ANALYSIS OF AIRCRAFT FLEETS OF U.S. MAJOR AIRLINES SINCE DEREGULATION

by

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ABSTRACT

The purpose of this thesis is to relate the U.S. Major airlines changing use of aircraft to aviation policy and technology since deregulation of the U.S. airline industry enacted in 1978.

First, a study of the airline fleet mix was carried out in order to understand how airlines have composed their fleets in the past and how they are preparing for the future. Airlines have responded very favorably to any changes in aircraft characteristics that have the potential to lower operational costs, such as the introduction of two-crew member cockpits and the acquisition of twin-engined aircraft whenever possible. Airline fleets are primarily made up of low capacity/short range aircraft, which is an indication of airlines concentrating in domestic markets where frequency of service is critical. The shift towards the usage of more fuel efficient and quieter aircraft engines is evident.

How the airlines actually operated their aircraft fleets in both domestic and international markets was also examined. The analysis focused on relating aircraft characteristics with the aircraft operation data published by the United States Department of Transportation. It was found that these airlines have concentrated their operations mostly in the domestic arena, representing 84.6% of total aircraft miles flown at the beginning of deregulation in 1978 and only decreasing to 84.1% by 1990. There has been an increase of 70% in the total number of miles flown. The cause for this growth can be attributed to numerous airline mergers, and the expansion to the international arena in search of new markets. In addition, airlines are flying their aircraft further. Traffic results indicate that aircraft may have been scheduled more cycles per day and that air traffic congestion has been increasing since deregulation.

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Dedication

I dedicate this thesis to my parents, my brother Jordi, and my sister Montse. And to my dear cousin Gemma, who left us much too soon. I will forever be thankful for the love and support they have given me.

J.F.
Cambridge, Massachusetts
January 1992

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Lastly, I would like to thank my parents, Dr. Andreu and Maria Antonia Ferrer, for their unconditional love and financial support.

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Chapter 1

Introduction

1.1 Objective of the Thesis

The objective of this study is to relate the use of aircraft by U.S. Major airlines to changing aviation policy and technology. Aviation policy refers primarily to the Deregulation Act of 1978; this Act freed competition in the airline industry, and allowed airlines to serve any domestic routes and set fares without government approval. Another aviation policy considered in this thesis is that of more strict aircraft noise requirements. Technology refers to the aircraft characteristics of interest to the airlines: aircraft type, year of certification, country of origin, number of crew, passenger capacity, aircraft range, number of engines, and fuel consumption. Results from this analysis could be used to identify the implications for the development of commercial aircraft technology in the future.

The sample for this analysis consists of all US airlines that have been US Major airlines during the entire period from 1978 to 1990. These airlines are American Airlines, Continental Airlines, Delta Airlines, Eastern Airlines, Northwest Airlines, Pan American World Airways, Trans World Airlines, and United Airlines. The analysis results presented in this thesis correspond to the aggregate of these airlines only.

1.2 Structure of the Thesis

This thesis is arranged into four additional chapters. Except for the last chapter, the structure used in all of them is similar, each having four main sections. The first section presents a chapter introduction; this section opens the chapter with the purpose of providing the reader with an overall picture of the motivation and contents. The second section presents formal definitions, theory background, and the sources of raw data. The third section deals with the actual analysis of the theory and data introduced in the previous section; it contains the methodology as well as the presentation and discussion of the results. Finally, the fourth section presents a chapter summary and conclusions. The following is a brief description of the contents of each remaining chapter.

Chapter 2 presents an analysis of the most basic element: the aircraft. This study is a necessary step before attempting to understand how the airlines compose and utilize their fleets. The aircraft analysis is carried out in terms of the aircraft technical features. This study consists of a statistical analysis intended to evaluate correlations among the aircraft characteristics and discuss those relationships that are significant.

Chapter 3 presents a study of the airlines aircraft mix in terms of the technical characteristics introduced in Chapter 2. This study forms the basis for understanding how these airlines have been composing their fleets in the past and how they are preparing for the future.

Chapter 4 presents a comparative analysis of the aircraft fleet operation in both domestic and international markets. The analysis focuses on relating the aircraft characteristics discussed in the previous chapters with the aircraft operation data, published by the United States Department of Transportation, which contains the following measures: revenue aircraft miles flown, revenue aircraft hours, revenue aircraft block hours, and aircraft days assigned to service by year, airline, operating entity, and aircraft type. In addition, the following computed parameters have been included in the analysis: revenue aircraft hours per day, revenue block hours per day, and revenue block hours to revenue aircraft hours ratio. Thus, this analysis forms the basis for understanding how these airlines have been operating their fleets.

Finally, Chapter 5 provides a general overview of the results obtained throughout the study.

Chapter 2

Analysis of Aircraft Characteristics

2.1 Introduction

This second chapter presents the analysis of the most basic element of this thesis, namely, the jet aircraft operated by the US Major airlines since deregulation. The study presented here is a necessary step before attempting to understand how the airlines compose and utilize their fleets. The aircraft analysis is carried out in terms of the following selected technical characteristics: aircraft type, year of certification, country of origin, number of crew, number of seats, range, number of engines, fuel consumption, and FAA noise stage.

Section 2.2 presents formal definitions of each basic aircraft characteristic. In addition, an aircraft categorization, which combines several basic technical features, is proposed. Section 2.3 consists of a statistical analysis intended to evaluate correlations among the aircraft characteristics selected in the previous section. A discussion of each significant relationship is included. Section 2.4 contains the chapter summary and conclusions.

2.2 Aircraft Characteristics

This section presents the definition of each selected aircraft characteristic: aircraft type, year of certification, country of origin, number of crew, number of seats, maximum range, number of engines, fuel consumption, FAA noise stage, and category. Information about these aircraft characteristics were obtained from a variety of sources and compiled by the author [1,2,3,4]. Each characteristic helps portray the nature of each aircraft. In addition, an aircraft categorization is proposed. The motivation of introducing such categorization is to group aircraft types that share several common technical features. In this manner, a more concise analysis can be carried out.

Aircraft Type: refers to an assigned code representing an aircraft and its versions. Aircraft types along with the code used to identify each type in this thesis are listed in Table 2.1.

Table 2.1: Aircraft Types

A300	Airbus Industrie A300-B4-200, -600, -600R
A310	Airbus Industrie A310-200, -300
A320	Airbus Industrie A320-200
A334	Airbus Industrie A330, A340

BA146	British Aerospace 146-100, -200, -300
B707	Boeing 707 (All Versions)
B727	Boeing 727-100, -200
B737	Boeing 737-200
B733	Boeing 737-300
B734	Boeing 737-400, -500
B747	Boeing 747-100, -200, -300, -SP
B744	Boeing 747-400
B757	Boeing 757-200
B767	Boeing 767-200, -200ER, -300, -300ER
DC8	McDonnell Douglas DC-8 (All Versions)
DC9	McDonnell Douglas DC-9 (All Versions)
MD80	McDonnell Douglas MD-81, -82, -83, -87, -88
DC10	McDonnell Douglas DC-10-10, -30
MD11	McDonnell Douglas MD-11
F100	Fokker 100
L1011	Lockheed L-1011-1, -100, -200, -500

Year of Certification: year an aircraft type was certified to fly as a commercial transport.

Country of Origin: refers to whether an aircraft type has been produced by a manufacturer in the United States of America (denoted by US), or elsewhere (denoted by N-US).

Number of Crew: number of crew members required to fly an aircraft type.

Number of Seats: number of available seats in a typical cabin configuration.

Maximum Range: maximum distance an aircraft type can fly. This parameter is measured in nautical miles, or nm.

