AIR TRAFFIC AND ITS IMPLICATIONS FOR THE ECONOMICS OF MAJOR AIRPORTS

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BY

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A thesis submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of

MASTER OF ARTS

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ABSTRACT

This thesis examines the relationship between air traffic and airport capacity at the major airports. A systematic analysis of the economics of air traffic and traffic forecasting provides the basis for subsequent discussion. It was found that the complexity of air traffic development made forecasting inherently difficult. The fact, combined with limitations in forecasting methods, has made the timing and size of investment in airport capacity hazardous. Evidence of over- and under-capacity problems is illustrated in terms of Canada's largest airports. These problems impose substantial costs on both the users and providers of airport facilities. Further, the airside impact of traffic has external cost impacts on the provision of landside airport facilities.

Improvement in forecasting techniques by widening their system scope and by verification through the use of different methods is recommended for better predictions of airport capacity needs. Based on an analysis of the economics of methods to alleviate congestion in the short term by demand management of traffic, further examination of these methods, with a view to implementation, is recommended.

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CHAPTER ONE

INTRODUCTION

1.1 OVERVIEW

This thesis examines the relationship between air traffic and airport capacity. It is concerned with a fundamental determinant, the dynamics of airport system development - the demand for capacity based on air traffic. Expansion of air traffic is reflected in more air routes, increased numbers of aircraft, arrivals and departures; and shifts in the relative importance of specific traffic centres have rendered the existing facilities of many major airports inadequate to accommodate this expansion. This has led to renewed interest in airport planning and management; more significantly it has highlighted the need for more accurate air traffic demand forecasting to improve the economics of long-term planning of major airports. Such airports require very large commitments of capital which have serious economic implications. The timing and quantification of this capital investment and its subsequent management are significant public policy problems.

Airports constitute one of the main components of the infrastructure for air transport and are part of the total transportation system which contribute to the economic growth of the country. For the purpose of this thesis, the focus is on major airports which, in Canada, are the international airports. The Canadian international airports are designated by the government as "airports of entry and departure for international air traffic, where customs, immigration, public health, animal and plant quarantine and similar services are provided" (Le and Shaw 1981, 57). The top nine international airports across Canada according to Transport Canada's statistics include the international airports at Toronto, Vancouver, Dorval, Calgary, Edmonton, Halifax, Mirabel, Ottawa and Winnipeg. For the purpose of this research work, reference will be confined to the four major airports at Toronto, Vancouver, Dorval and Mirabel.

Beginning from the seventies, most major airports had to undergo major expansion plans to meet the increase in air traffic demands. This has been the case for the three largest Canadian airports: Toronto's Lester B. Pearson International Airport, Vancouver's International Airport and Montreal's International Airport (Dorval). The Lester B. Pearson International Airport has the highest air traffic levels in Canada, and hundreds of millions of dollars have been spent on the expansions of its terminals since the early seventies. The next busiest Canadian airport is Vancouver's International Airport which also had to undergo expansions of its terminal in the seventies to meet the growing air traffic demand, as well as to accommodate the wide-bodied jets. A new and modern air freight terminal was built in 1973 to accommodate the rapid increases in air freight demand. In view of the continuing growth of the air traffic demand at Montreal

International Airport (Dorval), a new airport was built at Mirabel in 1975, to handle international flights and to ease the air traffic congestion at Dorval.

The main focus of this thesis is on air traffic demand and its economic effects on international airport planning and development. Toronto's Lester B. Pearson International Airport experienced a 50 percent increase in annual passenger air traffic growth since deregulation, and this is forecasted to reach 21.7 million passengers by 1991 (Transport Canada 1988b). Vancouver International Airport, the second busiest in Canada, experienced a 12 percent annual passenger growth rate and this is forecasted to reach 9.3 million by 1991 (Transport Canada 1988b).

The dynamics of air traffic demand bring about changes in the air transportation system which present the government with investment and management decisions. Should a new airport be built to meet higher levels of air traffic demand, or should there be expansion of existing airport facilities? These are very significant decisions, because if an airport facility is built too soon there is a waste of capital; if airport expansion or construction is unduly delayed, the air transport system and its users suffer economic costs and a degree of safety. Depending on the magnitude of air traffic demand increases, there is the prospect of major financial, economic and time costs for air carriers, passengers and shippers of cargo to compound the financial and economic problems of government. This thesis will examine the nature of demand forecasting of air traffic and its role in airport planning and management.

The subject of this thesis has been relatively neglected in transport literature. Much attention has been given to the planning of airport construction, economic impact studies for individual airports, and to cost-benefit studies of airports. Work in these areas is important and complementary to this thesis. The thesis contributes to the economics of airport development with particular reference to the air traffic-airport capacity linkage, and the dynamics of airport development and management.

1.2 OBJECTIVES AND SCOPE

The purpose of this thesis is to analyze the implications of air traffic demand for the planning of major airports and their economic management. The analysis in this thesis is directed towards three basic questions:

1) What are the economics of air traffic and the resulting demand for capacity at major airports?

2) What are the adaptive possibilities for airports in the light of unanticipated air traffic developments?

3) What are the public policy implications of air traffic

demand for capacity at major airports?

To develop the economic analysis, two main foundations are provided. The first of these is concerned with the economics of air traffic development. The second is air traffic demand forecasting. How is air traffic demand forecasting done? What are the strengths and limitations of alternative methods?

An analysis of the impact of air traffic growth on airport facilities is then provided. It will be seen that air traffic demand of passenger and cargo, will result in daily, weekly or seasonal peaking variations. With demand growth, peak periods of demand will strain airport facilities and create problems of congestion. Such congestion is very costly and airlines have appealed to regulatory authorities of all governments to cooperate in the solution of these problems. Effective forecasting of air traffic and proper size and timing of airport construction will, however, be seen to be fundamental to any solution of congestion problems.

Given the relatively fixed nature of airport infrastructure in the short run, the airport management will play a vital role in allocating efficiently existing resources during periods of peak in the air traffic demand. Several demand management options are evaluated for the handling of limited airport capacity. This includes the priorization and allocation of airport facilities to users with consideration of the offering of equal access to users.

To provide focus and perspective, material on airport planning is provided, followed by specific reference to Canada's three largest airports.

1.3 PROCEDURE

This thesis is organized into seven chapters. Following this introductory chapter, Chapter Two provides a brief historical review of past trends in airport development, with references to some major airports. Specific references will be made to the major airports in Toronto, Vancouver and Montreal. Particular emphasis will be given on their air traffic levels and how these relate to the expansion plans at each of the above-mentioned airports.

Chapter Three examines the economics of international air traffic operations, in terms of the airline output and the factors which determine the demand and supply of the international air traffic services. A further discussion will be made on the nature of the demand for air traffic services, which contributes to the variations of demand and congestion in the international airline industry.

Chapter Four discusses the different techniques that can be used to forecast the demand for air traffic services. Three broad techniques namely, qualitative, quantitative and decision analysis will be outlined. The methodology involved in developing models for air traffic demand will also be discussed. A basic economic air traffic demand model is first specified, and subsequently, the forecasting models for air passenger and air freight demand will be discussed. An evaluation is made for each of the techniques used to forecast air traffic demand, with a discussion on the strengths and limitations of each of them.

Chapter Five examines the economics of airport capacity. The relation between airport investments and capacity will be discussed. In view of the lumpiness of airport investments, such decisions can affect the economics of airport capacity. Constraints on airport capacity can lead to serious problems of congestion. The economics of peak loads and congestion are examined.

Chapter Six discusses the economics of airport management of the given airport capacity. Following an identification of the users of airport facilities, the discussion proceeds to a consideration of the assignment of gates and the allocation of limited space at the airport. The chapter then examines the possibilities of using pricing as an alternative to lower air traffic peaks at airports, in order to alleviate congestion problems.

Chapter Seven concludes the thesis with a concise review of the research findings. It provides responses to the three fundamental questions raised in the statement of objectives and scope presented earlier in this introduction.

CHAPTER TWO

DEVELOPMENT OF MAJOR AIRPORTS

2.1 INTRODUCTION

This chapter provides perspective on airport and airport development. In the very early days, little sophistication in the design of airports was required. With the advance of aviation, runways and passenger terminals replaced the simple settings on grass strips and huts. Stronger and longer runways were required to accommodate the heavier aircraft such as the jetliners when they were introduced in the seventies. New airport terminal designs also had to be developed to accommodate further advances in aircraft technology. To reflect these trends, the development of major international airports in the United States, Europe and the Asian Pacific regions will be discussed. Subsequently, historical trends for the major Canadian airports at Vancouver, Toronto and Montreal will be mentioned. Finally, important considerations in the planning of these major airports will be identified.

2.2 GENERAL AIRPORT DEVELOPMENT

To provide some background into the development of airports, some general development of passenger and cargo terminals will be mentioned. In addition, actual air traffic data will be used to illustrate the growth trends at major world airports.

2.21 BACKGROUND INFORMATION

The introduction of the jet aircraft offered significant cost savings which resulted in lower air fares. This stimulus, backed by general economic growth, produced substantial increases in traffic at major airports.

Every airport is characterized by airside and landside components. The airside component includes the airfield, aircraft and apron area. The landside component includes both passenger and cargo terminals, airport operations and administration, and the ground access system which serves as an interface between air and ground modes of transportation. At any major airport, the passenger terminal building, where passenger and baggage handling takes place, is the most important building, because of the predominance of passenger movement in air transport. The terminals also provide facilities to clear immigration, health and customs for passengers who arrive on international flights.

Blankenship distinguishes three distinct generations in the evolution of airport terminal buildings. From the thirties to the fifties, the first generation airport terminals only required "a surface building permitting a direct interchange between airport access modes and the aircraft" (Blankenship 1974, 28). However, as a result of the increase in the demand for air traffic services in the late fifties, second generation aircraft terminals with more aircraft positions and gates were built. This meant that passengers had to walk extra distances to board the aircraft. Thus, third generation airport terminals evolved to eliminate this problem, and mechanical means such as travellators were built to reduce this extra walking distance. At the same time, mechanical conveyor belts were also introduced to process the increased amount of passenger baggage. These automated systems helped to improve the efficiency of baggage handling.

Air cargo terminals also evolved from the very unsophisticated ways of handling cargo to more specialized handling. In their first form, the air cargo terminals served as warehouses, where the cargo were manually loaded and offloaded from the aircraft and left on the floor space until it was picked up for delivery. The documentation could arrive separately by air mail and the more valuable items were kept in the manager's office for safe keeping. However, as the demand for air cargo traffic increased, specialized document methods were developed along with the use of mechanized methods. The continued growth of air cargo traffic resulted in multiple handling of individual cargo shipments through containerization.

This mechanization of air cargo handling has helped to reduce the time required to handle cargo shipments. Containerization also helps to minimize the risks of theft and damage that may occur. However, international air cargo traffic requires customs clearance, duty, value added tax and other inspection requirements that involve time constraints.

2.22 AIR TRAFFIC AT MAJOR WORLD AIRPORTS

Major airports around the world have experienced rapid growth in their air traffic levels. In 1988, the International Civil Aviation Organization (ICAO), recorded an annual increase in passenger traffic of about 6.9 percent and an increase of about 11 percent in freight traffic. Total international traffic, of all air traffic, accounted for about 45 percent of passenger traffic and 77 percent of freight traffic. Table 1 shows the rankings of major countries performing passenger and freight traffic in scheduled services for the year 1988.

The problems of airport congestion are often present in major international airports throughout the world. The International Air Transport Association (IATA) forecasts that the growth of international airline traffic will average at 7 percent over the next five years. The United States is the world's most important aviation nation, and ICAO has reported a U.S. trend towards faster international traffic growth compared to the domestic traffic. In 1988, 43.1 percent of the world's passengers were carried by US airlines (Air Transport World 1989, 84).

New York is one of the largest air traffic hubs in the United States, and it ranked first among major world airports in terms of passenger and cargo air traffic levels. In 1987, the International Transport Association (ITA) recorded that a total of 77.89 million passengers and 1.4 million tonnes of air-freight has used New York as a hub. John F. Kennedy International Airport is the region's busiest and the world's seventh busiest in terms of passenger volume. It recorded a total of 30.2 million passengers in 1988 (Almanac Atlas and Yearbook 1989, 365). Kennedy's dependence on international travel, its high volumes of transfer passengers and time zone considerations are mainly responsible for the late afternoon and early evening peak periods at the airport, when international flights arrive and depart. It is not surprising then that a survey of the 20 busiest airports in 1988, recorded a 30 percent of arrival flight delays and 21 percent of departure flight delays at the Kennedy airport (Isensee 1988, 130). However, plans have been made to increase the airport's capacity to handle 45 million passengers annually by 1998.

The forthcoming liberalization for European air transportation in 1992, where all barriers to provide air services will be removed within the European Economic Community, is expected to further stimulate the European air traffic growth (Doz 1989, 34). The airlines in the United Kingdom carried a total of 28.5 million passengers and 405,419 metric tonnes of freight in 1987, where 18.5 million were international passengers and 354,636 were international freight. London ranked first among the major European

TABLE 1

SCHEDULED PASSENGER AND FREIGHT TRAFFIC IN 1988

Passenger Kilometres Performed (Millions)

Country	Rank	Total Traffic	Int'l Traffic
United States	1	674 300	152 900
Japan	3	84 900	45 200
United Kingdom	4	83 970	79 200
Canada	6	44 600	22 500
Singapore	9	28 000	28 000
Netherlands	11	24 130	24 074
Tonne Kilometres Performed (Millions)			
United States	1	77 650	21 345
Japan	2	12 080	8 485
United Kingdom	3	11 215	10 810
Canada	4	5 255	2 880
Netherlands	5	4 195	4 190
Singapore	6	4 100	4 100

Source: ICAO Bulletin July 1989, 15.

airports in terms of passenger traffic with a total of 54.8 million passengers in 1987. For the same year, it ranked second after Frankfurt in terms of cargo traffic. Frankfurt recorded a total of 909,300 tonnes of freight, while London recorded a total of 786,700 tonnes (ITA 1988, 71).

Heathrow, the world's fifth busiest airport, handled 34.7 million passengers for the year 1988 (Almanac Atlas and Yearbook 1989, 365). Gatwick handled 19.4 million passengers for that year and during the summer of 1988, there were flight delays for up to six hours at Gatwick airport. As an alternative solution, plans have been made to develop Stansted as London's third airport.

Although Schiphol airport principally serves Amsterdam, it is the major international airport for the Netherlands. It is a major gateway to Europe and also serves neighbouring municipalities in the Hague, Rotterdam, Leyden, Haarlem and Utrecht. It is favourably located close to the major industrial European centres and is presently ranked the fifth busiest airport for passengers in Europe. It recorded a total of 13.3 million passengers in 1987. In 1988, Schiphol airport handled 15.0 passengers and 575,000 tonnes of freight, an increase from the previous year of 10 percent and 12 percent respectively (Airport Support 1989, 7).

Schiphol airport also has excellent cargo facilities with good connections to the neighbouring European countries. It ranked fourth among the major European airports, with a total of 513,700 tonnes of freight in 1987 (ITA 1988, 71). Amsterdam and Singapore are both major gateways and distribution centres for air freight. Goods transitting in Singapore are not taxed because of Singapore's free trade zone, which facilitates the transhipment of air freight with minimum documentation. Recently, in March of 1989, Singapore Airlines and KLM Royal Dutch Airlines signed an agreement to operate a joint service all-freighter flight between Singapore and Amsterdam once a week, using Singapore Airlines B747 freighter aircraft which have a cargo capacity of 109 tonnes. This is expected to further increase the air freight traffic between the two countries and strengthen both their positions as major cargo centres for their regions. Besides this freighter service, Singapore Airlines has six weekly B747 flights between Singapore and Amsterdam, two of which are Combi services, and KLM has six weekly B747 flights between the two countries, three of which are Combis. The air cargo traffic between Singapore and Amsterdam has been growing strongly at an annual growth rate of 18 percent in the past five years, from 7,961 tonnes in 1982-83 to 18,047 tonnes in 1987-88.

ICAO ranks Amsterdam's Schiphol Airport as the fourth busiest airport in Europe and seventh busiest in the world in terms of cargo volume handled, while Singapore has been ranked the fourth busiest airport in Asia and tenth busiest in the world. Since 1984, Schiphol Airport has been voted the world's best airport by readers of Business Traveller, an international travel magazine read in more than fifty countries. However, in 1988, Singapore's Changi Airport was voted the top choice by the Business Travellers Magazine, in their survey which considered factors such as airport congestion, efficiency in passenger and baggage handling, transit facilities, duty-free shopping and ground access to the city centres.

Singapore owes this position to its strategic central, geographical location at the crossroads of Asia, and an excellent infrastructure as an important trading, commercial and financial centre. It is also a leading communication centre with an efficient, extensive telecommunication network which helps to facilitate investment and trade opportunities. All these provide a home base for Singapore to develop as an aviation hub for its region.

For the year 1988, the airport recorded a 12.4 percent increase in passenger growth, bringing it to 12.6 million passengers which put a strain on the terminal building that was designed to handle only 10 million passengers annually. This is projected to increase at an annual rate of 5 to 7 per cent to reach 20 million by the end of the century. Based on the above projections and the continually increasing air traffic demands, a second passenger terminal is presently being built and will be completed by 1990. This will double the passenger handling capacity at the airport to 20 million per year. There is also provision for a third passenger terminal building in the airport's master plan, to be built whenever the situation demands an expansion of airport facilities.

