AN EMPIRICAL INVESTIGATION OF THE EFFECTS OF MANAGERIAL AND OWNERSHIP STRUCTURE ON THE EFFICIENCY OF NORTH AMERICA'S AIRPORTS

by

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ABSTRACT

Over the past several decades, the worldwide trend for airport ownership and management has been a gradual movement towards privatization and away from direct governmental management of airport operations. However, several factors have contributed to privatization not being adopted in North America up to this point. Instead, there has been a movement towards quasi-privatization in the form of not-for-profit/non-share airport authorities. The principal objectives of establishing the authorities are three-fold:

1. To increase operational efficiency
2. To increase the commercialization of airports and become more responsive to user needs
3. To ensure financial self-sustainability of operations

The objective of this paper will be to examine whether there is empirical evidence to support the hypothesis that the airport authority structure achieves these objectives.

The airport industry in North America is characterized by four different managerial structures: Canadian airport authorities, US airport authorities, US city-run airports, and US port-run airports. After discussing the nature of the different managerial structures, 5 measures of productivity and efficiency are employed:

1. Variable Factor Productivity
2. Data Envelopment Analysis
3. Stochastic Frontier Analysis
4. Unit Cost Index
5. Operating Expense per Passenger

The analysis is based on a set of panel data covering 72 airports over the 10-year period from 1996-2005. The efficiency measures obtained are then adjusted for operational factors deemed to be beyond managerial control, in order to obtain an indication of managerial efficiency. Multivariate regression analysis is then undertaken to assess whether efficiency varies according to managerial structure. This study found that there is strong evidence that the authority structure achieves higher operating efficiency, a greater degree of commercialization, and is characterized by more proactive management. It is highly likely that gains in efficiency in the United States could be achieved by a further movement away from city-managed airports towards the airport authority form.

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1 INTRODUCTION

Over the last few decades, the North American aviation industry has undergone substantial changes in terms of the prevailing market structure and operating environment. These changes have been primarily driven by the deregulation of the airline industry, which has had wide-ranging ramifications. The financial environment facing airlines has been altered due to the changes in the competitive landscape between airlines and the evolving nature of airline competition has resulted in changes for consumers in terms of fare levels, service quality, and route offerings. While the changes in airport operations over this time period have not been as dramatic, they warrant consideration due to the important role that airports play in the industry and the public policy implications of airport governance.

1.1 Background

Throughout the world, many countries have privatized some of their airports over the past 10-20 years, and this process is still on-going in many countries. Broadly speaking, changes in the management and ownership of airports have occurred in two distinct phases (Kapur, 1995). In the early 1970s, a number of countries began to create airport corporations under public ownership, with the intent of improving efficiency and initiating access to private capital markets. Then in the 1980s, the role of the state in airport ownership evolved, as a number of countries used the private sector to finance airport investments directly and gain further efficiency improvements. This second wave of private sector involvement introduced privatization to the ownership/management of many airports. In stark contrast to this worldwide trend, however, North American airports have not adopted the privatization of airports. In the United States, and Canada to a lesser extent, the contractual and operational relationship between airports and airlines is a limiting factor against privatization, as in many respects the privatized nature of the airlines coalesces with the airport use agreements between the airlines and airports to serve as a *de facto* means of market discipline. While thus far eschewing privatization, North American airports have, though, in recent years begun to be organized as quasi-privatized airport authorities, although differences remain between Canada and the United States.

Prior to 1995, Transport Canada owned, operated, or subsidized 150 of the 726 certified airports in Canada. While the majority of airports in Canada were locally owned and operated, there was not a clearly defined role for the federal government in regards to the operations of Canada's airports. The Minister of Transport appointed a Task Force in 1985 to examine potential alternatives to the existing centrally-managed airport system, and the task force recommended the establishment of "Local Airport Authorities", and the initial lease agreements were established in 1992. In 1995, the implementation of Canada's National Airports Policy (NAP) began to be phased in over a period of 5 years. Under the terms of the NAP, 137 airports were transferred to private or local concerns, including 26 of Canada's primary airports that accounted for approximately 94% of Canada's passenger and cargo traffic. These 26 airports were classified as the National Airports System (NAS) and were leased to local airport authorities. Transport Canada retained ownership of these airports, but the local 'not-for-profit/non-share capital' authorities have been responsible for the financial and operational management of these 26 airports since that time.

The intent was to create a commercially-oriented system of airports and improve their efficiency and cost effectiveness by improving managerial and financial autonomy (Kapur, 1995). Following is a description of the existing structure of the Canadian Airport Authorities:

> Each authority is a non-profit corporation headed by a board of directors. Members are nominated by local municipalities and other representative local groups, but cannot be elected politicians or civil servants. Profits generated by LAAs are plowed back into future airport improvements, while losses are offset by Transport Canada through a reduction in lease payments. The LAAs are responsible for management, operation, and maintenance, as well as capital investment projects of the airports they lease. This includes runways, terminal buildings, industrial properties, parking, ground transportation, emergency response services, and financial, personnel, and administrative functions. (Kapur, 1995)

While the airport authorities in the NAS may have a different mandate than existed under the previous centrally-managed airport system, it is clear that the LAA structure is a far cry from privatization and the concomitant motivation of profitability.

In the United States, the nature of airport ownership and management has not undergone a watershed transformation akin to that of Canada, and changes have been much more gradual. As opposed to the situation in Canada, the federal government has historically had little direct control over US airports, as ownership has been at the regional or municipal level and cities and counties have typically been responsible for the operation of airports. Over the years, however, airport authorities have become more commonplace, and the management of US commercial airports is currently comprised of three alternate structures: airport authorities, port authorities and city-run departments. US airport authorities are similar in nature to that of Canadian airport authorities, insofar as they are not-for-profit/non-shareholder entities that re-invest retained earnings into future airport development programs and are by-in-large financially self-sustaining. The US also has several airports run by local Port Authorities, whereby the Port Authority operates the local seaport(s) as well as the local airport(s), or the Port Authority has both a 'Port Division' and an 'Airport Division'. Alternatively, many US airports continue to be operated as a separate department within the city's or county's administrative organization.

In examining the nature of airport governance in North America, it is natural to consider the implications that these varying institutional structures have on the operational performance of the airports. How does institutional structure affect the operating efficiency of airports? What underlying factors affect operating efficiency, and what are the relationships between these factors and the different institutional structures?

1.2 Purpose and Significance

The objective of this research will be to examine the effects of managerial and governance form on the efficiency of Canadian and American airports and the associated relationship with the extent of airport commercialization. The National Airports Policy in Canada had an explicit objective of increasing airport efficiency and cost effectiveness, and to strive for a greater commercial orientation, as put forth by Transport Canada in 2001[1]:

> Locally-owned and operated airports are able to function in a more commercial and cost-efficient manner, are more responsive to local needs and are better able to match levels of service to local demands. Recent experiences of the four existing airport authorities ... clearly demonstrate these realities.

By in large, American airport authorities purport to have similar objectives. Now that the NAP has been fully implemented for five years, it is important to evaluate the success of the policy in realizing its objectives. By examining the recent operational performance of North America's airports, insights can be gleaned as to whether the airport authority structure actually achieves these goals relative to the traditional case of government-run airports. The results of such a cross-structural comparison could provide useful information in informing future policy decisions as to the direction that the ownership and management of North America's airports should take. An assessment can be made as to whether the airport authority structure should be retained in Canada, and whether the US should continue to divest government control of airport operations to local airport authorities.

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[1] Retrieved from: http://www.tc.gc.ca/programs/airports/policy/nap/NASImplementation.htm (Date accessed: August 16, 2006)

1.3 Scope

The primary focus of this research will be a positive analysis of the recent performance of North America's major airports and an examination of the factors affecting both the operating efficiency and the cost effectiveness of the airports. After studying the relationship between institutional structures and operating performance, these results will be considered in conjunction with the operating characteristics and strategic decisions of the airports to determine which factors have the greatest effect on operating efficiency and to assess the differences in commercialization between the institutional structures, primarily focusing on the role of non-aeronautical revenues. The secondary focus of this research will be a normative assessment as to the desired structure of airport ownership and management, and potential ways in which the efficiency of North America's airports can be improved in the future. It should be noted that the issue of privatization is beyond the scope of this paper; the research here is more concerned with assessing the relative merits of existing ownership/operating structures. For a detailed discussion of the issue of privatizing North American airports, with an in-depth focus on the United States, see Gesell (1999).

This study involves panel data covering 72 North American airports over the period of 1996-2005. A lack of operational and financial data prior to the implementation of the NAP precluded a direct time series analysis of the effects of the policy in Canada. To compensate, US airports were added to the study in order to ascertain more generally the differences in efficiency and commercialization between city-managed[2] airports and airport authorities. Data collected include: operating revenues, operating expenses, traffic outputs, infrastructure inputs and various operating characteristics. The airports are classified according to four managerial structures, as shown in Table 1.1 and each structure is discussed in Section 3:

Table 1.1 Classifications of North American Airports Included in the Study

	Number of Airports	# of Observations (Airport-Years)
Canadian Airport Authorities	17	140
US Airport Authorities	19	189
US City-Run Airports	28	278
US Port Authorities	8	80
Total	**72**	**687**

[2] Note that throughout this paper the term "city-run" refers to US airports operated at both the city and county level

1.4 Outline and Organization

Section 1 provides an introduction to the objectives of the research and outlines the basis of the study. Section 2 contains a review of the relevant literature related to airport managerial structure and efficiency. Section 3 provides a discussion of the four types of airport structures included in the study and contains a comparison of the characteristics of each of the structures, with a primary focus on the degree of commercialization of the four categories of airports and the role of non-aeronautical revenues. Section 4 examines the operating efficiency, productivity, and cost effectiveness of the airports in order to assess the relative performance of the airports. To do so, five measures are utilized and introduced in turn: a multilateral output/input index number approach, data envelopment analysis, stochastic frontier analysis, and two indices examining operating costs. Section 5 then examines the efficiency results obtained in Section 4 to determine whether differences exist between the efficiency of the four categories of managerial structure. Section 6 concludes with a summary of key findings and suggestions for further research.

2 LITERATURE REVIEW

Across the globe, the interest in the productivity and efficiency of airports has increased in recent years alongside the continuing commercialization and deregulation that many airports and air transport systems have undergone, and this has been reflected in the amount of research being undertaken. Indeed, many studies have been undertaken to assess airport efficiency, representing numerous countries, employing several different methodologies, and reflecting varying research objectives. This section summarizes the relevant literature relating to airport efficiency and managerial and ownership structure.

By analyzing the efficiency of airport operations, inferences can be made in regards to the desirability of various management and ownership structures. By understanding which factors affect airport productivity and benchmarking the relative performance of airports, steps can be taken towards improving future performance. There have been numerous theoretical and empirical papers discussing the measurement of efficiency in the transportation sector, and the airport industry specifically. Oum et al (1992) provide an overview of the issues surrounding productivity measurement in transportation. Doganis (1992) contains a summary of the traditional measures of airport performance and efficiency, with a focus on partial factory productivity measures and "industry-oriented" performance measures. Forsyth (2000) discusses more complete measures of airport performance, including a brief overview of three of the methods employed in Section 4 of this paper (variable factor productivity, data envelopment analysis, and stochastic frontier analysis).

Total factor productivity (TFP) measures have been applied to airports in numerous studies. As discussed in Section 4.3, TFP is an index number approach which aggregates the numerous outputs and inputs of the airport into comparable output and input indices. Hooper and Hensher (1997) use the TFP approach to evaluate the efficiency of 6 Australian airports over the period of 1988-1992. Their approach is not equivalent to that employed in Section 4.3, however; their measure of output was based strictly on deflated revenues and they also included capital inputs[3]. The VFP procedure used in this paper is based on the research developed in Air Transport Research Society (2005) and discussed in Oum et al (2003). These studies have included 50-70 major airports throughout the world, including many of the North American airports in this paper. In addition to benchmarking the relative performance of the

[3] The inclusion of capital inputs results in a 'total' factor productivity approach, as opposed to the 'variable' factor productivity approach employed here.

airports, several regression analyses were undertaken to determine the underlying factors affecting productivity. These studies differ from many others in that non-aeronautical revenue is specified as an output in addition to passengers and aircraft movements.

The most prominent methodology applied in airport productivity studies has been that of data envelopment analysis (DEA), which is introduced in Section 4.4. Data envelopment analysis is a non-parametric approach which estimates an input (or output) frontier based on observed input and output levels, and efficiency is assessed by comparing the observed location of each airport relative to the estimated frontier. Salazar de la Cruz (1999) studied airport efficiency by using panel data from 16 Spanish airports for the years 1993-1995. Outputs in this study were passengers and revenues (total revenue, infrastructure-related aviation revenue, non-infrastructure related aviation revenue, and non-aviation revenue), and total costs were considered the input. The primary focus of this paper was on the level of scale economies of airport operations. Martin and Roman (2001) used DEA to examine the efficiency of 37 Spanish airports in 1997. They used three outputs - passengers, air traffic movements and cargo volume - and three inputs – expenditures on labour, capital, and materials. Gillen and Lall (1997) took a unique approach to evaluating airport efficiency by classifying airport operations into airside (aircraft movements) and landside (passengers handled) functions and estimated the efficiency and productivity for each side via DEA. This study also contained a second-stage analysis in order to examine the performance changes over time and across airports. Data from 21 US airports for the period of 1989-1993 were used, with the main objective being to separate airport operations into various components in order to identify sources of efficiencies.

Nyshadham and Rao (2000) studied European airport efficiency via total factor productivity (TFP) and explored the relationship between TFP and several partial factor productivity measures. Abbott and Wu (2002) studied the efficiency of 12 Australian airports over the period from 1990-2000 using a Malmquist TFP index and DEA, and Martin-Cejas (2002) utilized a translog cost function to evaluate Spanish airport efficiency. These studies provide an indication of the diversity of methods available to study airport efficiency.

Sarkis (2000) employed panel data from 44 major US airports over the period of 1990-1994 to explore operational efficiencies at airports. He constructed various complex DEA models with four inputs (operating costs, number of employees, gates and runways), five outputs (operating revenues, number of passengers, commercial and general aviation movements, and cargo volume), and explanatory variables such as the existence of hub airlines, and multi- or single-airport systems. He found that, on average, efficiencies have increased over the years and that the presence of hubbing and snowfalls strongly affected efficiencies at U.S. airports. In contrast, the type of airport system was not a significant determinant of efficiencies. Although he did not specifically examine the issue of managerial structure effects on efficiency, he did refer to Inamete (1993), which lists a number of factors that can affect airport performance, including: changes in public ownership structure through privatization; contracting out various functions of airports to private organizations; combining government and private airport ownership; increasing autonomy for government-owned airport organizations; creating government holding corporations; commercializing the activities of airport organizations; and creating competitive dynamics by having two or more public airport organizations.

Kapur (1995) reached similar conclusions in discussing different aspects of private and public ownership structures and the differences existing both across countries and within countries. Kapur states that:

> [p]ublicly-owned airports, with a few exceptions, generally have not performed at the same level of efficiency as compared to airports with private sector participation. Reasons contributing to the inefficiency of publicly-owned airports include: political interference in the appointment of management, uneven commercial structures, operational inefficiency resulting primarily from overstaffing and limited commercial orientation...the lack of responsiveness to user needs, and inadequate economic and environmental regulation.

It is also noted that the principal objective for the privatization of airports has been to increase private investment given the scarcity of public funds. Since US airports have access to tax-exempt revenue-backed bonds, this will not be as important of a pressure towards privatization as it is in other countries. Kapur found that worldwide, corporatized airport authorities achieved improved revenue diversification (via an increase in commercialization), increased efficiency and reduced costs via contracting non-essential services and reducing employment expenses.

While there have been numerous papers addressing the efficiency of airports, few have directly addressed the issue of ownership and managerial structures. Parker (1999) examined the efficiency of the BAA airports and the effect that their privatization had upon their efficiency. Using DEA, he found that there was no noticeable impact on technical efficiency subsequent to the privatization of the airports. Conversely, Yokomi (2005) used the

Malmquist TFP methodology and found that almost all of the airports under BAA Plc. achieved increased technical efficiency after privatization.

Tretheway (2001) provides an overview of the different managerial and ownership forms of airports throughout the world, including a discussion of the North American structures. However, there have been only two studies empirically considering differences in efficiency between North American city-run airports and airport authorities. Craig et al (2005) directly considered differences in efficiency between US city-operated airports and US airport authorities. Their study included unbalanced panel data for 52 airports over the period of 1978-1992, and differed from this paper insofar as they did not include non-aeronautical revenue output and they included an (inexact) proxy for capital input. They employed cost function analysis and found that US airport authorities had significantly higher technical efficiency than did the city-run airports.

Oum et al (2006) used variable factor productivity analysis on a sample of major North American, European, and Asia-Pacific airports for the years 2001-2003. They classified the airports according to five different categories of ownership/governance, including North American airport authorities and city departments. Their measure of efficiency is equivalent to the VFP procedure employed in this paper and included non-aeronautical revenues as an output and excluded capital inputs. They found that there was no statistical significance in the difference in efficiency between the two categories of airports. Their study differed in that it used a shorter time frame than this study, and they did not distinguish between Canadian and US airports and they did not isolate those airports operated by ports. Of note, they found significant evidence that airports that focus on commercial activities achieved significantly higher efficiency.

Heaver and Oum (2001) studied the transition of Canada's airports from the federal government to the local airport authorities. As they state,

> [t]he National Airports Policy essentially shifts the cost of running Canada's airports from the federal government (taxpayers) to those who actually use the facilities. Its aim is to improve economic efficiency by applying market discipline to the development and operation of airports and making airports more responsive to the needs of their customers and local communities.

They found that the Vancouver Airport Authority - the first airport to be transferred from Transport Canada - obtained very favourable early reviews, and their case study pointed to high passenger and cargo growth, the attraction of several airlines, increased concession revenues, and proactive airport development. However, they also stated the following:

> However, while the experience in Vancouver (and elsewhere) has been favourable, it is not clear that the current system of accountability is sufficient to guarantee that the airport management will perform well in the long run. The self-regulating mechanism of the Board of Directors may not be sufficient to ensure the long-run success of Canada's commercialization model. The Boards lack shareholders to whom they are accountable. There is concern that Boards may be "captured" by the airport management, may lose sight of responsibilities to gain wide community input and may take advantage of an airport's market position. Some experts argue that the UK-style privatization with the efficient price-cap regulation to discourage abuse of monopoly power is a better solution in the long run than the current Canadian approach.

The authors believed that the NAP would achieve short-run gains, but was not the optimal policy to avoid the exploitation of market power and long-run efficiency gains. It should be noted that the study was not quantitative in nature and was limited in its *ex post* discussion of the results of the NAP implementation.

Wiley (1986) provides a theoretical look at the appropriateness of the airport authority:

> In his 1953 landmark paper, Authorities as a Governmental Technique, presented at the height of this wave of mania for authorities, Austin Tobin provided the following concrete guidelines for determining the applicability of the authority form: (1) there is a task to be accomplished or a service to be performed, which in the judgement of the people as expressed through their government, either could not or should not be performed by private enterprise; (2) large amounts of capital are needed; (3) efficient management with initiative and business imagination is essential; (4) long-range planning must be in the hands of competent business, financial and professional technicians; (5) the task/service must be self-supporting; (6) free from political interference, bureaucracy and red tape; and (7) the scope of the task/service involves areas more extensive than the established boundaries of state and local government.

This viewpoint posits that the authority structure should be advocated only if the majority of these seven conditions achieve a positive response. Tobin warns that "an authority should not be created simply to replace the normal functions of the established bureaus or divisions of government; nor to lull the public into belief that the activity is self supporting when in reality it is subsidized; nor solely as a device to avoid debt limitations."

Overall however, the consensus seems to be that the movement to the airport authority structure should lead to increased efficiency relative to city management, and this sentiment is echoed by Doganis (1992):

> Some governments and municipalities, while maintaining ownership of their airports, have felt that they could be better operated and managed if those airports had greater autonomy. This has been achieved by setting up airport authorities with a specific brief to manage one or more airports...But its primary aim is generally to set up an administration with greater professional skills able to undertake and implement long-range plans while central or local political control is exercised only at the strategic policy level.

The next section will briefly summarize the different managerial structures before attention is turned to evaluating the efficiency of airport operations.

3 DISCUSSION OF MANAGERIAL STRUCTURES

3.1 Section Outline

This section will outline the characteristics of each of the four classifications of airport management structures in North America and will highlight several key differences between the different structures that could lead to differences in efficiency. Prior to examining the efficiency of the airports it is important to understand the operating environment in which the airports exist and to examine potential factors that could affect the efficiency results obtained in Section 4.

3.2 An Outline of the Different Forms of North American Airport Management

There are numerous differences and numerous similarities between the different management structures. The production process of all of the airports is relatively homogeneous; they all use physical capital inputs (runways, terminals, gates, etc) in conjunction with human capital in order to process passengers and facilitate the movement of aircrafts. Differences arise in strategic decisions made by airport operators (for example, the extent to outsource services, the extent to focus on non-aeronautical services, and the amount of marketing employed) and in exogenous factors largely beyond managerial control (the proportion of international passengers, the average aircraft size at the airport, the total number of passengers at the airport, and so forth). Differences in operational processes are likely to be generated by overarching differences in governance form and managerial incentives.

Principal-agent theory postulates that people respond to incentives, and this should be no different in airport operations. Indeed, the profit motive is put forth as the driving force behind efficiency gains achievable with privatization. In the absence of privatization, how effective is the not-for-profit/non-share airport authority structure in providing incentives for airport management to reduce inputs and/or increase outputs? On a spectrum of the degree of managerial incentive, it is difficult to presume where the authority structure would be located between the extremes of bureaucratic public-sector provision and unregulated private enterprise. Related to this, it is important to be cognizant of the fact that the appropriateness of efficiency measures is dependent upon the objectives of the "firms" being studied. The measures of efficiency employed in this study implicitly assume that the airports strive to increase outputs and reduce inputs. This assumption is plausible, but it also potentially overlooks possible objectives such as providing some specified level of service quality, generating regional economic benefits, and so forth. If the objectives of the different airport structures differ systematically, then the efficiency measures obtained may be biased towards one group.

With that said, the objectives of the airports studied appear to be relatively similar across airports: to increase passenger levels, to be cost efficient, to provide commercial services to airport visitors, and to provide high-quality services. The relative focus on each objective may differ somewhat between airports, and may be an underlying factor in differences in perceived efficiency. Each of the managerial structures will now be discussed briefly.

