) Improving passenger satisfaction level does not appear to have any significant negative effect on an airport's productivity;

(d) An airport that diversify and expand their non-aeronautical activities such as concessions and other commercial services are likely to achieve a higher VFP level by taking advantage of the demand complementarity between traffic volumes and commercial services;

(e) Airports with capacity constraints are expected to have higher VFP level although it will impose delays on aircraft and passengers;

(f) On the basis of the 'gross' VFP measures, Christchurch, Sydney, Auckland and Singapore are the high performers in Asia Pacific; Copenhagen, Heathrow, Zurich, Amsterdam, Barcelona, Madrid and Arlanda are the high performers in Europe; In North America, Atlanta, Raleigh-Durham, Charlotte, Indianapolis, Memphis, Phoenix, and Minneapolis/St. Paul are the high performers.

(g) The residual VFPs indicate that Auckland, Christchurch, Sydney are the high performers in Asia Pacific; Copenhagen, Amsterdam, Oslo, and Zurich, Gatwick are the high performers in Europe; and Atlanta, Charlotte, Raleigh-Durham, Vancouver are the high performers in North America

This paper concerns primarily with airports' operating efficiency, which is not necessarily strongly correlated with airports' profitability or financial structure. Nor did this study address the question of airport user charge levels or efficiency or effectiveness of airport security measures and performance. In future studies, these important issues will need to be addressed as well as continuing to measure and benchmark the productive efficiency performance.

Reference

Abbott, M. and S Wu (2002), "Total Factor Productivity and Efficiency of Australian Airports", *The Australian Economic Review*, Vol. 35, No. 3, 244-60.

Air Transport Research Society (ATRS) (2003), *2003 Airport Benchmarking Report: the Global Standard for Airport Excellence*, Vancouver.

Francis G., Humphreys I. and Fry J., 2002. The benchmarking of airport performance, *Journal of Air Transport Management* 8, 239-247.

Gillen D.W. and Lall A., 1997. Developing measures of airport productivity and performance: An application of data envelopment analysis. In: Proceedings of the Aviation Transport Research Group Conference, Vancouver, Canada.

Hooper P.G. and Hensher D.A., 1997. Measuring total factor productivity of airports: An index number approach, *Transportation Research E*, 33 (4), 249-259

Humphreys, I. and G. Francis (2002), "Performance Measurement: a review of airports", *International Journal of Transport Management*, 1, 79-85

International Air Transport Association (IATA) (2002), *Global Airport Monitor*, Geneva.

Martin, J.C. and C. Roman (2001), "An Application of DEA to measure the efficiency of Spanish airports prior to Privatization", Journal of Air Transport Management 7, 149-157.

Martin-Cejas, R.R. (2002), "An Approximation to the Productive Efficiency of the Spanish airports network through a deterministic cost frontier", Journal of Air Transport Management, 8, 233-238

Morrison, S. (1983) "Estimation of long-run prices and investment levels for airport runways" *Research in Transportation Economics* 1, 103-130.

Nyshadham, E.A. and V. K. Rao (2000), "Assessing Efficiency of European Airports", Public Works Management and Policy, Vol. 5. No. 1, October

Oum, T.H., and Yu, C. (1998). Winning Airlines: Productivity and Cost Competitiveness of the World's Major Airlines (Kluwer Academic Press, New York, London; 1998), 240 pages

Parker D., 1999. The performance of BAA before and after privatization, *Journal of Transport Economics and Policy* 33, 133-145.

Pels E., 2000. Airport Economics and Policy, Ph.D. Dissertation, #222 Tinbergen Institute Research Series, The Netherlands.

Pels, E. P. Nijkamp and P. Rietveld (2001), "Relative Efficiency of European Airports", Transport Policy 8, 183-192

Sarkis J., 2000. An analysis of the operational efficiency of major airports in the United States, *Journal of Operations Management* 18, 335-351.

Appendix A: List of Sample Airports

North America - United States		
Airport Code	***Airport Name***	***City, State***
1 ATL	Atlanta William B Hartsfield International Airport	Atlanta, Georgia
2 BOS	Boston Logan International Airport	Boston, Massachusetts
3 BWI	Baltimore Washington International Airport	Baltimore, Maryland
4 CLE	Cleveland-Hopkins International Airport	Cleveland, Ohio
5 CLT	Charlotte Douglas International Airport	Charlotte, North Carolina
6 CVG	Cincinnati/Northern Kentucky International Airport	Cincinnati, Ohio
7 DCA	Ronald Reagan Washington National Airport	Washington, DC
8 DEN	Denver-Stapleton International Airport	Denver, Colorado
9 DFW	Dallas/Fort Worth International Airport	Dallas, Texas
10 DTW	Detroit Metropolitan Wayne County Airport	Detroit, Michigan
11 EWR	Newark International Airport	Newark, New Jersey
12 FLL	Fort Lauderadale Hollywood International	Ft. Lauderadale, Florida
13 HNL	Honolulu International Airport	Honolulu, Hawaii
14 IAD	Washington Dulles International Airport	Washington, DC
15 IAH	Houston-Bush Intercontinental Airport	Houston, Texas
16 IND	Indianapolis International Airport	Indianapolis, Indiana
17 JFK	New York-John F. Kennedy International Airport	New York, New York
18 LAS	Las Vegas McCarran International Airport	Las Vegas, Nevada
19 LAX	Los Angeles International Airport	Los Angeles, California
20 LGA	LaGuardia International Airport	New York, New York
21 MCI	Kansas City International	Kansas City, Missouri
22 MCO	Orlando International Airport	Orlando, Florida
23 MDW	Chicago Midway Airport	Chicago, Illinois
24 MEM	Memphis International Airport	Memphis, Tennessee
25 MIA	Miami International Airport	Miami, Florida
26 MSP	Minneapolis/St. Paul International Airport	Minneapolis, Minnesota
27 ORD	Chicago O'Hare International Airport	Chicago, Illinois
28 PDX	Portland International Airport	Portland, Oregon
29 PHL	Philadelphia International Airport	Philadelphia, Pennsylvania
30 PHX	Phoenix Sky Harbor International Airport	Phoenix, Arizona
31 PIT	Pittsburgh International Airport	Pittsburgh, Pennsylvania
32 RDU	Raleigh-Durham International Airport	Raleigh, North Carolina
33 SEA	Seattle-Tacoma International Airport	Seattle, Washington
34 SFO	San Francisco International Airport	San Francisco, California
35 SLC	Salt Lake City International Airport	Salt Lake City, Utah
36 STL	St. Louis-Lambert International Airport	St. Louis, Missouri
37 TPA	Tampa International	Tampa, Florida