As for air cargo traffic, a 14 percent annual growth rate up to 1995 has been forecasted for this airport. The total cargo growth for 1988 was 22.3 percent bringing it up to a total of 512,506 tonnes (Civil Aviation Authority of Singapore 1988, 11). In order to meet the anticipated growth in the rapidly expanding air cargo industry, Singapore's Changi Airport is planning a fifth cargo terminal to be completed by 1992 to accommodate the strong growth in air cargo traffic expected to continue into the next decade.

ICAO forecasts a growth rate per annum of 11 percent for passengers and 13 percent for air freight in the Pacific region until 1995 (Chua 1989, 3). Japan, the largest aviation market in the Pacific, is presently making plans to expand Tokyo's Narita airport terminal and to build a second runway by 1992, as well as to complete the first phase of the Kansai International Airport in Osaka by 1993. The Japanese travel market has strong potential for growth, doubling in the past ten years to 6.6 million in 1987 (Rek 1989a, 539). Tokyo ranked first among major world airports in terms of air cargo when it recorded 1,420,000 tonnes of freight in 1987. For that same year, it ranked sixth in terms of passenger traffic when it recorded a total of 44.9 million passengers (ITA 1988, 69).

2.3 CANADIAN AIRPORT DEVELOPMENT

The Canadian airport system is classified according to the nature of air carrier operations and networks. The airport in the system form five major groups, namely international, national, regional, local commercial and local airports. The major airports in Canada are the international airports. These Canadian airports are part of both the international and domestic air transport systems of Canada. Major Canadian airport development is illustrated in terms of the major international airports located in Montreal, Toronto and Vancouver. These airports handle large volumes of passenger and cargo traffic on both international and domestic routes.

2.31 MONTREAL AIRPORTS

Montreal is the second largest Canadian city and port with major road, rail and air communication links. Its economic, financial, commercial and industrial activities also provide an excellent base for its air transport activities. It now has two major airports, Dorval and Mirabel.

2.311 DORVAL AIRPORT

The first civil aviation airport in Quebec was the military airport at St. Hubert which was opened to passengers in 1939. At the beginning of the Second World War, St. Hubert airport was reclaimed for military purposes. Dorval airport was built to replace St. Hubert, and it began operations in 1941 with three runways, all 200 feet wide, two at 5,000 feet and one at 5,270 feet in length.

The Montreal airport at Dorval is strategically located in the heart of the province of Quebec, only 7 miles from downtown Montreal. It became officially known as Montreal International Airport on November 1960. Air traffic had increased on the North Atlantic routes and in 1946, a total of 246,359 passengers had used the Dorval Airport. This total increased slightly more than double in 1952 to 589,216 passengers (Transport Canada 1985a, 428). This annual increase in air traffic put pressures on the airport terminal and in 1960, a new air terminal was opened. It was designed to provide better facilities for passengers and it became one of the largest and finest in the world. The two main runways were also extended to 7,000 feet in length.

The first air cargo building was opened in 1957, but it was demolished in 1964 because of traffic congestion. In 1964, a new cargo complex was completed to meet the growing demand for air cargo which reached 190,051 tonnes in 1975 (Transport Canada 1985a, 434).

As shown in Table 2, annual passenger traffic at Montreal's Dorval Airport was 3.8 million in 1968 and 6.7 million in 1975 (Statistics Canada, various issues).

The airport's passenger terminal building was planned to accommodate four million passengers, but in 1972, already six million passenger used the facilities. The air traffic growth was so rapid that the airport facilities had to be continuously expanded, in order to cope with the increase. By 1977, the airport had three runways, each 200 feet wide but had differing lengths of 7,000 feet, 9,600 feet and 11,000 feet. Since airline deregulation in 1984, Montreal's Dorval Airport has experienced a four percent increase in air traffic growth annually (Estok 1988, 1).

TABLE 2

DORVAL AIRPORT PASSENGER AND CARGO TRAFFIC
(1963 - 1975)

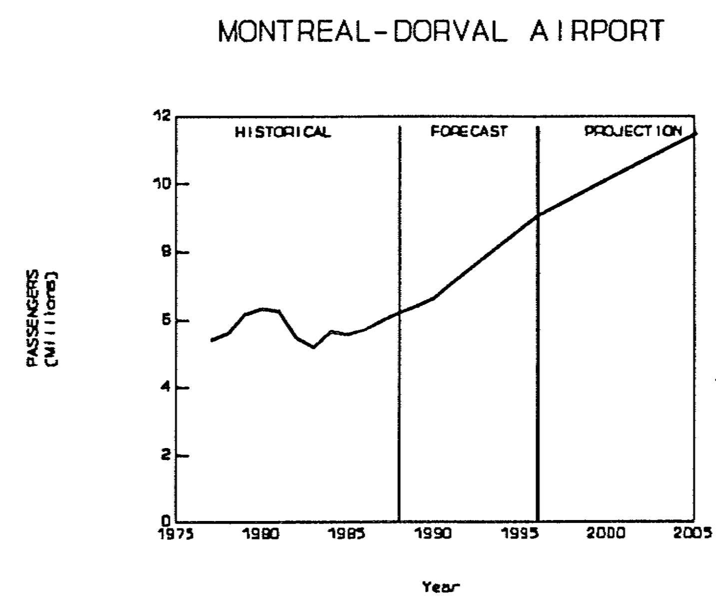
{ IN THOUSANDS }

Year	Passengers	Cargo (in Pounds)
1963	2 125	40 892
1964	2 325	52 457
1965	2 671	67 532
1966	3 024	91 984
1967	4 398	99 899
1968	3 753	148 794
1969	4 072	83 296
1970	4 516	208 508
1971	4 908	230 581
1972	5 551	252 432
1973	6 499	277 576
1974	7 070	246 337
1975	6 705	241 219

Source: Statistics Canada, Airport Activity Statistics, CS 51-201.

Figure 1 depicts a historical, forecast and projection of enplaned and deplaned passenger traffic for the airport. The term "forecast" is used for Transport Canada's actual, technical forecasts. An econometric model, the Passenger Origin-Destination Model (PODM) is used to forecast passenger demand. The term "projection" refers to an informed judgement by Transport Canada for the target year 2006, taking into account major economic growth factors. Transport Canada's forecasts for passenger traffic at Dorval airport from 1987-1996, show an average annual growth rate of 4.1 percent (Transport Canada 1988b).

Figure 1: Dorval Airport Passenger Traffic.



Source: Transport Canada, Air Traffic Statistics, 1988. See Appendix A for supporting details.

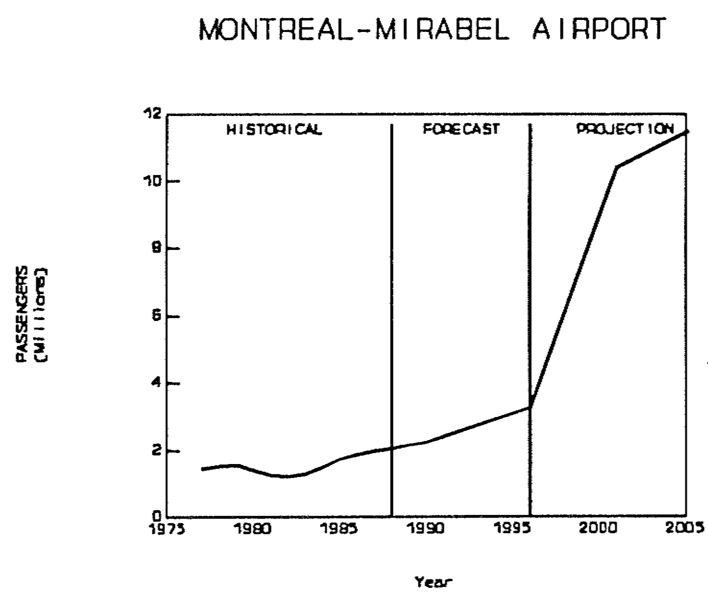
2.312 MIRABEL AIRPORT

The continued growth of air traffic demand rendered the airport facilities inadequate at Dorval. Mirabel International Airport began operations in 1975 to handle international flights, while Dorval handled only domestic flights within Canada and transborder traffic with the United States.

Mirabel Airport is located 51 kilometres northwest of Dorval and 55 kilometres northeast of Montreal. Mirabel's 65-metre control tower is the tallest control tower in Canada. It has a total land area of 17,000 acres, and operates twenty-four hours a day. The airport has two runways, each 12,000 feet long and 200 feet wide, a remote-gate air terminal building, and two air cargo terminals, one serves Air Canada while the other serves Canadian Pacific Air and the foreign airlines. Each of the terminals has a capacity of 200,000 tonnes a year.

Mirabel was projected to have 17 million passengers annually while Dorval would have about 3 million, but unfortunately this projected traffic for Mirabel did not materialize. The airport handled 2.8 million passengers in 1976, but there were only 1.3 million passengers in 1983; and there were only 49,059 aircraft movements compared to the 174,458 at Dorval in 1980 (Transport Canada 1985a, 442). Figure 2 shows the historical, forecasted and projected enplaned and deplaned passenger traffic for the Mirabel

Figure 2: Mirabel International Airport Passenger Traffic.



Source: Transport Canada, <u>Air Traffic Statistics</u>, 1988. See Appendix B for supporting details.

International Airport. Transport Canada's forecasts for passenger traffic at the airport from 1987-1996, show an average annual growth rate of 6.4 percent (Transport Canada 1988b).

2.32 TORONTO INTERNATIONAL AIRPORT

Toronto is Canada's major centre for air traffic and is the busiest airport in Canada. Toronto International Airport is also a major international hub for the domestic, regional and international air travel.

The city of Toronto had two airports, one aerodrome and one seaplane port in 1929. However in 1931, the city had to considered a new municipal airport, the Toronto Airport which commenced scheduled services in 1938, after the Federal Government's Department of Transport favoured Malton instead of Toronto island as the new airport site. It became officially known as "Toronto International Airport (Malton)" in 1960.

The first regular air service from Malton airport started in 1938. By 1946, it had an administration building, taxi-strips, aprons, and three runways of lengths 3,900 feet, 4,000 feet and 4,600 feet. These runways were further extended in 1949, two of which were extended to 200 feet width and 6,000 feet in length. A new terminal designed for a capacity of 460,000 passengers was built in 1949. In 1958, a new passenger terminal and an administration building were built.

The runways were continuously expanded to meet the increase in air traffic. The existing runways were further expanded to 5,050 feet, 7,200 feet and 11,050 feet. A new runway of 200 feet width and 9,500 feet length was completed in 1962. A new air terminal complex and control tower was also constructed in 1960, and the Terminal 1 complex started operations in 1964. The terminal was designed to accommodate 3.5 million passengers annually but by 1966, aircraft movements doubled and the airport terminal facilities were found to be inadequate. Air cargo traffic was also increasing and in 1964 the air cargo centre opened for operations. In 1975, annual air cargo had increased to 289,552,000 pounds, and annual passenger traffic reached 10.5 million (Statistics Canada, various).

The historical traffic trends for both passenger and cargo for the period from 1963 to 1975 is shown on Table 3. Annual air passenger traffic grew from 2.6 million in 1963 to 4.9 million in 1968. It continued to increase by 5.6 percent from 1971 to 6.7 percent in 1974. A total of fourteen million passengers used the airport in 1979 (Transport Canada 1985a, 649). The year 1987 recorded 9.0 million passengers used Terminal 1, almost triple the terminal's capacity to accommodate them, and most definitely, "Pearson International is operating in excess of capacity" (Dust 1989, A21). The passenger air traffic increased from 14 million in 1979 to 19.3 million in 1988. In 1988, 274,800 tonnes of cargo was

TABLE 3

TORONTO INTERNATIONAL AIRPORT PASSENGER AND CARGO TRAFFIC
(1963 - 1975)

{ IN THOUSANDS }

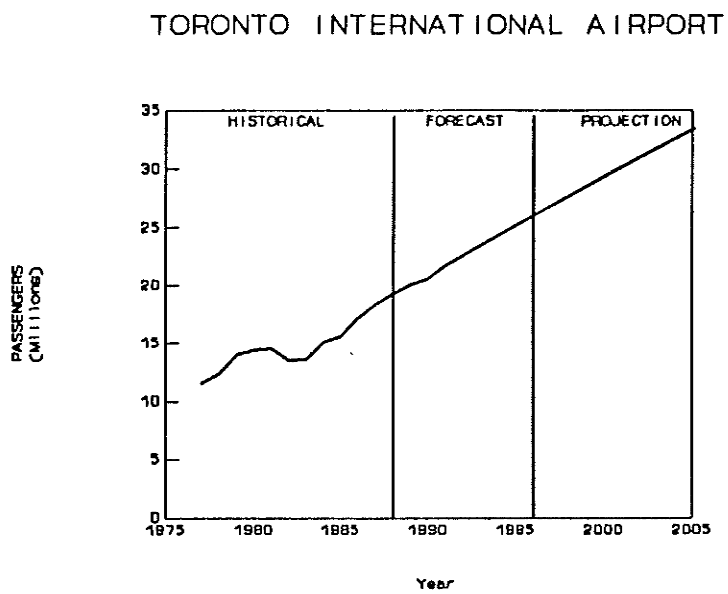
Year	Passengers	Cargo (in pounds)
1963	2 636	33 763
1964	2 806	44 537
1965	3 268	56 417
1966	3 771	80 847
1967	4 642	802 301
1968	4 880	126 466
1969	5 261	154 876
1970	5 965	186 862
1971	6 724	206 901
1972	7 671	217 465
1973	9 278	267 103
1974	10 483	292 573
1975	10 514	289 552

Source: Statistics Canada, Airport Activity Statistics, CS 51-201.

handled at the airport, recording an annual rate of 54 percent. Since the deregulation of the Canadian airline industry which started in 1983, it has been reported that annual traffic at Pearson has jumped by 50 percent (Calleja and Campian-Smith 1989, A3).

Figure 3 depicts the historical, forecasted and projected enplaned and deplaned passengers at the airport. Transport Canada's forecasts for passenger traffic at the airport from 1987-1996, show an average annual growth rate of 3.9 percent, where the passenger traffic is forecasted to reach 26 million passengers (Transport Canada 1988b).

Figure 3: Toronto International Airport Passenger Traffic.



Source: Transport Canada, Air Traffic Statistics, 1988. See Appendix C for supporting details.

Transport Canada also estimates an average annual air cargo growth of 2.7 percent for the airport. As it is today, the airport is already experiencing serious congestion problems and a solution is being sought to solve these problems. The airport requires 176 air traffic controllers, but is presently only working with 130 controllers. Thus, there is an obvious shortage of air traffic controllers.

It is obvious that the demand for air traffic services at this airport has outgrown the existing facilities. If the present expansions for Terminals 1 and 2, as well as the construction of a third Terminal cannot relieve the air traffic congestion, then a fourth Terminal and a fourth runway may be required. It is also fortunate that the original master plan for the airport can accommodate five terminals and eight runways.

2.33 VANCOUVER INTERNATIONAL AIRPORT

Vancouver International Airport is located on Sea Island, just 12.9 kilometres south of downtown Vancouver which is Canada's third largest metropolitan area. Vancouver serves as a gateway to the Pacific region and is a principal manufacturing, industrial, commercial and service centre. It provides an excellent base for the Vancouver International Airport which serves international, domestic, regional air carriers, local commercial operators, private business, government and military aircraft.

The first permanent airport for the city of Vancouver was the Vancouver Airport which began operations in 1931. It had an administrative building, two hangars and two runways, each 100 feet wide and 1,500 feet long. By 1938, another runway of 150 feet width and 3,000 feet length was added. In August, 1940, during World War II, Vancouver Airport was taken over by the Federal Government's Department of Transport and extensive, additional facilities and improvements were then made. The east-west runway was extended to 5,007 feet long and 200 feet wide, the North-South runway was extended to 5,170 feet in length and 200 feet in width, while the third runway was extended to 3,805 feet in length and 150 feet in width. Additional hangars and other buildings were constructed. The airport was returned to the City of Vancouver six months after the war in 1947 (Transport Canada 1985a, 672).

In 1948, with the Federal Government's approval, Vancouver Airport changed its name to Vancouver International Airport. In 1954, the runways and existing aprons were further developed. However, due to the huge amount of capital resources required to finance the airport, the Federal Government again took full control in 1962 and made major expansion plans for the Vancouver International Airport.

Air traffic at Vancouver International Airport has been growing very rapidly. As shown in Table 4, the annual passenger traffic at Vancouver International Airport had grown from 891,000 in 1963 to 1,945,000 in 1968 (Statistics Canada, various). This doubled to 3.8 million passengers by 1973 (Transport Canada 1980a, 43).

TABLE 4

VANCOUVER INTERNATIONAL AIRPORT PASSENGER AND CARGO TRAFFIC (1963 - 1975)

{ IN THOUSANDS }

Year	Passengers	Cargo (in Pounds)
1963	891	15 590
1964	962	19 783
1965	1 165	25 836
1966	1 442	34 417
1967	1 762	40 060
1968	1 945	56 614
1969	2 248	64 207
1970	2 520	72 673
1971	2 780	87 782
1972	3 151	85 499
1973	3 845	94 110
1974	4 337	101 062
1975	4 677	125 863

Source: Statistics Canada, Airport Activity Statistics, CS 51-201.