Number of Engines: number of jet powered engines mounted on an aircraft type as its means of propulsion.

Fuel Consumption: amount of fuel burned when an aircraft is operating at maximum cruise speed. This parameter is measured in kilograms per hour, or kg/h.

FAA Noise Stage: refers to the noise stage in which an aircraft type is classified, as defined by the U.S. Federal Aviation Administration. Currently, the following classification scheme is used: Stage 1, 2, and 3. Generally speaking, Stage 1 aircraft are those powered by older turbojet engines; Stage 2 aircraft are those powered by low bypass turbofan engines; Stage 3 aircraft are those newer aircraft powered by high bypass turbofan engines.

Category: refers to the categorization of an aircraft, developed exclusively for this thesis. This categorization is a function of several technical characteristics, namely, ***technology level***, ***passenger capacity***, and ***range***. The motivation for introducing such a categorization is to group aircraft types that share several common technical features, thereby making a more concise analysis.

Technology Level refers to the level of technology applied to an aircraft type. Quantitatively, this parameter is primarily a function of the aircraft's year of certification. It is assumed that aircraft manufacturers apply the latest available technologies to their products; thus, it is assumed that differences in manufacturing quality and technical support of Airbus Industrie, British Aerospace, Boeing, McDonnell Douglas, Fokker, and Lockheed are negligible. Four technological levels are proposed. Level 1 includes aircraft certified in the 1950s; level 2 includes aircraft certified in the 1960s; level 3 includes aircraft certified in the 1970s; level 4 includes aircraft certified in the 1980s and the early 1990s. Each level has a code: 1, 2, 3, and 4, respectively.

Passenger Capacity refers to the categories of available number of seats. Three passenger capacity classes are proposed: low, medium, and high. Low passenger capacity includes aircraft with up to 150 seats; medium passenger capacity includes aircraft with more than 150 seats but fewer than 300 seats; high passenger capacity includes aircraft with 300 or more seats. Each class has a code: L, M, and H, respectively.

Range refers to the categories of aircraft maximum range. Three range categories are proposed: short, medium, and long. Short range includes aircraft with maximum range of up to 3,000 nautical miles; medium range includes aircraft with maximum range of more than 3,000 but less than 5,000 nautical miles; long range includes aircraft with maximum range of 5,000 or more nautical miles. Each class has a code: S, M, and L, respectively. Table 2.2 summarizes the definition of ***Category***.

Table 2.2: Definition of *Category*

	Code	Category Characteristics
Technology Level	1	Year of Certification: 1950 - 1959
	2	Year of Certification: 1960 - 1969
	3	Year of Certification: 1970 - 1979
	4	Year of Certification: 1980 - Today
Aircraft Capacity	L	Number of Seats ≤ 150
	M	150 < Number of Seats < 300
	H	Number of Seats ≥ 300
Aircraft Maximum Range	S	Maximum Range ≤ 3,000
	M	3,000 < Maximum Range < 5,000
	L	Maximum Range ≥ 5,000

Finally, Table 2.3 presents the aircraft characteristics by aircraft type, as defined in this section. A notable exception is the A300 which, by our initial definition, belongs to technology Level 3; nevertheless, the technology level of the A300 resembles more closely to that of Level 4.

Table 2.3: Aircraft Characteristics

Aircraft Type	Year of Certif.	Count. of Origin	No. of Crew	No. of Seats	Max. Range nm	No. of Eng	Fuel Cons. kg/h	FAA Noi. Stg.	Cat.
A300	1974	N-US	3	260	3,900	2	5,600	3	4MM
A310	1985	N-US	2	200	4,000	2	4,700	3	4MM
A320	1988	N-US	2	150	2,900	2	3,100	3	4LS
A334		N-US	2	335	5,500	4	7,000	3	4HL
BA146	1981	N-US	2	75	1,200	4	2,500	3	4LS
B707	1954	US	3	180	5,200	4	5,000	1	1ML
B727	1964	US	3	145	2,600	3	4,500	2	2LS
B737	1967	US	2	105	1,300	2	4,100	2	2LS
B733	1984	US	2	130	2,000	2	3,900	3	4LS
B734	1988	US	2	140	2,200	2	3,300	3	4LS
B747	1970	US	3	400	5,300	4	13,000	3	3HL
B744	1989	US	2	425	7,100	4	11,300	3	4HL
B757	1982	US	2	185	3,300	2	5,100	3	4MM
B767	1981	US	2	205	4,200	2	5,200	3	4MM
DC8	1955	US	3	200	5,500	4	4,900	1	1ML
DC9	1965	US	2	100	1,200	2	4,200	2	2LS
MD80	1980	US	2	145	2,100	2	4,000	3	4LS
DC10	1970	US	3	280	4,200	3	9,600	3	3MM
MD11	1990	US	2	325	7,000	3	9,000	3	4HL
F100	1987	N-US	2	100	1,400	2	2,500	3	4LS
L1011	1970	US	3	280	4,400	3	7,900	3	3MM

2.3 Aircraft Characteristics Analysis

The objective of this section is to provide insight on how the different aircraft characteristics proposed in the previous section relate to each other. Section 2.3.1 presents the analysis methodology, which consists of carrying out a statistical analysis that evaluates the correlations among the aircraft characteristics. Section 2.3.2 presents the results of the proposed analysis. Section 2.3.3 presents a discussion of the relationships between aircraft characteristics found to be statistically significant.

2.3.1 Analysis Method

A descriptive statistic is used to summarize the relationships among the variables of interest in terms of their degree of linear correlation [5,6,7]. This measure represents the average of the products of the standarized variables; hence, it is called Product-Moment Correlation Coefficient, r, and is defined by Eqn. 2.1,

$$r = \frac{\Sigma xy - \frac{(\Sigma x)(\Sigma y)}{n}}{\sqrt{\Sigma x^2 - \frac{(\Sigma x)^2}{n}}\sqrt{\Sigma y^2 - \frac{(\Sigma y)^2}{n}}} \qquad \textbf{(Eqn. 2.1)}$$

x: first variable

y: second variable

n: number of observations in each sample

The most important properties of the product-moment correlation coefficient are:

1. Its numerical value lies between -1 and +1, inclusive.

2. The larger the absolute value of r is, the stronger the linear relationship is. A value of $r=1$ or $r=-1$ implies perfect correlation between the two variables. Likewise, r near zero indicates there is no linear relationship between the two variables.

3. The sign of r indicates whether the relationship between the variables is direct, $r>0$, or inverse, $r<0$.

In addition to the computation of the product-moment correlation coefficient, it is desirable to determine whether there is sufficient evidence to conclude with reasonable confidence that there exists a statistically significant relationship between the two variables. Consider the following two hypothesis:

H_0: no linear relationship exists between x and y

H_a: linear relationship exists between x and y

Then, H_0 is rejected if $|t| > t_{\alpha/2,n-2}$, where t is defined by Eqn. 2.2,

$$t=\frac{r}{\sqrt{\frac{1-r^2}{n-2}}} \qquad \textbf{(Eqn. 2.2)}$$

α: confidence level

n-2: number of degrees of freedom

r: product-moment correlation coefficient

$t_{\alpha/2,n-2}$: *critical value of t (distribution)*

This method provides a way to conclude with reasonable confidence that either a positive or negative linear relationship exists between x and y, or that H_0 cannot be rejected and therefore no linear relationship exists between x and y.

2.3.2 Presentation of Results

This section presents the results of the correlation analysis described in section 2.3.1. The results are shown in Table 2.4.