3.2.1 Canadian Airport Authorities

As mentioned in Section 1, all of the Canadian airports were initially centrally controlled at the federal level by Transport Canada. While the majority of airports in Canada were locally owned and operated, there was not a clearly defined role for the federal government in regards to the operations of Canada's airports. In 1992, five Local Airport Authorities were created. The initial results were favourable, and provided the impetus for the National Airports Policy (NAP). In 1995, the implementation of Canada's National Airports Policy (NAP) began to be phased in over a period of 5 years. By 2001, the 26 primary airports were classified as the National Airports System (NAS) and were leased to local airport authorities, and the structure of operations has existed to this day; Transport Canada retains ownership of these airports, but the local 'not-for-profit/non-share capital' authorities are responsible for the financial and operational management of these airports.

Prior to the devolution of federal government control, airport performance was undermined by several factors, including "a large centralized administration and restrictive labour agreements that increased airports' labour requirements." (Canada Transportation Act Review, 2001) With local control, the expectation was that airports would operate in a commercial and cost-effective manner and be more responsive to local needs. The following are some important characteristics of the Canadian airport authority structure:

- Not-for-profit/non-share: all retained earnings are reinvested in the airport to cover operating expenses and to contribute towards capital investment

- Airports lease the airport land under long-term leases with Transport Canada (rental payments are required under certain terms and conditions)
- Board of Directors represent local businesses and community interests: appointed by a standard procedure and chosen to have complementary skills in several areas (aviation, business, law, engineering, etc.)
- High degree of transparency: Board of Directors' backgrounds, compensation and appointment method must be divulged, financial statements must be made public, and competitive tendering of contracts is required
- Mandatory performance reviews every five years
- Airport Improvement Fees (charges levied directly to airport passengers) comprise a substantial portion of airport investment funds: Canadian airports do not have the ability to issue tax-exempt revenue bonds as do the US airports

Overall, there is a noticeable focus on efficiency and commercialization subsequent to the implementation of the NAP. The main difference between the US airports and the Canadian airports, apart from sources of financing, is that there is a unified policy in Canada outlining the requirements and objectives of the Canadian airports, including explicit standards of governance. Such a codified environment is absent in the United States and is manifested in the diversity of governance conditions between US airports. Appendix A.1 contains the Canadian airport authorities included in the study.

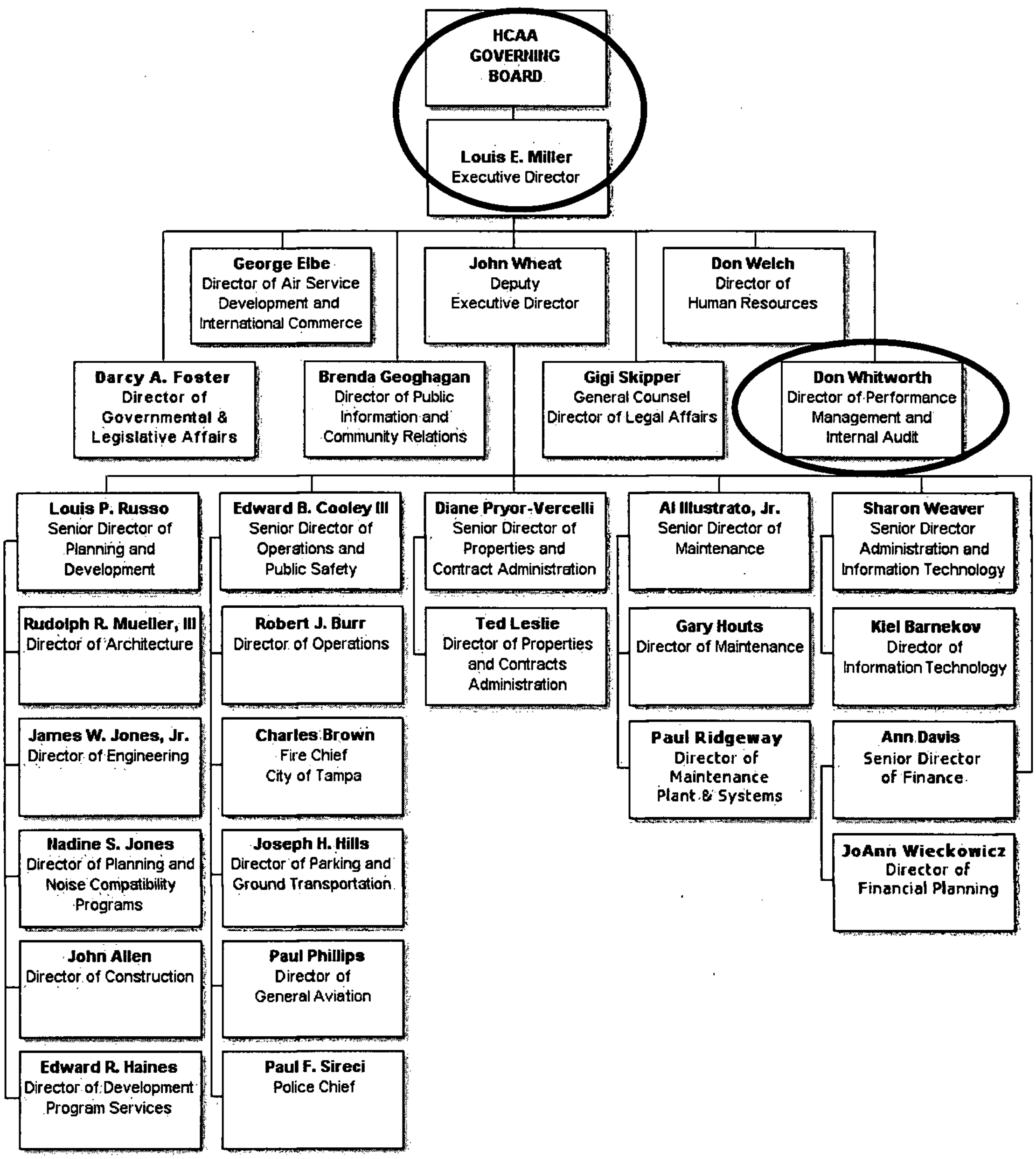
3.2.2 US Airport Authorities

Broadly speaking, the US airport authorities are highly similar to the Canadian authorities. They are also not-for-profit/non-share entities that reinvest retained earnings back into the airport. The US authorities also have a dedicated Board of Governors; however, there are not explicit requirements regarding Board composition and most Board members are not compensated. The most notable differences between the US and Canadian authorities are:

- The US authorities are not governed by a central policy/mandate
- In some cases ownership of the airports is transferred directly to the authority, while in other cases the airport is leased to the authority
- US authorities have the ability to issue revenue-guaranteed bonds to generate investment funds, and have more federal grant money available than do Canadian airports

Overall, the similarities between US and Canadian airport authorities outweigh the differences. An example of a US airport authority's organizational structure is provided in Figure 3.1. Of note is the relationship between the executive director and the governing board, and the existence of a director specifically charged with performance monitoring; this is consistent with the belief that the authority structure emphasises efficiency improvements. Appendix A.2 contains the US airport authorities included in the study.

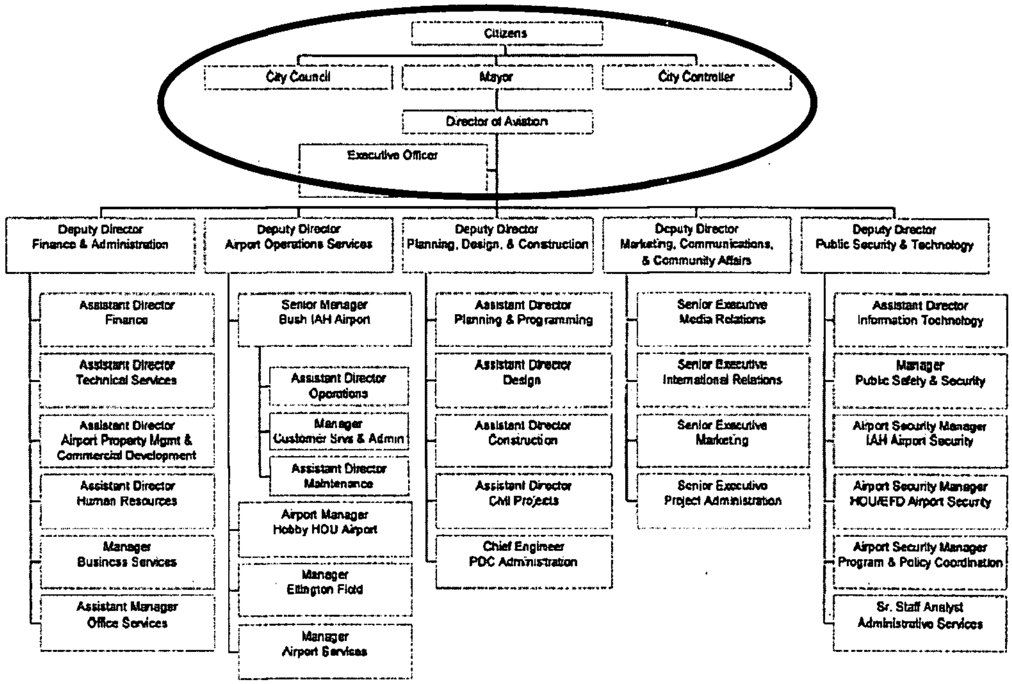
Figure 3.1 Organizational Chart: US Airport Authority (Tampa International Airport)



3.2.3 US City-Run Airports

Unlike Canada, the US continues to have several prominent commercial airports managed by local government departments. In this case, both ownership and management is retained by the government. Further, there are two scenarios. First, the airport may be operated as a component of the city or county's overall budget. Second, the airport may be managed as an enterprise fund of the city/county. In this case, the line between authority and government department is blurred somewhat, as all revenues are reinvested into the airport and it is treated as a self-sustaining operation. In this case, the main distinction is at the governance level; US city-run airports typically report to the local Mayor/Governor and City Council/Board of County Commissioners, for the case of city- and county-run airports, respectively. While some city-run airports have advisory boards, the members are not compensated and have no involvement in the day-to-day operations of the airport. Sources of funding are similar for US authorities and city-run airports. Figure 3.2 provides an illustration of a typical organizational structure for a city-run airport, with the governance relationship highlighted. Appendix A.3 contains the US city-run airports included in the study.

Figure 3.2 Organizational Chart: US City-Run Airport (Houston-Bush Intercontinental Airport)



3.2.4 US Port-Run Airports

The final, and least common, managerial form is that of US port-run airports. These airports were separated from the US authorities and city-run airports in order to try to achieve the highest homogeneity of groups as possible. The port-run airports combine characteristics of both the authority and city-run structures; of the 8 port-run airports in the sample, 5 are managed by port authorities and 3 are managed as government departments. In both cases separate seaport and airport divisions are created and have separate management directors but are overseen by the same governance structure. Since the sample of port-run airports in the study is relatively small, caution should be exercised in drawing any inferences from the results obtained. Appendix A.4 contains the US port-run airports included in the study.

3.3 A Cross-Structural Comparison of Operating Characteristics

While the essential functions performed do not vary greatly between the four groups of airports in the study, there are some differences that exist. These differences take the form of strategic decisions, the nature of the traffic served and other operating characteristics, and the relative input and output mixes employed. Several attributes of the four managerial structures are compared in Tables 3.1-3.8, with the most notable differences being highlighted in turn.

- *Operating revenues*: In terms of the distribution of operating revenues, the most notable difference is in the relative percentage of non-aeronautical revenue generated by the airport groups, as is shown in Table 3.1. The airport authorities, in both the US and Canada, generate a noticeably more significant amount of their operating revenue from non-aeronautical sources. This lends credence to the idea that the authority structure is indeed conducive to a higher degree of commercialization. It is also clear that the US city-run airports and the US port authorities operate at a much higher level of operating revenue, and the Canadian airports have a much greater reliance on levied passenger charges.
- *Operating costs:* As Table 3.2 shows, the scale of operating expenses varies considerably. Somewhat surprisingly, the US city-run airports have a higher proclivity to outsource services than do US airport authorities. In a sense, this would seem to run counter to the intuition of public-sector bureaucracy and private-sector commercialization.

Table 3.1 Cross-Structural Comparison: Operating Revenues

	Operating Revenues - Average Values, 2005			
	Canadian Airport Authorities	**US Airport Authorities**	**US City-Run Airports**	**US Port Authorities**
Number	17	19	28	8
	Distribution			
Landing Fee Revenue	39% (22%)	21%	20%	25%
Terminal Rental Revenue	24% (28%)	20%	27%	22%
Concession Revenue	15% (25%)	19%	21%	11%
Parking Revenue	15% (15%)	24%	18%	15%
Other Revenue	7% (15%)	16%	14%	27%
Total Aeronautical Revenue	63% (51%)	47%	54%	62%
Total Non-Aeronautical Revenue	37% (49%)	53%	46%	38%
	* numbers in parentheses indicate sample averages excluding Toronto (YYZ)			
	Level (2005 $US)			
Landing Fee Revene	25,344,897	24,451,245	30,833,565	71,830,552
Terminal Rental Revenue	15,344,508	22,921,123	42,985,125	65,075,002
Total Aeronautical Revenue	40,689,405	53,476,143	84,929,067	180,588,732
Concession Revenue	9,938,674	21,545,501	33,451,185	30,542,769
Parking Revenue	9,962,244	27,032,540	28,344,057	44,478,643
Total Non-Aeronautical Revenue	23,960,993	60,804,886	72,658,059	109,059,897
Total Operating Revenue	64,650,398	114,281,029	157,587,126	289,648,629
AIF/PFC Revenue	20,115,688	26,280,563	33,938,820	30,588,623
AIF/PFC Revenue per Passenger	3.88	1.44	1.25	1.37

Table 3.2 Cross-Structural Comparison: Operating Costs

	Operating Costs - Average Values, 2005			
	Canadian Airport Authorities	**US Airport Authorities**	**US City-Run Airports**	**US Port Authorities**
Number	17	19	28	8
	Distribution			
% Labour Expense	41%	42%	40%	28%
% Contractual Services	-	24%	31%	19%
% Soft Cost Expense	59%	34%	29%	53%
	Level (2005 $US)			
Labour Expense	10,164,251	29,853,731	41,023,268	50,836,674
Contractual Service Expense	-	17,356,833	31,847,381	34,221,642
Soft Cost Expense	21,044,011	23,819,648	29,727,089	95,059,088
Total Operating Expense	31,208,262	71,030,212	102,597,739	180,117,404

Table 3.3 Cross-Structural Comparison: Profitability

	Profitability - Average Values, 2005			
	Canadian Airport Authorities	**US Airport Authorities**	**US City-Run Airports**	**US Port Authorities**
Number	17	19	28	8
	(2005 $US)			
Operating Income	40,130,564	53,631,013	67,578,803	135,818,720
REVEX Ratio	1.78	2.06	1.94	2.08
Aeronautical Revenue per Passenger	6.3	4.0	4.2	8.0
Non-Aeronautical Revenue per Passenger	5.4	4.8	4.0	5.4
Total Operating Revenue per Passenger	11.7	8.8	8.2	13.4
Operating Expense per Passenger	8.6	5.4	5.6	8.2
Operating Income per Passenger	3.1	3.4	2.5	5.2

Table 3.4 Cross-Structural Comparison: Growth Rates

	Growth - Average Values, 2005			
	Canadian Airport Authorities	US Airport Authorities	US City-Run Airports	US Port Authorities
Number	17	19	28	8
	(1996-2005)			
Annual Operating Revenue Growth	6.5%	4.7%	3.6%	5.2%
Annual Non-Aeronautical Revenue Growth	8.1%	7.0%	3.5%	5.6%
Annual Passenger Growth	3.1%	2.3%	3.0%	2.9%
Annual Aggregate Output Growth	3.1%	3.7%	2.7%	3.1%
Annual Aggregate Input Growth	4.0%	2.4%	2.7%	2.7%
Annual Variable Factor Productivity Growth	-0.3%	1.1%	0.4%	0.5%

Table 3.5 Cross-Structural Comparison: Operating Characteristics

	Operating Characteristics - Average Values, 2005			
	Canadian Airport Authorities	US Airport Authorities	US City-Run Airports	US Port Authorities
Number	17	19	28	8
% International Passengers	18%	4%	8%	14%
% Transferring/Connecting Passengers	10%	25%	26%	12%
Passengers per Movement	30.4	60.2	72.3	80.2
Passenger Share - Dominant Airline	-	37%	44%	33%
Herfindahl-Hirschman Index - HHI (Top 5 Airlines)	-	2156.8	2622.9	1828.9
# of Scheduled Airlines	15.5	22.0	25.2	34.6
# of Non-Stop Destinations	26.5	75.8	83.0	86.1

Table 3.6 Cross-Structural Comparison: Aeronautical Charges

	Aeronautical Charges - Average Values, 2005			
	Canadian Airport Authorities	US Airport Authorities	US City-Run Airports	US Port Authorities
Number	17	19	28	8
	(2005 $US)			
Residual Methodology (%)	-	10 (53%)	18 (64%)	2 (25%)
Compensatory Methodology (%)	-	4 (21%)	6 (22%)	5 (62%)
Hybrid Methodology (%)	-	5 (26%)	4 (14%)	1 (13%)
Aeronautical Revenue per Passenger	4.4	4.0	4.2	8.0
Landing Fee per Movement (per Passenger)	63.6 (2.39)	72.7 (1.23)	88.2 (1.22)	201.5 (2.42)
Terminal Rental per m^2	194.0	193.8	211.7	422.4

Note: Canadian values exclude Toronto (YYZ)

Table 3.7 Cross-Structural Comparison: Traffic Output

	Traffic Output - Average Values, 2005			
	Canadian Airport Authorities	**US Airport Authorities**	**US City-Run Airports**	**US Port Authorities**
Number	17	19	28	8
International Passengers	1,845,019	1,118,384	3,022,129	4,657,492
Domestic Passengers	2,754,106	17,105,055	22,640,503	19,296,137
Total Passengers	4,599,125	18,223,439	25,662,632	23,953,630
Cargo (tonnes)	60,710	201,157	393,245	535,089
Aircraft Movements	99,363	278,217	337,089	301,225

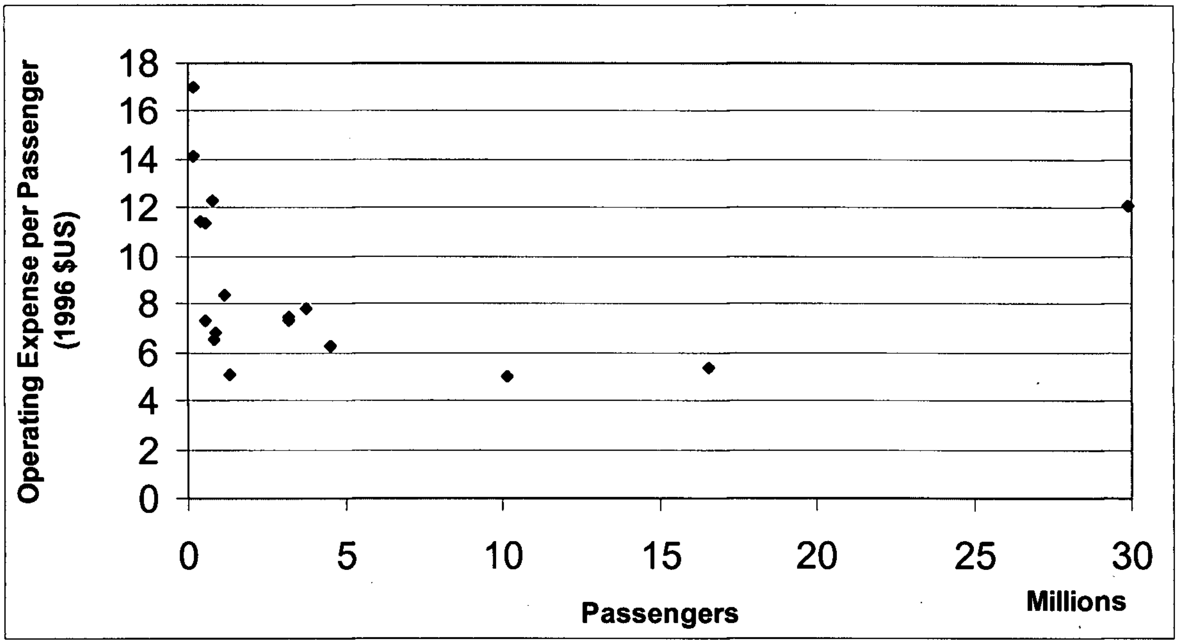
Table 3.8 Cross-Structural Comparison: Physical Infrastructure

	Physical Infrastructure - Average Values, 2005			
	Canadian Airport Authorities	**US Airport Authorities**	**US City-Run Airports**	**US Port Authorities**
Number	17	19	28	8
Runways	2.5	3.4	3.4	2.8
Runway Length (m)	5,969	9,508	9,620	7,712
Gates	20.1	72.2	73.4	70.5
Employees	139.9	475.2	688.7	401.0
Terminal Size (m^2)	59,245	134,568	209,863	185,932

- *Profitability:* As Table 3.3 shows, each of the four groups averaged sizeable operating profits. In general, operating profits were roughly twice the size of operating expenses (as shown by the REVEX ratio). The Canadian airports and the US port authorities had higher aeronautical revenue per passenger, and the authorities generate significantly more non-aeronautical revenue per passenger than do the US city-run airports. The US authorities had lower operating expenses per passenger and a higher operating margin than did the government-run airports.
- *Growth Rates*: Table 3.4 illustrates the growth of various factors over the 10-year period from 1996 to 2005. Of note, the airport authorities had a much higher growth rate in non-aeronautical revenues over this period, with Canadian airports obtaining an 8.1% rate of growth and the US airport authorities obtaining a 7% rate of growth, both in real terms. This again supports the belief that the authority structure leads to a greater degree of commercialization. Passenger growth rates were similar across the groups, and the US airport authorities managed the highest overall growth in VFP.
- *Operating Characteristics*: Table 3.5 shows several operating characteristics of the airport groups. The percentage of international passengers varies noticeably between groups, as does the percentage of connecting passengers and the average number of passengers per movement. The degree of airline concentration is the greatest at US city-run airports; the average airport in this group has 44% of their passengers owing to the dominant airline, while this rate is only 37% for the US airport authorities, and the Herfindahl-Hirschman Index of the top 5 airlines at each airport reflects this trend as well. Finally, the Canadian airport system is much less connected than is the US system; Canadian airports have a lower rate of transferring passengers, fewer scheduled airlines on average, and a smaller non-stop route network.
- *Aeronautical Charges*: As shown in Table 3.6, in the US the type of airline use agreement in place varies by group; the authorities are more likely to use a hybrid methodology than any of the three, the city-run airports are more likely to use a residual methodology, and the port authorities are more likely to use the compensatory methodology. The US airport authorities have the lowest aeronautical charges, while the port authorities have the highest aeronautical charges.
- *Traffic Output:* Table 3.7 summarizes the average traffic output of each group. The scale of output is demonstrably smaller for the Canadian airports, which limits the

comparability with the US airports. For the US airports, the authorities have a smaller average number of passengers, much less cargo activity, and fewer average aircraft movements per year. The scale of output is an important factor to consider in assessing the relative efficiency of the airports. Figure 3.3 plots the average operating costs of the airports against the level of passenger output. This figure shows significant economies of cost savings as output increases up to the level of 5 million passengers. This finding is consistent with Jeong (2005). 14 of the 17 Canadian airports (82%) handle less than 5 million passengers annually, while only 2 of 57 US airports (4%) handle less than 5 million passengers annually. This factor needs to be considered when calculating measures of technical efficiency.