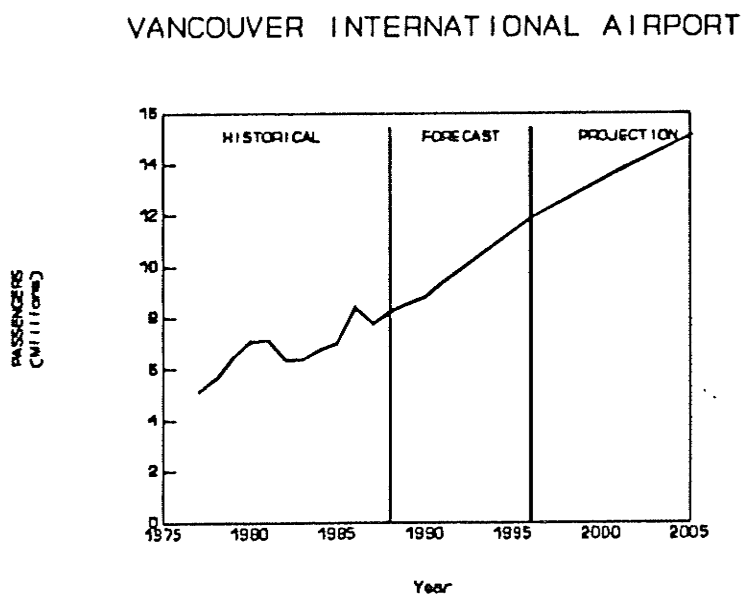
In order to cope with the expanding traffic at the airport, a new passenger terminal building, designed to hold 3.5 million passengers a year, was completed in September, 1968. This had to be modified later to accommodate the wide-bodied jets in 1971. The Dinsmore Bridge, completed in the late sixties, and the Arthur Laing Bridge, completed in the mid-seventies, improved ground access to the airport for the City of Vancouver.

By 1979, Vancouver International Airport ranked third for passenger traffic in Canadian airports, with an annual passenger traffic load of 6,476,500 passengers (Transport Canada 1985a, 675).

Air cargo had also increased from 25,680 tonnes annually in 1968 to 62,400 tonnes in 1978, an increase of about 9 percent annual growth rate (Statistics Canada, various). The air cargo terminal that began operations in 1968 was replaced by a new modern terminal in 1973 to meet the growing demand. Vancouver International Airport is trying to attract more cargo business from the Pacific Rim region, and soon the airport will be the first Canadian airport to have a main deck loader for all carriers to use.

During 1986, the scheduled passenger traffic at the airport was 7.2 million, and this 19.9 percent increase compared to 1985, could possibly be explained in part by the Exposition '86 that was held in Vancouver that year. Vancouver International Airport is presently the second busiest airport in Canada, and is the "second worst airport bottleneck" after Toronto's Pearson B. Lester International airport. The airport is hard pressed to provide adequate air traffic control. The airport was originally designed to handle 276,000 takeoffs and landings annually, but is now handling 300,000 (The Ottawa Citizen 1988, G6).

Figure 4: Vancouver International Airport Passenger Traffic.



Source: Transport Canada, Air Traffic Statistics, 1988. See Appendix D for supporting details.

Traffic growth at Vancouver International Airport has increased 12 percent annually since the airline deregulation in 1984 (Estok 1988, 1). Vancouver International Airport reported a 20 percent increase in passenger traffic from the previous year in January, 1988. This could be explained in part by the annual vacation and holiday season of tourists from the Pacific region. Singapore Airlines started twice weekly flights to Vancouver on July 1, 1988, and this widened the flow of air traffic across the Pacific to and from Vancouver.

Figure 4 depicts the historical, forecast and projected enplaned and deplaned passenger traffic at Vancouver International Airport. Transport Canada's forecasts for passenger traffic at the airport from 1987-1996, show an average annual growth rate of 4.7 percent, where the passenger traffic is forecasted to reach 11.9 million passengers (Transport Canada 1988b).

2.4 AIRPORT DEVELOPMENT AND PLANNING

Airports are a 'lumpy' element in the economic development of air transport systems because of their substantial capital investment requirements. They are also fundamental to the infrastructure of air transport. For these reasons, long-term planning is required.

2.41 CRITERIA IN AIRPORT PLANNING

Long-range strategic planning is important for all major airports. This can range from a time horizon of ten years to twenty years. The general criteria in airport planning are to provide adequate airport facilities, system flexibility, minimum walking distances, convenience to users and the feasibility of expansion meet any increase in air traffic demand. A maximum degree of safety should also be incorporated into every airport operation.

The most important criterion in planning the airside component is the configuration of the runway and taxiway system to allow for maximum runway capacity. "Years of experience have proven that aircraft runway capacity must be above all other criteria" (Sullivan 1973, 79). The capacity of the runway is a basic factor in determining the capacity of the airport. The number of runways, lengths, separation, aircraft mix and its operating characteristics have significant effects on the runway capacity. According to ICAO, "an airport runway may generally be considered to have reached capacity when delays to departures average four minutes during the normal two-hour period of the week" (ICAO 1977, 172).

However, the airside component will have to be matched by the landside component: terminals and ground access system. In order to ensure maximum capacity at major airports, careful planning must be done to accomodate freight, passengers and their vehicles at the terminals. Very substantial amounts of architectural and engineering planning must be integrated in this process.

2.42 AIRPORT PLANNING AND AIR TRAFFIC DEMAND

The capacity of an airport depends on the supply factors such as the capacity of runways and the capacity of passenger and cargo terminals. However, the volume and character of air traffic demand provides the fundamental economic impact on airport capacity. Both the airside and landside components of the airport will be influenced by air traffic demand.

The airside component, the runway and taxiway capacity, is affected by the nature of air traffic demand. It is affected by considerations of passenger or freight, and long haul or short haul sectors, which determine the different types of aircraft used. This heterogeneity of aircraft fleet influences capacity needs in terms of the length of the runways and the size and location of the taxiways.

The landside component of the international airport is also affected by the nature of air traffic demand. Business passengers create different peak demand from tourist passengers. This has important implications in the capacity of passenger terminals, especially the check-in and baggage areas, immigration, customs, health and security check-points, which would be fully utilized to capacity during the peak periods.

The nature of the demand, whether the passenger traffic is more business traffic or tourist traffic, has implications on the short-long-haul sectors, which in turn influence the number of flights that can be offered by the types of aircraft thought feasible to operate on specific routes. Business passengers are more time-constrained and would prefer non-stop, direct flights with higher frequencies. However, the criteria for flight scheduling include profitability, maximum aircraft utilization, as well as maximum load factors. A trade-off exists between scheduling more flights using smaller but higher cost aircraft, and scheduling less flights using larger but lower costs aircraft. Larger aircraft result in more unit cost savings, as well as a reduction in break-even load factors. Schedules with more frequent flights offer better services to the passengers who do not have to wait longer times at the airport to get on a desired flight. The flight schedules may be planned on a daily or weekly basis, according to the flight routings, long or short haul sectors, departure or arrival time preferences and time-zone influences. However, the most important consideration in such planning is still the characteristic of the air traffic demand at the airport.

Therefore, air traffic demand forecasting is an important tool in international airport planning. It is always difficult to forecast the future, but quantitative forecasts are necessary guides to long-range planning. It is basic to the planning of an airport, because it gives the planner an idea of the future size and character of the airport. More precise forecasted air traffic demand helps to determine both the airside and landside airport facilities that will be required to meet the increasing air traffic demand.

2.5 SUMMARY

This chapter has provided a perspective on general airport development. The main purpose of this chapter has been to draw attention to the importance of air traffic levels and growth at major airports around the world. Specific and more detailed attention has been given to the major airports at Montreal, Toronto and Vancouver. There is a significant relationship between air traffic levels and growth and the airport capacity requirements at each airports. Significant under or over-capacity reflects, in part, airport planning problems. The traffic levels at Mirabel (low) and the significant growth rates at the other airports are noteworthy in this regard.

CHAPTER THREE

ECONOMICS OF AIR TRAFFIC

3.1 INTRODUCTION

The objective of this chapter is to analyze the economics of air traffic operations in terms of output and the factors which determine the demand and supply of air traffic. In view of the increase in air traffic levels and congestion problems at some of the major airports, there has been a growing concern to gain a better understanding of the growth in air traffic demand relative to the expansion of the air traffic facilities. The nature of the air traffic demand and the different market segmentation result in variations of demand and congestion in the international airline industry.

The chapter begins with a section on the economics of air traffic demand, which includes a discussion of the complexity of the nature of air traffic operations and the heterogeneity of air passenger and air freight traffic. This section also provides an analysis of the nature and factors affecting the demand for both passenger and air freight traffic. Following this, factors affecting the supply of air traffic services will be discussed. Special mention will be made on the characteristics of scheduled international air traffic operations which is subjected to bilateral agreements. This particular section begins with an analysis of the performance of international air traffic for Canada in terms of scheduled and non-scheduled passenger, and air freight traffic. It then examines the economic and non-economic regulation of international air traffic operations. The strength of this regulation has important impacts on the supply of air traffic, thus affecting the traffic activity levels at the airports.

3.2 ECONOMICS OF AIR TRAFFIC DEMAND

The production of air traffic services can be measured in terms of either available or revenue passenger-miles for first and economy class passenger traffic. Air freight traffic can be measured in terms of available or revenue ton-miles. However, this product is quite complex, because apart from merely transporting the passengers or freight by air, it has to do so at a certain time, with a specified degree of service, safety and security. Some air travellers value time more that others, and they may be more willing to pay a higher price, depending on the nature of their demand. In some of the air freight shipments, time and speed play very significant roles, while other categories of air freight demand may value reliability and safety more. It should be noted that there are very substantial analytical and statistical problems involved in the estimation of demand elasticities (see Stubbs et al., 186-190).

3.21 AIR PASSENGER TRAFFIC DEMAND

The demand for air transport is relatively sensitive to per capita income growth, and also is price elastic for leisure travel. Business travel, however, is considered to have a price elasticity of less than unity. To cater to different types of traffic, airlines offer scheduled and non-scheduled service and, also offer different price levels for different qualities of service, thus engaging in a mix of price and non-price rivalry. Since aircraft capacity cannot be stored, charter services aim at full capacity flights to compete on a low unit price basis, while timing their flights to gain 100 percent loads. In recent years, scheduled passenger flights have offered 'seat sales' at low prices. These seat sales reflect airline seat management by which the airline calculates when it will have empty seats which are offered at a price above the marginal cost of providing the seat. These sales are 'hedged' by conditions to prevent passenger seat demand transfer from a more lucrative class of seat. In general, this practice has acted to expand air traffic.

Improvements in the quality of service variables will increase the demand for passenger air traffic services. These may be measured in terms of shorter journey times, greater flight frequencies, and quieter and more comfortable travelling conditions.

The other determinants of passenger air traffic demand are the country's geographical location and rate of population growth in the country. A country's air traffic activities will increase if it is strategically located with wide networks for easy transfers to major air routes for the passengers. Increases in the country's population will provide a larger base for potential air passenger traffic demand.

The market for air passenger travel is strongly affected by trip purposes. Business passenger air traffic uses scheduled services while leisure passenger air traffic often takes advantage of the lower charter fares. The passenger air traffic demand is not an end in itself; the demand for air traffic services is a derived demand. To the business traveller, the air trip is merely an input to the firm in order for them to secure a business deal and to the leisure travellers, the passenger demand serves as a means to a larger vacation plan. In this respect, it is highly complementary to broad economic developments. Thus, economic growth and development will have significant impacts on the demand for air traffic services.

The passenger traffic segmentation into business and leisure passenger demand, based on different price elasticities of demand, has already been noted. Traffic expansion through lower fares with more limited service has expanded traffic through the leisure-oriented market where time costs are not such a sensitive matter as they are in the business market. However, both markets are subject to traffic expansion based on income growth.

The market segmentation into business and leisure passenger market also influences the variations in the timings of passenger traffic. Passenger air traffic is characterized by daily, weekly and seasonal variations in the demand. These variations occur because the business trips are subject to a five-day work schedule, while the leisure trips are often associated with the holiday seasons. Business air traffic demand often creates daily peaks, usually in the early mornings and evenings, and also weekly peaks especially on Mondays and Fridays. The leisure passenger air traffic demand often creates weekend and seasonal peaks, particularly during the religious public holidays and annual holidays. The different markets also affect the air traffic system operation. Business air trips tend to be more short-haul and are more sensitive to the availability of the flights, the frequency of the services and the duration of the flight time, where non-stop flights would be more desirable. On the contrary, leisure travel demand along different routes vary according to the attractiveness of the destinations or tourist spots. Their trips tend to be more flexible and long-haul, where speed, convenience and comfort are more desired. These peaking variations in the demand for air traffic services can be very problematic to the airlines, in terms of planning their capacity utilization.

The market segmentation of passenger traffic to business and leisure demand also has implications for the types of services required by the public in terms of scheduled and non-scheduled air traffic services. Scheduled passenger air traffic operations which provide air traffic services throughout the year find it difficult to cope with peak demands. The non-scheduled operations cater particularly to the peak seasonal and holiday passenger air traffic. Nevertheless, the scheduled passenger air traffic operations have the advantage of securing the market share for the higher fare business passenger market because of their regular schedules.

3.22 AIR FREIGHT TRAFFIC DEMAND

Major air carriers provide both scheduled and non-scheduled, charter transportation of air freight, express and mail. The volume of enplaned and deplaned cargo on scheduled services for the top fifty Canadian airports recorded an increase of 8.9 percent in 1987 relative to 1986. There is no doubt that this rapid growth in the air cargo industry will continue in the future. Growth in air freight traffic had been substantial from the time of the uneconomical, high cost piston-engine all cargo planes to the turbo-props, B-707, DC-8 jets and finally, the economical B-747 jumbo jets which greatly reduced the costs to the shippers.

The nature of air freight demand is different from that of passenger air traffic demand, since air freight demand is more heterogeneous in nature. This can be further categorized to emergency air freight, ultra-high value air freight, routine perishable air freight traffic and the routine non-perishable services freight traffic. The main characteristics of the emergency air freight traffic are that they are unplanned and irregular in nature, where time and speed play significant roles, and the costs of shipment are less significant. This category of air freight includes urgently required vaccines, or automobile and machinery spare parts, where firms may lose their customers unless rapid delivery is guaranteed. Ultra-high value freight includes goods such as jewellery, diamonds, gold and valuable items which require much higher security. Thus, the nature of both these categories of air freight requires a high quality of services, including special clearance through customs. As such is the case, this category of freight shipment is more costly to handle.

Routine perishable freight shipments are also very time sensitive, but unlike the emergency air freight, they are planned in nature. This category includes fish, vegetables and newspaper which have a very short commercial life span, and in order to preserve the life span of the commodities shipped by air, the ultimate consumers will have to pay the much higher cost.

The routine non-perishable freight is also planned and can move by surface mode, but the higher costs are more than offset by savings in the total distribution cost. Due to the increased speed which reduces the time of the goods in transit and costs of holding these inventories, there may be substantial cost savings in warehousing, reduced stock holdings, packaging, delivery and handling facilities. Thus, speed and reliability are important factors for this air freight industry.

The level of economic growth of the country is one of the major determinants of air freight demand, and like the business passenger air traffic demand, the air freight demand is also complementary to the use of other goods and services. Scheduled air freight demand is seasonal and the demand for non-scheduled freight charters is also cyclical. Air freight demand is often not demanded for itself but it is largely derived from the demand for other basic commercial products. The international production line concept further encouraged the use of international air freight. Therefore, air cargo will continue to play an important role in international commerce. Increases in economic growth of the countries and higher average income levels, are expected to increase the demand for air freight.

The level of air freight rates, relative to the competitive modes, also influences the demand for air freight traffic services. The air freight's major competitors include rail and truck transportation. Although air freight transportation is still more expensive than surface transportation, this difference in the rate structure is narrowing because of the rapid technological improvements which increase the speed, flexibility and the quality improvement of the air freight services. This has given the customers a higher level of services and confidence, compared to rail or truck transportation. The improved service characteristics also include increased flight frequency, schedule convenience, low pilferage, ground handling damage and increased reliability.

Air freight traffic is different from passenger traffic, because it requires no inflight services and the midnight air traffic curfew restrictions often affect the air freight traffic more than the passenger traffic. It is also strongly influenced by commercial factors which determines the air freight structure and needs.

Air freight growth is also affected by the availability of suitable aircraft. Air freight can be carried in the belly compartment of passenger aircraft or freighters (all-cargo aircraft which carry no passengers). This gives more flexibility to the departure and arrival times of the all-cargo aircraft which can take place in the wee hours of the night. Containerization of air freight also improves ground operation handling. However, due to the many complaints of the aircraft noise by residents living near the airports, some international airports have resorted to curfew restrictions during the midnight hours, and this has unfavourable effects for the international air freight traffic.

Most of the attempts by the all-cargo carriers to gain advantage over the combination carriers have been unsatisfactory. These specialized air freighter aircraft are often converted passenger aircraft which are not properly modified to suit freight handling. The early piston-engine aircraft were neither economical nor profitable for air cargo operations. As aircraft technology advanced, the introduction of the wide-bodied jumbo jets represented a significant breakthrough in the air cargo industry. These jets increased substantially the amount of belly cargo capacity, and the long-range B-747 jet passenger aircraft have substantial space for air freight in the baggage holds of the combination aircraft. It seems to be more air freight is now carried as a secondary payload on the passenger aircraft, but in view of its rapid growth, it may overtake the passenger volume. Therefore, the future of this type of passenger cum cargo combination poses a dilemma for aviation planners, who may have to consider integrating both the passenger and cargo terminals at the airports.