The first and second columns correspond to all the possible non-redundant pair combinations of the following aircraft characteristics: number of crew, number of seats, maximum range, number of engines, fuel consumption, FAA noise stage, and year of certification (in terms of technology level). The *country of origin* parameter has not been included in this analysis because it is not a technical characteristic, *per se*. The third column lists the r value for each relationship. The fourth column includes the absolute values of t. The fifth column lists the critical value of t, $t_{\alpha/2,n-2}$; for the purposes of this analysis, *reasonable confidence* is defined as a 95% statistical confidence level, or $\alpha=0.05$. Hence,

$t_{\alpha/2,n-2} = t_{0.025,19} = 2.09$. The sixth column shows whether or not the two variables are significantly correlated.

Table 2.4: Correlation Analysis Results

x	y	r	$\lvert t \rvert$	$t_{\alpha/2,n-2}$	Signif.?
Number of Crew	Number of Seats	0.30	1.37	2.09	NO
Number of Crew	Maximum Range	0.31	1.44	2.09	NO
Number of Crew	Number of Engines	0.43	2.06	2.09	NO
Number of Crew	Fuel Consumption	0.37	1.75	2.09	NO
Number of Crew	FAA Noise Stage	-0.42	2.01	2.09	NO
Number of Crew	Technology Level	-0.59	3.17	2.09	YES
Number of Seats	Maximum Range	0.88	8.00	2.09	YES
Number of Seats	Number of Engines	0.52	2.67	2.09	YES
Number of Seats	Fuel Consumption	0.93	11.21	2.09	YES
Number of Seats	FAA Noise Stage	0.26	1.18	2.09	NO
Number of Seats	Technology Level	0.15	0.66	2.09	NO
Maximum Range	Number of Engines	0.60	3.23	2.09	YES
Maximum Range	Fuel Consumption	0.76	5.07	2.09	YES
Maximum Range	FAA Noise Stage	-0.04	0.18	2.09	NO
Maximum Range	Technology Level	-0.04	0.17	2.09	NO
Number of Engines	Fuel Consumption	0.52	2.67	2.09	YES
Number of Engines	FAA Noise Stage	-0.31	1.44	2.09	NO
Number of Engines	Technology Level	-0.35	1.63	2.09	NO
Fuel Consumption	FAA Noise Stage	0.20	0.89	2.09	NO
Fuel Consumption	Technology Level	0.00	0.01	2.09	NO
FAA Noise Stage	Technology Level	0.94	11.49	2.09	YES

2.3.3 Discussion

This section presents a discussion of the eight relationships, listed in Table 2.4, found to be statistically significant.

2.3.3.1 Number of Crew Versus Technology Level

The number of crew members required to fly an aircraft is negatively correlated to the technology level. Three crew members are required to fly all aircraft listed under Level 1 whereas two crew members are required to fly the aircraft listed as Level 4. For Levels 2 and 3, only the smaller aircraft --such as the B737 and DC9-- can be flown by two crew members.

This pattern is due to the improvement of flight decks through the use of digital technology [8]. Systems such as ECAM (Electronic Centralized Aircraft Monitors) and EICAS (Engine Indicating and Crew Alert Systems), included in the newer aircraft, execute tasks formerly conducted by flight engineers. These systems have the potential of actually decreasing the workload of the remaining two pilots, thereby increasing in-flight safety (and decreasing flight costs). Other advantages of digital equipment include the potential of increasing maintenance efficiency, both in cost and convenience, because of their capability to process diagnostic checks of virtually all on-board aircraft systems.

2.3.3.2 Number of Seats Versus Maximum Range

Number of seats is positively correlated to aircraft range (refer to Figure 2.1).

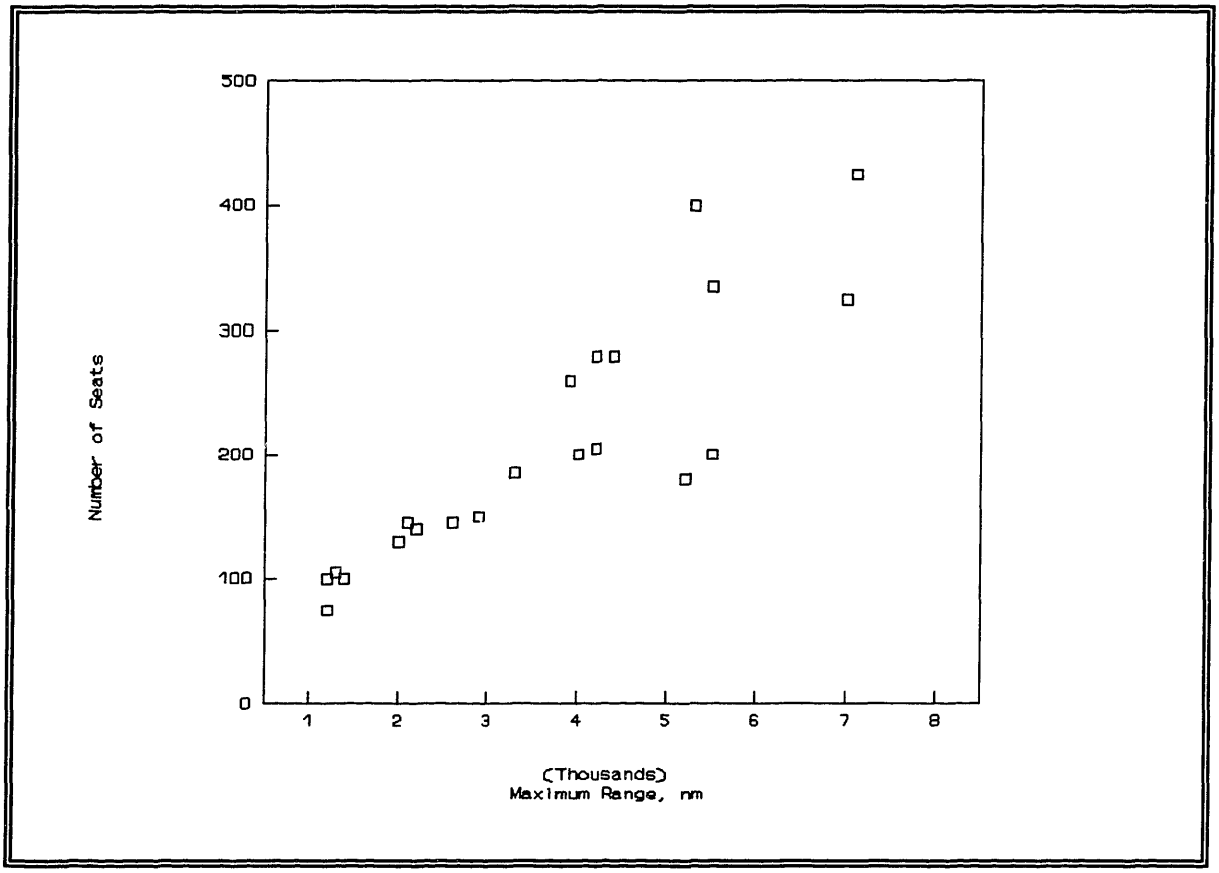

Fig. 2.1: Number of Seats Versus Maximum Range

High capacity aircraft are desirable for longer routes. This fact is dictated not by technological capability, but by economics. Because *wait time*[1] is not as critical on a longer flight, airlines tend to offer a lower frequency of service and consequently utilize higher capacity aircraft. The advantages of operating in this manner can be demonstrated

[1]Average time a passenger is willing to wait for service

analytically. Consider the following analysis [9,10]. The demand for a given flight is given by Eqn. 2.3,

$$D = IP^{\alpha}T^{\beta} \qquad \textbf{(Eqn. 2.3)}$$

I: airline image[2]