North America – Canada		
Airport Code	***Airport Name***	***City, Province***
38 YEG	Edmonton International Airport	Edmonton, Alberta
39 YOW	Ottawa International	Ottawa, Ontario
40 YUL	Montréal-Dorval International Airport	Montréal, Québec
41 YVR	Vancouver International Airport	Vancouver, British Columbia
42 YYC	Calgary International Airport	Calgary, Alberta
43 YYZ	Toronto Lester B. Pearson International Airport	Toronto, Ontario

List of Sample Airports

	Europe	
Airport Code	**Airport Name**	**City, Country**
44 AMS	Amsterdam Schiphol International Airport	Amsterdam, Netherlands
45 ARN	Stockholm Arlanda International Airport	Stockholm, Sweden
46 BCN	Barcelona El Prat Airport	Barcelona, Spain
47 BHX	Birmingham International Airport	Birmingham, England
48 BRU	Brussels International Airport	Brussels, Belgium
49 CDG	Paris Charles de Gaulle International Airport	Paris, France
50 CIA	Rome Ciampino Airport	Rome, Italy
51 CGN	Cologne/Bonn Konrad Adenauer International	Cologne, Germany
52 CPH	Copenhagen Kastrup International Airport	Copenhagen, Denmark
53 DUB	Dublin International Airport	Dublin, Ireland
54 DUS	Flughafen Dusseldorf International Airport	Dusseldorf, Germany
55 FCO	Rome Leonardo Da Vinci/Fiumicino Airport	Rome, Italy
56 FRA	Frankfurt Main International Airport	Frankfurt, Germany
57 GVA	Geneva Cointrin International Airport	Geneva, Switzerland
58 HAM	Hamburg International Airport	Hamburg, Germany
59 HEL	Helsinki Vantaa International Airport	Helsinki, Finland
60 LGW	London Gatwick International Airport	London, England
61 LHR	London Heathrow International Airport	London, England
62 MAD	Madrid Barajas International Airport	Madrid, Spain
63 MAN	Manchester International Airport	Manchester, England
64 MUC	Munich International Airport	Munich, Germany
65 MXP	Milan Malpensa International Airport	Milan, Italy
66 ORY	Paris Orly Airport	Paris, France
67 OSL	Oslo Airport	Oslo, Norway
68 VIE	Vienna International Airport	Vienna, Austria
69 ZRH	Zurich International Airport	Zurich, Switzerland

	Major City and National Airport Authorities	
Airport Code	**Airport Name**	**City, Country**
ADP	Aeroports de Paris	Paris, France
ADR	Aeroporti di Roma	Rome, Italy
AENA	Spanish Airports and Air Navigation	Spain
Aer Rianta	Aer Rianta	Ireland
CAA-Findland	Civil Aviation Administration of Finland	Finland
CAA-Sweden	Swedish Civil Aviation Administration	Sweden

List of Sample Airports

Asia-Pacific			
	Airport Code	Airport Name	City, Country
70	AKL	Auckland International Airport	Auckland, New Zealand
71	BKK	Bangkok International Airport	Bangkok, Thailand
72	CGK	Jakarta Soekarno-Hatta International Airport	Jakarta, Indonesia
73	CHC	Christchurch International Airport	Christchurch, New Zealand
74	CNX	Chiang Mai International Airport	Chiang Mai, Thailand
75	HDY	Hat Yai International Airport	Hat Yai, Thailand
76	HKG	Hong Kong Chek Lap Kok International Airport	Hong Kong, Hong Kong
77	HKT	Phuket International Airport	Phuket, Thailand
78	ICN	Incheon International Airport	Seoul, Korea
79	KIX	Osaka Kansai International Airport	Osaka, Japan
80	KUL	Kuala Lumpur International Airport	Kuala Lumpur, Malaysia
81	MEL	Melbourne Tullamarine International Airport	Melbourne, Australia
82	NRT	Tokyo Narita International Airport	Tokyo, Japan
83	PEK	Beijing Capital International Airport	Beijing, China
84	PEN	Penang International Airport	Penang, Malaysia
85	PVG	Shanghai Pudong International Airport	Shanghai, China
86	SEL	Seoul Gimpo International Airport	Seoul, South Korea
87	SHA	Shanghai Hongqiao International Airport	Shanghai, China
88	SIN	Singapore Changi International Airport	Singapore, Singapore
89	SYD	Sydney Kingsford Smith International Airport	Sydney, Australia
90	TPE	Chiang Kai-Shek International Airport	Taipei, Taiwan

National Airport Authorities		
Airport Code	Authority Name	Country
ATT	Airport Authority of Thailand	Thailand
PTII	P.T. (Persero) Angkasa Pura II	Indonesia