The modern, mechanized air freight terminals and other ground support services, together with containerization techniques, all help to facilitate the handling of air freight, and this increases the demand for air freight services. Containerization has reduced the time in handling the air freight shipments and increased its overall efficiency, as well as allow for greater protection against damage and theft. Thus, increases in air freight traffic demand also require an efficient, readily available air freight system which includes containerization to reduce damage and pilferage, pick-up and speed of delivery, billing and collection and other promotional, marketing facilities.

3.3 SUPPLY OF AIR TRAFFIC SERVICES

The airline industry is often regarded as a high technology industry, and the rate of technological change has been very rapid during the last thirty years. The technological improvements, either in terms of aircraft technology or automation of airline systems, have significantly reduced costs.

Air traffic is dependent not only on demand but also on the supply of service by airlines. However, there are aspects of demand which influence costs, such as route traffic density, variations in demand over time and sector lengths. Before addressing these aspects, a brief analysis of the costs of supplying the air traffic services could be helpful. The costs of supply of air traffic services can be broken down into two main categories: direct operating costs which constitute 58 percent of the total operating costs, and indirect operating costs which constitute 42 percent of the total operating costs (Doganis 1985, 82).

Direct operating costs for aircraft are the costs related to its flight operations which include flight crew salaries and related expenses, fuel and oil costs, airport charges, rental of flight equipment and insurance charges. The flight crew costs, fuel costs and passenger inflight services costs are the variable direct operating costs that can be avoided if a flight is cancelled. The direct operating costs also include maintenance and overhaul operations, and depreciation costs, which are all fixed operation costs. This category of costs vary directly with the size and type of aircraft which are the main determinants of unit costs. Fuel consumption also varies according to the aircraft size and types, route structure and sector lengths. Fuel costs significantly represent about one-third of total airline costs. International aviation fuel prices escalated during the two world oil crises in 1973 and 1979, and these events seriously impacted on the airline costs. Therefore, airlines resorted to the use of more fuel efficient aircraft, and the reduction of their flight frequencies, to improve the situation (Doganis 1985, 84).

In view of the nature of aircraft technology, similar aircraft types will produce similar related costs of operations. However, airlines' costs may differ through their different capabilities in scheduling their aircraft, flight crew and other personnel. The direct operating costs are influenced by the efficiency of scheduling and the nature of their route systems. Thus, the choice of the aircraft and the route traffic density are major determinants of direct operating costs.

The indirect operating costs are a function of the air traffic volume and the nature of the routes being served. This category includes the general and administration costs, station and ground services, passenger services, reservation, ticketing, sales and promotion. These indirect operating costs are more labour-intensive, and are more affected by the changes in the inflation rate, in terms of wages and salaries. Several studies have shown that the supply of air traffic services has economies with respect to aircraft size and distance. The larger the size of the aircraft and the longer the stage length, the lower would be the airlines indirect operating costs per available ton-mile (Bonsor 1984, 53). However, the size, type and utilization of aircraft selected for a particular route is influenced by the route traffic density and sector length on that route.

Route traffic densities influence the frequencies required, and thus will affect the potential or annual utilization of capacity of the aircraft, which is the number of hours flown by each aircraft. Low route traffic densities require smaller aircraft but this may pose difficulties in the full utilization of the aircraft capacity, and also difficulties in the maintenance of the personnel and flight crew. This will result in lower utilization rates which will then increase the costs of operations. The more dense the routes, the more possible it is for the aircraft to be fully utilized to capacity, and thus, the lower the costs.

The sector length also influences the size and type of aircraft to be selected. The short-haul sectors are more subjected to competition from other modes of travel, and the frequency and timing of these flights are very important. As for the long-haul flights, comfort is more important, and the quieter and larger aircraft should be more appropriate.

As route traffic density and sector length increase, there will be a decline in the indirect operating costs, because these costs will be spread over longer distances. This explains why wide-bodied jetliners can lead to significant cost savings. Their speed gain over the long-haul flights helps to reduce the aircraft operating costs. However, larger aircraft require more fuel to cover their given distance. The payload of an aircraft is the capacity to carry passengers, baggage, freight or mail, excluding the fuel carried. The aircraft in the long-haul sectors use more fuel at the expense of the payload, and the range of an aircraft is generally constrained by the maximum fuel they can carry, because the payload has to be replaced by the fuel in order to increase the range of that aircraft (Stubbs, Tyson and Dalvi 1980, 191). However, larger wide-bodied aircraft such as Boeing B-747, with their large seat and range capacity, and low break-even load factor, will generate lower operating costs on a unit payload capacity (Wheatcroft 1964, 99).

Another significant variable influencing the unit costs of production would be the load factor. Unit operating costs increase as the air traffic volume increases, but not all units of capacity can be translated into units of services sold. The load factor represents the ratio of utilized capacity to available capacity, and airlines with high load factors would increase capacity. In the United States, "the steady increase in the average system load factor has improved efficiency of airline operations resulting in a reduction in per passenger costs" (Taneja 1981, 130).

The total direct operating costs per aircraft would not be affected by the load factor, because whether the plane is operating full or half load, the size of the crew and other maintenance costs would not change. If a flight is cancelled, only some of the flight operation costs will be reduced, but many other joint costs still have to be incurred, whether the flight is cancelled or not.

The break-even load factor is the percentage of capacity or seats when the total revenues equals the total costs of the operations. The marginal break-even load factor is the increase in the total break-even load factor, and profits can be increased if the revenues received from the extra operations are above the marginal break-even load factor. Air fares also affect the break-even load factor because it determines the average net revenues received. As for smaller aircraft, the number of seats required to break-even will increase with the stage length because of the payload-range relationship of the aircraft. Thus, the economic implication of the break-even load factor is another factor influencing the choice of flight routings given certain load factors.

As the load factor increases, the average costs per passenger for producing any specific trip will fall. However, the high load factor may result in the lowering of the quality of service, in terms of convenience to the passengers. Also, during peak periods, passengers who desire to travel on a flight may have to be turned away.

The structure of the airline's network is also a contributing factor to the air traffic load. Major airlines with well-defined route networks of feeder, hub-and-spoke pattern of operations, tend to have higher load factors. This is because most of the passengers would prefer to travel with the same airline, in order to minimize the risk of baggage losses and to eliminate other unnecessary risks if their flight transfers involved more than one airline (Taneja 1981, 117).

Variations in demand over time also influence the supply of air traffic services. The seasonal, weekly and daily peak periods of demand, create a need for extra capacity, where more aircraft, crew, other ground ticketing and catering facilities would be required. However, these extra operations would be under-utilized in the off-peaked periods and could be quite costly for the airlines, and they would be much better off if they cater for the more regular pattern of air traffic demand throughout the year.

Route traffic densities and sector length may not always be at the airlines disposal, because they may be affected by the country's geographical, political, economical and social factors. However, the airlines still have some control in the area of flight scheduling, and it can be used to ensure high utilization of their aircraft by scheduling their flights at the most desired times to meet the public's demand for the air traffic services. They can increase their flight frequency on the denser air traffic routes where there are more competitors, and try to increase their market share on these routes.

However, air carriers have to consider the availability of their aircraft fleet and pressures of competition when scheduling their flights, in order to put the most economical aircraft into use in their attempts to lower their costs. Other factors include the scheduling of flight crew and ground operations personnel. Air carriers should also avoid unnecessary fixed costs which are less economical, and operate on a variable cost basis which is more flexible for catering the peak demand of the air traffic services. It is inevitable that air carriers have to schedule their peak air traffic, and some air carriers may even operate large aircraft to cater for the peak traffic. The daily morning and evening peak periods caused by business passenger traffic on short-haul sectors, may be provided by more frequent and smaller aircraft offering shuttle operations with express check-in counters to facilitate the check-in procedures. During the off-peak periods, air carriers may lease out their aircraft or offer lower fares to attract more passengers.

The provision of air traffic services is a joint product activity, because the same ground handling staff serve the flights operating different routes. Also, airlines do not own the airport terminal or runway that is required to deliver their product of air traffic services. In view of the limited airport infrastructure, one possibility to reduce the congestion would be to employ more part-time ground handling staff to work only during the peak periods. This could then reduce the redundancy of employing full-time staff, and also incur less of the indirect operating costs.

3.4 INTERNATIONAL AIR TRAFFIC OPERATIONS

International air traffic operations refer to both scheduled and non-scheduled passenger and freight operations that originate or terminate at a point in Canada to and from a point outside Canada. Both operations are performed in extremely complex regulatory environments, involving bilateral agreements, restrictions in capacity, tariffs and promotional policies designed to stimulate the air traffic demand.

3.41 SCHEDULED AND NON-SCHEDULED TRAFFIC

International air traffic services can be facilitated by means of scheduled and non-scheduled operations, where they serve to diversify the air traffic services offered. International scheduled air traffic operations provide commercial air transportation of passengers, freight or mail between points in Canada and points outside Canada, and are performed according to published and regular time-tables. This type of regular, designated air carrier operations is the most important air traffic service in the airport planning process, and it includes both the passenger and air-freight traffic services. For the top fifty Canadian airports as a whole, international scheduled passenger traffic increased from over 3.4 million passengers in 1986 to 4.1 million passengers in 1987 (Statistic Canada, various).

Table 5 shows the performance of scheduled and non-scheduled international passenger traffic for Vancouver International Airport, Toronto International Airport and a total of the top fifty Canadian airports for the period 1984 - 1987. It can be clearly seen that there is an upward trend in the scheduled international air passenger traffic. Toronto International Airport performed first on the list of the top fifty Canadian airports. It also ranked top on the list for the scheduled air cargo traffic with an increase of 8.8 percent over the previous year. Vancouver International Airport ranked second on the list with an increase in scheduled air cargo traffic of 2.3 percent for 1987, with a total of 87,548 tonnes of enplaned and deplaned air cargo in 1986 to 89,522 tonnes in 1987. Toronto International Airport (Lester B. Pearson International Airport) was rated the busiest Canadian airport in 1987, with 30.6 percent of the national air traffic activity (Statistics Canada, various).

TABLE 5

INTERNATIONAL SCHEDULED AND NON-SCHEDULED
AIR TRAFFIC PERFORMANCE
IN CANADA (1984 - 1987)

Year	City	Scheduled	Non-scheduled
1984	VANCOUVER	445 181	368 454
	TORONTO	1 174 203	1 664 685
	TOP 50 AIRPORTS	2 932 956	3 920 000
1985	VANCOUVER	445 989	328 073
	TORONTO	1 396 516	1 900 087
	TOP 50 AIRPORTS	3 200 098	4 427 000
1986	VANCOUVER	540 357	415 947
	TORONTO	1 586 994	1 929 296
	TOP 50 AIRPORTS	3 440 047	3 932 000
1987	VANCOUVER	602 565	324 452
	TORONTO	1 968 689	2 212 603
	TOP 50 AIRPORTS	4 076 649	3 775 802

Source: Statistics Canada, Air Carrier Statistics, Annual.

Non-scheduled operations offer charter and special flights performed for renumerations on an irregular basis.

These operations include both passenger and air-freight traffic services. Non-scheduled air traffic demand is highly unpredictable because it is dependent on peak seasons, and this makes advance aircraft utilization planning very difficult. However, they are well suited to exploit the passenger tourist markets. An example of this is the non-scheduled charter inclusive tours which includes not only air transportation costs, but also accommodation and other sightseeing tours costs. This may be equivalent to the applicable published fare for that particular air trip by itself. By the mid-seventies, the non-scheduled traffic on the North Atlantic routes gained much popularity as it approached the volume of the scheduled passenger traffic (Taneja 1981, 50).

One factor which concerns the air carriers providing both scheduled and non-scheduled services is the load factor. Since the cost of operations is not affected by the number of passengers on a flight, a higher load factor would be more profitable, and will improve the efficiency for the airline operations, reducing costs per passenger. The non-scheduled charter operations seem to have this advantage, because they cater especially for the tourist-attractive destinations where they can ensure higher load factors. However, they may have problems trying to attract this holiday traffic all year round, because the tourist market is subject to holiday seasons. The tourists also have to consider the hassles of charter group flights where the departure times are fixed, and the tickets once purchased, are non-refundable.

Most regular, scheduled air traffic operations operate 'three-class' services on their flights, and they cater more for the business passenger air traffic. Therefore, unlike the non-scheduled air services, the scheduled air traffic services offer a wider variety of choices to the passengers who can purchase first-class, business or economy class air tickets. There is also a diversity of economy class fares depending on the routes involved, and these range from apex excursion fares, weekend excursion and monthly excursion fares, each with their own sets of restrictions regarding the date of ticket purchase, date of travel, length of stay, departure dates and the non-refundable nature of the tickets which can only be used for the air carriers specified on the tickets.

The increase in passenger load for the charter flights and the higher growth rates for the non-scheduled services pose a growing concern for the scheduled airlines. This indicates the importance of passenger air fares. Competition between the scheduled and non-scheduled air carriers, can be explained by the oligopolistic structure of the airline industry. There exists a few dominant air carriers and many smaller, less competitive ones, with the concept of price leadership and uncertainty regarding pricing policies. Therefore, the airlines engage in price and non-price competition in terms of seats and quality of the air traffic services. The non-storability characteristic of the air traffic service creates more competition among the airlines as each tries to dispose of their non-storable aircraft seats.

Since the public needs both types of scheduled (providing regular, dependable and flexible world routes), and non-scheduled (offering much lower fares to passengers) air traffic services, the question of balancing competition between them must be taken into consideration (Taneja 1981, 49).

3.42 REGULATION OF INTERNATIONAL AIR TRAFFIC

The regulation of international air traffic operations may be both economic and non-economic in nature. These regulations, whether tightly or loosely enforced, have implications on the supply of traffic and the airport activity levels. The quality of international air traffic operations has diversified from international scheduled operations to include the international non-scheduled operations, and this has created further problems in the regulatory framework. Governments now have to be more specific about the type of airline operations they are allowing their carriers to offer to the public. Formerly, the regular, designated air carriers offered only scheduled air traffic services, but nowadays, non-scheduled charter services can also be operated by the scheduled air carriers.

Most of the non-economic international air traffic regulation pertains to operational and safety requirements. This form of regulation has been more strictly enforced recently because of the increased number of air crashes and air traffic congestion problems which have raised much fear from passengers about their safety when they travel by air. The regulation of safety standards in airline operations range from the technical standards of regulating the airworthiness of the aircraft, air traffic control, soundness of the aircraft and its maintenance, to the regulation of international airports and navigational facilities. In Canada, this non-economic regulation is carried out by the Canadian Aviation Safety Board.

As for the economic regulation, the Paris Convention of 1919 gave each nation the right over its own airspace. However, the Chicago Convention in 1944 and the Geneva Conference of 1947, both failed to reach multi-lateral air agreements on the main issues of traffic rights, capacity and air tariffs. The liberal policy of the United States conflicted with the protectionist policy of the United Kingdom and other European countries. This resulted in bilateral air agreements between respective nations for the exchange of traffic rights and the inter-airline pooling agreements for airline capacity.

The International Air Transport Association (IATA) was set up in 1945 as an international body to represent airlines' interests, set passenger fares and cargo rates, establish tariff structures, co-ordinate and standardize airline operations.

The bilateral air agreements between nations deal with the regulation of capacity, schedules of routes and fares to ensure fair exchanges of rights between the nations. Thus, these bilaterals affect the flight frequencies and the whole network of international air traffic routes. Most bilaterals are protectionist in nature, but the Bermuda Agreement of 1946 between the United States and the United Kingdom is more liberal in nature. Most international airlines operate according to the various bilaterals signed by their home country, but their degree of restrictions vary, although most of them acknowledge the tariffs set by IATA.

The move towards liberalization of aviation regulatory policies in most countries has become quite widespread. One of the new concepts in international regulation is the multiple designation of traffic rights in the bilaterals, whereby each party can designate any number of air carriers to operate on their agreed routes. An example of deregulation through bilaterals is the United States - Netherlands agreement signed on March 1978 where there is multiple designation for both scheduled and charter services, with no capacity or frequency restrictions. The multiple designation of U.S airlines resulted in an increase in the number of air carriers and total scheduled air traffic in the deregulated markets. Hub and spoke network patterns in the air routings also emerged as a result of deregulation, generating airline profitability and producer efficiency. However, consumers are not so well off as they have to bear with the airport peaks, long queues and large crowds in the busy hubs which are major collection and dissemination points for passengers and goods. All these have important implications on the airport activity levels and airport infrastructure requirements to meet the increase in air traffic levels due to these new regulatory measures.

There are also inter-airline pooling agreements for most international sectors which involve major air carriers, where each of them schedule their flights between the two countries, so as to ensure a better spread of departure times for the passengers throughout the day. These pooling arrangements between the airlines increase load factors, reduce costs and most of all, they remove frequency competition between the airlines for the same routes. The airlines would not mind operating during off-peak times, because of the revenue-sharing by the air carriers, and this helps to reduce the peaks at the airports. Pool agreements can also involve three or four airlines and this is quite common in South-east Asia. An example of this tripartite pooling involves the 'Thai International Airways, Cathay Pacific Airways and Singapore Airlines' pool for the Singapore to Bangkok routing.