P: price

α: price elasticity of demand, defined by Eqn. 2.4,

$$\alpha = \frac{P}{D}\frac{\partial D}{\partial P} \qquad \textbf{(Eqn. 2.4)}$$

T: Total travel time, defined by Eqn. 2.5,

$$T = t_0 + \frac{t_1}{n} \qquad \textbf{(Eqn. 2.5)}$$

t_0*: sum of access time*[3]*, egress time*[4]*, enplanement processing time*[5]*, block time*[6]*, and actual flight time.*

t_1*: constant used to compute average wait time for service*

n: daily frequencies

β: time elasticity of demand, defined by Eqn. 2.6,

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[2] A substitute for all the quality of service variables such as flight availability, reliability, safety, and comfort

[3] Average time from origin to airport by ground transport

[4] Average time from airport to destination by ground transport

[5] Average time for ticketing, boarding, including a time margin to ensure not missing flight departure

[6] Average time for deplaning, customs, baggage, and arranging ground transportation

$$\beta = \frac{T}{D}\frac{\partial D}{\partial T} \qquad \textbf{(Eqn. 2.6)}$$

Frequency elasticity, ϵ_n, defined by Eqn. 2.7, can be used to determine how sensitive demand is with respect to frequency of service,

$$\epsilon_n = \frac{n}{D}\frac{\partial D}{\partial n} \qquad \textbf{(Eqn. 2.7)}$$

Then,

$$\begin{aligned} \epsilon_n &= \frac{n}{D}\frac{\partial}{\partial n}\left(IP^{\alpha}\left(t_0 + \frac{t_1}{n}\right)^{\beta}\right) \\ &= -\beta\,\frac{n}{D} IP^{\alpha}\, T^{\beta-1}\,\frac{t_1}{n^2} \qquad \textbf{(Eqn. 2.8)} \\ &= -\beta\,\frac{\left(\frac{t_1}{n}\right)}{T} \end{aligned}$$

If ϵ_n has a small value, demand hardly responds to changes in frequency of service, and *vice versa*. For long haul flights, (t_1/n) is smaller in proportion to T; therefore, it is economically desirable for airlines to offer a lower frequency of service on a higher capacity aircraft. This analysis demonstrates why it is economically more feasible to offer a one daily flight on a long route, say New York-Barcelona, carrying 300 passengers in a Boeing 747 than three daily flights carrying 100 people in a Boeing 727 --an aircraft which could have been designed (or modified) to cross the Atlantic Ocean. Hence, economic concerns result in a positive linear correlation between the aircraft's passenger capacity and its range.

2.3.3.3 Number of Seats Versus Number of Engines

Number of seats is positively correlated to number of engines (refer to Figure 2.2).

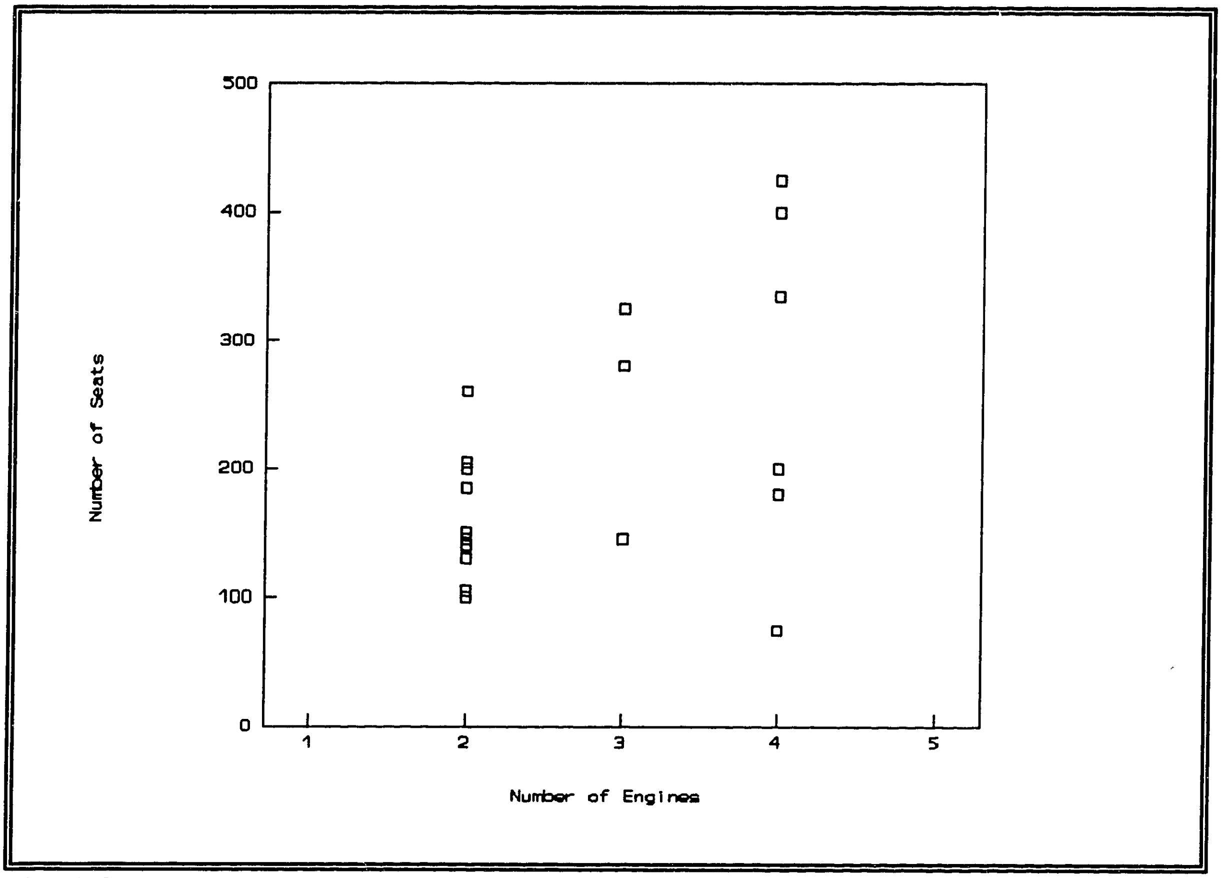

Fig. 2.2: Number of Seats Versus Number of Engines

A combination of technology and economic considerations determine the number of engines used in an aircraft. In general, a greater number of seats calls for bigger aircraft, and bigger aircraft require higher thrust levels. Up until the 1970s, the biggest aircraft were designed with four engines for purely technical reasons: not enough thrust could be generated with a fewer number. The B707, DC8, and B747 projects are good examples of this condition; similarly, engineers had no option but to include three engines in the DC10 and the L1011 projects, originally designed as twins [11].

In the 1970s more powerful engines were made available, and economics became the most critical consideration in the newer aircraft designs. Nine out of thirteen aircraft types in production or under development today, including the best-selling widebody and narrowbody families, are twins. The trijet may appear as a compromise between two and four engine aircraft but no brand new projects are in development (the MD11, and MD12 programs are based on the DC10 project).

As for the aircraft treated in this thesis, there is a great deal of overlap of passenger capacity versus number of engines. However, a tendency toward new higher capacity twin aircraft is apparent (e.g. A300, A310, B767). In fact, all new aircraft with the exception of the B744, A334, and MD11 are twins. The least popular arrangement is the trijet with 20% of the aircraft types examined here falling into this category. Twins account for the 50% of aircraft types and four-engine aircraft account for the remaining 30%.

2.3.3.4 Number of Seats Versus Fuel Consumption

With a linear correlation coefficient value of 0.93, number of seats is strongly and positively correlated to fuel consumption (refer to Figure 2.3).