Figure 3.3 Operating Expenses per Passenger at Canadian Airports



- *Physical Infrastructure:* Finally, Table 3.8 provides information on the capital inputs of the airports. The US airports are generally similar in their degree of capital inputs, and are much larger than the Canadian airports in this regard. Interestingly, in addition to having a higher proportion of outsourcing than do the US airport authorities, the US city-run airports also have a higher number of average employees. This is partly due to the larger average size of US government-run airports. The average number of passengers per employee for the four groups in 2005 is as follows:

- Canada Airport Authorities: 26,079
- US Airport Authorities: 35,197
- US City-Run Airports: 41,260
- US Port-Run Airports: 68,301

This again supports the view that US city-run airports rely more heavily on outsourced services.

Figures 3.4-3.11 illustrate some interesting relationships as well. Figure 3.4 shows how both the US and Canadian airport authorities have increased their focus on non-aeronautical revenues over the past decade, and how the US city- and port-run airports have increasingly relied on aeronautical revenue sources and Figure 3.5 illustrates the growth in non-aeronautical revenues per passenger, in real terms. Not only do the authorities have a greater focus on non-aeronautical revenue sources, they have become more effective in exploiting non-aeronautical revenue sources over the years, whereas the city-run airports have stagnated in this regard.

Figure 3.4 Percentage of Non-Aeronautical Revenue: 1996-2005

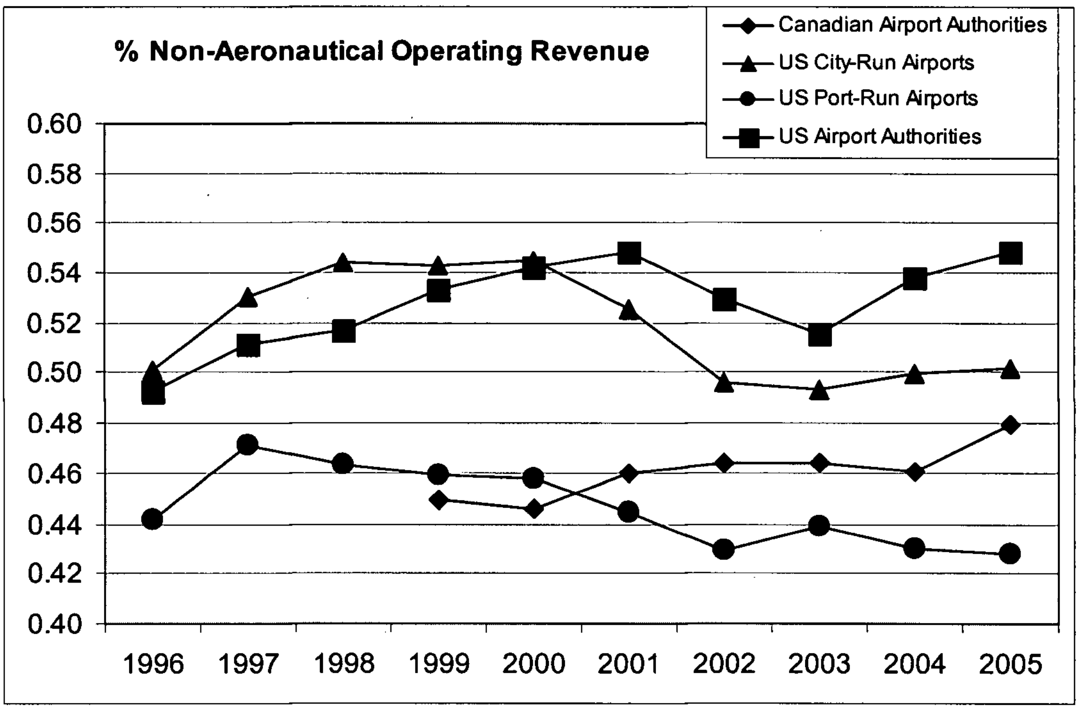
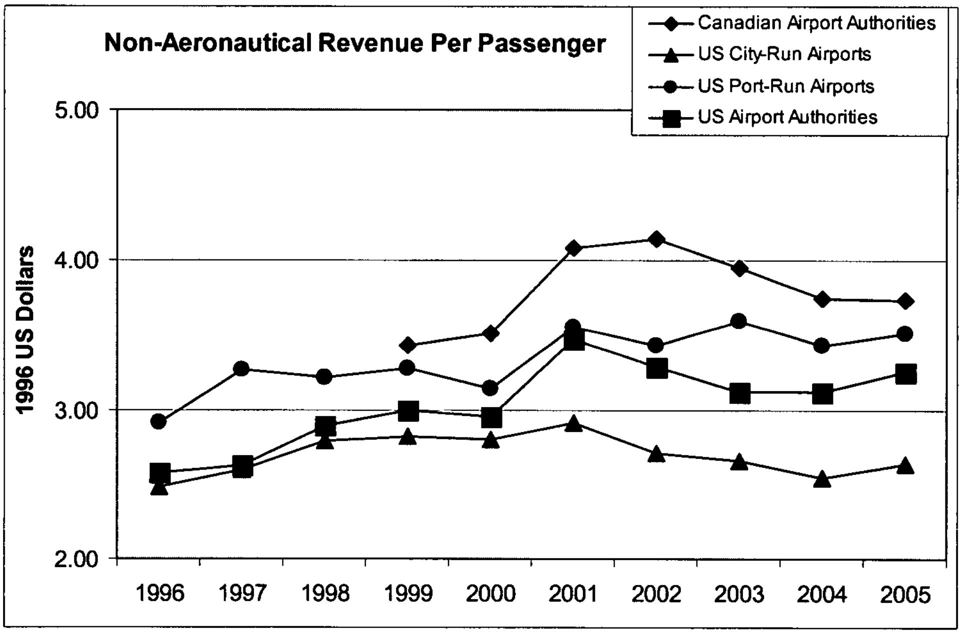


Figure 3.5 Non-Aeronautical Revenue per Passenger: 1996-2005



As Figure 3.6 shows, aside from the port-run airports, the aeronautical charges per passenger have increased slightly in real terms, with no discernable difference between US airport authorities and city-run airports. Figure 3.7 shows the amount of aeronautical revenue per aircraft movement; the relative rankings differ from Figure 3.6 due to differences in average aircraft size operating at the airports (see Table 3.5).

Figure 3.6 Aeronautical Revenue per Passenger: 1996-2005

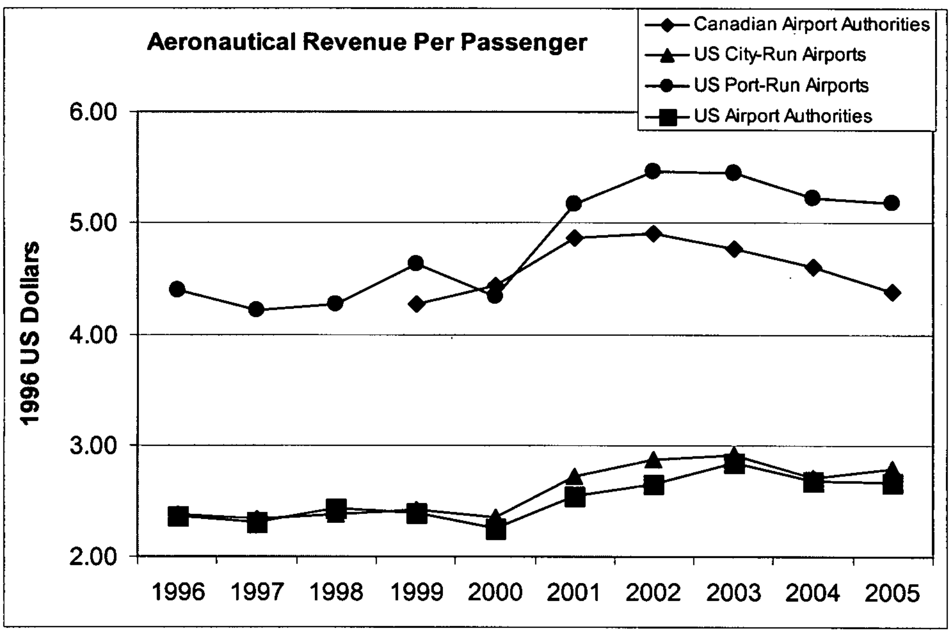


Figure 3.7 Aeronautical Revenue per Aircraft Movement: 1996-2005

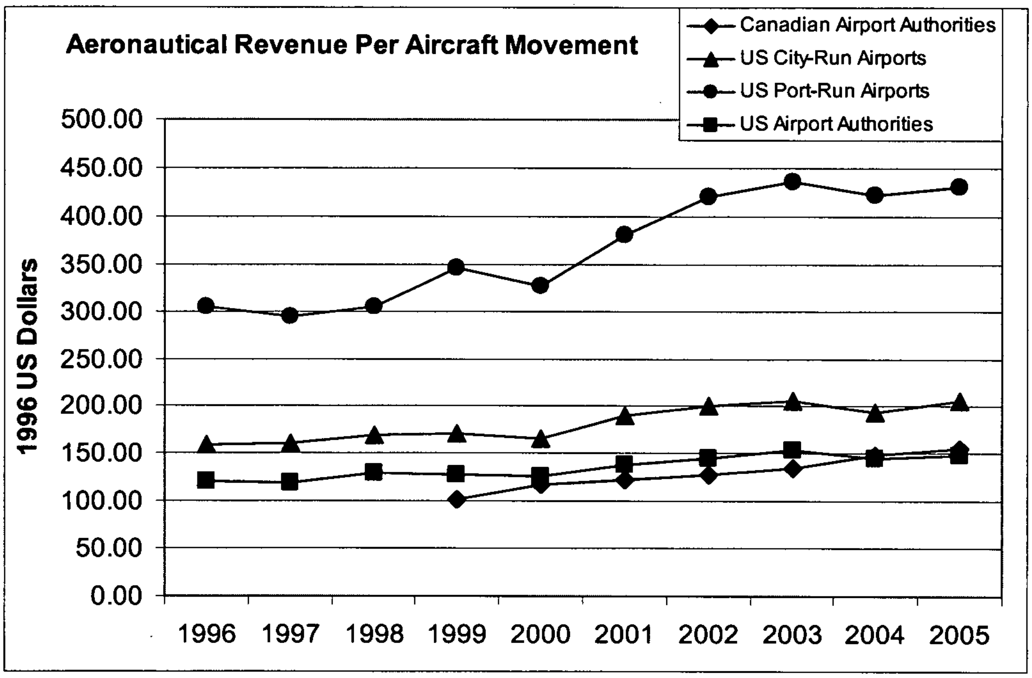


Figure 3.8 Passenger Facility Charges as a % of Operating Revenue: 1996-2005

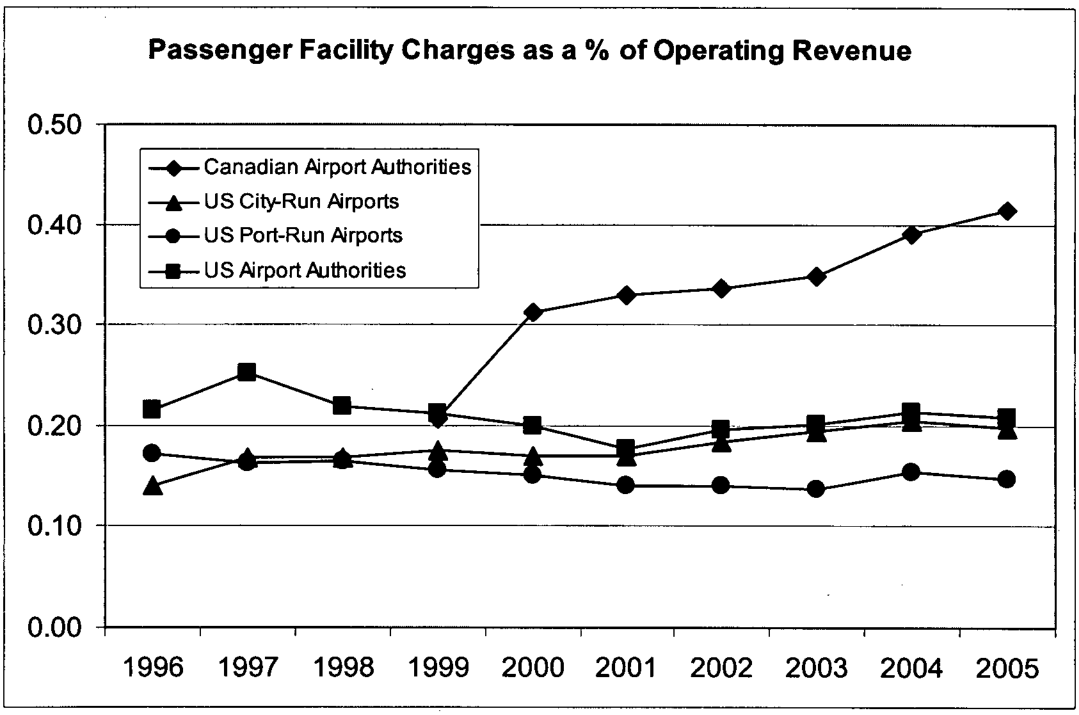
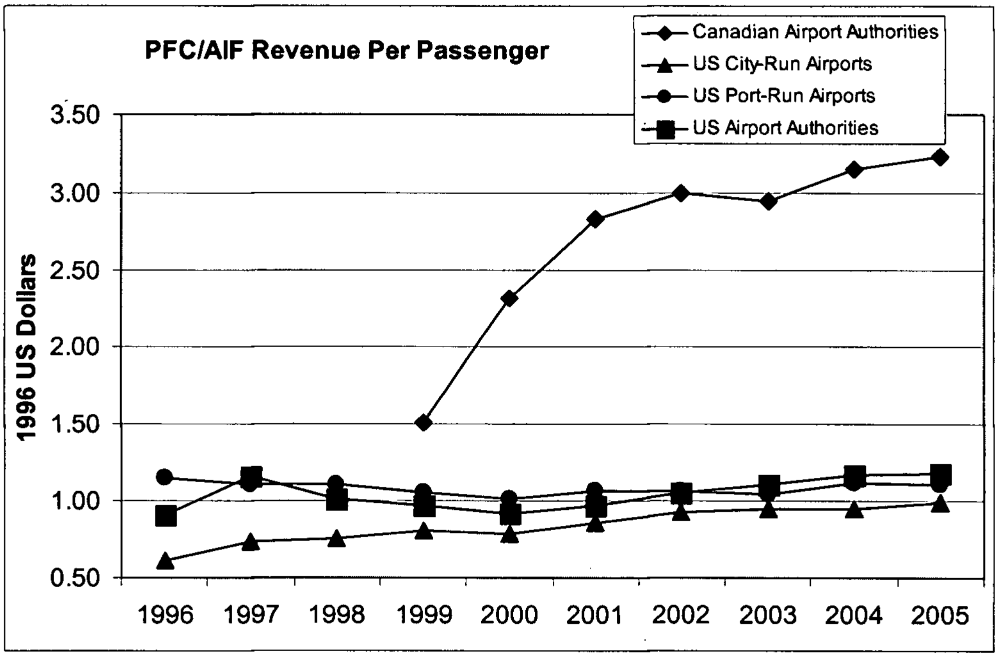


Figure 3.9 Passenger Facility Charges per Passenger: 1996-2005



Figures 3.8 and 3.9 pertain to revenues obtained via passenger facility charges. The differences are negligible between the US airports, but the Canadian airports have a much greater reliance on this source of revenue. In 1999, passenger facility charges were roughly 20% the size of total operating revenues, and this figure exceeded 40% in 2005. These revenues are being generated specifically to fund investment projects at the airports; an intriguing area for future research is the desirability of passenger facility charges and the implications for investment and the efficacy of the governance mechanisms in place to facilitate optimal investment decisions.

Figure 3.10 shows how operating expenses per aircraft movement changed over time. Interestingly, each airport group exhibited a decrease in cost efficiency, in real terms. Comparing Figure 3.10 with Table 3.3 provides an interesting result; Canadian airports are the least cost effective on a per passenger basis, but are the most cost effective on a per aircraft movement basis. This reinforces the fact that different measures can provide very different results. According to this measure though, US airport authorities are again more efficient that US city-run airports. Finally, Figure 3.11 compares the profitability per passenger of the airports. There has been little change over the past years, and the US airport authorities are slightly more profitable than are US city-run airports.

Figure 3.10 Operating Expense per Aircraft Movement: 1996-2005

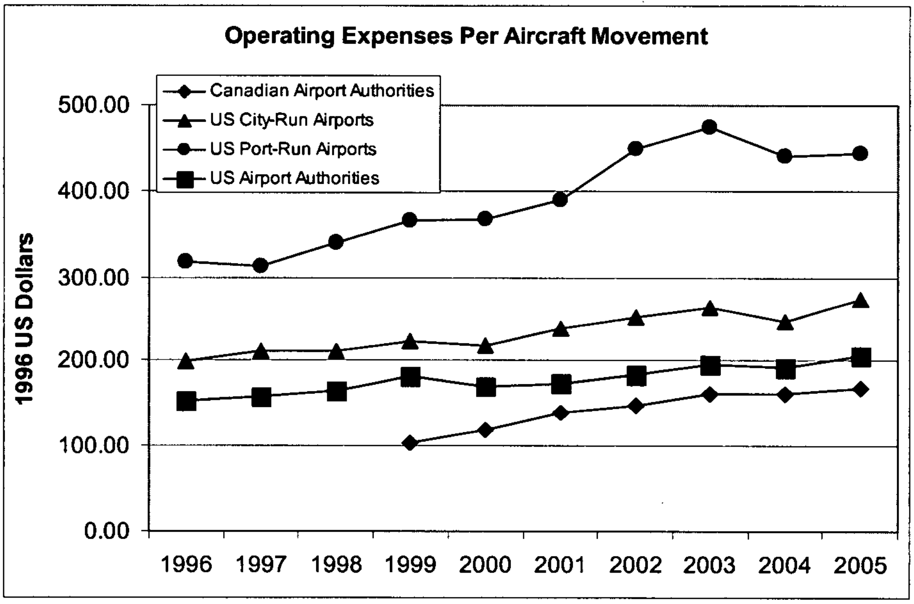
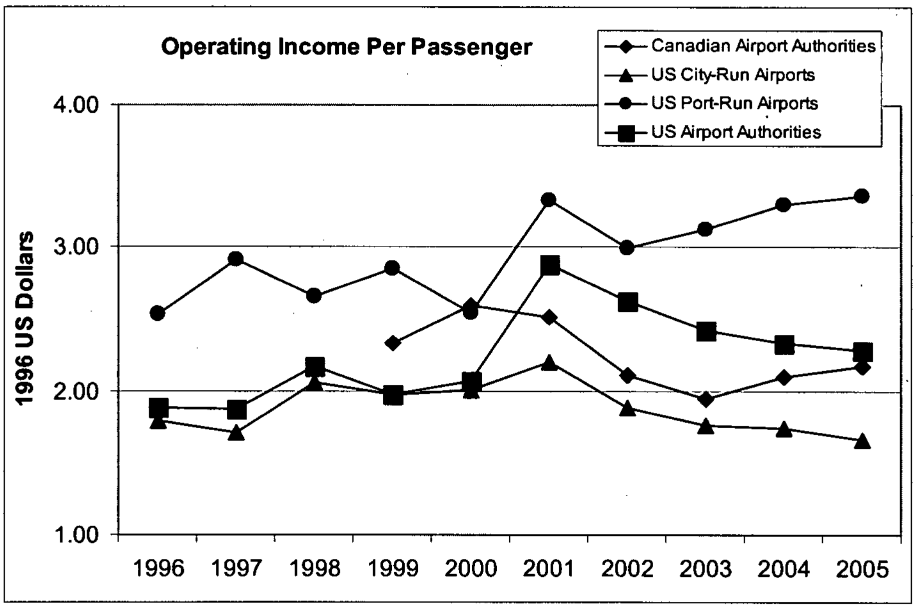


Figure 3.11 Operating Income per Passenger: 1996-2005



This section has served to illustrate that there are several important differences in the operating characteristics of the different airport groups. Of special interest is the strong evidence that the airport authority structure does indeed result in a higher degree of commercialization. Graham (2003) discusses the recent emphasis on non-aeronautical revenue sources:

> There have been a number of factors which have contributed to the growth in dependence on non-aeronautical revenues. First, moves towards commercialization and privatization within the industry have given airports greater freedom to develop their commercial policies and diversify into new areas. A more business-oriented approach to running airports has also raised the priority given to commercial facilities. Such facilities were traditionally considered to be rather secondary to providing essential air transport infrastructure for airlines. Managers are now eager to adopt more creative and imaginative strategies and to exploit all possible aeronautical and non-aeronautical revenue generating opportunities.
>
> Greater attention began to be placed on the commercial aspects of running an airport such as financial management, non-aeronautical revenue generation and airport marketing. The operational aspects of the airport traditionally had overshadowed other areas and most airport directors and senior management were operational specialists. However, the commercial functions of an airport gradually were recognized as being equally important and, as a result, the resources and staff numbers employed in these areas were expanded.

The airport authorities have a greater focus on non-aeronautical revenue sources, which is reflective of a proactive approach to airport management. Oum et al (2006) found a strong relationship between airport commercialization and efficiency; Section 4 will turn to measuring the efficiency of the airports and Section 5 will examine whether the airport authority also achieves its other primary objective – increased efficiency.

4 EVALUATION OF EFFICIENCY AND THE EFFECTS OF INSTITUTIONAL FORM

4.1 Section Outline

As discussed in the literature review, there have been several studies related to the efficiency of airports. The studies have utilized various techniques to measure efficiency and have had varying objectives in doing so. This section will now turn to estimating the efficiency of the major airports in North America. This is a worthwhile objective in and of itself, as it is necessary to first ascertain *which* airports are efficient before it can be determined *why* these airports are efficient. This section begins with a discussion of the data used throughout the study. Five methodologies are subsequently introduced and applied in turn in order to estimate the efficiency of the airports in the study. Multiple measures of efficiency are used in order to provide a more accurate assessment of the underlying productivity of the airports; it has been established that empirical efficiency results may vary between different methods of analysis (Oum et al, 1999) and the section concludes with a brief comparison of the results between the different methods.