The regulation of scheduled air traffic operations has been specified in the most part as bilateral air services agreements, in the Paris and Chicago Conventions. However, non-scheduled air traffic regulations have not been explicitly specified at any time, and is usually left entirely to each state's discretion. They are usually subject to national and unilateral regulation of individual states, where their first step is to gain approval to fly to another nation. This approval may take a long time to process and may affect the non-scheduled airlines' long-range planning.

The relaxing of the requirement for prior authorization for non-scheduled operations in 1956 by the member states of the European Civil Aviation Conference led to the development of non-scheduled, inclusive tour charters within Europe. However, other nations such as the United Kingdom and the United States used national regulatory controls on the non-scheduled international air traffic operations. Thus, there is much uncertainty involving these non-scheduled services, because the rights of such operations are entirely up to each government, and "they are at the mercy of the destination countries which may give or refuse landing authorization" (Doganis 1985, 40).

While the United States has included non-scheduled charter rights explicitly in a few of its bilateral charter agreements, there is a need for more adequate international regulation of the non-scheduled international air traffic operations in order to ensure adequate and fair competition between the international scheduled and non-scheduled services. These regulations influence the types of services available to cater for the public's demand for air traffic services, and may also have implications on the progress of the international air transport industry as a whole.

Of considerable importance in the planning of airports is the designation of international 'gateways'. Initially Canada restricted its gateways through international agreements to Montreal and Vancouver. Progressively, other gateways, especially Toronto, have been permitted with resulting shifts in traffic flows and in major airport traffic volumes.

3.5 SUMMARY

This chapter has shown that air traffic is complex in nature and is sensitive to fundamental changes in a country's economy. The passenger traffic varies by trip purposes, business or leisure, by carrier response, scheduled or non-scheduled, and the nature of their system operation. Regulatory changes also play a role in traffic development, especially with respect to specific major airports. International traffic is affected by different factors than domestic traffic. Finally, cargo traffic, an important type of traffic growth has its own very distinctive patterns. The complex economics of air traffic obviously pose serious challenges for traffic forecasting and airport planning.

CHAPTER FOUR

AIR TRAFFIC FORECASTING

4.1 INTRODUCTION

Air traffic forecasting is highly dependent on the state of the economy because of the income and activity impacts on air transport economics. Additionally, regulatory changes, developments in airline system operation, and the introduction of new types of aircraft also affect the forecasting of air traffic. Such forecasting is therefore, uncertain because of fundamentally complex dynamics. The problem is accentuated in long-range forecasting, because it is necessary to presume a set of socio-economic circumstances that may occur five to twenty years in the future. Nevertheless, long-range forecasting and well-defined air-traffic projections are necessary to aid the planning of future aviation facilities and important because of the magnitude of the airport investments involved. Air traffic forecasting provides basic economic information about the demand for airports. It can give definition to the magnitude and timing of airport investment.

Section 4.2 discusses the significance of air traffic forecasts for airport planning. Although the forecasting of potential air traffic is important, there is very little documentation available to airport planners which outlines the basic procedures for analyzing and forecasting air traffic.

The alternative methods that can be used to forecast air traffic demand include the quantitative, qualitative and decision analysis techniques (Taneja 1978, 1). This chapter focuses on the quantitative group of forecasting techniques, in particular, the econometric or regression techniques that have gained much popularity in these recent years. The sections following this will discuss different forecasting techniques, forecasting methodology, selected air traffic forecasting models, and the limitations of these forecasting techniques.

4.2 SIGNIFICANCE OF AIR TRAFFIC FORECASTS

Aviation forecasts are used to assess the current and future operations, to determine the expansion of airport facilities, the development of new aircraft, financial planning, air transport management, as well as the training of air traffic controllers. Long-range forecasting is required because of the magnitude of the airport investments involved. It is used by aircraft manufacturers to determine future market potential for their aircraft. Airports also require forecasts to determine the size of their terminal buildings, runway capacity and the provision of vehicle space requirements. Government agencies also require aviation forecasts in order to budget, regulate, evaluate and formulate aviation policies.

From an economic viewpoint, the penalties for over-production of these airport facilities could be very severe because the capital investments made on airports are very large. The timing of these investment decisions is also very crucial, because if the capital commitment is premature, economic pay-offs may not be as the planners originally expected. If the timing is too late, airport congestion costs can be severe. If the airport is located too far from the city, or the vehicle parking is positioned too distant from the terminals, these may incur unnecessary time costs to the users.

Therefore, air traffic demand forecasts for specific airports are important, as they help to project future air traffic growth trends at a specific airport. This makes it possible for the airport investment decisions to be made according to the growth in air traffic levels prior to the expansion at the airport.

4.3 FORECASTING TECHNIQUES OF TRAVEL DEMAND

Taneja (1978) outlines the three broad categories of forecasting methods used in air transport namely, qualitative, quantitative and decision analysis methods. These three different techniques are shown in Figure 5. The qualitative techniques include executive judgment, the Delphi approach, as well as the technological techniques (exploratory and normative). Executive judgement and experience allow forecasts to be made very quickly. The Delphi approach requires a consensus forecast based on opinions of group expertise. This technique is used by airframe manufacturers and trade associations. The technological technique has been used to forecast future changes in technology and their impacts. The first category of technological techniques include exploratory which techniques can be further grouped into extrapolative and speculative methods.

Figure 5: Methods to Forecast Air Transportation.

Qualitative	Quantitative	Decision Analysis
1. Judgement	1. Time-Series Analysis:	1. Market Research
2. Delphi	a) ratio analysis	2. System Dynamics
3. Technological	b) trend projection	3. Heuristic
a) exploratory	c) moving averages	4. Probabilistic
b) normative	d) spectral analysis	
	e) adaptive filtering	
	f) box-jenkins	
	2. Causal Methods	
	a) regression	
	b) econometric	
	c) simulation	
	d) bayesian	
	e) spatial equilibrium	

Source: Taneja, N.K. "Airline Traffic Forecasting." Lexington Books, Toronto, 1978, p.2.

The extrapolatory method is based on certain growth patterns which tend to occur in the S-curve logistic and envelope techniques. Simulation of different outcomes can be performed here, and some examples include input-output analysis and cross-impact studies. Speculative techniques rely more on the individual's intuition to anticipate future trends, and basically deals with the question of 'what is possible'. The next category is the normative technique which basically examines the questions of 'what is desired', and 'what is expected'.

The quantitative techniques include time-series analysis and causal methods. The former includes ratio analysis, trend projection, moving averages, spectral analysis, adaptive filtering, and box-jenkins. The causal methods include regression, econometric, simulation, bayesian and spatial equilibrium. The econometric method is a more complete form of statistical, economic measurement and includes model specification while regression analysis deals only with the calibration stage of these models (Taneja 1978, 9).

The difference between time-series and causal analysis is that the pure time-series analysis deals with the question of 'when' the occurrence takes place, while causal analysis attempts to answer the 'why' question. Thus, time-series analysis is merely statistical and does not capture changes in the economy, technology or air fares. It may predict the level of air traffic demand, but will not be able to explain why demand is at that level. For example, trend projection predicts the level of demand based on past occurrence, but does not take into consideration the factors that affect that demand. Another example is the ratio analysis method that is used to forecast airport passenger demand based on past data, instead of considering demand factors.

In contrast to this, causal analysis does incorporate factors that may have caused changes in the level of demand. Among this group of techniques, spatial equilibrium analysis is used very often in forecasting air traffic demand. An example of the spatial equilibrium model is the trip-distribution model which includes the gravity model, often to estimate the air traffic demand between two cities or regions.

Button (1982) describes the spatial equilibrium model in his sequential modelling technique which involves the aggregates of individuals and traffic zones within a travel network. Within this forecasting framework, the four sub-models include the sequence of trip generation, trip distribution, modal choice and route assignment. The trip generation submodel uses multiple regression techniques or category analysis to forecast the number of trips originating and ending within each traffic zone. The trip distribution submodel then uses the zonal trips obtained in the first stage to distribute the total zonal trips between each pair of origin-destination zones. Spatial equilibrium models such as gravity models have been used for this purpose. The modal choice submodel assigns proportions of each traffic split to the alternative modes of transport. Finally, trip bundles are assigned for each mode to specific routes in the network. However, one major weakness of sequential modelling is the uni-directional flow of the submodels. This results in a lack of feedback from the various stages in the forecasting process.

Taneja's (1978) third broad group of forecasting technique is decision analysis. This group uses both the qualitative and quantitative methods in their forecasts which incorporates 'uncertainty and risk' elements. Taneja sub-categorized this decision analysis group into market research, system dynamics, heuristic and probabilistic techniques. The last two sub-categories are not commonly used to forecast air traffic demand.

Market research techniques relates the demand for air traffic services to economic and demographic growth. The passengers are segregated according to the nature of travel (business or pleasure), age, vocation, education and income. The forecasts are made by estimating the growth in air travel for each of these groups. According to Button's interactive model, individuals are considered as decision-making units and there are behavioral aspects that underlie their travel patterns. The system dynamics model requires the use of complex computer packages with mathematical formulae to simulate the dynamic responses to changes in the system.

Besides generating the forecasts, other policy options can be evaluated by the use of sensitivity analyses.

Of all the travel demand models mentioned above, the spatial equilibrium model which uses multiple regression techniques is most commonly used in air traffic demand models. Gravity models which belong to this group are thought to give the most precise economic interpretation, and are used in the air traffic forecasting model for Canadian airports. The econometric model attempts to explain the variations in air traffic through the variations of relevant independent variables of the system. With the availability of new computer technology, regression models have become increasingly sophisticated.

4.4 FORECASTING METHODOLOGY OF AIR TRAVEL DEMAND

Figure 6 shows the basic procedures for the regression model development and the forecasting of air passenger traffic demand, outlined by Taneja (1978, 10).

The initial step in producing any air traffic forecast is to review past trends, using either cross-sectional or time-series data, in order to provide an indication of the general characteristics of the market. The second step is to identify socio-economic factors and service-related factors that may affect the demand for air travel. The socio-economic factors include the general economic, social, political and geographical considerations.

The service-related factors include transport variables such as the costs of air travel in terms of money and time costs, and other quality variables such as comfort, safety, convenience, aircraft speed, journey times, flight frequency and some load factors.

The next step is to develop the model from the above socio-economic and service-related factors, and this requires a specification of the demand variables, data collection, calibration and finally, an evaluation of the model to determine the effectiveness of the air traffic demand model in explaining and forecasting air traffic services.

4.41 BASIC MODEL SPECIFICATION

Sound model specification for air traffic demand is the most important aspect of the regression model development. For the purpose of forecasting air traffic demand, the objective is to find the minimum number of independent variables that best "reflects the theoretical aspects of the underlying process" and also "maximizes the prediction and control of the dependent variables" (Taneja 1978, 146).

The basic economic model can be specified according to the variables affecting the demand for air passenger traffic and air-freight traffic. These variables were discussed in sections 3.31 and 3.32 respectively.

Figure 6: Forecasting Procedure for Air Passenger Traffic Demand.

Data		Availability
Review Past Travel Trends at Major International Airports -----	Identify Factors Influencing Air Traffic Demand	----- Quantification Reliability Consistency Size of Base Projected Values

Regression Model Development

- Alternative Models and Assumptions
- Specification of Demand Variables
- Data Collection
- Model Calibration
- Model Evaluation

Traffic Forecast

Forecast Evaluation

Final Forecast

Source: Taneja, N.K. "Airline Traffic Forecasting." Lexington Books, Toronto, 1978, p.10.

International trade and tourism in a country also affect the demand for its air traffic services. The level of exports will affect the outbound international air freight, while the level of imports will affect the inbound international freight. The exchange rate between the two countries not only affect their trade, but also the purchasing power of the travellers. The level of economic activity also has an impact on the demand for business travel.

After specifying the variables in the model, the relationship between the dependent and independent variables can be specified using the appropriate functional forms or precise mathematical equations. The more common functional forms include the linear form, multiplicative form, exponential form, non-linear form, the difference model or combination of these forms. The choice of an appropriate functional form for the air traffic demand model depends on past "historical traffic trends, data considerations, time period of the forecast, and certain desired properties of the demand functions, such as constant or variable price elasticity of demand" (Taneja 1978, 121).

4.42 DATA COLLECTION

Apart from theoretical considerations, the selection of the independent variables also depends on the availability of empirical data. Certain independent variables pertaining to the quality of air services may not be quantifiable and, in such cases, a proxy may have to be used as a measure of that quality.

Sometimes, the value of the dependent or independent variables cannot be measured over a continuous range, and if the variable has a discrete value, the regression equation may have to employ the use of dummy variables, which can also be used to handle situations such as airline strikes, the state of the economy, wars and seasonality adjustments (Taneja 1978, 120). The reliability, consistency and the size of the data base are important considerations. The sources of statistical data on air traffic services can be obtained from international organizations such as IATA, ICAO and the Department of Civil Aviation Authority Group in each country.

4.43 MODEL CALIBRATION

The time-frame for the forecast will also influence the specification and calibration of the model which is normally performed using multiple regression analysis. Short-term forecasts usually range from one month to a year, and are used for the planning of current policy and developments. Mid-term forecasts can range from one year to five years and are used for market and route planning. Long-term forecasts usually cover a period of five to twenty years and are generally used for the development of aircraft fleet and the long-term planning of airport infrastructure (Taneja 1978, 137).

Air traffic demand models can be calibrated using either cross-sectional or time-series data, or pooled data which is a combination of the two. However, cross-sectional data may not represent the 'typical' or true process, and they also pose heteroscedasticity problems, because one market may be more business-oriented than the other. Time-series data may pose autocorrelation problems because the error terms are usually correlated over time. This usually happens when "either a significant variable has been left out or when the specification of the model excludes a cyclical variable that affects the dependent variable" (Taneja 1978, 74). Pooled data may provide a better sample size but further combine the problems of heteroscedasticity and autocorrelation related to cross-sectional and time-series data. Thus, the model has to be very carefully specified, in order to provide more reliable estimates of the regression coefficients.

4.44 MODEL EVALUATION

The final step in the model development would involve an evaluation of the model, a reformulation of the model in terms of its theoretical basis, underlying assumptions, empirical data base and the statistical validity of the estimation procedure. It is important that the purpose of forecasting the air traffic demand and the time frame be made explicit and clear.

Errors in forecasts can occur if the model has not been specified correctly to represent the true process. Statistical problems such as multicollinearity, autocorrelation and heteroscedasticity should also be checked and corrected. The model should also be statistically tested for its validity, with the aid of the F-statistic, the Durbin-Watson coefficient, the Chow Test, the multiple correlation coefficient and the standard error of the coefficient.

The main purpose of evaluating the model would be to determine the effectiveness of the calibrated demand model in explaining the demand for air traffic services. Thus, the standard error of the demand coefficients and the model's standard error of estimation should be kept at its minimum level. Once this is established, reliable forecasts can be produced by using the demand model and projections of its explanatory variables.

4.5 SELECTED AIR TRAFFIC MODELS

To provide further insight into the air traffic forecasting process, air traffic forecasting models will now be used for illustration, which will incorporate leisure and business traffic demand. The second will illustrate air cargo forecasting.

4.51 PASSENGER AIR TRAFFIC MODEL

The passenger demand model by Smith and Toms, done on Australian passengers for the years 1964 to 1977 has been selected for the purpose of this thesis. This model takes into account the differences in the elasticities of air transport demand, by segmenting the airline passenger market into the leisure and business travel demand.

The nature of demand for passenger travel can be classified under leisure or business purposes. This has implications on the elasticities of air transport demand, which are important for the airport planners in terms of flight scheduling. The price elasticity of demand is expected to be relatively higher for the leisure than for the business airline passenger market.

4.511 LEISURE DEMAND SPECIFICATION

The explanatory variables identified in the model by Smith and Toms include per capita real income, air fares, exchange rates, population of Australians born overseas, and finally, the proportion of Australians residing overseas (Smith and Toms 1978). Travelling overseas can be very expensive and tourists have to consider carefully the price of the trip and their incomes. Therefore, it is expected that the price and income elasticities of passenger demand in this leisure market would be relatively high. The exchange rate between the two countries influences the purchasing power of the tourists, as well as air fares. A devaluation in country X's currency relative to the Australian currency would lower country X's accommodation and other costs of purchasing goods in country X. Smith and Toms also included two other variables to account for the passenger visitation of relatives which are affected by the population of Australians born overseas, as well as the proportion of Australians now residing overseas. Smith and Tom's basic specification of the leisure market is a double-log formulation represented as follows:

$$\text{Ln DP} = \text{Ln a} + \text{b Ln F} + \text{c Ln Y} + \text{d Ln E} + \text{e Ln MA}$$

where DP is the per capita demand for leisure travel; F is the real equivalent air fare; Y is the per capita income; E is the exchange rate; MA is the proportion of the Australian population born in the overseas country of origin or destination of travel; and the coefficients to be estimated are represented by a, b, c, d and e.