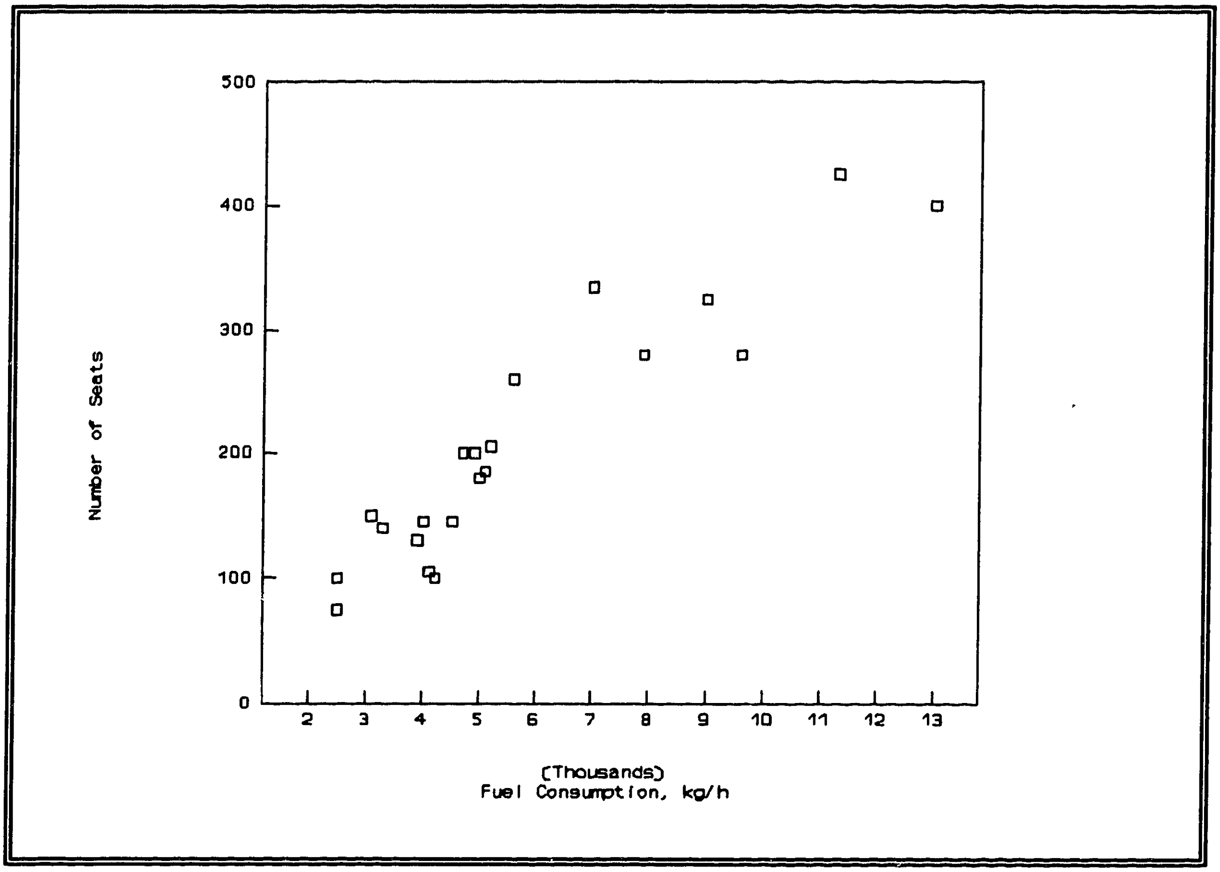

Fig. 2.3: Number of Seats Versus Fuel Consumption

This is relationship is well understood. Number of seats is directly related to aircraft volume and weight. As volume increases, so does aerodynamic drag and weight; as weight increases so does the power requirement. More drag and power can only call for greater fuel consumption.

2.3.3.5 Maximum Range Versus Fuel Consumption

Maximum range positively correlates to fuel consumption (refer to Figure 2.4).

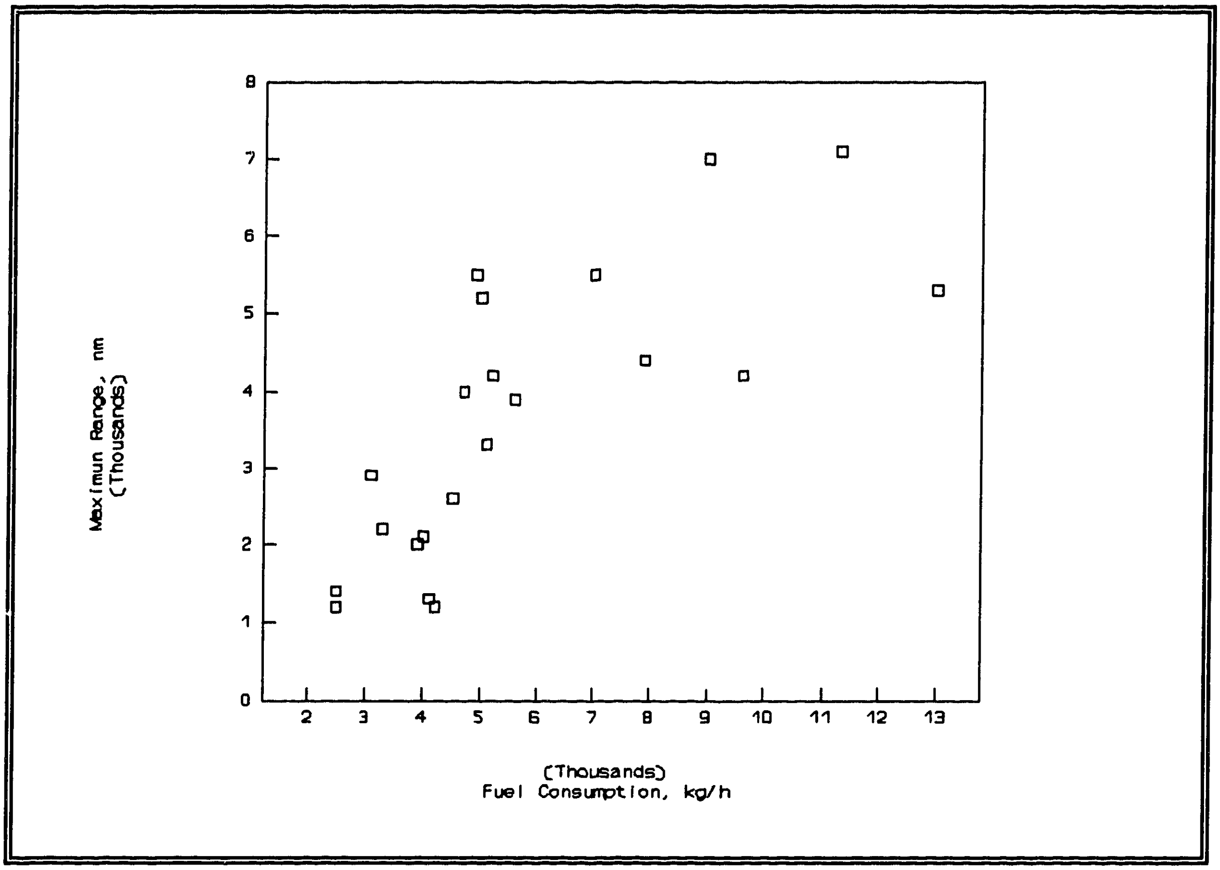

Fig. 2.4: Maximum Range Versus Fuel Consumption

As depicted, aircraft with greater range have a greater fuel consumption rate. This is a by-product of two previously addressed relationships. If number of seats is related positively to maximum range and number of seats is related positively to fuel consumption, then maximum range must be related positively to fuel consumption. As discussed, bigger aircraft are expected to burn more fuel, but there is yet another reason for which a given aircraft burns proportionally more fuel in longer routes [12,13]. Consider specific range, γ, defined by miles per pound of fuel burned, mi/lb.