As mentioned at the outset, a key impetus of Canada's National Airports Policy was the belief that a shift to the Airport Authority structure would increase operating efficiency. A common notion is that government bureaucracy is associated with X-inefficiency, so it is worthwhile to examine whether this notion holds in the case of airport operations. To test this hypothesis, several complementary methodologies will be employed. The technical efficiency of airport operations will be measured by three different procedures:

1. multi-lateral index number approach
2. data envelopment analysis
3. stochastic frontier analysis,

and an analysis of the cost effectiveness of the airports will also be employed:

4. unit cost index number approach
5. operating expenses per passenger

In some respects, productivity analysis remains a nebulous concept, insofar as the very definition of productivity is often the subject of debate, in addition to the lack of a universal agreement as to which methodologies provide the "correct" computation of productivity, however it may be defined. Generally, productivity is defined as the ratio of outputs to inputs, or the rate at which inputs are transformed into outputs. In the case of a firm with a single input and a single output, the calculation of productivity is relatively trivial. But when a firm produces multiple outputs from multiple inputs, as is the case with the airport activities examined in this paper, the computation of productivity is not nearly as precise and poses several computational and philosophical barriers.

The literature concerning productivity analysis is expansive, and continually evolving. Many approaches to measuring productivity analysis have been developed, with a substantial variation in the underlying assumptions involved, the data required, and the transition from theory to practice. As mentioned above, productivity can be thought of as the ratio of outputs to inputs or the productive output per unit of input. When productivity improvement is considered, two viewpoints can be taken. First, productivity can be increased by increasing the output of the firm relative to a constant (or decreased) level of inputs. Second, productivity can be increased by decreasing the input of a firm required to produce a given (or increased) level of outputs. This is an important distinction that will be brought to bear in a subsequent section of the paper.

Assessing the productivity of airports is an important endeavour. Below are some motivating factors for assessing productivity:

- Managerial performance can be evaluated
- The "best practices" of the airports determined to be efficient can be replicated by less efficient airports
- In an industry that exhibits public-sector involvement, such as the airport industry, productivity analysis can be used as a monitoring device
- The sources of efficiency and the causes of productivity changes (both improvements and declines) can be investigated
- The efficacy of various operational and institutional policies can be evaluated

The above factors are not an exhaustive list of the reasons for undertaking productivity analysis, but are intended to convey the relevance of the issues discussed throughout this paper.

4.2 The Data

As shown in Table 1.1, the study contains 72 airports that are categorized according to four ownership/management forms. The data form an unbalanced panel covering the years

1996-2005 and contain 687 observations in total. The following sources were utilized in obtaining the relevant data:

- Airport websites and annual reports
- US financial data: FAA Airport Financial Reporting website
- Statistics Canada
- Bureau of Transportation Statistics
- Airports Council International – North America
- Direct correspondence with airports

This section will briefly discuss the various outputs and inputs that are used throughout this study.

4.2.1 Outputs

Traditionally, the outputs of airports have been considered to be passengers, freight and aircraft movements. This viewpoint has focused on the role of the airport as a node within the transportation network that facilitates the movement of passengers and freight. Certainly, this can still be seen as the inherent reason for the existence of airport infrastructure. However, when the activities of an airport are considered from the airport operator's point of view, this conception of output is incomplete. In considering the activities of airport operators in recent years, it is apparent, from both words and action, that non-aviation related activities have become an increasingly important component of airport operations. Providing passengers and local residents with commercial services has been a central component of airport marketing activities and development initiatives. The issue of airport commercialization was addressed in greater detail in Section 3, but it suffices here to introduce the inclusion of non-aeronautical output in the study.

Three outputs of airport operations are included in this study:

- *Passengers*: The number of passengers utilizing an airport is generally the central output when considering airport operations. The figures in this paper include both enplaning and deplaning passengers on both domestic and international flights, calculated on an annual basis.

- *Aircraft Movements:* Another output to be considered is the number of commercial aircraft movements occurring at the airport. This measure includes both landings and takeoffs; general aviation and military operations were removed from the data.
- *Non-Aeronautical Revenue*: The final output considered is non-aeronautical revenue, generally in the form of food and beverage sales, retail activities, rental car services, other concession-type services, land and property revenues, and parking revenues, which are particularly significant for North American airports given the strong reliance of most North American cities on the private automobile. Commercial activities at airports have taken on increasing importance over the years, as the contribution of commercial activities towards financial success has been documented. Indeed, many airports have attempted to improve efficiency and reduce the fees charged to airlines in order to attract additional flights to the airport and spur commercial activities.

An explanation as to why cargo/freight handled at the airport is not included as an output is as follows. Traditionally, both passengers and freight have been viewed as the primary outputs of an airport. However, the operations of North American airports differ from most airports in regard to cargo. At the majority of US airports, cargo is transported primarily in the belly of passenger flights, and is by in large handled by the airlines, third-party cargo handling companies, and others that lease space and facilities from airports (Oum et al, 2006), so there is little overall participation from the airport operator. To examine the importance of cargo output to the airports in the study, the operating revenue of the airports was regressed against the number of international passengers, the number of domestic passengers, and the volume of cargo handled by the airports. The results are displayed in Table 4.1.

The coefficients reported in Table 4.1 can be interpreted as the marginal revenue of each of the measures of traffic volume[4]. As expected, international passengers have a higher marginal revenue value than do domestic passengers, at $18.62 and $2.22 respectively[5], and both results are strongly statistically significant. On the other hand, the marginal revenue of cargo is not statistically different from zero, supporting the view that cargo volume is not an

[4] Note that the model presented is likely not representative of the complete revenue function of the airports; it is intended to assess the relative importance of passengers and freight to the airports in the study
[5] Figures are in 1996 $US

important element of North American airport operations and thus does not need to be considered as an output when analyzing the efficiency of North American airports.

Table 4.1 The Marginal Revenue Contribution of Traffic Output

Dependent Variable: Operating Revenue

	Coefficient	Standard Error	*t*-stat
Intercept	2.481E+07	2.723E+06	9.111
International Passengers	18.619	0.8136	22.890
Domestic Passengers	2.234	0.1572	14.210
Cargo	7.998	8.526	0.938
R^2	0.7933		
Adjusted R^2	0.7924		
Observations (n)	687		

4.2.2 Inputs

Relatively speaking, the outputs of an airport are more easily identified and measured than are the inputs. Not only are there theoretical difficulties in determining the correct measure of input usage, there are serious pragmatic limitations in obtaining economically meaningful input data. In the present study, three principal categories of inputs are identified and briefly discussed:

- *Labour input:* Labour input can be measured in two ways. One, the number of employees (full-time equivalent) employed directly by the airport operator, and two, the expenditures upon those employed directly by the airport and its management, including wages, salaries, benefits, and so forth. It is important to note that this does not include outsourced labour services. The amount of outsourcing varies by airport, and the expenditures on such activities are included in the soft cost expenditure value.
- *Soft cost expenditures:* This category is representative of all operating expenses (variable costs) exclusive of labour expenditures, financing costs, and capital costs. It is a residual figure that, in the case of airports, generally includes contractual services (outsourcing), materials purchases, utilities and maintenance expenditures, marketing costs, and so on.
- *Capital assets*: Physical/capital assets are a significant input into the operations of airports. Although airports have a service component, the production of airport output is inherently infrastructure intensive. An analysis of airport productivity is incomplete

without incorporating capital usage. However, there are many serious impediments to the comparison of capital inputs between airports. Doganis (1992) contains a pertinent discussion of this issue. Ideally, a complex capital input index representing economic depreciation would be constructed to account for the capital input of each airport (see Christensen and Jorgensen (1969) and Diewert (1980) for the theory underlying capital input measurement), but the data required is prohibitive for this study. Accounting depreciation is used as a proxy for capital input usage in many studies; however, the method of computing accounting depreciation varies significantly across airports, and reliable measures were not readily available and thus would provide little probative value. Another approach to measuring capital asset inputs is to directly include the physical assets of each airport. Available data for this study include:

- the number of employees directly employed by each airport's operating authority,
- the number of gates,
- the number of runways and total runway length (measured in metres), and
- the total terminal size (measured in square metres) of each airport.

While these figures are useful in understanding the operations at each airport, they are very crude indicators of capital usage, because they fail to provide information on the quality of the assets, the age of the assets, and the cost of usage of these inputs.

Further complications in measuring expenditures on capital infrastructure and facilities include the fact that airport infrastructure is discrete in nature (Oum and Zhang, 1990), the investment period is extended over many years, and the lead-time for new projects is also very long. In the United States, many airports also have capital assets that have been financed directly by the airlines[6], and the amount of government subsidization, the sources of financing/debt, and the tax rates facing airports are heterogeneous across the sample.

As a result, the focus on efficiency in this study will primarily regard capital inputs as fixed, and efficiency will be estimated in relation to the existing level of capital inputs. It is important to be cognizant of the fact that observed operating costs are a function of the underlying capital inputs, and as such, the efficiency results in this study are incomplete.

[6] For example, United Airlines has its own terminal at Washington Dulles International Airport (IAD), Continental Airlines financed a terminal at Houston-Bush International Airport (IAH), and Delta Airlines financed a terminal at John F. Kennedy International Airport (JFK).

Ideally, the efficacy of the various operating structures would be assessed according to both operating efficiency as well as capital investment decisions. Given the substantive nature of airport investment decisions, welfare gains from socially optimal investment decisions are likely a greater magnitude than are gains obtainable from improvements in operating efficiency. The issue of airport investment and the governance implications and incentives of the various operating structures has significant implications for public policy, and is an intriguing area for further research.

Finally, it should be noted that the financial data used in the study has undergone adjustments to facilitate comparisons. Canadian figures have been adjusted by the World Bank's Purchasing Power Parity (PPP) index to normalize financial values between the two countries. Then both the US and Canadian data were adjusted by the Consumer Price Index (CPI)[7] to account for inflation over the study period. Thus, financial data is measured in 1996 $US, unless indicated otherwise, and changes observed over time can be regarded as real-value changes. After briefly addressing the potential limitations of the study, the remainder of Section 4 is devoted to developing the models used to estimate the efficiency of the airports.

4.2.3 Study Limitations

Before proceeding with the estimation of efficiency, it is important to address the potential limitations of the study. The primary limitation is the failure to include capital inputs in estimating efficiency. The production function of an airport can be considered as follows:

$Output = f(l, sc; \bar{o}, k)$ where

l = labour

sc = soft costs

$\bar{o}$ = vector of operating characteristics

k = capital inputs

Data regarding labour and soft costs is available, and efficiency results obtained can be adjusted if necessary to account for differences in operating characteristics between airports. However, the present study does not account for capital inputs. This can present a problem in three instances:

1. It treats the level of capital as fixed, $\bar{k}$: this may not be an appropriate assumption over a 10-year period

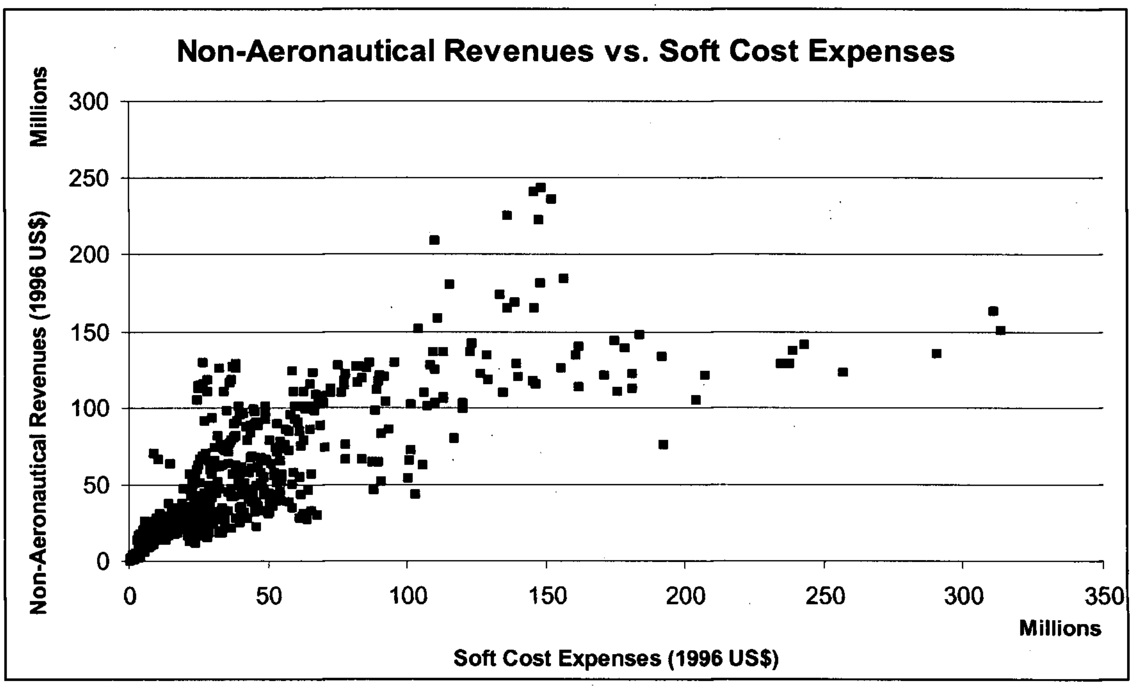
[7] The CPIs were obtained from the Bureau of Labour Statistics (BLS) and Statistics Canada, respectively.

2. It fails to determine whether the level of capital employed is optimal, k^*: as mentioned previously, an important factor in assessing the merits of the different managerial structures is determining how effective each structure is at investing in the optimal level of infrastructure
3. It does not account for differences in the capital usage between airports, in terms of quantity and/or quality, $k_i \neq k_j$: this may bias the efficiency results towards airports with higher levels of capital inputs if there are economies of scale in capital inputs

As such, this study estimates variable operating efficiency, and in some respects reflects of efficiently the airports are able to use their existing levels of capital. A more accurate assessment would include capital inputs.

Another potential limitation of the study is that it does not control for variances in input prices facing the airports. An adequate input price index was not readily available to normalize expenditures across airports. Ideally, a producer price index would be used to control for input prices and a consumer price index would be used to control for output prices facing the airports. However, this limitation may be minimal due to the fact that non-aeronautical revenues (an output) correlate strongly with soft cost expenses (an input), as shown in Figure 4.1. Therefore, any differences in the price levels between airports may largely cancel out.

Figure 4.1 The Correlation Between Input and Output Price Levels



4.3 Multilateral Output/Input Index Number Analysis

Given the multiplicity of inputs and outputs accompanying airport operations, aggregation is necessary in order to obtain a holistic view of airport productivity. Theoretically, however, this is not a trivial matter. For instance, how does one combine output in physical measurements (the number of passengers and the number of aircraft movements) with output in financial measurements (non-aeronautical revenue) to obtain a valuation of total output? There are a large number of approaches that vary in their method of aggregation to produce output and input index numbers.

4.3.1 Variable Factor Productivity Index Number Background and Derivation

In this paper the (flexible) translog functional form is used in order to provide aggregate output and input indices. By dividing the aggregate output index by the aggregate input index, one obtains a measure of the airport's productivity. Since capital inputs are not included in the calculations, it is a variable measure of productivity, as opposed to a measure of total factor productivity incorporating capital inputs.

The methodology used in this paper was first proposed by Caves, Christensen, and Diewert (1982). The translog multilateral output index, $\ln\delta^*_{kl}$, is defined by Caves, Christensen, and Diewert as:

$$\ln\delta^*_{kl} = \overline{\ln\delta_k} - \overline{\ln\delta_l} = \frac{1}{2}\sum_i (R_i^k + \overline{R}_i)(\ln Y_i^k - \overline{\ln Y_i}) - \frac{1}{2}\sum_i (R_i^l + \overline{R}_i)(\ln Y_i^l - \overline{\ln Y_i})$$

The index is formed by an exhaustive series of binary comparisons between the observations of each airport and the sample mean, with the result being a transitive set of comparisons across all observations. Y_i^k represents the i^{th} output (i = 1,2,3) for the k^{th} airport (k = 1,2,3,…,72) and R_i^k representing the revenue share of the i^{th} output for the k^{th} airport. $\overline{R}_i$ and $\overline{\ln Y_i}$ represent the arithmetic mean of the revenue share of the i^{th} airport across the sample and the geometric mean of the output of the i^{th} airport across the sample, respectively.

In words, the translog multilateral output index is computed by normalizing the logarithm of the three outputs (passengers, aircraft movements, non-aeronautical revenue) relative to the mean value of the airports in the study and then aggregating these relative outputs based on their respective share of total operating revenue in order to provide a measure of total output relative to the other airports in the sample.

Analogous to the output index above, Caves, Christensen, and Diewert also specified a translog multilateral input index, $\ln \rho_{kl}^{*}$, as:

$$\ln \rho_{kl}^{*} = \overline{\ln \rho_k} - \overline{\ln \rho_l} = \frac{1}{2}\sum_n (W_n^k + \overline{W}_n)(\ln X_n^k - \overline{\ln X_n}) - \frac{1}{2}\sum_n (W_n^l + \overline{W}_n)(\ln X_n^l - \overline{\ln X_n})$$

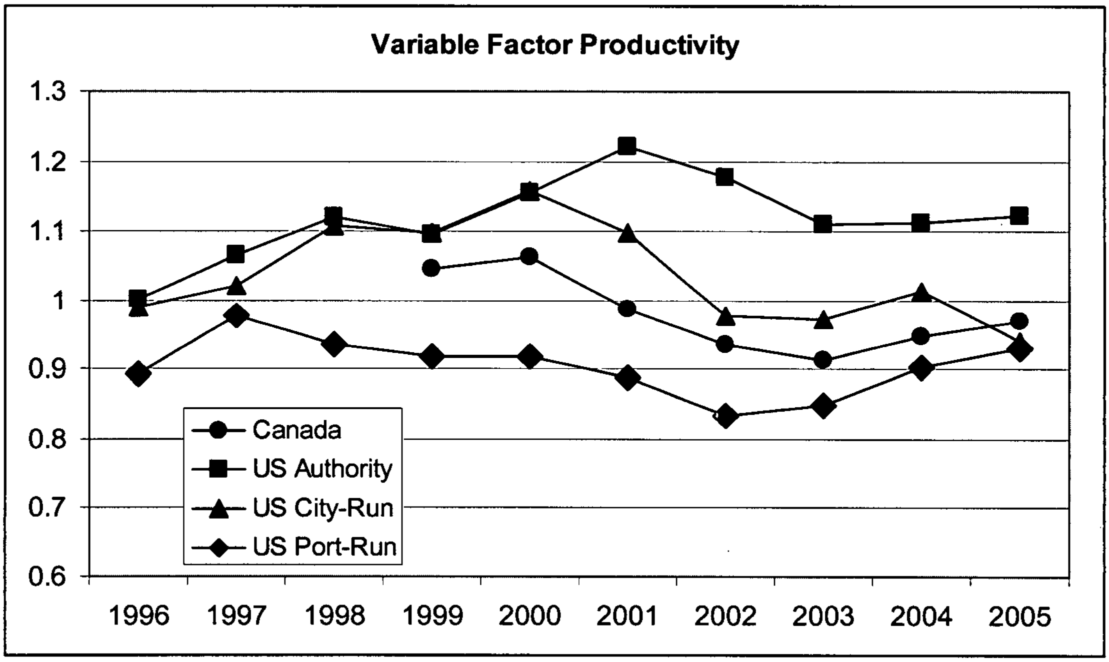
whereby X_n^k represents the n^{th} input (n = 1,2) for the k^{th} airport (k = 1,2,3, ...,72), W_n^k is the cost share of the n^{th} input for the k^{th} airport, $\overline{W}_n$ is the arithmetic mean of the cost share of the n^{th} input over the airports in the sample, and $\overline{\ln X_n}$ is the geometric mean of the n^{th} input over the airports in the sample. The intuition is equivalent to that of the output index above; in order to compute the translog multilateral input index, the two inputs (labour input and soft cost expenses) are aggregated based on their share of total operating costs, in accordance with the formula mentioned above, to provide an aggregate measure of variable inputs.

Once the aggregate output and input indices are computed, the variable factor productivity (VFP) of the airports is tabulated by dividing the output index by the input index, such that $\ln VFP = \frac{\ln \delta_{kl}^{*}}{\ln \rho_{kl}^{*}}$.

4.3.2 Variable Factor Productivity Index Number Efficiency Results

The VFP results are illustrated in Figure 4.2 where the mean VFP values for each operating structure are shown for the study period. As can be seen, the US airport authorities had the highest average VFP value throughout the 10-year period, generally followed by the US city-run airports, although the results between the city-run airports, the port authorities, and the Canadian airports converged in recent years. Of note is the systematic decrease in productivity found in 2001/2002 due to the 9/11 attacks (there was an industry-wide decrease in passenger outputs and an increase in operating expenses), and the subsequent rebound in productivity that occurred in 2003-2005. Detailed analysis of the factors affecting VFP is contained in Section 5. The rankings of individual airports according to VFP are shown in Appendix A.5.

Figure 4.2 Mean VFP Results by Airport Managerial Structure



4.4 Data Envelopment Analysis

The second method of productivity analysis employed in this paper is that of data envelopment analysis (DEA). DEA is a well-developed procedure, and for the sake of brevity, the derivation will not be provided here. This mathematical programming methodology and the exposition of the two forms of efficiency it estimates were initially put forth by Farrell (1957). The methodology was refined, and labelled as data envelopment analysis, by Charnes, Cooper, and Rhodes (1978). An excellent reference is Fare, Grosskopf, and Lovell (1994), and thorough reviews of the methodology are contained in Charnes et al. (1994), Ali and Seiford (1993) and Coelli et al. (2005).

4.4.1 DEA Background and Derivation

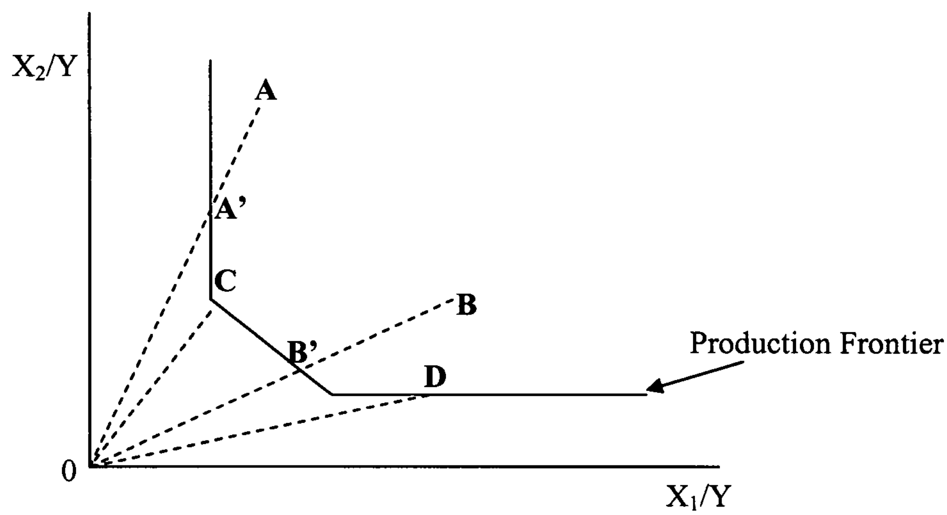
DEA is a non-parametric mathematical programming model that uses linear programming methods in order to determine a piece-wise linear production frontier. This frontier encapsulates all of the observed data points (no points can lie beyond the production frontier), and then calculates the efficiency of each airport relative to this estimated frontier. DEA has the ability to incorporate multiple inputs and multiple outputs, and has become a widely-used method of analysis, including several studies on airports, as was discussed in the literature review section. The primary advantage of using DEA is that it does not require an exhaustive amount of data, particularly input prices which can be difficult to obtain for airports. DEA does have its limitations; notably, there is not an underlying economic rationale in the derivation of weights used. Also, the model here is not intended to convey changes in productivity over time. The efficiency results are re-calibrated each year, so the relative efficiency of the airports can only be determined on a year-to-year basis with the model employed here; the factors affecting the DEA efficiency results are analyzed in Section 5.