They used separate regression equations to estimate the demand for Australians travelling overseas to United Kingdom, New Zealand, United States, Germany, Italy, Japan, Malaysia and Singapore, as well as the demand for these overseas visitors to travel to Australia. Their analysis involved pooling time-series and cross-sectional data, for the period March 1964 to March 1977. Their data for the explanatory variables were taken from various ABS bulletins, United Nations Statistical Publications, IMF, OECD, and their fares were gathered from various sources. In their model, Smith and Toms assumed the elasticity of population to be one, so that if the Australian population increased by 10 percent, the overseas travel demand is assumed to increase by 10 percent too, ceteris paribus. Their fare variable was a weighted sum of the various fare types including first class, full economy, excursion and other fare types. Both incomes and fares were deflated by the Consumer Price Index. They obtained the following results:

$$
\begin{aligned}
\text{Ln DP} = {} & \underset{(3.8)}{1.15} - \underset{(-19.88)}{1.78}\ \text{Ln F} + \underset{(12.3)}{2.36}\ \text{Ln Y} + \underset{(3.3)}{0.55}\ \text{Ln E} + \underset{(34.5)}{0.48}\ \text{Ln MA} \\
& + \underset{(12.6)}{0.57}\ \text{SD} - \underset{(-7.3)}{0.52}\ \text{CD2} - \underset{(-7.2)}{1.16}\ \text{CD5}
\end{aligned}
$$

(t-values are in parentheses)

where R squared value was 0.920; SD is a seasonal dummy to account for the normal seasonal variations in travel; CD2 is a dummy variable with value 1 when data for Italy are used, and zero otherwise, to account for factors which relate to travel between Australia and Italy, but cannot be identified explicitly; CD5 is a dummy variable with value 1 when New Zealand data are used, and zero otherwise.

Their results show that for Australians travelling overseas, the fare and income elasticities were -1.8 and 2.4 respectively, which did not differ very significantly from the demand model for overseas visitors to Australia, where the fare and income elasticities were -1.8 and 2.1 respectively.

4.512 BUSINESS DEMAND SPECIFICATION

The business market is quite different from the leisure market, and total demand instead of individual demand is analyzed here. Thus, per capita income is not applicable here, but the volume of trade between the countries would affect this market. Smith and Toms used the sum of imports and exports in real terms as one of their explanatory variables to account for the volume of trade. The level of fares was also measured in real terms, and the effects of the unidentified factors were accounted for in their model when they included a time trend. Their basic specification is as follows:

$$\text{Ln } D = \text{Ln } a + b \text{ Ln } F + c \text{ Ln } XM + dT$$

where D is the total demand for business travel; F is the real equivalent air fare; XM is the sum of exports and imports measured in real terms; T is time; and a, b, c and d are the coefficients to be estimated. Their regression analysis was estimated on a pooled time-series and cross-sectional basis for the period March 1964 to September 1975. Their results were as follows:

$$\begin{aligned}\text{Ln } D = \underset{(4.6)}{1.75} - \underset{(-23.1)}{1.23} \text{ Ln } F + \underset{(14.5)}{0.83} \text{ Ln } XM + \underset{(5.5)}{0.015}\, T - \underset{(-10.3)}{1.27}\, CD3 \\ + \underset{(3.9)}{0.43}\, CD4 + \underset{(5.8)}{0.71}\, CD6\end{aligned}$$

(t-values are in parentheses)

where the R squared was 0.760; CD3 is a dummy variable with value 1 when data for Japan are used, and zero otherwise; CD4 is a dummy variable with value 1 when Malaysia and Singapore data are used, and zero otherwise; and CD6 is a dummy variable with value 1 when UK data are used, and zero otherwise.

Their results showed that the coefficients of the trade and fares variables were strongly significant with appropriate signs of values 0.8 and -1.2 respectively for Australians travelling overseas, as well, 0.8 and -1.0 respectively for overseas visitors to Australia.

Although Smith and Toms obtained the correct signs for the price and income elasticity coefficients, their values varied substantially for each country. However, we can conclude from this Australian air traffic demand analysis, that the leisure airline passenger market demand is more responsive to price changes than the business passenger demand.

4.52 AIR FREIGHT TRAFFIC MODEL

The air freight traffic model selected for this discussion was done by Raymond Cohen for the years 1958 to 1970 in the United States. Air-freight traffic demand is dependent on the industrial characteristics of the economy, and various measures such as gross national product, industrial production index and economic activity levels have high correlations with the air-freight traffic volumes.

The model by Raymond Cohen assumed the demand for air-freight to be influenced by the general economic activity (GNP), air-freight rates and the level of service or quality of competing modes like truck and rail freight transport were assumed to be unchanged. Since individual rate structures of each mode were too complex to obtain, average yield (revenue per ton-mile) data were used. Cohen's air-freight model specification can be represented as follows:

$$\text{Ln DF} = \text{Ln a} + \text{b Ln GNP} + \text{c Ln F}$$

where DF is the domestic scheduled air freight traffic in revenue ton-miles; GNP is the economic activity indicator; and F is the air freight rates.

Cohen's model used quarterly freight traffic data from the period 1958 to 1970. In order to deseasonalize his data, he introduced seasonal dummy variables into his model. He obtained the following results from his regression analysis:

$$\begin{aligned}\text{Ln DF} = & \underset{(-9.28)}{-.1360\text{ D1}} - \underset{(-4.66)}{.0687\text{ D2}} - \underset{(-3.21)}{.0466\text{ D3}} + \underset{(2.45)}{.1543\text{ DC}} \\ & + \underset{(177.27)}{2.5850\text{ Ln GNP}} - \underset{(-45.56)}{1.4098\text{ Ln F}}\end{aligned}$$

(t-values are in parentheses)

where D1, D2, D3 represent seasonal dummy variables for the first, second and third quarters of the calendar year respectively; and DC represents the dummy variable to account for data inconsistency.

The multiple coefficient of determination of the above model was 0.997, which indicate that the model has a high explanatory power, where 99.7 percent of the changes of air-freight demand traffic, can be explained by the explanatory variables in the model. Thus, the high t-value for GNP in Cohen's model confirmed that air freight demand is significantly influenced by the level of economic activity.

4.6 AIR TRAFFIC FORECASTING LIMITATIONS

Many studies on the air traffic demand have been limited by the data available and the methodology which could be used. Adequate historical air traffic data may not be readily available, especially in the less developed countries.

The three broad groups of techniques used to forecast air traffic demand were outlined in section 4.3. However, there are strengths and limitations associated with each of these techniques.

The qualitative techniques can be very useful when the model cannot be objectively analyzed, or when historical data are not readily available. These techniques do rely very much on the judgement and credibility of the analyst who must be an expert in the field of study. The forecasts produced with these techniques are also subject to the accuracy of the information received, either through questionnaires or interviews with the organizations involved in the study. However, the exploratory and normative techniques in this group allow the forecaster to identify critical linkages and patterns, and to simulate outcomes assuming different scenarios which can be very useful in the analysis.

The quantitative group of forecasting techniques rely on historical data and trends for their analysis. These data have to come from actual activities that had occurred in the past, and they may not always be available. This makes the statistical inference very difficult. In the causal methods of this group of techniques, the forecaster uses economic theory to identify the behaviourial parameters in his structural equation. Just as pure economic theory is limited in its static nature based on certain assumptions, the econometric models do not tell us very much about the dynamics of air traffic demand. The results obtained in the specification of the econometric models refer only to static theory. However, econometric models are useful in that they are theory-based, and they bring in empirical content to enhance the theory.

The final group of forecasting techniques mentioned was the decision analysis group, which combines both qualitative and quantitative techniques. These methods involve both a subjective probability input and the use of a mathematical formulation. They are useful when dealing with uncertainty and risk analysis, both of which are elements in forecasting. However, the difficulty often lies in the ability of the analyst to quantify and interpret the subjective responses accurately. So far, the probabilistic and heuristic methods which belong to this group of forecasting techniques have not been applied to the demand for air transportation.

Econometric models have been very popularly used to forecast air traffic. An important assumption in the time series model to forecast air transport demand is the constant relationship over the period for which the model was calibrated. However, the relationship between the dependent and explanatory variables may have changed over those years and the model may not be valid for all short, medium or long haul sectors. Similarly, pooled data may also be inappropriate over the different lengths of haul, because of the different market characteristics. Thus, these models may be adequate forecasting tools, but unfortunately, they are too insensitive to policy issues (Cohen 1974, 131).

It is quite unfortunate that most of the econometricians' forecasts on air traffic demand have not been particularly accurate. One of the limitations is the fundamentally static nature of econometrics, while the economics of air traffic demand is very dynamic in nature. The constantly changing environment of the air transport industry includes the regulatory changes in the industry. An example of this would be the recent deregulation of the Canadian airline industry, and the great surges in the air traffic demand levels at major Canadian airports today have been quite unanticipated. Many econometricians adjust the estimates from their models, using information about factors in the economy whose influences are not incorporated in their model. However, it is still difficult to modify the air traffic demand forecasts, in the light of unanticipated policy changes. In the dynamic deregulated environment, very rapid increases in the air traffic levels and the development of hub-and-spoke networks were unforseen at the time of deregulation. This resulted in much congestion and delays at the major hub airports such as Toronto's Pearson International Airport and Vancouver International Airport.

The forecasting models used in Canada to produce a national set of airport activity forecasts is an aggregate model which generates forecasts for the major Canadian airports, as well as the smaller cities in the aviation network. A major limitation to this model is the differences between model predictions and actual airport activity which will have to be adjusted for local anomalies because airports in the smaller cities may not exhibit the same degree of demand as other major airports.

It is important to bear in mind that air traffic forecasting models are only approximations of the real world. There is no forecasting technique that is perfectly accurate in its prediction. The choice of the most appropriate technique to use may be affected by the objective of the forecast, the given time frame, and data availability in cost considerations. If historical data or data on certain independent variables are not available, then the forecasting may have to resort to qualitative, as opposed to quantitative techniques. However, if the above factors do not pose as constraints, then the forecaster can choose the best technique based on its predictive ability. The experience and judgment of the forecaster will still influence this decision. Sometimes, airlines use the mix of these techniques to produce their short-term and long-term forecasts.

The limitations of air traffic demand models lie in the extent to which these models can cope with the dynamics of air traffic demand. Econometric forecasting models are consistent and logical in their causal relationship. Given the causal relationship, the econometrician has to rely on someone else's forecasts of the independent variables in his model. However, such economic forecasts may vary with different institutions which prepare the forecasts for the variables. It should be noted that although this is a quantitative model, there are qualitative aspects where judgment of the econometricians is required. For example, the selection of independent variables in the model are entirely up to the discretion of the econometricians. Despite these weaknesses, econometric forecasting is consistent and logical in their causal relationships. This gives it an added advantage over the time-series trend projections where time is the only variable related to air traffic demand.

4.7 SUMMARY

This chapter has discussed methodologies of forecasting air traffic. The chapter draws attention to the importance and limitations of such forecasting. Special attention is given to econometric methods using regression analysis. It was concluded that in order to achieve better estimates of the parameters of air traffic models, consideration should be given to the whole system of air traffic relevant to the forecast. Assumptions and relationships between the variables and the base conditions should be explicitly stated to facilitate necessary revisions of forecasts in the light of changing dynamics.

The chapter reveals that there is a variety of methods available for forecasting. In view of the difficulties inherent in air traffic forecasting and the unavoidable limitations of any single method it would seem advisable to use more than one method to provide complementary checks on forecasts.

CHAPTER FIVE

ECONOMICS OF AIRPORT CAPACITY

5.1 INTRODUCTION

Major airports have large networks of air routes which feed air traffic of difficult types to and from the airports. Changes in traffic volume and competition have important implications for the use of airport capacity. The next section discusses important aspects in the timing of airport investment. The timing of such investments can determine an airport's level of capacity, and can result in under-utilization or over-utilization of airport capacity. Section three describes the problems associated with rapidly increasing air traffic demand which cause heavy demands and peak-load congestion on landside facilities, airways and airport access. Congestion imposes time costs and inconvenience on passengers, disrupts the system economics of air carriers, creates difficulties for airport personnel and others who use the airport. The final section concludes with a brief summary of the chapter.

5.2 AIRPORT INVESTMENT AND CAPACITY

Chapter four discussed the significance of air traffic demand forecasts. These forecasts and the timing of the airport capital investments play important roles in determining the capacity of the airports. The air traffic level is also an important guide to the timing of airport investment decisions. These decisions will involve a considerable impact on the cost of developing the airport infrastructure. When airport investments occur too early or too late, the resulting under-utilization or over-utilization of airport capacity imposes serious costs on the air transport system.

Airport investments are very lumpy and if built too soon, they tie up money in terms of capital expenditures. The magnitude of the waste of resources that results from such decisions can be very large. They are large in financial and operating terms and probably even more serious in terms of opportunity costs. For example, the cost of Montreal's Mirabel International Airport, built in the mid-seventies, was $500 million. However, to date, the airport still has not reached the desired levels of airport activity. Mirabel was projected to have five times the air traffic level of Dorval, but by 1980, the aircraft movements at Mirabel were only a third of Dorval airport. "As late as 1984, critics were still arguing that Mirabel should be closed because it was impractical and cost too much money to run" (Davidson 1988, 1). One of the major complaints of Mirabel airport is the location of the airport which is 50 kilometres north of Montreal. It takes about 45 minutes to drive to the city, and there are no direct highways to link Montreal's Dorval and Mirabel airports. This makes it very difficult for passengers who have to transfer between the two airports. Montreal's Mirabel airport was designed to handle international flights, while Dorval would handle the domestic flights.

Thus, this is an indication of how costly decisions on airport investments can be. The airport activity forecasts are very sensitive to the demand for air traffic services at the airport. In the case of Mirabel airport, the demand forecasting should include the strategic shift of air traffic demand in Eastern Canada which focused on Toronto instead of Montreal as a major air hub. This structural shift should have been incorporated in the demand forecasts for both the airports in Montreal and Toronto. If the airports are built ahead of their demand, or if the location of the airport is not convenient to air travellers, the huge sums of capital tied up may not be fully justified. This results in wastage of capital resources which could be put to better use in other areas.

To cite an example, the $500 million dollars that was invested in the construction of Mirabel airport in 1975 would cost approximately $1,020 million in current value. This has been calculated using the construction price index for 1988 (Statistics Canada 1988b). In 1984, the airport was operating at only 14 percent of its capacity to handle 10 million passengers and 500,000 tonnes of freight annually. This results in higher deficits in the operations of the airport, and "Canadian taxpayers are footing the bill for the $50 million annual losses Mirabel has rolled up in almost 4 years of operation" (The Vancouver Sun 1979, A4).

On the other hand, if the airport investments are unduly delayed, they pose major capacity constraints on the airport infrastructure. The passenger and cargo traffic levels may exceed the capacity the airport has been designed for annually. This leads to airport congestion and delay which have economic consequences. A very striking example of this is Toronto's Pearson International airport. Presently, the demand for air traffic exceeds the capacity to accommodate this demand. The two terminals were built to handle 12.5 million passengers a year, but more than 20 million passengers are now using the terminals. Over the past ten years, expansion plans costing about fifty million had been made to improve Terminal 1. However, the improved facilities still proved inadequate to cope with the ever increasing air traffic demand at the airport. Since the deregulation of the Canadian airline industry which started in 1983, "traffic at Pearson has jumped by 50 percent" (Calleja and Campion-Smith 1989, A3). The passenger air traffic increased from 14 million in 1979 to 19.3 million in 1988. The president of Norr Airport Planning Associates estimates that the cost of improving the airport's infrastructure could be as much as $100 million (Picton 1988, A1).

The air traffic levels at Toronto International Airport increased steadily in 1985, and it has not stopped expanding.

Toronto International Airport is experiencing severe congestion and Transport Canada is looking for solutions to expand the existing facilities at the airport. The second busiest airport in Canada after Toronto International Airport is the Vancouver International Airport which is also facing rapid increases in its air traffic levels. The airport's runway capacity is no longer capable of handling the extra air traffic levels, and the airport is facing congestion problems similar to that experienced at Toronto's Pearson International Airport. In terms of delay, it is the second worst airport in Canada after Toronto.

One of the possible reasons for the rapid increase in air traffic levels is the 'feeder hub-and-spoke' arrangement that has placed heavier demands on the major international airports. With the liberalization of the Canadian aviation policy in 1984, the federal government encouraged competition among the air carriers. In the case of Vancouver, planning probably did not sufficiently allow for the relatively high growth rate of Pacific Ocean air traffic. The shortfall in expansion is serious for both passenger and cargo traffic competition. According to Transport Canada's executive director Roy Jamieson, "our airport infrastructure just isn't designed for the competitive environment that has occurred since deregulation" (Bagnall 1988, 6). His long-term solution for Toronto's Pearson International Airport would be for the government to expand the airport's facilities.

However, it is important to emphasize that these are very costly solutions. According to a world airport development survey, "the construction costs alone of new airports during the next 14 years will amount to $90-billion or about $10 billion more than was estimated a year ago" (<u>The Financial Times</u> 1987, B3).

In view of the huge sums of airport capital investments involved, strategic planning is essential for all major airports. The planning horizon or time frame for such airports is usually long-range, and it can range from a time period of ten years to twenty years.

In general terms, the criteria in airport planning would be to provide adequate capacity to meet the required air traffic demand levels. These investments should be sensitive to strategic as well as more routine changes in air traffic demand. An understanding of the nature and requirements of air traffic demand at the airport is a necessity.

Flexibility is an important consideration in airport planning. This relates to how adaptable the airport can be to alterations in its layout required to meet the rapid growth of air traffic and space demands. According to ICAO's definition, flexibility is "the ability to increase the operating capacity within existing physical limits". Likewise, expansibility is "the ability to be physically extended to the limits of the site to provide additional space and extra capacity using either new or existing operating procedures"

(ICAO 1977, Appendix A). The structure and materials selected should be easily adaptable to future changes or expansion, with little cause of disruption to the other areas.