Then specific range is given by Eqn.2.9,

$$\gamma = \frac{\textit{miles flown per hour}}{\textit{fuel flow (lb/h)}} = \frac{V}{\xi T} \qquad \textbf{(Eqn. 2.9)}$$

V: aircraft speed (mi/h)

ξ: spec. fuel consump. (lbs. of fuel per lbs. of thrust per hr.)

T: thrust

For cruise conditions (non-accelerated flight), W = L and T = D where,

W: total aircraft weight

L: total aircraft lift

T: total engine thrust

D: total aircraft drag

Then,

$$D = \frac{D}{L}W \qquad \textbf{(Eqn. 2.10)}$$

and

$$\gamma = \frac{V}{\xi T} = \frac{V}{\xi D} = \left(\frac{V}{\xi}\frac{L}{D}\right)\frac{1}{W} = \epsilon\frac{1}{W} \qquad \textbf{(Eqn. 2.11)}$$

The term $(V/\xi)(L/D)$ is called range factor, ϵ, and is a measure of the aerodynamic and propulsive system range efficiency. With this, total cruise range, R, is given by Eqn. 2.12,

$$R = \int_{W_f}^{W_i} \gamma \, dW = \int_{W_f}^{W_i} \epsilon \frac{1}{W} dW = \epsilon \ln \frac{W_i}{W_f} \qquad \textbf{(Eqn. 2.12)}$$

W_i: initial aircraft weight

W_f: final aircraft weight

This is the Brégeut Range Equation for jet aircraft. Let $W_i = W_{aircraft} + W_{fuel}$ and $W_f = W_i - W_{fuel} = W_{aircraft}$. Then,

$$R = \epsilon \ln\left(1 + \frac{W_{fuel}}{W_{aircraft}}\right) \qquad \textbf{(Eqn. 2.13)}$$

Another way to write this function is

$$y = \ln\left(1 + \frac{x}{a}\right) \qquad \textbf{(Eqn. 2.14)}$$

The behavior of this function is pictured in Figure 2.5, and it confirms the fact that the relationship between range and fuel burnt is not linear. As suggested in Equation 2.13, the non-linearity is due to the fact that unburned fuel must be carried further in aircraft of greater range.

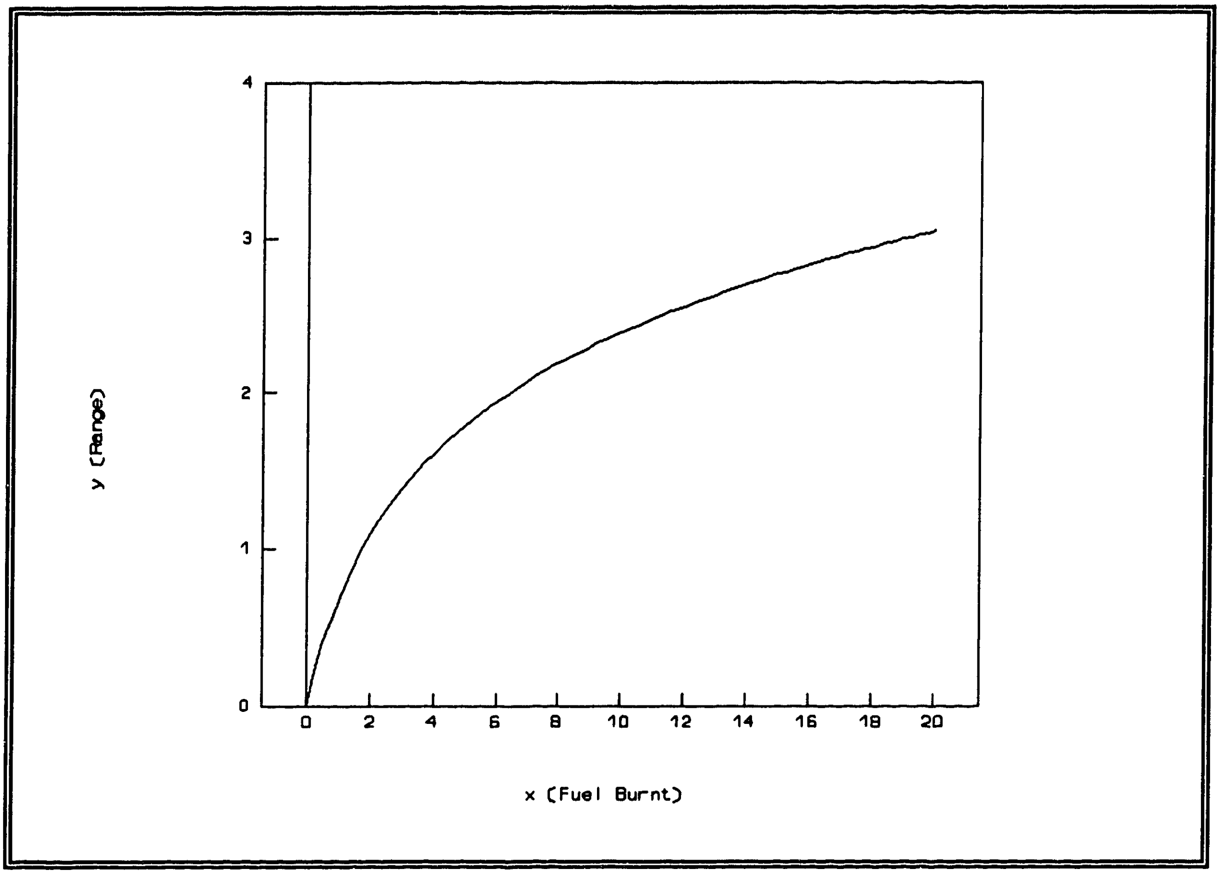

Fig. 2.5: Behavior of Brégeut's Range Equation

2.3.3.6 Maximum Range Versus Number of Engines

Maximum range is positively correlated to number of engines (refer to Figure 2.6). A combination of aviation policy, technology, and economics determines the number of engines used in an aircraft. Until the 1970s, the biggest aircraft and thus the aircraft with greater range were designed with more engines because not enough thrust could be generated