In relation to this frontier, the analyst is able to determine the technical efficiency of each unit (an indicator of the unit's ability to generate maximal output from a given set of inputs) as well as the allocative efficiency of each unit (an indicator of how efficiently each unit utilizes their inputs, given the prices of each input and the production technology available) (Coelli et al., 2005). These two aspects of efficiency must be considered in conjunction in order to ascertain the total efficiency of a firm. It should be noted that we are concerned with technical efficiency in this study. As such, we are referring to the operational performance of the airports when we discuss technical efficiency. The computation of allocative efficiency is intrinsically difficult, given the prohibitive level of data required on the input and output prices facing each airport. In the case of the North American airports examined in this paper, the disparate regions exhibit a large fluctuation in input and output prices, and as such the construction of accurate price indices and the related examination of allocative efficiency are beyond the scope of this paper.

DEA can take two different orientations – an output orientation and an input orientation. The output orientation examines the degree to which "quantities can be proportionally expanded without altering the input quantities used", while the input orientation examines the degree to which "input quantities can be proportionally reduced without changing the output quantities produced" (Coelli, 2005). The analysis in this paper utilizes the input orientation. The demand facing airports is by and large exogenous to the airport management's decision-making process, as air transportation is a derived demand; the demand for air transport is dependent upon the demand for business trips, vacation plans, and other traveller decisions that are beyond the control of airport management. Airport management does, however, have a degree of control over the inputs and processes used at the airport. For this reason, the input-oriented approach is favoured for this analysis.

Graphically, the theory of technical efficiency can be understood by examining Figure 4.3. The production frontier is constructed from the observed data of the airports in the sample. In the case of the input orientation, each observation will be either on the frontier or above and to the right of the frontier. The technical efficiency of each observation can be determined by examining the radial distance from the origin to the observed point. The technical efficiency measure will be between 0 and 1; airports C and D will have a technical efficiency rating of 1.00, as they are located on the frontier. Airports A and B, however, are located beyond the frontier, and are thus relatively inefficient (they could theoretically produce the same output while using less input). The technical efficiency rating of airport A will be calculated as 0A'/0A, and the technical efficiency rating of airport B will be calculated as 0B'/OB (with both ratings being less than 1.00). Clearly, the farther the firm is from the frontier, the lower is their technical efficiency.

Figure 4.3 An Illustration of DEA Input-Oriented Technical Efficiency



The DEA methodology can also be illustrated mathematically. In addition to having both input and output orientations, DEA analysis can be formed with either the assumption of constant returns to scale (CRS) or variable returns to scale (VRS). First, consider the CRS model (first proposed by Charnes, Cooper and Rhodes (1978))[8]:

[8] This section again draws upon Coelli (1998, pp. 140-142).

- There are K inputs and M outputs for N firms
- The column vectors x_i and y_i represent the inputs and outputs, respectively, of the i^{th} firm.
- The data for all N firms are represented by the KxN input matrix, X, and the MxN output matrix, Y.
- A ratio of all outputs over all inputs ($u'y_i/v'x_i$) is determined, where u is an Mx1 vector of output weights, and v is a Kx1 vector of input weights.

The optimal input and output weights are then determined by the following linear programming model:

$$\begin{aligned} &\mathrm{Max}_{u,v}\ (u'y_i/v'x_i), \\ &\text{Subject to } (u'y_j/v'x_j) \leq 1, \qquad j=1,2,\ldots,N, \\ &\qquad u, v \geq 0. \end{aligned}$$

An equivalent linear programming model (the envelopment form) is as follows:

$$\begin{aligned} &\mathrm{Min}_{\theta,\lambda}\ \theta, \\ &\text{Subject to } -y_j + Y\lambda \geq 0, \\ &\qquad \theta x_j - X\lambda \geq 0, \\ &\qquad \lambda \geq 0, \end{aligned}$$

where θ is a scalar value representing the efficiency score ($0 \leq \theta \leq 1$) of each firm, and λ is a Nx1 vector of constants. This problem is then iterated for each firm in the sample.

Banker, Charnes, and Cooper (1984) proposed a revision to the constant returns to scale model above that allows for the presence of variable returns to scale. If a firm is not operating at optimal scale, then the efficiency score that is calculated is biased by the impact of scale inefficiencies. The envelopment form of the linear programming model shown above can be adjusted when it is assumed that variable returns to scale exist. An additional constraint, that of convexity ($N1'\lambda = 1$, where N1 is an Nx1 vector of 1s), is added to the model specification, resulting in the following linear programming problem:

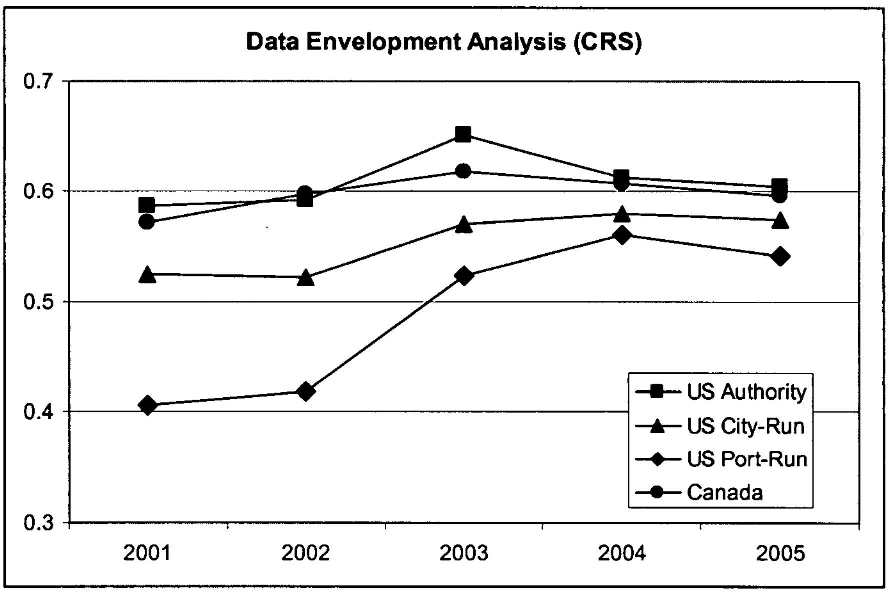
$$\begin{aligned} &\mathrm{Min}_{\theta,\lambda}\ \theta, \\ &\text{Subject to } -y_j + Y\lambda \geq 0, \\ &\qquad \theta x_j - X\lambda \geq 0, \\ &\qquad N1'\lambda = 1 \\ &\qquad \lambda \geq 0. \end{aligned}$$

The frontier in this situation becomes a so-called "convex hull" that provides a closer fit with the observed data points than does the frontier in the constant returns to scale specification. As such, the technical efficiency score in the VRS scenario is always greater than or equal to the technical efficiency score indicated by the CRS model. The additional constraint imposed in the VRS case has the effect that, in the VRS case, each inefficient firm is only compared to firms of a similar size; this measure tries to extricate the inefficiency attributable to scale inefficiencies. In the CRS model, each and every firm is compared with one another, regardless of the size of each firm.

4.4.2 DEA Technical Efficiency Results

In order to perform the DEA analysis, Tim Coelli's DEAP software was used[9]. This software solves the envelopment form of the linear programming model. As mentioned above, an input orientation was selected. The model included balanced panel data for the years 2001-2005[10]. The results presented here are intended to be comparable with the index number results. As such, the technical efficiency estimates here have excluded capital inputs. The model includes 3 outputs (passengers, aircraft movements, and non-aeronautical revenue) and 2 inputs (labour expenses and soft cost expenses). Figure 4.4 shows the results of the DEA analysis assuming constant returns to scale[11]. It should again be emphasized that Figure 4.4 does not represent technical efficiency change over time; the focus is on the relative values on a year-to-year basis. The rankings of individual airports according to DEA are shown in Appendix A.6.

Figure 4.4 Mean DEA Results by Airport Managerial Structure



[9] The software can be found at the Centre for Efficiency and Productivity Analysis' website located at http://www.uq.edu.au/economics/cepa/software.htm

[10] The full study period of 1996-2005 was not used due to the unbalanced nature of the panel data prior to 2001.

[11] Note that the concept of 'returns to scale' is incomplete due to the lack of capital inputs

4.5 Stochastic Frontier Analysis

The third productivity analysis method used is stochastic frontier analysis (SFA). The foundation of stochastic frontier analysis was constructed by Meeusen and van den Broeck (1977) and Aigner, Lovell, and Schmidt (1977). Since then, many different extensions of SFA have been developed, in order to deal with varying data availability and differing assumptions about the statistical characteristics of this data. SFA can be used to estimate both production functions and cost functions. In this case, a stochastic production frontier is estimated, and technical efficiency is assessed relative to this frontier.

4.5.1 Stochastic Frontier Analysis (SFA) Background and Derivation:

Stochastic frontier analysis specifies a production function, and, as its name implies, assumes an inherent randomness in this function. In other words, the production function is not deterministic; it is subject to an error term which is postulated to consist of two components that must be separated. The production function is specified as follows:

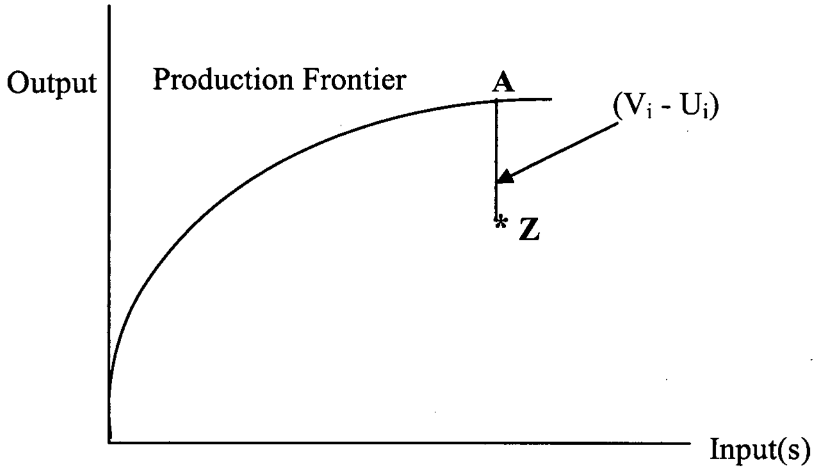
$Y_i = x_i\beta + (V_i - U_i)$ where i=1,...,N (the number of firms in the sample)

The notation is as follows:

- Y_i is the production of the i^{th} firm
- x_i is a Kx1 vector of the i^{th} firm's inputs
- β represents a vector of parameters that must be estimated
- V_i are random variables that are generally assumed to be independent and identically distributed $[N(0,\sigma_V^2)]$
- U_i are non-negative random variables that represent the technical inefficiency in the i^{th} firm's production activities (also assumed to be independent and identically distributed $[N(0,\sigma_U^2)]$
- U_i and V_i are assumed to be independent of one another

This is illustrated by Figure 4.5. AZ represents the degree to which the observed production of the firm falls short of the maximum possible level of production, given the estimated production function frontier generated by the observed input and output levels. AZ is composed of the two random variables, V_i and U_i. SFA attempts to determine how much of AZ is attributable to these two components. Of interest is U_i, as the components of V_i are beyond the control of the airport's management and obfuscate the true underlying technical efficiency of the airport. SFA attempts to extricate stochastic effects and measurement error to isolate U_i and more accurately predict technical efficiency levels.

Figure 4.5 Graphical Representation of a Stochastic Production Frontier



4.5.2 SFA Technical Efficiency Results

In order to estimate the technical efficiency of the airports, the stochastic frontier analysis was performed using Tim Coelli's FRONTIER software[12]. The dependent variable (the observed output) was the logarithm of the translog multilateral output index developed in Section 3.3, which aggregated passengers, air traffic movements and non-aeronautical revenue into a single index number. The two independent variables (the observed inputs) were labour expenditures and soft cost expenses. The production function was specified as a translog production frontier using balanced panel data for the 72 airports for the period 2001-2005. A truncated normal distribution was assumed, and the following quadratic production function was estimated:

$$\ln(Q_i) = \beta_0 + \beta_1\ln(S_i) + \beta_2\ln(L_i) + \beta_3\ln(S_i)^2 + \beta_4(K_i)^2 + \beta_5\ln(S_i)\ln(L_i) + (V_i - U_i),$$

where Q_i, S_i, and L_i are the multilateral output index, soft cost expenses, and labour expenses, respectively. V_i is assumed to be normally distributed and U_i has a truncated normal distribution. Coelli et al (2005) indicates that the technical efficiency estimate is defined as:

$$EFF_i = E(\exp Y_i^*|U_i, X_i)/ E(\exp Y_i^*|U_i=0, X_i)$$

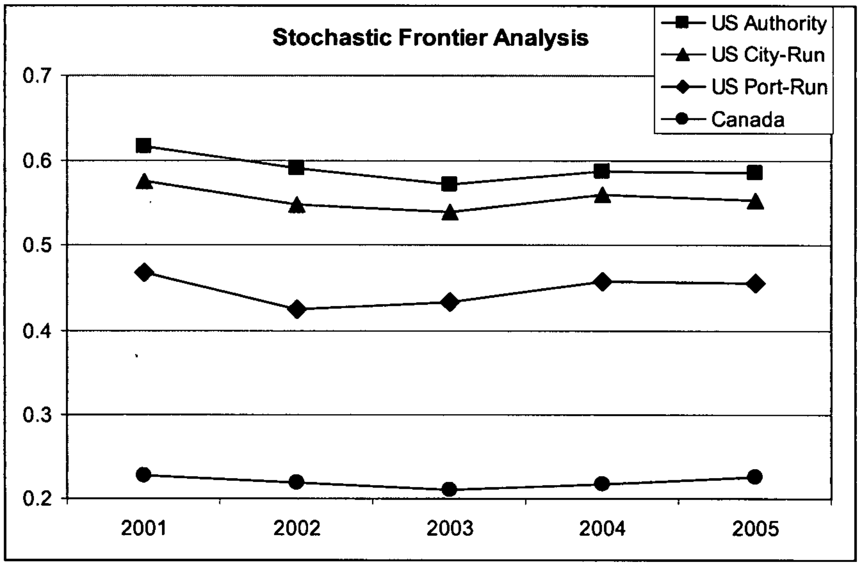
where Y_i* is the production of the i^{th} firm[13]. As a stochastic production function was estimated in this case (as opposed to a stochastic cost function), the efficiency measure is equal

[12] As with the DEAP program, the FRONTIER program can be downloaded from The Centre for Efficiency and Productivity Analysis' website at: http://www.uq.edu.au/economics/cepa/software.htm

[13] The production of the i^{th} firm is denoted as $\exp Y_i^*$ in this case as the model used the logarithm form of the dependent variable.

to exp(-Ui). The technical efficiency results of the SFA are summarized in Figure 4.6. The US airport authority airports again achieve the highest estimated efficiency. There is a large discrepancy between the relative ranking of the Canadian airports according to SFA and according to VFP and DEA. The cause of this discrepancy will be explored in Section 5[14]. The rankings of individual airports according to SFA are shown in Appendix A.7.

Figure 4.6 Mean SFA Results by Airport Managerial Structure



4.6 Unit Cost Index Analysis

The above procedures have all dealt with the productivity of airports – how effectively they are able to transform inputs into outputs. Another approach is to consider the cost effectiveness of airports; that is, how costly is it for the airports to produce some specified level of output? To this end, two figures are computed. First, a unit cost index was computed. The unit cost index is defined as follows:

$$UnitCost = \frac{TotalOperatingExpenses}{AggregateOutputIndex}$$

Where operating expenses represent total expenditures on labour and soft costs, and are measured in 1996 $US and are not adjusted for regional cost levels, and the aggregate output index is that computed in the VFP measurements. These results are shown in Figure 4.7 and the rankings of individual airports are contained in Appendix A.8.

[14] The main difference in the SFA results is due to differences of scale; as shown in Section 5, SFA indicates significant efficiency gains associated with increasing output scale, which is the cause of the low ranking for Canadian airports by this methodology

A similar measure, which has more intuitive appeal, is that of Operating Expense per Passenger. This is defined as:

$$OperatingExpensePerPassenger = \frac{TotalOperatingExpenses}{TotalPassengers}$$

Operating expenses are again shown in constant 1996 $US, so any changes represent 'real' changes over time. The results are shown in Figure 4.8 and a complete listing by individual airport is included in Appendix A.9.

Figure 4.7 Mean Unit Cost Index Results by Airport Managerial Structure

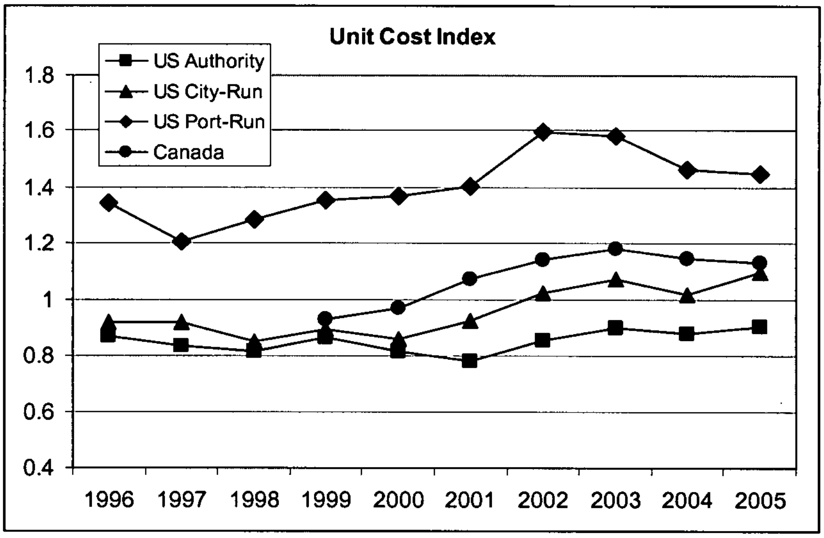
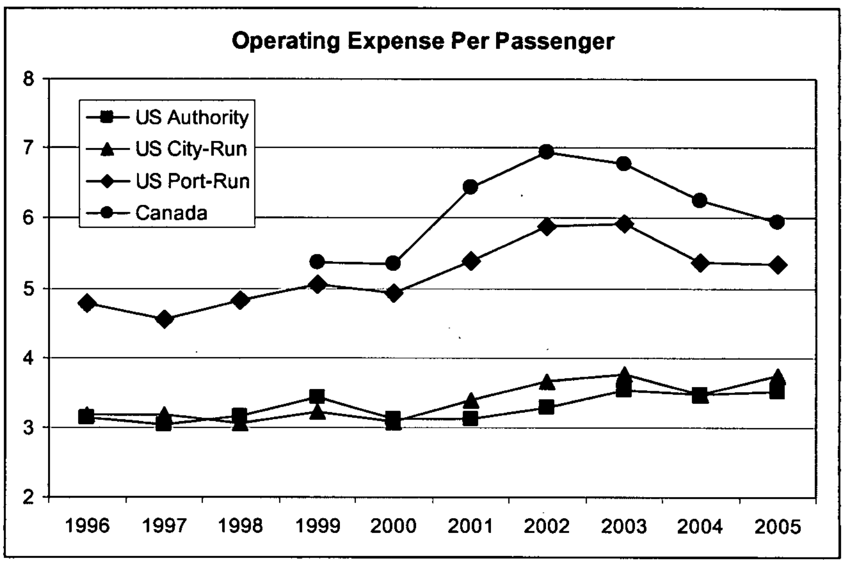


Figure 4.8 Mean Operating Expense per Passenger by Airport Managerial Structure



4.7 Discussion of Results and Comparison between Methodologies

In total, five measures of efficiency have been calculated. They are each 'gross' measures of efficiency, insofar as they have not been adjusted for input prices and they have not controlled for systematic factors affecting efficiency that are beyond managerial control. These factors will be discussed in Section 5. It is of interest to compare how the different measures of efficiency view each of the airports. Table 4.2 provides the relative ranking of the airports according to each measure, including the mean ranking of each airport and its standard deviation. Overall, the rankings are largely consistent, although some disparities do exist in some cases. Table 4.3 provides a Spearman Rank Correlation Matrix, which indicates the similarity of rankings between the measures. Most correlation coefficients are reasonably high, although the stochastic frontier results appear to vary the most from the other measures.