5.3 FACTORS ON AIRPORT CAPACITY

The magnitude of the problem of congestion can be better understood by examining the peaking characteristics at major airports. The nature of the air traffic demand and the different market segmentation result in daily and seasonal fluctuations in the demand. "Airport traffic peaking refers to the variable nature of air transportation demand. A peak period may encompass an entire season, a vacation period, a group of days or in its most dramatic expression, only a few minutes or hours in a day" (Transport Canada 1985b, 1).

These characteristics were observed in a study done in the late seventies by Transport Canada on the peak variation patterns of the major airports at Toronto, Vancouver and Dorval airports (Transport Canada 1977). In the case of Toronto International Airport, day-to-day variations for non-holiday weeks, showed the peak days were on Thursdays and Fridays, with a significant reduction of air traffic on Saturdays. This reduction could probably be explained by the drop in business air traffic on the weekends. This variation pattern was also observed at Dorval Airport, with peak traffic volumes on Fridays and the low volumes on Saturdays and mid-weeks.

However, Vancouver International Airport reported a different daily variation pattern, with Sundays recording higher peak traffic volumes than Fridays which also had typically high volumes. As for Saturdays, the drop in air traffic volumes were not as significant as the other two airports. The Sunday peaks could be explained in part by the once-a-week international flights which bring in jumbo-loads of passengers on Sundays.

It is interesting to note that the holiday week traffic variation pattern was similar for all the three airports, which showed traffic peaks on Fridays and Mondays with the lowest traffic on Tuesdays and Wednesdays.

Seasonal air traffic variations for all the three airports recorded peak traffic volumes regularly during the summer months of June to August, with a secondary peak in January.

This air traffic peaking at major airports results in high utilization of capital goods such as runways and terminals during peak times, but under-utilization of such capital goods during off-peak times. It follows then that while the airport facilities may be unused at certain times, the airport's capacity may be stretched to its maximum during periods of peak demand.

Some of the factors creating air traffic peaks include the geographical location of the airports, route timings, aircraft range and performance, crew time restrictions, curfew restrictions and other government regulations. More often than not, the capacity of carrying goods and passengers along the busiest air routes exceed the airport's capacity to handle the demand for air traffic. In view of the complex air traffic international route networks, the curfew times imposed on certain airports will create more peak situations for other airports along their route networks. Congestion and capacity problems have been the result of the rapidly expanding air traffic demand, relative to the expansion of the air traffic facilities at most international airports. The following section will discuss some of the economic consequences of airport congestion and delay.

5.4 ECONOMIC IMPLICATIONS OF CONGESTION

The problem of congestion will arise whenever there is an increase in air traffic services beyond the facilities available at the airport to meet the increased air traffic volumes.

The costs of international air traffic peak-load congestion can be viewed as both subjective, objective, short term as well as long term. The subjective element is difficult to measure, because of the marginal valuations of individuals who may place a lower value on a crowded plane trip compared to a less crowded aircraft. Their reasons may range from comfort to the quality of inflight services they may receive on the trip.

The objective congestion costs relate to the value that individuals place on their travel times. Airport congestion and delay incur time losses to passengers and also incur more of the indirect operating costs of airlines.

Congestion in the airside area may occur when the runways are congested and there are queues of aircraft waiting for departure or landings. This not only incurs time losses to passengers, it also causes aircraft operating costs to increase because of the extra fuel needed for the increase in block-time which includes both actual flying time and time needed for taxing, landing and take-offs. Such time delays also reduce the productivity of the aircraft, in terms of the mileage flown within a year.

Congestion in the landside component of airport may take place both in the enplaning and deplaning concourses. Whether passengers have to wait in long lines to check-in or to claim their luggage, this means that the passenger have to spend extra time at the airport, incurring time costs to them and also increasing their total journey times.

It would be helpful to analyze the economic costs of congestion before we look into the possible measures of alleviating it. The short term costs of international air traffic peaking include the higher operating costs to air carriers in terms of more manpower requirements, as well as to government authorities providing for air traffic control services and inspection services such as immigration, custom, agricultural, health and security services. The long term costs involve higher investments in the airport infrastructure such as runways, terminals, as well as higher investments by airlines in purchasing aircraft and other necessary servicing facilities. These long term investments may further incur social costs by causing inconvenience to the residents who live near the airport.

It is obvious that peaking causes inconvenience, and that every individual involved in some form of airport activity will suffer from congestion at the international airports in one way or the other. Airline passengers both enplaning and deplaning, will suffer in terms of time losses incurred by having to wait in long line-ups for check-in, baggage claims, immigration and customs clearance. They may also suffer in terms of higher anxiety levels fearing that they would eventually miss their flights, because they may have to circle desperately around the airport for available car park facilities, join queues of other passengers for baggage security checks before joining another long queue to be checked-in, yet another queue for passport clearance and upon reaching the departure lounges or holding rooms that are so packed with boarding passengers; it really seems to take forever to get to their aircraft seat. Besides the lowering of quality service standards, the safety standards may also be adversely affected, especially when there is a shortage of air traffic controllers who are primarily responsible for safe landing and takeoff of every aircraft.

The airlines also suffer because when their flights are delayed, their aircraft are not fully utilized, they need additional staff to attend to delay passengers or send delay messages, and these incur more expenditure than is normally required. Thus, the airlines indirect operating costs will increase, when these flight delays impose additional ground facilities at the airport. During peak air traffic periods, more airline personnel will be required for ground handling of passengers, baggages, ticketing, as well as aircraft maintenance services. Airside congestion or lack of runways to land may also incur additional airline costs in terms of fuel lost when the aircraft has to circle around to wait for available runways to land.

Peak period air traffic demand also has implications for the air carrier's utilization of their aircraft fleet. The planning of aircraft fleet is also on a planning horizon, ranging from short-medium-long-ranges in the time frame. The flight schedules may be planned on a daily or weekly basis, according to the flight routings, long or short haul sectors, departure or arrival time preferences and time-zone influences. However, the criteria for flight scheduling include profitability, maximum aircraft utilization and maximum load factors.

In order to cater for the peak period demand, a trade-off exists between scheduling more flights using smaller but higher cost aircraft, and scheduling less flights using larger but lower cost aircraft. Larger aircraft result in more unit cost savings, as well as a reduction in break-even load factors. Schedules with more frequent flights offer better services to the passengers who do not have to wait longer times at the airport to get on a desired flight. Thus, the trade-off between aircraft types and their frequencies is dependent on the air traffic demand levels.

Airport authority groups also suffer because if there is congestion at the airport, most complaints from the users will be obviously directed to the airport authority groups concerned, especially when there is a lack of airport facilities, or when the existing facilities break down due to over-utilization.

Finally, the inspection services, greeters and well-wishes are also affected by this air traffic peaking. Immigration and customs, as well as the health, agriculture and security inspection services will face much pressure during such peak times. The greeters and well-wishes are also affected in terms of difficulties gaining access to crowded washrooms, concessions and poor standards of services. Peaking results in higher costs at congested airports, and given the limited airport resources, demand management options have been sought to help alleviate this problem.

5.5 SUMMARY

This chapter focused on the importance of timing airport investment to avoid waste of resources. Both too early or too late investment impose social costs through over- or under-capacity of major airports. The economics of congestion including peak-load problems have been discussed in this chapter. Given that further airport investment is usually a long-term solution, airport congestion problems lead to a discussion of demand management options available as short-term methods to alleviate congestion problems at existing airports. Discussion of this topic is the focus of the next chapter.

CHAPTER SIX

AIRPORT MANAGEMENT, PRICING AND CAPACITY

6.1 INTRODUCTION

After discussing the economics of airport capacity in chapter five, this chapter examines the various demand management options available for a given airport capacity. Although there are both short-term and long-term measures, this chapter will focus only on the short term solutions, since long-term solutions require investment in capacity expansion which has already been discussed.

6.2 AIRPORT MANAGEMENT AND CAPACITY

This chapter will look at the various possible measures of alleviating the peaks in air traffic operations. Several demand management options will be considered. It is important to keep in mind a fair system should not discriminate against potential users of the airport facilities. For the purpose of this discussion, the following definitions will be used: "Airfield capacity is the rate of aircraft movements on the runway/taxiway system which results in a given level of delay. Terminal capacity is the ability of the terminal area to accept the passenger, cargo and aircraft that the airfield accommodates" (Wells 1986, 94).

Basically, the two possible measures of alleviating peaking problems include both short term and long term measures. Longer term solutions that can be used to reduce the air traffic include heavy investments in the airport infrastructure, such as the extension or building of new runways and airport terminals. The training of sufficient air traffic controllers, as well as the possibilities of using smaller airports close to the major international airports could also help to alleviate the congestion problems at the airports. In order to handle their increased air traffic levels, both Toronto and Vancouver airports are considering possibilities of a new runway. However, these long-term solutions are costly and they may take a few years to materialize. The next few sections will focus on the short-term measures that can be used to alleviate airport congestion problems.

6.21 AIRPORT TRAFFIC RESTRICTIONS

The most immediate short-term solution would be the administrative management of restricting and limiting the number of flights, and priorizing the access of the facilities to certain air traffic operations. These restrictions are often directed at peak hours of airport operations to certain types of traffic operations which include charter flights, training flights and general aviation which are mainly large business jets and executive flights. The regulation of these classes of traffic restricts hours of operation during certain hours of the day at the airport. "The appeal of traffic restrictions lies in their relative simplicity and ease of application" (Transport Canada 1985b, 44).

However, excluding certain operators from the use of these airport facilities is "a denial of the right of access", and one of CATA's strategic objectives is "to ensure that Canadians are afforded reasonable accessibility to the national civil air transportation system" (Transport Canada 1982, 36). Thus, airlines should also try to co-operate to re-adjust their flight schedules according to the capacity available at the airports, instead of competing with each other to schedule their flights during the peak times of the day or week. Sometimes, the government authorities may have to intervene, in order to ensure that all airlines re-schedule their flights to help alleviate the congestion at the airport. If all the airlines schedule their international flights close together, then several jumbo-jets or other aircraft will be leaving and arriving at about the same time, adding strains on the airfield capacity. This would further constrain the terminal capacity, crowding the departure and the arrival lounges, immigration, customs and security check-points, as well as baggage claim areas at the airport.

A very recent Canadian experience can be found at Toronto's Pearson International Airport, when the federal government restricted the number of flights to 70 per hour, as a short term measure to reduce the air traffic activity levels at the airport. Only the scheduled and charter flight operations were given priority to operate, while other categories like general aviation and other aircraft have to use the airport facilities during off-peak periods.

For some international airports such as Toronto where there is a curfew at the airport between midnight to 7 a.m., this ban on night flights may constrain the airport's facilities during the hours just before and after the restricted hours of operation. Another possibility of reducing the airport's congestion would be to shorten the curfew times this increasing the operating hours at the airport. Whenever possible, curfews should be lifted because all-freighter aircraft can operate during the night, and this can help to alleviate the congestion at the airport during the day. According to Transport Canada's officials, "adding an hour to each end of the operating day would increase Pearson's productivity up to 20%" (Bagnall 1988, 6). However, it is quite inevitable for most aircraft operating international long-haul routes to operate during peak times at the airports along its routing, because of the changing time zones involved along its international route networks. Table 6 shows the selective regulation of certain types of traffic at representative international airports.

TABLE 6

TRAFFIC REGULATION AT SELECTIVE INTERNATIONAL AIRPORTS

Airport	Type of Traffic Specification	Restrictions
Bombay	Non-scheduled flights are not permitted	During 1400 to 0230 GMT on any day
Copenhagen	Restriction on training flights	
Frankfurt	Restriction on VFR and IFR flights	At certain hours
Hong Kong	Restriction on general aviation movements	At certain hours
London - Heathrow	Restriction on general aviation movements	All hours

Source: Transport Canada, Airport Traffic Peaking and Congestion Study, TP 6851, October, 1985, p.44.

6.22 AIRPORT GATE MANAGEMENT

The use of gates is affected by the aircraft's arrival, departure and turnaround times, depending on the ground handling times required for the different aircraft types and the passenger load. In Canada, the responsibility of gate management lies with the Terminal Service Centre. Gate assignments are done on a non-discriminatory basis, in order to promote efficient and optimal services to passengers. Thus, all air carriers of the same category of operation have equal access in this gate assignment process which will be briefly listed as follows: (Transport Canada 1981)

- Prior to the assignment of gates, each air carrier is expected to submit their schedule for planning purposes.

- Scheduled unit toll and regular chartered flights operating at least four days a week will be given the top priority, followed by other unit toll and regular chartered flights with fixed schedules. Other passenger charters with known arrival and departure times and other categories will be considered thereafter.

- Larger aircraft are presumed to carry more passengers and will be given priority over smaller aircraft, in order not to cause inconvenience to a greater number of passengers.

- Aircraft gates will be allocated for the air carrier's exclusive, preferential or common use. An exclusive gate is assigned for the exclusive use of a specific carrier. A preferential gate is assigned for the preferential use of a specific carrier. A common gate is shared by the use of carriers not accommodated at preferential gates. For preferential gates, the carriers must indicate a gate utilization of 35 percent or more within the year.

- The maximum gate occupancy times varies according to the aircraft capacity and is standardized for planning purposes, as shown in Table 7.

- In order to allow for some flexibility in operational planning, each of the gate assignments is separated by at least 15 minutes.

- Finally, the gate assignment plan is frequently adjusted weekly and daily to reflect any changes in schedules such as additions, diversions or cancellations of flights.

Therefore, during periods of peak demand when the aircraft gates become a scarce resource, an efficient allocation of these gates will be necessary to ensure that all potential air carriers have equal access to them. "For each airport, a set of gate management procedures shall be developed reflecting the specific operating characteristics and facilities for that airport" (Transport Canada 1981, 3).

TABLE 7

MAXIMUM GATE OCCUPANCY TIMES

Aircraft Seating Capacity	Originate	Terminate	Through	Through Int'l or Transborder[1]	Turnaround
	Aircraft Type				
Over 450	1:00	:45	:45	1:30	3:00
401-450	1:00	:45	:45	1:30	3:00
351-400	1:00	:45	:45	1:30	3:00
301-350	1:00	:45	:45	1:30	2:00
251-300	1:00	:45	:45	1:30	2:00
201-250	1:00	:45	:45	1:30	2:00
151-200	1:00	:45	:45	1:30	2:00
101-150	:45	:30	:45	1:15	1:30
51-100	:45	:20	:30	1:00	1:30
26-50	:30	:20	:30	1:00	1:30

1 Through International/Transborder flights with full Canadian Inspection Services, ie., ongoing passengers (and their baggage) must deplane, clear inspection services and re-board.

Source: Transport Canada, Gate Assignment, January, 1981, p.A-I.

6.23 SCHEDULE COORDINATION

A report by the Canadian Air Transportation Administration surveying 35 Canadian airports in 1982 to analyze the air traffic peaking problems, identified schedule coordination as the most promising of all the demand management options, because it "best satisfies all the primary, technical and practical criteria for Canadian application" (Transport Canada 1982, 47).

Section 6.21 discussed the consequences of airport traffic restrictions which would definitely cause dissatisfaction among those deprived of the airport use during peak periods. This situation may be improved by more effective consultations and coordination between the air carriers and the airport authority groups to smoothen the international air traffic peaks. However, this degree of involvement by the airport authorities varies with different airport's requirements. Basically, they monitor and evaluate the effectiveness of the airline schedule coordination, as well as coordinate any changes in the schedules with the airlines. In Canada, "Toronto and Vancouver international airports are the only airports requiring a structural, continuous system of national or international coordination for either airside or airport systems" (Transport Canada 1982, 49). Therefore, schedule coordination is flexible in that it can vary from informal local airport authority coordination to formal IATA international coordination.

The IATA system of achieving schedule coordination is used by more than forty international airports to help alleviate their traffic peaking congestion. IATA holds bi-annual meetings to coordinate the international schedules, with historical precedence given the topmost priority by the coordinator, followed by other factors such as crew restrictions, curfew restrictions, quotas at certain airports, size and types of operations and the effects on competition and public convenience (Transport Canada 1985b, 31).

6.24 AIRPORT SLOT ALLOCATION

Another direct form of demand management option is the allocation of limited number of slots available at the airport, especially during peak hours of operation at the airports. Many different methods have been used to assign slots, and these methods range from a first come first served basis to slot lotteries and slot auctions. The first come first served system has been criticized for its inequitable nature, while the slot lottery allocation system based on 'luck' has also been criticized by major air carriers who have to depend on chance and luck to win the slot lotteries.

"Slot auctions have been advocated as the best method of allocating scarce airport landing rights on the grounds that if airport access must be limited, it should be treated as a scarce resource and priced accordingly. The method to accomplish this is a system whereby the price of airport access is determined by demand. Slot auctions allow peak-hour access only to those users willing to pay a market-determined price" (Wells 1986, 213).

In order to maximize the allocation of slots, the air carriers are expected to place a monetary value for the slots they want to utilize. If the carrier wishes to use the airport slot during a peak-period, then he must be willing and prepared to pay more than the others for the use of the slots.

There are many different kinds of auctions and various methods have been used by the airport authorities to sell these airport slots. They range from progressive auction, Dutch auction, sealed-bid auction to trading post auction, with varying degrees for slots to be auctioned simultaneously or individually (Transport Canada 1985b, 35).

However, slot auctioning may put the new entrants at a disadvantage, because the major air carriers are often the most financially viable and can afford to outbid them for the peak-hour airport slots. There are also some practical problems relating to the administration of slot auctions, and the question remains as to whether the local airport authority or federal government should undertake this responsibility.