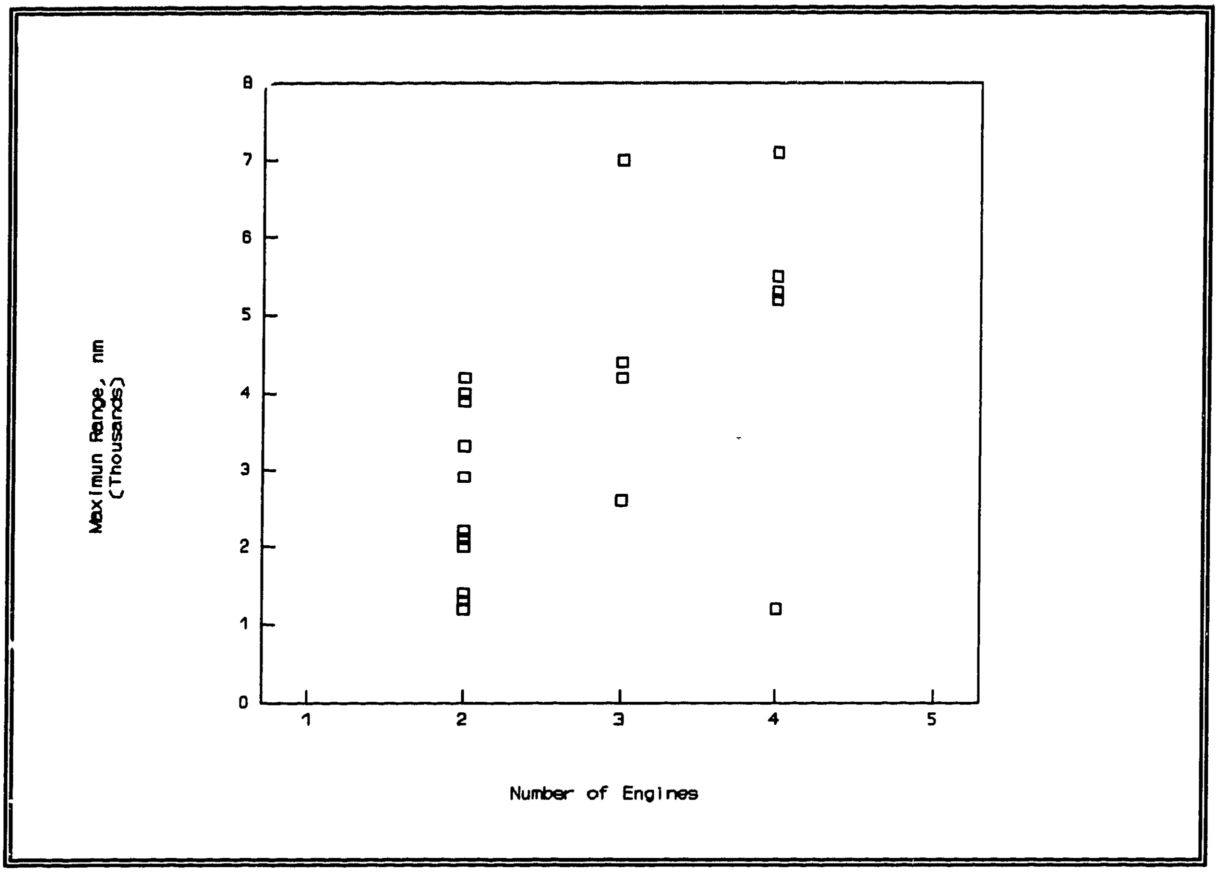

Fig. 2.6: Maximum Range Versus Number of Engines

with fewer. As soon as more powerful engines were made available, economics became the most critical consideration in the newer aircraft designs. Aviation policy also affected twin-engine designs. In the name of safety, the Civil Aeronautics Administration (predecessor of the Federal Aviation Administration), dictated that twins should fly no further from a landing site than the distance they could cover in sixty minutes on one engine. The law was re-examined when Boeing, Airbus and their customers realized the potential of the B767 and A300/A310 for medium and long range operations. ETOPS (Extended-range Twin Operations) rules are now established out to 180 minutes, and require an inflight shutdown rate below 0.02 per 1,000 engine hours. This shutdown rate has been achieved because engines are today far more reliable. There have been only five engine shutdowns during the ETOPS portion of some 125,000 over water flights to date, four happening in the five months following the first flight in May 1985 [14].

2.3.3.7 Number of Engines Versus Fuel Consumption

Number of engines is positively correlated to fuel consumption (refer to Figure 2.7)

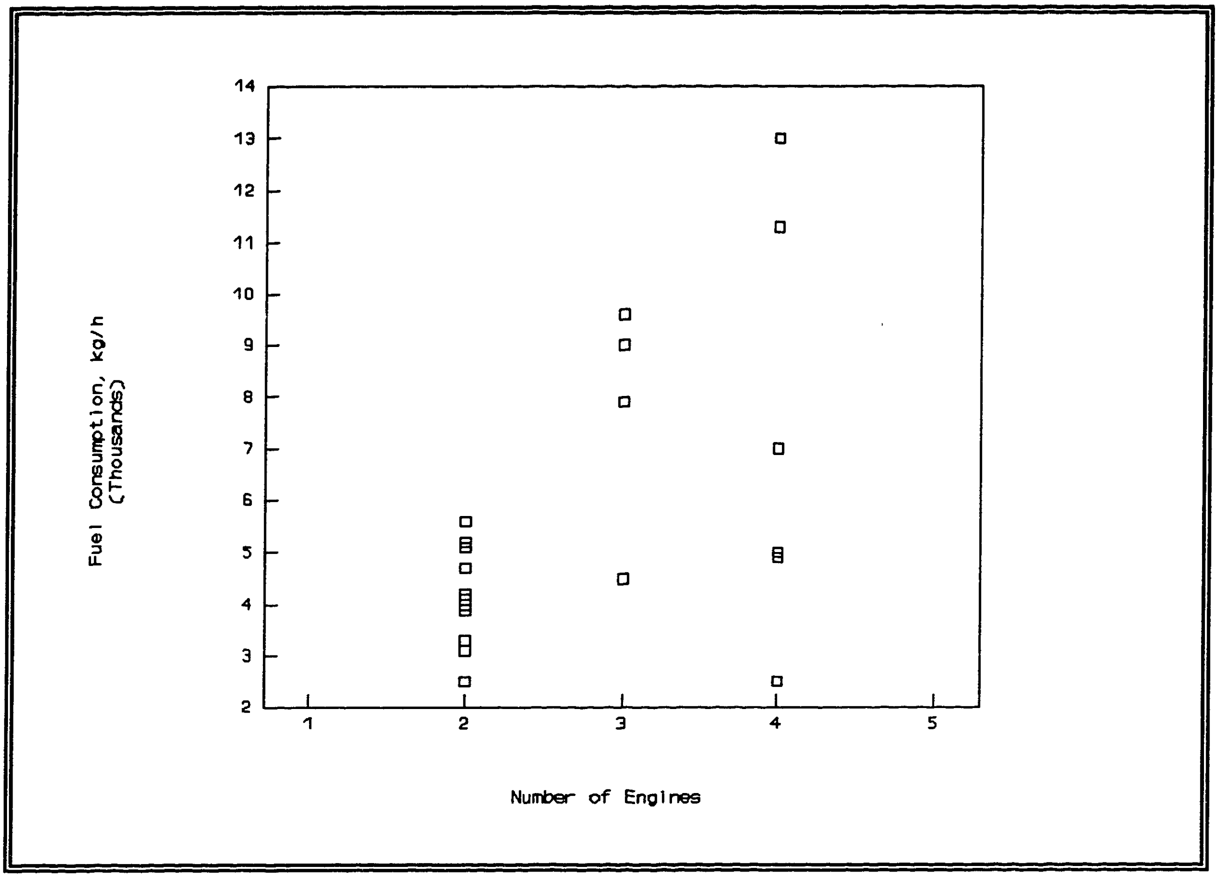

Fig. 2.7: Fuel Consumption Versus Number of Engines

The same rationale proposed in the previous sections applies here because passenger capacity is directly correlated to fuel consumption. Figures 2.6 and 2.7 are analogous.

2.3.3.8 FAA Noise Stage Versus Technology Level

FAA noise stage is positively correlated to Technology Level. All Technology Level 1 aircraft are classified under FAA noise Stage 1[7]; all Technology Level 2 aircraft are classified under FAA noise Stage 2; all Technology Level 3 and 4 aircraft are classified under FAA noise Stage 3. Aviation policy together with technological advances have triggered the production of engines not only more fuel efficient, but quieter and environmentally more acceptable as well.