Table 4.2 Comparative Rankings between Methodologies – Year 2005

		VFP	Unit Cost	Expense/Pax	DEA	SFA	Mean	St. Dev.
ATL	Atlanta	1	1	1	1	1	*1.0*	*0.0*
CLT	Charlotte-Douglas	2	2	2	1	4	*2.2*	*1.1*
TPA	Tampa	7	5	9	11	5	*7.4*	*2.6*
LAS	Las Vegas	9	6	6	19	2	*8.4*	*6.4*
RDU	Raleigh-Durham	4	3	7	10	18	*8.4*	*6.0*
MSP	Minneapolis-St. Paul	3	9	5	33	3	*10.6*	*12.8*
CVG	Cincinnati/Kentucky	10	12	3	22	12	*11.8*	*6.8*
YVR	Vancouver	6	10	31	6	6	*11.8*	*10.9*
PHX	Phoenix	17	15	8	18	7	*13.0*	*5.1*
BNA	Nashville	8	8	10	17	23	*13.2*	*6.6*
FLL	Ft. Lauderdale	23	17	12	7	8	*13.4*	*6.7*
YYC	Calgary	13	14	21	1	20	*13.8*	*8.0*
MCO	Orlando	20	22	18	9	9	*15.6*	*6.2*
SLC	Salt Lake City	16	11	4	41	11	*16.6*	*14.3*
HNL	Honolulu	34	19	14	13	10	*18.0*	*9.5*
SNA	Santa Ana	19	24	30	1	27	*20.2*	*11.5*
YYJ	Victoria	5	4	23	8	62	*20.4*	*24.5*
ABQ	Albuquerque	14	13	15	26	40	*21.6*	*11.5*
MKE	Milwaukee	12	16	26	21	36	*22.2*	*9.3*
RIC	Richmond	18	7	36	14	53	*25.6*	*18.7*
IND	Indianapolis	27	18	38	28	22	*26.6*	*7.5*
RNO	Reno-Tahoe	21	21	24	20	47	*26.6*	*11.5*
MCI	Kansas City	35	23	25	27	26	*27.2*	*4.6*
PDX	Portland	25	31	35	29	16	*27.2*	*7.2*
SEA	Seattle	32	35	28	30	13	*27.6*	*8.6*
IAD	Washington (Dulles)	26	34	44	24	14	*28.4*	*11.3*
CMH	Columbus	15	20	37	36	37	*29.0*	*10.7*
RSW	Southwest Florida	24	26	19	37	41	*29.4*	*9.2*

		VFP	Unit Cost	Expense/Pax	DEA	SFA	Mean	St. Dev.
PBI	Palm Beach	38	28	34	12	42	***30.8***	***11.7***
DFW	Dallas/Fort Worth	29	36	11	55	25	***31.2***	***16.1***
DEN	Denver	30	41	29	40	24	***32.8***	***7.4***
IAH	Houston	36	44	13	70	17	***36.0***	***23.0***
DTW	Detroit	42	47	22	54	21	***37.2***	***15.0***
YXE	Saskatoon	22	27	49	23	65	***37.2***	***19.0***
DCA	Washington (Reagan)	43	42	42	45	15	***37.4***	***12.6***
CLE	Cleveland	46	39	39	39	28	***38.2***	***6.5***
MDW	Chicago (Midway)	49	54	20	35	33	***38.2***	***13.6***
SAN	San Diego	51	53	27	31	29	***38.2***	***12.7***
YEG	Edmonton	28	29	43	43	49	***38.4***	***9.4***
YQT	Thunder Bay	39	30	54	1	68	***38.4***	***25.4***
YWG	Winnipeg	11	25	55	50	52	***38.6***	***19.5***
JAX	Jacksonville	40	33	45	34	44	***39.2***	***5.5***
SMF	Sacramento	53	40	48	25	30	***39.2***	***11.8***
PHL	Philadelphia	52	48	17	63	19	***39.8***	***20.7***
BOS	Boston	33	52	56	32	31	***40.8***	***12.2***
OAK	Oakland	58	55	47	16	32	***41.6***	***17.5***
AUS	Austin	47	38	33	52	43	***42.6***	***7.4***
ORD	Chicago (O'Hare)	48	49	16	53	51	***43.4***	***15.4***
YOW	Ottawa	31	43	57	46	54	***46.2***	***10.2***
YQR	Regina	41	32	46	48	66	***46.6***	***12.5***
PIT	Pittsburgh	55	50	51	51	35	***48.4***	***7.7***
STL	St. Louis	57	51	32	68	34	***48.4***	***15.3***
YXU	London	56	37	67	15	69	***48.8***	***22.8***
YHZ	Halifax	44	46	53	56	57	***51.2***	***5.9***
LGA	New York (LaGuardia)	37	66	58	60	45	***53.2***	***11.9***
BWI	Baltimore-Washington	64	62	40	64	38	***53.6***	***13.4***
SJC	San Jose	63	61	61	49	39	***54.6***	***10.3***
YQM	Moncton	54	45	65	44	67	***55.0***	***10.8***
EWR	Newark	50	68	64	38	59	***55.8***	***12.0***
MSY	New Orleans	69	64	41	59	55	***57.6***	***10.7***
LAX	Los Angeles	62	59	50	61	58	***58.0***	***4.7***
SAT	San Antonio	68	60	52	62	48	***58.0***	***8.0***
YYT	St. John's	45	56	59	67	63	***58.0***	***8.4***
YQB	Quebec	60	57	69	42	64	***58.4***	***10.2***
ALB	Albany	61	58	63	58	56	***59.2***	***2.8***
SFO	San Francisco	59	63	60	65	50	***59.4***	***5.8***
ONT	Ontario	65	65	62	66	46	***60.8***	***8.4***
YYZ	Toronto	66	70	68	47	60	***62.2***	***9.3***
MIA	Miami	67	71	66	72	61	***67.4***	***4.4***
JFK	New York (Kennedy)	70	72	71	57	70	***68.0***	***6.2***
YYG	Charlottetown	71	67	70	71	72	***70.2***	***1.9***
YSJ	Saint John	72	69	72	69	71	***70.6***	***1.5***

Table 4.3 Spearman Rank Correlation Matrix – Year 2005

VFP	1.00	-	-	-	-
Unit Cost Index	0.93	1.00	-	-	-
Expense/PAX	0.73	0.75	1.00	-	-
DEA	0.71	0.79	0.51	1.00	-
SFA	0.60	0.58	0.79	0.47	1.00
	VFP	Unit Cost Index	Expense/PAX	DEA	SFA

5 THE IMPACT OF MANAGERIAL STRUCTURE ON EFFICIENCY

The cross-structural comparison in Section 3 provided an indication that the US airport authorities achieved the highest operating efficiency and cost effectiveness. However, this section will perform regression analyses to econometrically determine whether there are meaningful differences in efficiency depending upon managerial structure. Table 5.1 provides the results of five separate regression analyses performed, whereby the dependent variables are each of the efficiency measures obtained in Section 4. Several factors that could potentially affect the efficiency results obtained are included as independent variables. The first five independent variables characterize operating characteristics deemed to be beyond managerial control. The percentage of non-aeronautical revenue is used as an indicator of the business strategy of management. The Canada-US exchange rate variable is used to capture any effects differing between countries that are separate from the differences in managerial structure. Finally, several dummy variables were included to capture differences in efficiency according to managerial structure.

The results are quite consistent across each of the methodologies. There are some variations in the estimated effects of the various operating characteristics. Of interest in this study, however, are the results concerning commercialization and managerial structure, and the results will be discussed in turn.

5.1 The Relationship between Commercialization and Efficiency

As the literature review mentioned, Oum et al (2006) found very strong evidence that there is a high correlation between airport commercialization and efficiency. Their findings are corroborated in this study: Increasing the percentage of non-aeronautical revenue has a significant positive effect on variable factor productivity and DEA technical efficiency, and also significantly increases cost effectiveness[15]. Oum et al (2006) believe diversifying revenue sources into commercial and other non-aeronautical business allows airports to achieve higher operating efficiency and that "many airports aim to increase revenues from commercial services and other non-aeronautical activities in order to reduce aviation user charges, thus attracting more airlines. Such business diversification strategies...exploit the well-known demand complementarity between aeronautical services and commercial services".

[15] Note that the negative coefficient in the Unit Cost Index and Operating Expense per Passenger regression analysis is indicative of lower costs and the positive coefficient in the VFP and DEA regression analyses indicates higher efficiency.

Table 5.1 Regression Results of Factors Affecting Operating Efficiency

Dependent Variable	VFP		Unit Cost		Oper. Expense per PAX		DEA		SFA	
Regression Form	OLS (log-log)		OLS (log-log)		OLS (log-log)		Tobit (lin-log)		Tobit (lin-log)	
	Coefficient	*t*-stat	Coefficient	*t*-stat	Coefficient	*t*-stat	Coefficient	*t*-stat	Coefficient	*t*-stat
Intercept	-3.919	-	23.430	-	10.649	-	-6.7273	-	3.3067	-
Output Scale (Index)	0.035	1.219	-0.065	-2.073 *	-0.010	-0.294	0.1593	0.869	1.3476	7.150 *
Aircraft Size (Pax/ATM)	-0.134	-3.420 *	0.093	2.202 *	-0.313	-5.638 *	-0.8476	-3.751 *	-0.5944	-2.659 *
Runway Utilization (ATM/runway)	0.172	5.488 *	-0.258	-7.665 *	-0.524	-11.800 *	0.7558	3.835 *	0.3488	1.800
% International Pax	-0.009	-1.472	-0.003	-0.505	0.432	-0.517	-0.0075	-0.217	-0.1621	-4.630 *
% Transfer/Connecting Pax	0.072	6.253 *	-0.070	-5.696 *	-0.131	-8.054 *	-0.0689	-1.066	0.0520	0.810
% Non-Aeronautical Revenue	0.597	14.450 *	-0.772	-17.390 *	-0.421	-7.195 *	1.3871	4.071 *	0.2759	0.826
Canada-US Exchange Rate	0.080	0.104	-0.558	-0.674 *	-0.559	-0.512 *	-	-	-	-
<u>*Dummy Variables*</u>										
Canadian Airport Authority	0.218	4.983 *	-0.177	-3.966 *	-0.202	-4.327 *	0.8122	3.131 *	0.4842	1.881 *
US Airport Authority	0.085	3.396 *	-0.050	-1.951 *	-0.061	-2.398 *	0.0542	0.379	0.3914	2.730 *
US Port Authority	0.005	0.163	0.183	5.117 *	0.323	6.840 *	0.2504	1.211	0.0932	0.453
Multiple Airports	-0.134	-4.745 *	0.245	8.057 *	0.296	7.399 *	-0.4100	-2.479 *	-0.8254	-4.934 *
Year	0.013	2.085 *	0.001	0.183	0.016	1.918 *	0.1237	3.102 *	-0.0372	-0.945
R^2	0.420		0.522		0.538		0.371		0.763	
Adjusted R^2	0.4092		0.5134		0.5296		-		-	
Log-likelihood value	6.29		-11971.00		-1122.90		60.87		272.29	
Observations (n)	687		687		687		360		360	

Note: An asterisk next to the *t*-statistic indicates statistical significance at the 0.05 level

In addition to demand complementarities between commercial and aeronautical services, it is interesting to examine whether there are efficiency complementarities as well. To do so, the aggregate output index was re-calculated, removing the non-aeronautical revenue output. The VFP regression results were then carried out in order to isolate the impact of non-aeronautical revenues on the efficiency of aeronautical activities, with the results presented in Table 5.2.

Table 5.2 Impact of Non-Aeronautical Revenue on Aeronautical Efficiency

Dependent Variable Regression Form	VFP (non-aeronautical revenue output removed) OLS (log-log)		
	Coefficient	*t*-stat	
Intercept	-0.587	-	
% Non-Aeronautical Revenue	0.150	2.612	*
Dummy Variables			
Canadian Airport Authority	0.097	2.336	*
US Airport Authority	0.123	3.251	*
US Port Authority	-0.191	-4.019	^
R^2	0.075		
Adjusted R^2	0.0699		
Log-likelihood value	-313.60		
Observations (*n*)	687		

Note: * represents statistical significance at the 0.05 level, ^ at the 0.1 level

This analysis provided interesting results; increasing the percentage of non-aeronautical revenues by 10% increases aeronautical efficiency by 1.5%, over and above the direct benefits of increasing revenues. Further research could be beneficial in determining whether economies of scope exist between commercial and aeronautical activities, or whether this relationship is a reflection of skilled management being concurrently more technically efficient and more proactive in generating commercial revenues.

5.2 The Effects of Managerial Structure on Efficiency

Table 5.1 addresses the differences in efficiency between managerial structures. The explanatory variables allow for an extrication of efficiency effects attributable to differences in structure. The results are very consistent across all five measures of efficiency: the airport authority structure achieves significant improvements in both productive efficiency and cost effectiveness relative to the government-run airports[16]. As Table 5.3 shows, after controlling for exogenous factors, Canadian airport authorities are between 12%-24% more efficient than US city-run airports, and US airport authorities are between 5%-12% more efficient than US city-run airports.

Table 5.3 Efficiency Differences between Authorities and City-Run Airports

Methodology	Canadian Airport Authorities	US Airport Authorities
VFP	24% more efficient	9% more efficient
DEA	12% more efficient	no difference
SFA	15% more efficient	12% more efficient
Unit Cost Index	16% more cost effective	5% more cost effective
Expense per Pax	18% more cost effective	6% more cost effective

Note: Results relative to US city-run airports

Next, the regression results in Table 5.1 can be used to create a residual measure of VFP that explicitly controls for factors beyond managerial control. To do so, the observed VFP is compared to the expected VFP, given the operating characteristics of the airport. The residual (either positive or negative) is then attributed to managerial skill, and the impact of output scale, aircraft size, runway utilization, the percentage of international passengers, and the percentage of transferring/connecting passengers is thus removed from the VFP measure. A one-way ANOVA analysis was then conducted to determine whether managerial efficiency was dependent upon airport structure. As Table 5.4 shows, there is again strong evidence that both the Canadian and the US airport authorities outperform the US city-run airports.

Table 5.4 The Effects of Managerial Structure on Efficiency – Residual VFP

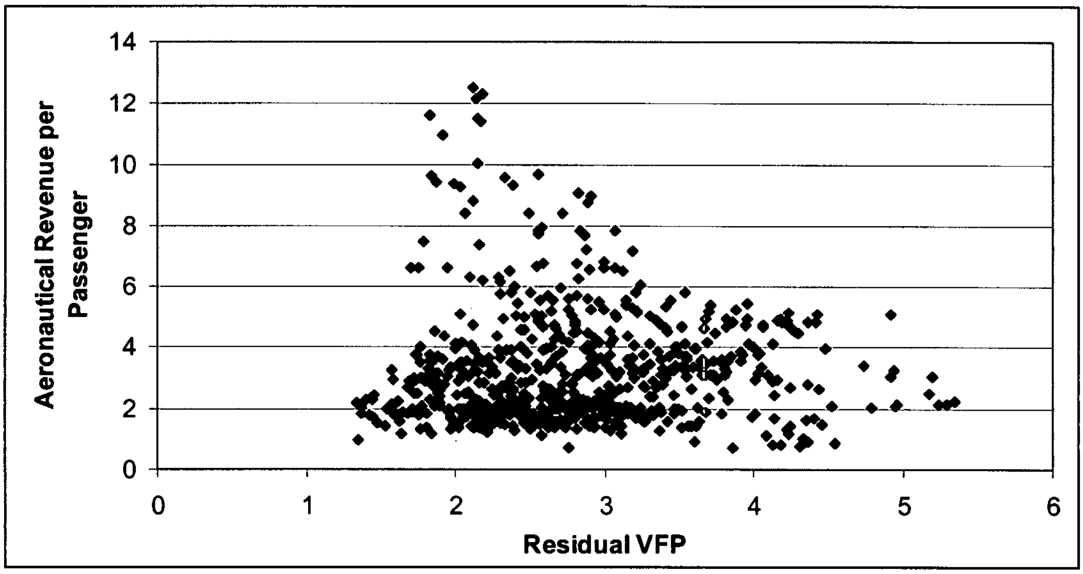
Management Structure	*Count*	*Sum*	***Average***	*Variance*
Canadian Authorities	140	487.44	**3.48**	0.51
US Authorities	189	518.23	**2.74**	0.45
US City-Run	278	699.06	**2.51**	0.49
US Port-Run	80	217.37	**2.72**	0.20

Source of Variation	*SS*	*df*	*MS*	*F*
Between Groups	88.889	3	29.63	66.29
Within Groups	305.274	683	0.45	
Total	394.163	686		

[16] The three dummy variables for Canadian authorities, US authorities, and US port-run airports are relative to the base case of US city-run airports

Finally, what are the implications of managerial efficiency on the level of user charges? Forsyth (2000) believes that since airports possess considerable monopoly power, they thus have the scope to operate inefficiently, and pass on the higher costs which result from this inefficiency to their customers (i.e. the airlines). There is no evidence of this for the North American airports, however, as there is no correlation between the level of managerial efficiency (in the form of residual VFP) and the level of user charges (in the form of aeronautical revenues per passengers), as shown in Figure 5.1.

Figure 5.1 Relationship between Managerial Efficiency and Aeronautical Charges



6 CONCLUSION

6.1 Summary of Key Findings

Prior to the implementation of Canada's National Airports Policy, several anticipated results were put forth. The main focus was on the expected increase in operating efficiency and commercialization of operations and the long-term goal of financial self-sustainability. Now, five years subsequent to its implementation, there is strong evidence that such proclamations were more than "policy speak"; the benefits of the airport authority structure are indeed borne out in the data, and robust across several different measures of operating efficiency. Both US and Canadian airports generate significantly more non-aeronautical revenue than do the US city-run airports, and the authorities have also achieved much higher growth rates over the past decade. Additionally, both the authorities are more efficient and more cost effective than the city-run airports; on the order of 12-24% for Canadian airport authorities and 5-12% for US airport authorities.

When factors beyond managerial control are controlled for, the efficiency advantage of the authority structure persists. Potential sources for the higher efficiency of the airport authorities are:

- Greater managerial autonomy: financially, operationally, and/or strategically
- A more effective governance structure owing to a specialized Board of Governors
- A reduction in X-inefficiency associated with public sector bureaucracy
- Increased incentives due to the ability to re-invest retained earnings

Inter-related to these findings, the study also found that airports that focus on generating non-aeronautical revenues are more technically efficient, regardless of whether non-aeronautical revenue is classified as an output.

6.2 Suggestions for Further Research

There are several potential areas for further research. Work could be done to incorporate capital assets in order to get a more holistic view of airport efficiency and to assess how effective the governance structures are in determining levels of capital investment. Further research into the linkage between efficiency, non-aeronautical revenues, and aeronautical charges is also warranted in order to obtain a better understanding of the causes and the effects since the three factors are in many ways tied together. Finally, while there is evidence that the NAP has been successful and that the US should further embrace the airport authority structure, it remains to be seen whether the airport authority structure is indeed the optimal structure for the North American airport industry. If the benefits of the airport authority structure espoused are accurate, it is likely that these benefits would be even stronger under privatization. Would a move towards privatization, with an appropriate regulatory framework to control for market power, represent a further improvement? At present, no Canadian airports are privatized (either fully or partially), so this thesis was not able to compare the performance of the current institutional forms with partial or fully privatized forms. With the important public policy and industry implications inherent in the type of airport ownership and managerial forms, this is an area that warrants further research.

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Appendix A.1 Canadian Airport Authorities Included in Study

Airport Authorities - Canada

IATA Code	*Airport Name*	*Owner*	*Operator*	*Date Transferred*
YYC	Calgary International Airport	Transport Canada	Calgary Airport Authority	July 1, 1992
YYG	Charlottetown Airport	Transport Canada	Charlottetown Airport Authority Inc.	March 1, 1999
YEG	Edmonton International Airport	Transport Canada	Edmonton Regional Airports Authority	August 1, 1992
YQM	Greater Moncton International Airport	Transport Canada	Greater Moncton International Airport Authority	September 1, 1997
YHZ	Halifax Airport	Transport Canada	Halifax International Airport Authority	February 1, 2000
YQB	Jean Lesage International Airport	Transport Canada	Aéroport de Québec Inc	November 1, 2000
YXU	London International Airport	Transport Canada	Greater London International Airport Authority	August 1, 1998
YOW	Ottawa International Airport	Transport Canada	Ottawa Macdonald Cartier Intl. Airport Authority	February 1, 1997
YQR	Regina Airport	Transport Canada	Regina Airport Authority	May 1, 1999
YSJ	Saint John Airport	Transport Canada	Saint John Airport Inc.	June 1, 1999
YXE	Saskatoon John G. Diefenbaker International Airport	Transport Canada	Saskatoon Airport Authority	January 1, 1999
YYT	St. John's International Airport	Transport Canada	St. John's International Airport Authority	December 1, 1998
YQT	Thunder Bay International Airport	Transport Canada	Thunder Bay International Airports Authority Inc.	September 1, 1997
YYZ	Toronto Pearson International Airport	Transport Canada	Greater Toronto Airports Authority	December 2, 1996
YVR	Vancouver International Airport	Transport Canada	Vancouver International Airport Authority	July 1, 1992
YYJ	Victoria Airport	Transport Canada	Victoria Airport Authority	April 1, 1997
YWG	Winnipeg International Airport	Transport Canada	Winnipeg Airports Authority	January 1, 1997

Appendix A.2 US Airport Authorities Included in Study

Airport Authorities - United States

IATA Code	Airport Name	Owner	Operator
ALB	Albany International Airport	Albany County Airport Authority	Albany County Airport Authority
BNA	Nashville International Airport	Metropolitan Nashville Airport Authority	Metropolitan Nashville Airport Authority
CMH	Port Columbus International Airport	Columbus Regional Airport Authority	Columbus Regional Airport Authority
CVG	Cincinnati/Northern Kentucky International Airport	Kenton County Airport Board	Kenton County Airport Board
DCA	Ronald Reagan Washington National Airport	Metropolitan Washington Airports Authority	Metropolitan Washington Airports Authority
DFW	Dallas/Fort Worth International Airport	Cities of Dallas and Fort Worth	DFW Airport Board
DTW	Detroit Metropolitan Wayne County Airport	Wayne County	Wanye County Airport Authority
IAD	Washington Dulles International Airport	Metropolitan Washington Airports Authority	Metropolitan Washington Airports Authority
IND	Indianapolis International Airport	Indianapolis Airport Authority	Indianapolis Airport Authority (BAA Indianapolis LLC)
JAX	Jacksonville International Airport	Jacksonville Airport Authority	Jacksonville Airport Authority
MCO	Orlando International Airport	City of Orlando	Greater Orlando Aviation Authority
MSP	Minneapolis/St. Paul International Airport	Metropolitan Airports Commission	Metropolitan Airports Commission
PIT	Pittsburgh International Airport	Allegheny County Airport Authority	Allegheny County Airport Authority
RDU	Raleigh-Durham International Airport	Raleigh-Durham Airport Authority	Raleigh-Durham Airport Authority
RIC	Richmond International Airport	Capital Region Airport Commission	Capital Region Airport Commission
RNO	Reno/Tahoe International Airport	Reno-Tahoe Airport Authority	Reno-Tahoe Airport Authority
SAN	San Diego International Airport	San Diego County Regional Airport Authority	San Diego County Regional Airport Authority
STL	St. Louis-Lambert International Airport	City of St. Louis	St. Louis Airport Authority
TPA	Tampa International Airport	Hillsborough County Aviation Authority	Hillsborough County Aviation Authority