6.3 AIRPORT PRICING AND CAPACITY

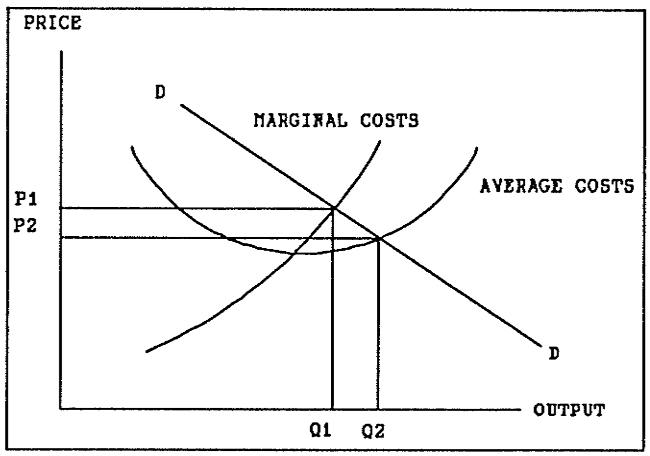
This section examines the possible uses of airport pricing to deal with the air traffic peaking and capacity problems at international airports. Presently, airport pricing plays an insignificant role in determining airport access. There is no differential peak-hour landing fees which are uniformly charged throughout the day, week, month and year according to the aircraft type and weight. Thus, aircraft for international flights are charged higher landing fees than domestic flights. But the time of the flights is not being taken into consideration.

6.31 <u>OPTIMAL AIRPORT PRICING</u>

There are various alternative pricing strategies that can be used to price airport services according to the costs of providing them. Figure 7 shows the average and marginal costs pricing for the congested facilities at the airport. The average and marginal costs to the users of the congestable facilities increase as more users saturate the use of the facilities. Average costs pricing would result in the price P_2 of using the airport facilities set equal to average costs and the equivalent demand of Q_2. This price option is only economically efficient when the industry is characterized by constant returns of scale. However, this pricing mechanism does not account for any price differences in the use of the facilities during peak and off-peak periods. Thus, congestion becomes an unpriced entity and this is the present pricing strategy used at Canadian airports, where both landing fees and passenger airport taxes do not vary according to the different times of the day or week.

Marginal costs pricing would result in the price P_1 of using the airport facilities set was equal to marginal costs or the cost of producing an extra unit of the facilities and an equilibrium demand of Q_1. This pricing system results in a more efficient allocation of resources than average cost pricing. However, under constant returns to scale conditions, both average and marginal pricing systems would give the same results.

Figure 7: Average and Marginal Cost Pricing for a Congested Facility.

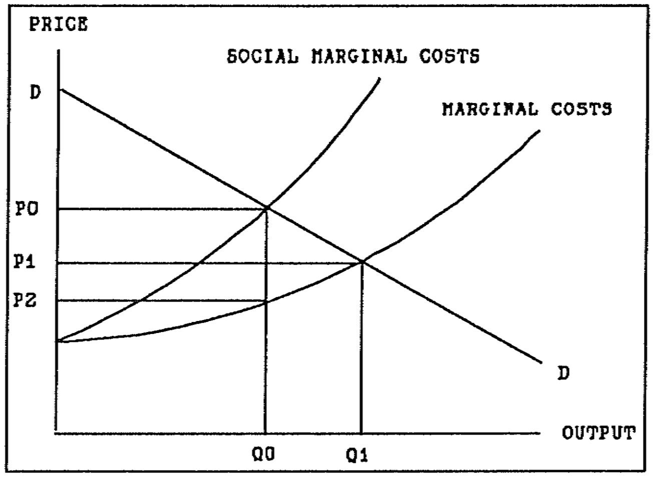


Congestion at the airport will not only cause time losses to the passengers, but also cause the operating costs of the aircraft to increase. These additional costs associated with airport congestion are commonly referred to as the marginal costs of congestion. Since airport congestion is an externality, the appropriate price mechanism should reflect this externality cost or the marginal cost of congestion.

Social marginal pricing is an extension of the marginal cost pricing system. It recognizes the external costs such as noise, pollution and congestion costs imposed by users on other users of the facilities. "Optimal pricing in the presence of congestion requires that the price be set equal to the marginal costs of production plus the marginal congestion cost" (Bonsor 1984, 37). This means that besides paying a share of the additional operating costs at the time the airport facilities are demanded, the users will also be charged a fee for imposing externality costs associated with their operations.

Figure 8 shows that the optimal pricing with congestion would result in the optimal price set equal to P_0 and an equilibrium demand of Q_0, where P_0P_2 is the marginal cost of congestion. Thus, the price of using the airport facilities would be set at the social marginal costs of using that facility, this leads to a socially optimal allocation of resources, thus maximizing economic efficiency. Proponents for social marginal cost pricing contends that it "provides a stronger incentive for off-peak use than a scheme based on marginal facility costs alone" (Wells 1986, 211). Among the alternative to airport pricing policy, social marginal cost pricing is the first best solution that has been recommended to guide the pricing of Canadian airports (Gillen, Oum and Tretheway 1988, 28).

Figure 8: Optimal Congestion Pricing.



However, this pricing policy does not guarantee enough revenues for the airports to break-even. Under such circumstances, Ramsey pricing can be applied as a second best solution: "Ramsey pricing would minimize the loss in economic efficiency while achieving the financial break-even. This pricing principle states that when a revenue constraint exists, the ratio of markup (the excess of the selling price over marginal cost) must be proportional to the inverse of the price elasticity of the product in question" (Gillen, Oum and Tretheway 1989, 9). In order to help the airport authority recover revenues, Ramsey pricing uses the different price elasticities among the different users to charge higher prices for price inelastic users who are least likely to respond to the price increase during the peak periods.

6.32 PEAK PERIOD AIRPORT PRICING

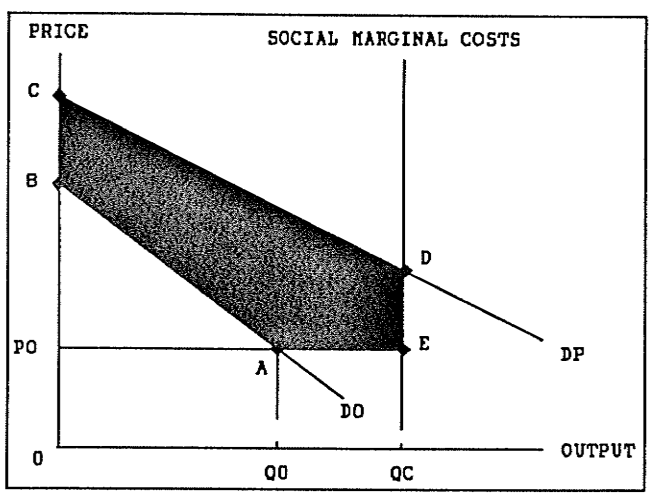
Airport capacity, in terms of runways, terminals and airport access, is a scarce resource facing heavy constraints during the peak periods and this capacity should be priced and allocated to maximize economic efficiency. The capacity of the airport generally refers to the ability of the airport to handle a given volume of air traffic demand. Therefore, airport capacity and air traffic demand are closely related, because it is the demand of air traffic services that determines the amount of airport capacity required.

Congestion occurs when air traffic demand increases relative to the fixed airport capacity. The air carriers are primarily responsible for bringing in huge loads of passengers and goods in their larger aircraft, increasing the problems of adequate aircraft parking space, counter space and other facility requirements. However, the present pricing strategies used at most international airports today, do not reflect this importance of air traffic demand, especially during the peak-periods of demand. For example, most of the landing fees at international airports are based on the weight of the aircraft, irregardless of the time of day. This pricing system does not consider the different levels of demand for the airport facilities at different times of the day, and certainly does not reflect the higher costs of airport operations required during the peak levels of demand for the airport facilities.

Therefore, differential pricing may be a better alternative pricing method to achieve a more uniform level of demand for the airport facilities. Users would be willing to pay more to enable them to use the airport facilities during peak hours "but the total demand at these hours would fall. The existing amount of airport use would tend to spread more evenly throughout the day" (Eckert 1972, 427). Users who are responsible for the peak demand should be charged a higher price compared to the off-peak period users, in order to justify "the allocation of capacity costs which are joined to a number of sub-periods to the demands of those periods" (Webb 1973, 109). In this way, the scarce airport facility can be allocated to the users who value it most and "the overall value to society from the use of its scarce airport resources would rise" (Webb 1973, 433).

Figure 9 shows the peak and off-peak demands for a fixed airport infrastructure with Q_C as its capacity limit.

Figure 9: Peak-Load Pricing.



In order to maximize total social benefits, differential pricing can be applied here to the peak period demand D_P, and the off-peak demand D_0. The peak period users pay a price of OP_P, while the off-peak period users pay only the capacity's running costs which are assumed to be a constant unit cost of OP_0. The outputs for the peak and off-peak periods are Q_C and Q_0 respectively. As shown in the diagram, this pricing strategy leads to a maximum obtainable total aggregate social benefit of both P_0AB and P_0CDE areas. Therefore, this peak-period pricing system helps to allocate the given capacity among the potential users, based on their willingness to pay for the use of the airport infrastructure.

Peak-period pricing should be directed to the air carriers who wish to gain access to the airport facilities during the peak periods. They would have to absorb this peak-hour fee just as they absorb the costs of delay, and they may be able to cross-subsidize the higher costs for operating peak-hour flights with lower off-peak costs operating at other times of operations. "Access to airports is not limited except by the user's willingness to bear the additional cost imposed during peak hours" (Wells 1986, 213). However, if the air carriers decide not to pay the higher fees during the peak hours, then they have to consider off-peaking their flights in order to avoid the payment. This action by the air carriers should then help to level off the air traffic peaks at the airport.

Therefore, peak hour pricing can serve as an effective market signal for the users to utilize the airport facilities during the off-peak times. Besides attempting to level off the airport traffic demand, peak hour pricing also provides additional revenues which can be used to further expand the facilities at the airport. However, peak-hour pricing should be considered for the whole airport system because of the complementary relationship between the airside and landside facilities at the airports. The demand for the use of runway facilities and aircraft parking bays affects the demand for the use of gates and other terminal facilities required by the passengers and goods brought in by the air carriers.

6.4 SUMMARY

This chapter has discussed the economics of short-term airport demand management designed to alleviate airport congestion. Such management is designed to lessen user costs and to postpone the need for major airport investment directed to capacity expansion.

The discussion included the operation of airport gates and the pricing of airport use by carriers. In general, the techniques offer benefits but they are not a panacea for the basic problem of the proper planning of airport capacity.

CHAPTER SEVEN

CONCLUSION

This thesis has investigated air traffic and its implications for the economics of major airports. More specifically, the thesis has been directed towards answers to three questions. In recapitulation these are:

1) What are the economics of air traffic and the resulting demand for capacity at major airports?

2) What are the adaptive possibilities for airports in the light of unanticipated air traffic developments?

3) What are the public policy implications of air traffic demand for capacity at major airports?

Initially, a review of the development of major airports was conducted. The review was designed to provide perspective and included specific information on the major airports at Montreal, Toronto and Vancouver, and the patterns of traffic development at these airports. In the next two chapters, the economics of air traffic and methods for forecasting air traffic were presented. These chapters provided the basic analysis needed for any understanding of the demand for airport capacity demand from the operation of air transport systems. The economic implications of over- and under-forecasting of this demand for capacity were then discussed. Following this discussion the following chapter was devoted to an examination of short-term solutions to congestion problems at airports through demand management.

It was found that air traffic is complex in nature and is subject to shifts based on both general economic changes and internal alterations in the development of air transport. Further, it is structurally complicated with domestic and international components, business and leisure travel components, passenger and cargo components, and scheduled and non-scheduled components. These components when taken in combination and conditioned by shifting government policies towards the industry, act in concert with economic dynamics to produce the complexity identified above.

It was further found that air traffic forecasting can be done by many different methods. When the most promising method, from the economic point of view, was examined, it was apparent that air traffic forecasting is not only hazardous because of the nature of air traffic and its economics but also because of limitations inherent in forecasting. The resulting demand for airport capacity at major airports is, therefore, vulnerable to serious errors in timing and quantity.

Explanation of the adaptive possibilities for airports in the light of over- and under-capacity focused principally on the possibilities of management of the demand for airport facilities under conditions of under-capacity and congestion. Over-capacity is largely a matter of sunk costs although the question of airport operation at a loss is usually a source of continuing concern.

Demand management through the gate assignments and peak-load pricing appears to offer a variety of possibilities of improvement in the economics of airport capacity in the face of costly traffic congestion. The solutions provided are basically short-run in nature.

It was concluded that the cost of the misallocation of resources through incorrect provision of airport capacity in timing and amount is a serious public policy problem. To lessen the range of error and resulting cost through errors based on the demand for airport capacity, which in turn, is based on air traffic, it is recommended that air traffic forecasting be given substantial support. Further, it is recommended that the forecasting method or methods should encompass the full range of air transport system conditions. Additionally, it is recommended that checks on forecasting accuracy be provided through the use of more than one forecasting method.

Finally, it is recommended that public policy be directed to further investigation of economies that can be achieved through air traffic demand management at airports with a view to application of these methods when warranted.

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Appendix A

Dorval Airport
Passenger Traffic Volumes
(1977 - 2006)

Year	Total	Percentage Changes
Historical		
1977	5 386 100	3.69
1978	5 584 800	10.34
1979	6 162 300	2.31
1980	6 304 400	-1.35
1981	6 219 400	-12.57
1982	5 437 900	-5.42
1983	5 143 000	9.09
1984	5 610 699	-1.16
1985	5 545 450	2.36
1986	5 676 261	4.95
1987	5 957 000	3.91
Forecast		
1988	6 190 000	3.90
1989	6 393 000	2.50
1990	6 607 000	6.10
1991	7 010 000	3.80
1996	9 060 000	3.80
Projection		
2001	10 390 000	-
2006	11 700 000	-

Average Annual Growth Rate

1977-87	1.0%
1987-96	4.1%
1987-2006	3.3%

Source: Transport Canada, Air Traffic Statistics, 1988.

Appendix B

Mirabel Airport
Passenger Traffic Volumes
(1975 - 2006)

Year	Total	Percentage Changes
Historical		
1975	93 756	11.49
1976	1 171 025	0.24
1977	1 447 300	0.04
1978	1 509 900	0.03
1979	1 551 300	-0.09
1980	1 407 300	-0.12
1981	1 244 700	-0.03
1982	1 213 400	-0.05
1983	1 278 200	0.15
1984	1 466 815	0.17
1985	1 716 307	0.08
1986	1 850 168	0.62
1987	1 964 400	0.04
Forecast		
1988	2 048 000	4.7
1989	2 131 000	4.3
1990	2 208 000	5.2
1991	2 392 000	6.5
1996	9 060 000	6.5
Projection		
2001	3 940 000	-
2006	4 700 000	-
Average Annual Growth Rate		
1977-87	3.2%	
1987-96	6.4%	
1987-2006	4.9%	

Source: Transport Canada, Air Traffic Statistics, 1988.

Appendix C

Toronto International Airport
Passenger Traffic Volumes
(1977 - 2006)

Year	Total	Percentage Changes
Historical		
1977	11 544 800	7.08
1978	12 362 500	13.57
1979	14 040 500	2.72
1980	14 422 700	0.80
1981	14 538 500	-7.02
1982	13 517 300	0.46
1983	13 579 100	10.89
1984	15 057 833	2.95
1985	15 502 359	10.45
1986	17 121 660	7.02
1987	18 324 000	5.05
Forecast		
1988	19 250 000	3.4
1989	20 019 000	2.6
1990	20 558 000	5.0
1991	21 690 000	2.7
1996	26 000 000	3.2
Projection		
2001	34 000 000	-
2006	34 490 000	-

Average Annual Growth Rate

1977-87	4.7%
1987-96	3.9%
1987-2006	3.3%

Source: Transport Canada, Air Traffic Statistics, 1988.

Appendix D

Vancouver International Airport
Passenger Traffic Volumes
(1977 - 2006)

Year	Total	Percentage Changes
Historical		
1977	5 110 000	9.90
1978	5 615 600	15.33
1979	6 476 600	9.08
1980	7 064 400	0.97
1981	7 132 600	-10.83
1982	6 359 800	0.17
1983	6 370 400	6.26
1984	6 769 056	3.68
1985	7 018 077	19.90
1986	8 414 800	-7.82
1987	7 757 000	5.89
Forecast		
1988	8 214 000	4.70
1989	8 540 000	2.90
1990	8 780 000	5.80
1991	9 330 000	3.90
1996	11 860 000	3.60
Projection		
2001	13 720 000	-
2006	15 400 000	-

Average Annual Growth Rate

1977-87	4.3%
1987-96	4.7%
1987-2006	3.6%

Source: Transport Canada, Air Traffic Statistics, 1988.

Appendix E

International Flight Landing Fees:
Montreal, Toronto (Lester B. Pearson) & Vancouver
International Airports

1. Minimum Fee - $ 7.62

	Column I	Column II	Column III
Item	Aircraft Weight	Fee per 1,000 kg for Jet Aircraft	Fee per 1,000 kg for Turboprop Aircraft
1.	Not more than 30,000 kg	$ 2.73	$ 2.22
2.	More than 30,000 kg but not more than 70,000 kg	3.37	2.93
3.	More then 70,000 kg	4.66	4.07

Source: Transport Canada, Air Services Fees Regulations, November 1, 1989.