Appendix A.3 US City-Run Airports Included in Study

City-Run Airports - United States

IATA Code	*Airport Name*	*Owner*	*Operator*
ABQ	Albuquerque International Sunport	City of Albuquerque	Aviation Department
ATL	Hartsfield-Jackson Atlanta International Airport	City of Atlanta	Department of Aviation
AUS	Austin-Bergstrom International Airport	City of Austin	Department of Aviation
BWI	Baltimore Washington International Airport	State of Maryland	Maryland Aviation Administration
CLE	Cleveland-Hopkins International Airport	City of Cleveland	City's Department of Port Control, Airport Division
CLT	Charlotte Douglas International Airport	City of Charlotte	Department of Aviation
DEN	Denver International Airport	City and County of Denver	Department of Aviation
FLL	Fort Lauderdale Hollywood International Airport	Broward County	Broward County Aviation Department
HNL	Honolulu International Airport	State of Hawaii	Airports Division, Department of Transportation
IAH	Houston-Bush Intercontinental Airport	City of Houston	Houston Airport System
LAS	Las Vegas McCarran International Airport	Clark County	Clark County Department of Aviation
LAX	Los Angeles International Airport	City of Los Angeles	Los Angeles World Airports (City Department)
MCI	Kansas City International Airport	City of Kansas City	Kansas City Aviation Department
MDW	Chicago Midway Airport	City of Chicago	Chicago Airport System - Department of Aviation
MIA	Miami International Airport	Miami-Dade County	Miami-Dade Aviation Department
MKE	General Mitchell International Airport	Milwaukee County	Milwaukee County - Department of Public Works
MSY	Louis Armstrong New Orleans International Airport	City of New Orleans	New Orleans Aviation Board
ONT	Ontario International Airport	City of Los Angeles	Los Angeles World Airports (City Department)
ORD	Chicago O'Hare International Airport	City of Chicago	Chicago Airport System - Department of Aviation
PBI	Palm Beach International Airport	Palm Beach County	Palm Beach County - Department of Airports
PHL	Philadelphia International Airport	City of Philadelphia	City of Philadelphia, Department of Commerce - Division of Aviation
PHX	Phoenix Sky Harbor International Airport	City of Phoenix	City of Phoenix - Aviation Department
SAT	San Antonio International Airport	City of San Antonio	Department of Aviation
SFO	San Francisco International Airport	City and County of San Francisco	Airport Commission (department of the City and County of San Francisco)
SJC	Norman Y. Mineta San José International Airport	City of San Jose	City of San Jose - Airport Department
SLC	Salt Lake City International Airport	Salt Lake City	Salt Lake City Department of Airports
SMF	Sacramento International Airport	County of Sacramento	Sacramento County Airport System - Department within County
SNA	John Wayne Airport	Orange County	Orange County - Department

Appendix A.4 US Port-Run Airports Included in Study

Port-Run Airports - United States

IATA Code	*Airport Name*	*Owner*	*Operator*
BOS	Boston Logan International Airport	Massachusetts Port Authority	Massachusetts Port Authority - Aviation Department
EWR	Newark Liberty International Airport	Port Authority of New York and New Jersey	Port Authority of New York and New Jersey
JFK	New York-John F. Kennedy International Airport	Port Authority of New York and New Jersey	Port Authority of New York and New Jersey
LGA	LaGuardia International Airport	Port Authority of New York and New Jersey	Port Authority of New York and New Jersey
OAK	Oakland International Airport	Port of Oakland	Port of Oakland - Aviation Division
PDX	Portland International Airport	Port of Portland	Port of Portland - Aviation Division
RSW	Southwest Florida International Airport	Lee County Port Authority	Lee County Port Authority
SEA	Seattle-Tacoma International Airport	Port of Seattle	Port of Seattle - Aviation Division

Appendix A.5 VFP Rankings by Individual Airport

Canadian Airport Authorities

		Variable Factor Productivity									
		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
YYJ	Victoria	-	1.53	1.67	1.76	1.72	1.74	1.49	1.58	1.61	***1.62***
YVR	Vancouver	1.51	1.57	1.59	1.64	1.75	1.61	1.47	1.40	1.48	***1.48***
YWG	Winnipeg	-	1.25	1.21	1.20	1.19	1.07	1.15	1.19	1.26	***1.29***
YYC	Calgary	1.71	1.50	1.42	1.33	1.34	1.27	1.21	1.05	1.13	***1.22***
YXE	Saskatoon	-	-	-	1.08	1.27	1.24	1.10	1.04	1.12	***1.13***
YEG	Edmonton	0.85	0.87	0.86	0.92	1.01	0.98	0.97	0.94	1.02	***1.08***
YOW	Ottawa	-	1.11	1.15	1.20	1.25	1.26	1.21	1.08	1.03	***1.05***
YQT	Thunder Bay	-	-	0.89	0.90	0.97	0.99	1.03	1.19	1.07	***1.00***
YQR	Regina	-	-	-	0.92	0.91	0.81	0.79	0.81	0.92	***0.96***
YHZ	Halifax	-	-	-	-	1.04	0.83	0.83	0.83	0.89	***0.90***
YYT	St. John's	-	0.87	0.92	0.88	0.85	0.83	0.77	0.81	0.82	***0.89***
YQM	Moncton	-	-	0.63	0.74	0.82	0.82	0.74	0.74	0.76	***0.81***
YXU	London	-	-	-	0.89	0.93	0.78	0.76	0.79	0.80	***0.79***
YQB	Quebec	-	-	-	-	-	0.76	0.73	0.66	0.64	***0.73***
YYZ	Toronto	1.10	1.13	1.00	0.94	0.87	0.75	0.68	0.52	0.57	***0.54***
YYG	Charlottetown	-	0.48	0.59	0.67	0.50	0.52	0.51	0.51	0.51	***0.51***
YSJ	Saint John	-	-	-	0.60	0.59	0.54	0.46	0.42	0.48	***0.49***
	Mean	1.29	1.15	1.08	1.04	1.06	0.99	0.94	0.91	0.95	***0.97***

US Airport Authorities

		Variable Factor Productivity									
		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
MSP	Minneapolis-St. Paul	1.47	1.63	1.49	1.55	1.58	1.42	1.58	2.23	1.68	***1.71***
RDU	Raleigh-Durham	-	1.73	1.70	1.95	2.08	2.00	2.04	1.71	1.59	***1.64***
TPA	Tampa	1.04	1.10	1.17	0.76	1.31	1.29	1.33	1.27	1.34	***1.41***
BNA	Nashville	1.24	1.22	1.35	1.34	1.36	1.40	1.32	1.26	1.36	***1.39***
CVG	Cincinnati/Kentucky	1.25	1.31	1.35	1.41	1.38	1.20	1.32	1.32	1.35	***1.34***
CMH	Columbus	1.10	1.08	1.15	1.09	1.18	1.34	1.26	1.20	1.19	***1.20***
RIC	Richmond	1.02	1.19	1.19	1.23	1.25	1.27	1.18	1.20	1.08	***1.16***
MCO	Orlando	1.20	1.25	1.20	1.18	1.12	1.06	1.15	1.04	1.09	***1.14***
RNO	Reno-Tahoe	1.14	1.15	1.18	1.17	1.18	1.23	1.06	0.99	1.07	***1.14***
IAD	Washington (Dulles)	0.78	0.82	0.90	0.85	0.81	0.75	0.68	0.80	1.04	***1.10***
IND	Indianapolis	0.95	0.78	0.78	0.76	0.83	2.00	2.08	1.11	1.05	***1.09***
DFW	Dallas-Fort Worth	1.04	1.12	1.62	1.35	1.30	1.17	1.19	1.11	1.32	***1.06***
JAX	Jacksonville	0.90	0.99	1.04	1.02	1.01	1.26	0.94	0.91	0.88	***0.96***
DTW	Detroit	1.00	1.07	1.04	1.03	1.07	1.07	0.90	0.84	0.83	***0.94***
DCA	Washington (Reagan)	0.60	0.63	0.58	0.63	0.86	0.88	0.75	0.79	0.88	***0.92***
SAN	San Diego	0.62	0.55	0.85	0.78	0.77	0.72	0.60	0.67	0.85	***0.84***
PIT	Pittsburgh	0.67	0.70	0.71	0.68	0.64	1.05	1.00	0.91	0.86	***0.80***
STL	St. Louis	1.32	1.26	1.28	1.31	1.39	1.26	1.18	0.98	0.83	***0.79***
ALB	Albany	0.67	0.69	0.71	0.71	0.83	0.85	0.81	0.78	0.83	***0.71***
	Mean	1.00	1.07	1.12	1.09	1.16	1.22	1.18	1.11	1.11	***1.12***

US City-Run Airports

		Variable Factor Productivity									
		1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
ATL	Atlanta	2.31	2.73	2.99	2.89	3.03	2.74	2.49	2.79	2.81	-
CLT	Charlotte-Douglas	-	1.80	1.84	1.78	1.85	1.85	1.84	1.72	1.71	***1.78***
LAS	Las Vegas	1.23	1.28	1.25	1.26	1.36	1.31	1.23	1.22	1.43	***1.38***
MKE	Milwaukee	1.17	0.97	0.97	1.03	1.09	1.24	1.12	1.20	1.26	***1.28***
ABQ	Albuquerque	0.66	0.61	1.31	1.24	1.27	1.21	1.24	1.18	1.16	***1.20***
SLC	Salt Lake City	1.27	1.16	1.23	1.17	1.16	1.16	1.15	1.09	1.08	***1.18***
PHX	Phoenix	1.35	1.33	1.40	1.37	1.43	1.45	1.16	1.20	1.18	***1.17***
SNA	Santa Ana	1.11	1.17	1.18	1.18	1.35	1.33	1.01	1.06	1.12	***1.15***
FLL	Fort Lauderdale	0.79	0.85	1.05	1.10	1.20	1.19	1.00	1.02	1.09	***1.12***
DEN	Denver	0.87	0.82	0.90	0.85	0.82	0.80	0.80	0.92	1.04	***1.06***
HNL	Honolulu	1.85	1.72	1.64	1.64	1.63	1.55	0.93	0.88	0.99	***1.02***
MCI	Kansas City	0.97	0.99	1.01	1.41	1.30	1.20	0.92	1.00	1.00	***1.02***
IAH	Houston	0.95	0.99	1.04	1.05	1.18	1.07	0.94	0.94	1.00	***1.01***
PBI	Palm Beach	0.85	0.91	1.01	0.95	1.07	1.01	0.86	0.92	0.97	***1.00***
CLE	Cleveland	0.77	0.68	0.86	0.75	1.12	0.89	0.76	0.82	0.94	***0.87***
AUS	Austin	0.92	0.86	0.76	0.83	0.96	0.88	0.86	0.78	0.86	***0.87***
ORD	Chicago (O'Hare)	0.72	0.77	1.07	0.99	1.02	0.87	0.83	0.85	0.92	***0.86***
MDW	Chicago (Midway)	1.14	1.02	1.32	1.37	1.46	1.21	0.91	0.95	0.97	***0.85***
PHL	Philadelphia	0.70	0.77	0.80	0.72	0.79	0.79	0.76	0.64	0.70	***0.84***
SMF	Sacramento	0.76	0.81	0.78	0.79	0.82	0.83	0.71	0.75	0.73	***0.84***
SFO	San Francisco	0.91	0.92	0.86	0.82	0.89	0.73	0.63	0.57	0.77	***0.74***
LAX	Los Angeles	0.79	0.79	0.94	0.84	0.76	0.69	0.64	0.65	0.67	***0.68***
SJC	San Jose	0.81	0.89	0.93	0.82	0.76	0.84	0.75	0.71	0.70	***0.66***
BWI	Baltimore-Washington	0.89	0.96	0.97	1.10	1.25	1.11	0.88	0.67	0.67	***0.63***
ONT	Ontario	0.68	0.67	0.76	0.69	0.70	0.60	0.68	0.61	0.60	***0.60***
MIA	Miami	0.88	0.87	0.82	0.85	0.80	0.63	0.68	0.54	0.55	***0.53***
SAT	San Antonio	0.74	0.72	0.73	0.71	0.76	0.86	0.90	0.86	0.86	***0.53***
MSY	New Orleans	0.60	0.58	0.61	0.57	0.56	0.71	0.66	0.69	0.66	***0.53***
	Mean	0.99	1.02	1.11	1.10	1.16	1.10	0.98	0.97	1.02	***0.94***
	Mean (excluding ATL)	0.94	0.96	1.04	1.03	1.09	1.04	0.92	0.90	0.95	***0.94***

US Port-Run Airports

		Variable Factor Productivity									
		1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
RSW	Southwest Florida	0.86	0.84	0.86	0.92	0.94	0.87	0.88	0.95	1.04	***1.11***
PDX	Portland	0.80	1.22	1.09	1.23	1.22	1.16	1.12	1.07	1.13	***1.10***
SEA	Seattle	1.25	1.19	1.05	1.08	1.00	0.92	0.88	0.92	0.99	***1.04***
BOS	Boston	1.11	1.15	1.22	1.18	1.25	1.13	1.11	1.08	1.02	***1.04***
LGA	New York (LaGuardia)	0.90	1.01	0.96	0.81	0.90	0.85	0.74	0.85	0.94	***1.01***
EWR	Newark	0.89	0.97	0.95	0.78	0.77	0.81	0.66	0.73	0.82	***0.85***
OAK	Oakland	0.81	0.86	0.81	0.81	0.79	0.85	0.77	0.77	0.81	***0.77***
JFK	New York (Kennedy)	0.54	0.57	0.54	0.54	0.49	0.52	0.51	0.43	0.46	***0.52***
	Mean	0.89	0.98	0.93	0.92	0.92	0.89	0.83	0.85	0.90	***0.93***

Appendix A.6 DEA Rankings by Individual Airport

Canadian Airport Authorities

DEA - Without Capital Inputs (CRS)

		2001	2002	2003	2004	2005
YYC	Calgary	0.813	0.827	0.965	0.890	***1.000***
YQT	Thunder Bay	0.851	1.000	1.000	1.000	***1.000***
YVR	Vancouver	0.772	0.881	1.000	1.000	***0.991***
YYJ	Victoria	1.000	1.000	1.000	1.000	***0.912***
YXU	London	0.967	0.918	0.867	0.859	***0.743***
YXE	Saskatoon	0.673	0.641	0.722	0.661	***0.622***
YQB	Quebec	0.629	0.689	0.635	0.555	***0.509***
YEG	Edmonton	0.358	0.387	0.421	0.464	***0.508***
YQM	Moncton	0.580	0.647	0.575	0.542	***0.508***
YOW	Ottawa	0.512	0.487	0.510	0.507	***0.501***
YYZ	Toronto	0.419	0.458	0.479	0.511	***0.497***
YQR	Regina	0.385	0.414	0.449	0.466	***0.482***
YWG	Winnipeg	0.473	0.481	0.494	0.467	***0.470***
YHZ	Halifax	0.296	0.334	0.388	0.405	***0.444***
YYT	St. John's	0.387	0.380	0.401	0.359	***0.334***
YSJ	Saint John	0.322	0.333	0.313	0.318	***0.319***
YYG	Charlottetown	0.286	0.289	0.296	0.331	***0.301***
Mean		**0.572**	**0.598**	**0.619**	**0.608**	***0.597***

US Airport Authorities

DEA - Without Capital Inputs (CRS)

		2001	2002	2003	2004	2005
MCO	Orlando	0.757	0.865	0.902	0.909	***0.878***
RDU	Raleigh-Durham	1.000	1.000	1.000	0.821	***0.861***
TPA	Tampa	0.692	0.769	0.852	0.874	***0.849***
RIC	Richmond	0.667	0.737	0.932	0.773	***0.782***
BNA	Nashville	0.522	0.509	0.623	0.677	***0.720***
RNO	Reno-Tahoe	0.823	0.630	0.622	0.650	***0.682***
CVG	Cincinnati/Kentucky	0.561	0.763	0.733	0.698	***0.643***
IAD	Washington (Dulles)	0.298	0.296	0.483	0.614	***0.610***
IND	Indianapolis	0.721	0.698	0.650	0.572	***0.593***
SAN	San Diego	1.000	1.000	1.000	0.579	***0.568***
MSP	Minneapolis-St. Paul	0.470	0.540	0.998	0.599	***0.565***
JAX	Jacksonville	0.602	0.440	0.514	0.549	***0.562***
CMH	Columbus	0.578	0.578	0.556	0.545	***0.561***
DCA	Washington (Reagan)	0.358	0.301	0.472	0.519	***0.503***
PIT	Pittsburgh	0.460	0.443	0.438	0.510	***0.469***
DTW	Detroit	0.354	0.322	0.413	0.425	***0.454***
DFW	Dallas-Fort Worth	0.429	0.521	0.399	0.491	***0.446***
ALB	Albany	0.379	0.373	0.431	0.480	***0.426***
STL	St. Louis	0.493	0.479	0.372	0.377	***0.327***
Mean		**0.588**	**0.593**	**0.652**	**0.614**	***0.605***

US City-Run Airports

DEA - Without Capital Inputs (CRS)

		2001	2002	2003	2004	2005
ATL	Atlanta	1.000	1.000	1.000	1.000	***1.000***
CLT	Charlotte-Douglas	1.000	1.000	1.000	1.000	***1.000***
SNA	Santa Ana	0.893	0.834	1.000	1.000	***1.000***
FLL	Ft. Lauderdale	0.675	0.697	0.797	0.801	***0.953***
PBI	Palm Beach	0.616	0.608	0.765	0.773	***0.812***
HNL	Honolulu	1.000	0.649	0.839	0.828	***0.804***
PHX	Phoenix	0.653	0.613	0.743	0.737	***0.696***
LAS	Las Vegas	0.530	0.555	0.663	0.706	***0.695***
MKE	Milwaukee	0.530	0.566	0.691	0.673	***0.655***
SMF	Sacramento	0.459	0.465	0.559	0.547	***0.607***
ABQ	Albuquerque	0.491	0.519	0.623	0.596	***0.603***
MCI	Kansas City	0.552	0.476	0.551	0.603	***0.601***
MDW	Chicago (Midway)	0.285	0.417	0.488	0.607	***0.561***
CLE	Cleveland	0.414	0.381	0.417	0.514	***0.518***
DEN	Denver	0.321	0.362	0.438	0.486	***0.513***
SLC	Salt Lake City	0.468	0.527	0.469	0.478	***0.512***
SJC	San Jose	0.496	0.481	0.496	0.483	***0.480***
AUS	Austin	0.431	0.439	0.445	0.453	***0.463***
ORD	Chicago (O'Hare)	0.271	0.315	0.378	0.447	***0.461***
MSY	New Orleans	0.462	0.411	0.472	0.426	***0.405***
LAX	Los Angeles	0.363	0.368	0.418	0.394	***0.383***
SAT	San Antonio	0.470	0.654	0.502	0.464	***0.375***
PHL	Philadelphia	0.353	0.351	0.314	0.314	***0.371***
BWI	Baltimore-Washington	0.604	0.494	0.450	0.447	***0.369***
SFO	San Francisco	0.270	0.253	0.284	0.350	***0.369***
ONT	Ontario	0.279	0.375	0.325	0.311	***0.338***
IAH	Houston	0.569	0.532	0.558	0.487	***0.302***
MIA	Miami	0.251	0.286	0.301	0.309	***0.250***
Mean		**0.525**	**0.522**	**0.571**	**0.580**	***0.575***

US Port-Run Airports

DEA - Without Capital Inputs (CRS)

		2001	2002	2003	2004	2005
OAK	Oakland	0.634	0.685	0.824	0.930	***0.733***
PDX	Portland	0.537	0.507	0.572	0.595	***0.589***
SEA	Seattle	0.363	0.405	0.444	0.501	***0.573***
BOS	Boston	0.422	0.450	0.553	0.556	***0.567***
RSW	Southwest Florida	0.365	0.396	0.525	0.513	***0.523***
EWR	Newark	0.350	0.365	0.502	0.543	***0.520***
JFK	New York (Kennedy)	0.311	0.312	0.403	0.445	***0.429***
LGA	New York (LaGuardia)	0.266	0.226	0.368	0.408	***0.401***
Mean		**0.406**	**0.418**	**0.524**	**0.561**	***0.542***

Appendix A.7 SFA Rankings by Individual Airport

Canadian Airport Authorities

SFA - Without Capital Inputs

		2001	2002	2003	2004	2005
YVR	Vancouver	0.792	0.769	0.761	0.769	***0.774***
YYC	Calgary	0.603	0.584	0.562	0.584	***0.633***
YEG	Edmonton	0.316	0.312	0.316	0.346	***0.378***
YWG	Winnipeg	0.321	0.322	0.332	0.336	***0.351***
YOW	Ottawa	0.344	0.324	0.317	0.332	***0.340***
YHZ	Halifax	0.247	0.240	0.256	0.271	***0.282***
YYZ	Toronto	0.457	0.405	0.239	0.235	***0.206***
YYJ	Victoria	0.145	0.139	0.143	0.151	***0.163***
YYT	St. John's	0.102	0.101	0.107	0.110	***0.120***
YQB	Quebec	0.107	0.101	0.099	0.103	***0.108***
YXE	Saskatoon	0.097	0.095	0.093	0.097	***0.107***
YQR	Regina	0.083	0.077	0.080	0.080	***0.090***
YQM	Moncton	0.072	0.071	0.079	0.081	***0.089***
YQT	Thunder Bay	0.069	0.070	0.079	0.072	***0.072***
YXU	London	0.057	0.061	0.065	0.064	***0.069***
YSJ	Saint John	0.029	0.028	0.027	0.027	***0.028***
YYG	Charlottetown	0.025	0.025	0.025	0.026	***0.027***
Mean		**0.228**	**0.219**	**0.211**	**0.217**	***0.226***

US Airport Authorities

SFA - Without Capital Inputs

		2001	2002	2003	2004	2005
MSP	Minneapolis-St. Paul	0.775	0.798	0.840	0.813	***0.805***
TPA	Tampa	0.770	0.768	0.758	0.774	***0.785***
MCO	Orlando	0.748	0.774	0.738	0.743	***0.746***
CVG	Cincinnati/Kentucky	0.658	0.700	0.705	0.716	***0.716***
IAD	Washington (Dulles)	0.562	0.506	0.582	0.693	***0.686***
DCA	Washington (Reagan)	0.625	0.549	0.603	0.646	***0.654***
RDU	Raleigh-Durham	0.602	0.636	0.604	0.610	***0.634***
DTW	Detroit	0.697	0.605	0.570	0.565	***0.616***
IND	Indianapolis	0.799	0.795	0.574	0.593	***0.614***
BNA	Nashville	0.595	0.563	0.556	0.584	***0.604***
DFW	Dallas/Fort Worth	0.710	0.705	0.688	0.752	***0.598***
SAN	San Diego	0.594	0.549	0.546	0.577	***0.581***
STL	St. Louis	0.748	0.714	0.647	0.581	***0.562***
PIT	Pittsburgh	0.697	0.667	0.609	0.602	***0.551***
CMH	Columbus	0.562	0.550	0.514	0.513	***0.519***
JAX	Jacksonville	0.532	0.367	0.370	0.393	***0.439***
RNO	Reno-Tahoe	0.389	0.354	0.347	0.377	***0.406***
RIC	Richmond	0.375	0.346	0.350	0.314	***0.342***
ALB	Albany	0.308	0.296	0.299	0.325	***0.298***
Mean		**0.618**	**0.592**	**0.574**	**0.588**	***0.587***

US City-Run Airports

SFA - Without Capital Inputs

		2001	2002	2003	2004	2005
ATL	Atlanta	0.908	0.900	0.905	0.908	***0.908***
LAS	Las Vegas	0.813	0.796	0.799	0.832	***0.821***
CLT	Charlotte-Douglas	0.790	0.796	0.780	0.779	***0.790***
PHX	Phoenix	0.831	0.778	0.790	0.782	***0.773***
FLL	Ft. Lauderdale	0.732	0.690	0.696	0.722	***0.750***
HNL	Honolulu	0.842	0.709	0.689	0.728	***0.736***
SLC	Salt Lake City	0.708	0.700	0.680	0.680	***0.723***
IAH	Houston	0.786	0.746	0.734	0.736	***0.638***
PHL	Philadelphia	0.641	0.624	0.543	0.564	***0.633***
DEN	Denver	0.461	0.438	0.536	0.600	***0.600***
MCI	Kansas City	0.671	0.578	0.577	0.590	***0.594***
SNA	Santa Ana	0.580	0.516	0.545	0.574	***0.589***
CLE	Cleveland	0.590	0.527	0.529	0.589	***0.583***
SMF	Sacramento	0.544	0.512	0.539	0.533	***0.581***
MDW	Chicago (Midway)	0.554	0.565	0.577	0.609	***0.564***
MKE	Milwaukee	0.472	0.469	0.499	0.519	***0.540***
BWI	Baltimore-Washington	0.748	0.651	0.545	0.549	***0.503***
SJC	San Jose	0.614	0.541	0.511	0.501	***0.489***
ABQ	Albuquerque	0.464	0.485	0.468	0.475	***0.480***
PBI	Palm Beach	0.440	0.394	0.423	0.445	***0.473***
AUS	Austin	0.496	0.465	0.433	0.452	***0.465***
ONT	Ontario	0.416	0.443	0.394	0.394	***0.406***
SAT	San Antonio	0.427	0.420	0.417	0.437	***0.381***
SFO	San Francisco	0.300	0.270	0.226	0.398	***0.370***
ORD	Chicago (O'Hare)	0.309	0.328	0.352	0.434	***0.368***
MSY	New Orleans	0.437	0.406	0.409	0.393	***0.336***
LAX	Los Angeles	0.310	0.290	0.301	0.269	***0.223***
MIA	Miami	0.245	0.326	0.212	0.217	***0.200***
Mean		**0.576**	**0.549**	**0.540**	**0.561**	***0.554***

US Port-Run Airports

SFA - Without Capital Inputs

		2001	2002	2003	2004	2005
SEA	Seattle	0.635	0.623	0.640	0.685	***0.692***
PDX	Portland	0.683	0.643	0.631	0.646	***0.647***
BOS	Boston	0.653	0.649	0.617	0.588	***0.572***
OAK	Oakland	0.613	0.586	0.578	0.610	***0.571***
RSW	Southwest Florida	0.351	0.347	0.397	0.432	***0.474***
LGA	New York (LaGuardia)	0.430	0.323	0.369	0.422	***0.424***
EWR	Newark	0.278	0.151	0.190	0.234	***0.216***
JFK	New York (Kennedy)	0.102	0.082	0.052	0.047	***0.049***
Mean		**0.468**	**0.425**	**0.434**	**0.458**	***0.456***

Appendix A.8 Unit Cost Rankings by Individual Airport

Canadian Airport Authorities

Unit Cost Index

		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
YYJ	Victoria	-	0.54	0.59	0.57	0.58	0.58	0.65	0.62	0.62	***0.63***
YVR	Vancouver	0.61	0.61	0.64	0.65	0.54	0.68	0.69	0.71	0.71	***0.72***
YYC	Calgary	0.52	0.58	0.63	0.69	0.67	0.72	0.77	0.89	0.85	***0.78***
YWG	Winnipeg	-	0.72	0.82	0.82	0.82	0.91	0.92	0.92	0.89	***0.89***
YXE	Saskatoon	-	-	-	0.91	0.75	0.80	0.90	0.93	0.89	***0.90***
YEG	Edmonton	1.07	1.11	1.14	1.10	0.97	1.01	1.03	1.07	0.97	***0.94***
YQT	Thunder Bay	-	-	0.98	0.99	0.90	0.95	0.89	0.78	0.87	***0.94***
YQR	Regina	-	-	-	0.82	1.00	1.15	1.16	1.11	0.99	***0.96***
YXU	London	-	-	-	0.90	0.80	0.95	1.01	1.01	0.96	***1.00***
YOW	Ottawa	-	0.84	0.88	0.84	0.79	0.81	0.87	0.99	1.07	***1.07***
YQM	Moncton	-	-	1.39	1.21	1.04	1.06	1.17	1.19	1.16	***1.09***
YHZ	Halifax	-	-	-	-	0.92	1.24	1.24	1.19	1.11	***1.10***
YYT	St. John's	-	0.97	0.86	0.90	1.11	1.20	1.34	1.22	1.27	***1.25***
YQB	Quebec	-	-	-	-	-	1.29	1.31	1.45	1.52	***1.34***
YYG	Charlottetown	-	1.92	1.53	1.31	1.88	1.74	1.83	1.82	1.76	***1.71***
YSJ	Saint John	-	-	-	1.23	1.61	1.79	2.09	2.20	1.94	***1.89***
YYZ	Toronto	0.65	0.73	0.92	1.01	1.13	1.37	1.53	2.03	1.91	***2.00***
	Mean	0.71	0.89	0.94	0.93	0.97	1.07	1.14	1.18	1.15	***1.13***

US Airport Authorities

Unit Cost Index

		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
RDU	Raleigh-Durham	-	0.37	0.40	0.35	0.33	0.35	0.36	0.46	0.54	***0.52***
TPA	Tampa	0.68	0.65	0.62	1.03	0.58	0.60	0.60	0.66	0.64	***0.64***
RIC	Richmond	0.73	0.63	0.66	0.67	0.65	0.63	0.64	0.62	0.69	***0.65***
BNA	Nashville	0.70	0.72	0.66	0.69	0.68	0.69	0.73	0.75	0.68	***0.67***
MSP	Minneapolis-St. Paul	0.61	0.59	0.66	0.64	0.66	0.75	0.67	0.51	0.65	***0.69***
CVG	Cincinnati/Kentucky	0.61	0.60	0.61	0.60	0.62	0.74	0.70	0.71	0.71	***0.73***
IND	Indianapolis	0.82	1.00	1.03	1.07	0.97	0.39	0.41	0.80	0.84	***0.80***
CMH	Columbus	0.67	0.71	0.70	0.76	0.75	0.66	0.73	0.81	0.82	***0.82***
RNO	Reno-Tahoe	0.70	0.72	0.72	0.76	0.73	0.72	0.82	0.92	0.87	***0.83***
MCO	Orlando	0.77	0.73	0.76	0.79	0.79	0.84	0.78	0.87	0.86	***0.84***
JAX	Jacksonville	0.82	0.75	0.74	0.77	0.81	0.69	0.87	0.94	0.98	***0.97***
IAD	Washington (Dulles)	1.16	1.10	1.03	1.12	1.19	1.32	1.49	1.27	0.98	***0.98***
DFW	Dallas-Fort Worth	0.86	0.82	0.59	0.69	0.76	0.88	0.90	0.94	0.77	***0.99***
DCA	Washington (Reagan)	1.44	1.39	1.52	1.44	1.02	1.02	1.24	1.17	1.06	***1.06***
DTW	Detroit	0.92	0.86	0.88	0.98	0.94	0.97	1.19	1.25	1.25	***1.13***
PIT	Pittsburgh	1.42	1.32	1.38	1.40	1.38	0.86	0.91	1.02	1.05	***1.16***
STL	St. Louis	0.65	0.69	0.71	0.72	0.66	0.74	0.84	1.03	1.13	***1.17***
SAN	San Diego	1.05	1.24	0.78	0.88	0.89	0.96	1.20	1.23	1.15	***1.18***
ALB	Albany	1.02	0.99	1.01	1.09	1.03	1.05	1.11	1.17	1.10	***1.35***
	Mean	0.87	0.84	0.81	0.86	0.81	0.78	0.85	0.90	0.88	***0.90***

US City-Run Airports

		Unit Cost Index									
		1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
ATL	Atlanta	0.33	0.28	0.26	0.28	0.27	0.32	0.35	0.33	0.32	-
CLT	Charlotte-Douglas	-	0.37	0.36	0.38	0.37	0.38	0.39	0.43	0.43	***0.42***
LAS	Las Vegas	0.58	0.59	0.63	0.67	0.63	0.67	0.72	0.71	0.61	***0.65***
SLC	Salt Lake City	0.56	0.66	0.64	0.70	0.69	0.70	0.74	0.78	0.80	***0.73***
ABQ	Albuquerque	1.25	1.35	0.61	0.65	0.66	0.72	0.71	0.74	0.77	***0.74***
PHX	Phoenix	0.59	0.61	0.60	0.62	0.60	0.61	0.77	0.74	0.76	***0.78***
MKE	Milwaukee	0.77	0.93	0.95	0.89	0.87	0.76	0.83	0.79	0.78	***0.79***
FLL	Fort Lauderdale	0.94	0.91	0.74	0.72	0.67	0.70	0.84	0.85	0.82	***0.80***
HNL	Honolulu	0.44	0.48	0.52	0.52	0.51	0.53	0.89	0.98	0.82	***0.81***
MCI	Kansas City	0.80	0.82	0.79	0.60	0.65	0.71	0.96	0.90	0.86	***0.85***
SNA	Santa Ana	0.77	0.73	0.76	0.77	0.68	0.70	0.94	0.93	0.89	***0.88***
PBI	Palm Beach	1.03	0.96	0.88	0.93	0.82	0.87	1.06	0.99	0.96	***0.93***
AUS	Austin	0.63	0.70	0.88	0.89	0.82	0.97	1.00	1.12	1.00	***1.01***
CLE	Cleveland	1.04	1.23	0.95	1.10	0.78	0.99	1.17	1.10	0.96	***1.03***
SMF	Sacramento	0.91	0.84	0.88	0.93	0.89	0.92	1.13	1.10	1.15	***1.04***
DEN	Denver	1.10	1.21	1.12	1.21	1.26	1.33	1.36	1.19	1.05	***1.04***
IAH	Houston	0.93	0.89	0.87	0.91	0.65	0.73	0.84	0.88	0.88	***1.09***
PHL	Philadelphia	1.17	1.06	1.03	1.17	1.06	1.11	1.15	1.38	1.32	***1.13***
ORD	Chicago (O'Hare)	1.52	1.46	1.10	1.20	1.19	1.29	1.27	1.22	1.07	***1.13***
MDW	Chicago (Midway)	1.16	1.25	1.04	1.03	0.97	1.17	1.19	1.17	1.07	***1.21***
LAX	Los Angeles	0.86	0.89	0.77	0.90	1.01	1.20	1.32	1.32	1.34	***1.39***
SAT	San Antonio	0.97	0.97	0.98	1.03	0.94	0.82	0.77	0.82	0.83	***1.47***
SJC	San Jose	0.99	0.93	0.91	1.07	1.19	1.14	1.31	1.39	1.43	***1.47***
BWI	Baltimore-Washington	0.84	0.78	0.79	0.72	0.65	0.76	1.04	1.34	1.32	***1.50***
SFO	San Francisco	1.01	1.02	1.14	1.27	1.22	1.60	1.86	2.08	1.51	***1.53***
MSY	New Orleans	1.37	1.42	1.33	1.42	1.45	1.11	1.24	1.22	1.28	***1.55***
ONT	Ontario	1.08	1.13	1.01	1.24	1.25	1.46	1.20	1.52	1.58	***1.58***
MIA	Miami	1.23	1.26	1.32	1.27	1.34	1.73	1.58	1.99	1.95	***2.11***
	Mean	0.92	0.92	0.85	0.90	0.86	0.93	1.02	1.07	1.02	***1.10***
	Mean (excluding ATL)	0.94	0.94	0.87	0.92	0.88	0.95	1.05	1.10	1.05	***1.10***

US Port-Run Airports

		Unit Cost Index									
		1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
RSW	Southwest Florida	0.96	1.00	0.99	0.95	0.91	1.00	1.01	0.95	0.91	***0.89***
PDX	Portland	1.09	0.72	0.83	0.76	0.80	0.85	0.91	0.96	0.93	***0.95***
SEA	Seattle	0.71	0.72	0.91	0.95	1.02	1.11	1.15	1.11	1.00	***0.98***
BOS	Boston	0.98	0.95	0.92	0.96	0.91	1.03	1.07	1.13	1.17	***1.17***
OAK	Oakland	1.01	0.96	1.03	1.06	1.08	1.03	1.16	1.20	1.10	***1.23***
LGA	New York (LaGuardia)	1.62	1.40	1.54	1.83	1.63	1.71	2.14	1.85	1.65	***1.61***
EWR	Newark	1.62	1.42	1.50	1.78	1.81	1.76	2.30	2.06	1.82	***1.83***
JFK	New York (Kennedy)	2.79	2.47	2.55	2.56	2.79	2.72	3.05	3.39	3.12	***2.92***
	Mean	1.35	1.21	1.28	1.36	1.37	1.40	1.60	1.58	1.46	***1.45***

Appendix A.9 Operating Expense per Passenger Rankings by Individual Airport

Canadian Airport Authorities

		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
		Operating Expense per Passenger (1996 $US)									
YYC	Calgary	2.38	2.52	2.75	2.90	2.79	3.56	3.84	4.24	3.52	***3.31***
YYJ	Victoria	-	2.35	3.18	3.01	3.01	3.10	3.54	3.19	3.21	***3.38***
YVR	Vancouver	3.25	3.32	3.86	4.00	3.34	4.51	3.81	3.88	3.75	***3.59***
YEG	Edmonton	4.70	4.57	4.73	4.69	4.06	4.53	4.80	4.84	4.33	***4.18***
YQR	Regina	-	-	-	3.32	5.15	6.18	5.65	5.25	4.43	***4.36***
YXE	Saskatoon	-	-	-	4.59	3.78	4.53	5.20	5.17	4.55	***4.53***
YHZ	Halifax	-	-	-	-	4.11	5.36	5.17	5.12	4.64	***4.85***
YQT	Thunder Bay	-	-	4.71	4.75	4.17	4.39	4.51	4.28	4.36	***4.88***
YWG	Winnipeg	-	3.25	4.47	4.61	4.58	5.62	6.04	5.84	5.24	***4.96***
YOW	Ottawa	-	3.82	4.62	4.40	3.99	4.14	4.39	4.92	5.23	***5.20***
YYT	St. John's	-	4.48	4.35	5.20	5.48	6.70	8.38	6.70	6.70	***5.58***
YQM	Moncton	-	-	12.75	11.39	8.68	8.63	11.50	9.07	8.54	***7.60***
YXU	London	-	-	-	7.43	6.01	8.48	8.32	8.14	7.76	***7.65***
YYZ	Toronto	2.56	3.04	4.17	4.45	4.93	6.38	7.01	9.37	7.93	***8.04***
YQB	Quebec	-	-	-	-	-	9.37	9.36	10.17	9.52	***8.20***
YYG	Charlottetown	-	9.12	9.58	8.89	10.91	11.28	12.10	10.88	10.56	***9.41***
YSJ	Sain John	-	-	-	6.85	10.59	12.72	14.37	14.00	11.96	***11.36***
	Mean	3.22	4.05	5.38	5.37	5.35	6.44	6.94	6.77	6.25	***5.95***

US Airport Authorities

		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
		Operating Expense per Passenger (1996 $US)									
CVG	Cincinnati/Kentucky	1.40	1.35	1.39	1.41	1.46	1.95	1.73	1.77	1.79	***1.84***
MSP	Minneapolis-St. Paul	1.54	1.49	1.73	1.64	1.67	2.01	1.87	1.46	1.88	***2.00***
RDU	Raleigh-Durham	-	1.21	1.33	1.09	0.95	1.14	1.48	1.89	2.15	***2.05***
TPA	Tampa	2.71	2.59	2.58	4.08	2.31	2.48	2.50	2.78	2.57	***2.66***
BNA	Nashville	2.75	2.94	2.64	2.71	2.55	2.73	3.03	3.09	2.83	***2.75***
DFW	Dallas-Fort Worth	2.14	2.08	1.63	1.78	1.87	2.34	2.48	2.42	2.28	***2.79***
MCO	Orlando	2.89	2.79	3.12	3.19	3.31	3.75	3.32	3.47	3.25	***3.18***
DTW	Detroit	2.39	2.26	2.14	2.48	2.41	2.72	3.23	3.68	3.54	***3.33***
RNO	Reno-Tahoe	2.28	2.21	2.47	2.78	2.72	2.86	3.26	3.59	3.37	***3.46***
SAN	San Diego	2.74	3.29	2.10	2.42	2.35	2.68	3.51	3.64	3.39	***3.51***
STL	St. Louis	1.48	1.62	1.66	1.67	1.53	1.93	2.20	3.03	4.01	***3.61***
RIC	Richmond	4.19	4.02	4.47	4.62	4.52	4.85	4.59	4.36	4.15	***3.75***
CMH	Columbus	2.51	2.69	2.81	3.02	3.42	3.16	3.44	3.85	3.90	***3.77***
IND	Indianapolis	6.87	6.92	8.60	8.85	7.90	3.30	3.67	3.88	4.06	***3.84***
DCA	Washington (Reagan)	4.17	4.69	5.44	6.05	3.44	4.03	4.47	4.91	4.29	***4.13***
IAD	Washington (Dulles)	4.18	4.10	4.06	4.34	4.36	5.09	5.64	5.66	4.36	***4.22***
JAX	Jacksonville	3.35	3.03	3.07	3.02	3.28	4.03	3.37	3.79	4.27	***4.25***
PIT	Pittsburgh	4.06	3.81	4.07	4.37	4.15	2.63	2.84	3.46	3.78	***4.69***
ALB	Albany	4.99	4.80	4.75	5.50	5.19	5.46	5.71	6.40	6.05	***7.06***
	Mean	3.15	3.05	3.16	3.42	3.13	3.11	3.28	3.53	3.47	***3.52***

US City-Run Airports

		Operating Expense per Passenger (1996 $US)									
		1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
ATL	Atlanta	0.76	0.69	0.68	0.67	0.63	0.76	0.78	0.73	0.73	**-**
CLT	Charlotte-Douglas	-	0.79	0.82	0.94	0.90	0.95	0.99	1.08	0.99	***0.89***
SLC	Salt Lake City	1.41	1.66	1.62	2.00	1.92	2.01	2.13	2.18	2.27	***1.95***
LAS	Las Vegas	1.59	1.76	1.94	2.04	1.87	2.15	2.30	2.28	1.92	***2.02***
PHX	Phoenix	1.72	1.85	1.89	2.01	1.94	2.01	2.36	2.19	2.27	***2.31***
FLL	Fort Lauderdale	3.15	3.09	2.65	2.48	2.28	2.56	2.87	2.84	2.63	***2.86***
IAH	Houston	2.86	2.67	2.65	2.83	1.78	2.01	2.27	2.41	2.37	***2.90***
HNL	Honolulu	2.08	2.32	2.61	2.62	2.45	2.71	3.14	4.02	3.03	***2.91***
ABQ	Albuquerque	4.47	4.91	2.30	2.39	2.46	2.88	3.05	3.11	3.17	***3.01***
ORD	Chicago (O'Hare)	4.08	3.95	2.99	3.34	3.34	3.60	3.54	3.32	2.86	***3.06***
PHL	Philadelphia	3.38	3.03	2.87	3.43	3.03	3.41	3.27	3.72	3.40	***3.13***
MDW	Chicago (Midway)	3.55	4.12	3.02	2.94	2.70	3.24	3.31	3.11	2.81	***3.29***
MCI	Kansas City	2.97	2.97	3.06	2.37	2.43	2.82	3.89	3.64	3.43	***3.46***
MKE	Milwaukee	3.10	4.03	4.32	4.17	3.94	3.52	3.88	3.62	3.50	***3.47***
DEN	Denver	3.56	3.97	3.78	4.12	4.34	4.62	4.85	4.11	3.56	***3.55***
SNA	Santa Ana	3.01	2.87	3.01	3.07	2.82	3.25	3.81	3.81	3.64	***3.58***
AUS	Austin	2.07	2.28	3.11	3.34	3.29	4.08	4.13	4.33	3.68	***3.65***
PBI	Palm Beach	3.86	3.60	3.55	3.67	3.36	3.59	4.26	3.97	3.73	***3.65***
CLE	Cleveland	3.24	3.67	3.00	3.55	2.57	3.57	4.18	3.81	3.54	***3.89***
BWI	Baltimore-Washington	2.80	2.69	2.87	2.68	2.45	2.67	3.51	3.76	3.36	***4.06***
MSY	New Orleans	4.07	4.17	4.03	4.17	4.10	3.06	3.33	3.25	3.13	***4.07***
SMF	Sacramento	3.60	3.48	3.63	3.98	3.78	3.86	4.96	4.89	4.94	***4.48***
LAX	Los Angeles	2.79	2.88	2.92	2.99	3.18	4.10	4.42	4.44	4.25	***4.57***
SAT	San Antonio	2.99	3.00	3.05	3.20	3.03	2.70	2.55	2.79	2.83	***4.84***
SFO	San Francisco	3.20	3.29	3.85	4.25	4.16	6.33	6.75	7.63	5.39	***5.62***
SJC	San Jose	3.90	3.75	4.00	4.55	4.86	5.02	5.83	6.03	5.92	***5.97***
ONT	Ontario	3.95	4.03	3.77	5.09	5.24	6.27	5.20	6.17	6.27	***6.47***
MIA	Miami	7.68	7.67	7.85	7.24	7.61	7.45	6.73	8.01	7.86	***7.65***
	Mean	3.18	3.19	3.07	3.22	3.09	3.40	3.65	3.76	3.48	***3.75***

US Port-Run Airports

		Operating Expense per Passenger (1996 $US)									
		1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
RSW	Southwest Florida	3.53	3.61	3.95	3.83	3.55	3.52	3.55	3.50	3.25	***3.25***
SEA	Seattle	2.83	2.94	3.16	3.15	3.47	3.95	3.90	3.63	3.35	***3.53***
PDX	Portland	4.09	2.69	3.05	2.99	3.36	3.74	3.70	3.89	3.70	***3.68***
OAK	Oakland	3.81	3.95	4.23	4.34	4.12	4.47	4.67	4.58	4.24	***4.45***
BOS	Boston	3.95	3.88	3.86	4.06	3.81	4.99	4.97	5.31	4.95	***5.14***
LGA	New York (LaGuardia)	5.93	5.74	5.32	5.66	4.92	5.38	6.58	6.53	5.71	***5.58***
EWR	Newark	5.61	5.24	5.58	6.82	6.55	6.81	9.17	8.47	7.38	***7.46***
JFK	New York (Kennedy)	8.43	8.40	9.46	9.56	9.63	10.25	10.55	11.40	10.27	***9.60***
	Mean	4.77	4.55	4.83	5.05	4.93	5.39	5.89	5.91	5.35	***5.33***