2.3.3.9 Other Relationships

There are two other relationships of aircraft characteristics that almost meet our pre-determined level of 95% confidence for statistical significance: Number of Crew versus Number of Engines, and Number of Crew versus FAA Noise Stage. Number of crew is positively related to number of engines. In other words, aircraft having a greater number of engines tend to have three-member crews, and *vice versa*. While it has been discussed that

[7]Notable exceptions are those aircraft that have undergone re-engining programs

today's technology allows for two-crew member cockpits, regardless of the aircraft size, the statistical study includes the older models such as the twins B737s and DC9s which required two-crew members, and all the other three/four engined aircraft such as the B707s, B747s, DC8s, DC10s, and L1011s which required three-crew member cockpits. These aircraft are still an integral part of the sample airline fleets and are thus quite significant to the computations of this statistical analysis.

In addition, number of crew is negatively related to FAA noise stage. This result is expected because separate technological advances have made possible the introduction of quieter engines and the elimination of the third crew member, the flight engineer.

2.4 Conclusion

This second chapter examines the aircraft types that are or will be utilized by the US Major airlines, in terms of a selected number of technical characteristics. Through statistical analysis, eight relationships have been found to be significant.

The number of crew members required to fly aircraft is negatively correlated to the technology level. As technology advances, more cockpit tasks become automated. This process has lead to aircraft types (those under technology Level 4) to have computers that perform tasks formerly carried out by a third crew member, namely, the flight engineer.

Aircraft capacity in terms of available number of seats is positively correlated to the aircraft range. In other words, bigger aircraft are, in general, designed to have greater range. It is argued that this is primarily dictated by economics rather than engineering constraints. It is economically desirable to offer less frequency of service and consequently higher capacity aircraft for the longer haul routes.

Aircraft capacity is positively correlated to the number of engines. While there is an economically sound tendency to design aircraft with fewer engines, there are instances in which the lack of high-thrust engine availability leaves no option but to add more engines to the aircraft.

Aircraft capacity is also positively correlated to fuel consumption. Bigger aircraft have greater weight and aerodynamic drag; hence they require more powerful engines, which burn more fuel.

Fuel consumption is positively correlated to range as well. This is not only because bigger aircraft are correlated to longer ranges, but because more unburned fuel must be carried further.

Range is positively correlated to the number of engines. Again, there is an eagerness to design aircraft with fewer engines, but the constraints of aviation policy and technology compromise this economically driven tendency.

Number of engines is positively correlated to fuel consumption. As discussed, high capacity and longer range aircraft tend to have more engines, thus burning more fuel.

Finally, technology level is positively correlated to the FAA noise stage categorization. As technology advances, engines are built to be quieter.

Notes

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Chapter 3

Analysis of Aircraft Fleets

3.1 Introduction

This third chapter presents a study of the aggregate aircraft fleet mix of the sample airlines in terms of the technical characteristics discussed previously. The time interval of this analysis roughly corresponds to the first decade of airline industry deregulation in the United States. This chapter forms the basis for understanding how the sample airlines have been composing their fleets in the past, and how they are preparing for the future. The results of this study are particularly relevant to the last chapter, where aircraft utilization by the sample airlines is explored in detail.

Section 3.2 presents an aircraft fleet survey for the sample airlines in terms of actual fleet, deliveries, and removals. Section 3.3 contains the methodology, presentation of results, and discussion of the analysis. Section 3.4 presents a summary and conclusions of the chapter.

3.2 Aircraft Fleet

This section presents a survey of the fleet mix of the sample airlines in terms of actual fleet, deliveries, and removals. The term *actual fleet* refers to the aircraft operated by the airline; *deliveries* refers to the aircraft delivered in past years or aircraft scheduled to be delivered in the future (firm orders); *removals* refers to the aircraft removed from the fleet. The survey is computed by aircraft type, for every other year. The survey of actual aircraft fleet is presented from 1978 (the year when deregulation was enacted) to 1990; the survey of aircraft deliveries, and removals is presented from 1980 to 1992. Because this study only considers the US airlines that have been US Major airlines during the entire period from 1978 to 1990, there are some limitations that must be kept in mind. For instance, the aircraft fleet structure of People Express, an airline which could be considered as an important example of the potential products of deregulation, is not discussed in this thesis. Likewise, the numerous smaller airlines, which are an integral part of the U.S. airline industry, have also been excluded.

Abbreviations for the sample airlines used hereafter are listed in Table 3.1. The term *aggregate* refers to the combination of the sample airlines used in this thesis. Letter **E** following a year number, such as 1992E, indicates that data for that year are *Estimates*. The relevant data to this thesis are presented in appendices, as summarized in Table 3.2.

Table 3.1: Airline Codes

	American Airlines
CO	Continental Airlines
DL	Delta Air Lines
EA	Eastern Air Lines
NW	Northwest Airlines
PA	Pan Am World Airways
TW	Trans World Airlines
UA	United Air Lines

Table 3.2: Location of Aircraft Fleet Databases

Aircraft Fleet	Appendix A
Aircraft Deliveries	Appendix B
Aircraft Removals	Appendix C

The sources used to build the actual aircraft fleet database are Rolls Royce's "U.S. Airlines Indicators & Projections" (from 1978 to 1988), and Exxon's "Turbine-Engined Fleets of the World's Airlines; No.2, 1990" for 1990. The source used to build the aircraft deliveries, and aircraft removals databases is Rolls Royce's "U.S. Airlines Indicators & Projections".

3.3 Aircraft Fleet Analysis

3.3.1 Analysis Method

This section presents the analysis methodology used to study the aircraft mix for the aggregate of sample airlines. These analyses are carried out with respect to actual fleet, deliveries, and removals. The analysis deals with how the aggregate aircraft fleet mix has been changing since deregulation. The percentage of the aggregate fleet mix is computed for each characteristic. The characteristics considered in this analysis are: aircraft type, aircraft manufacturer, country of origin, number of crew members, technology level, capacity (number of seats), range, number of engines, FAA Noise stage, and category.

Table 3.3 lists the abbreviations of the calculations carried out. The computations have been performed for the aggregate of sample airlines. The source for this analysis is the raw data described in Section 3.2, and presented in appendices A, B, and C.

Table 3.3: Description of Terms for Aircraft Fleet Analysis

	Year of survey
# A/C	Total Number of Aircraft
A300 .. L1011	% Aircraft Type[1]
AIRBS .. MD	% Aircraft Manufacturer[2]

[1]Refer to Table 2.1

US / N-US	% Country of Origin (US or non-US)
2CREW / 3CREW	% Number of Crew Members (2 or 3)
LVL1 .. LVL4	% Technology Level (Level 1, 2, 3 or 4)
L CAP .. H CAP	% Capacity (Low, Medium, or High)
S RNG .. L RNG	% Range (Short, Medium, or Long)
2-ENG .. 4-ENG	% Number of Engines (2, 3, or 4)
STG-1 .. STG-3	% FAA Noise Stage (1, 2, or 3)
1ML .. 4HL	% Aircraft Category[3]

3.3.2 Presentation of Results

Table 3.4 indicates the location of the aircraft fleet analysis databases described in Section 3.3.1.

Table 3.4: Location of Aircraft Fleet Analysis Databases

Aircraft Fleet Analysis	Appendix D
Aircraft Deliveries Analysis	Appendix E
Aircraft Removals Analysis	Appendix F

[2]Airbus Industrie, British Aerospace, Boeing, Fokker, Lockheed, and McDonnell Douglas, respectively

[3]Refer to Table 2.2

3.3.3 Discussion

A discussion of the analysis carried out in the previous section is presented here. As an overview, consider Figure 3.1 which depicts the aggregate number of aircraft for the sample airlines from 1980[4] to 1990.

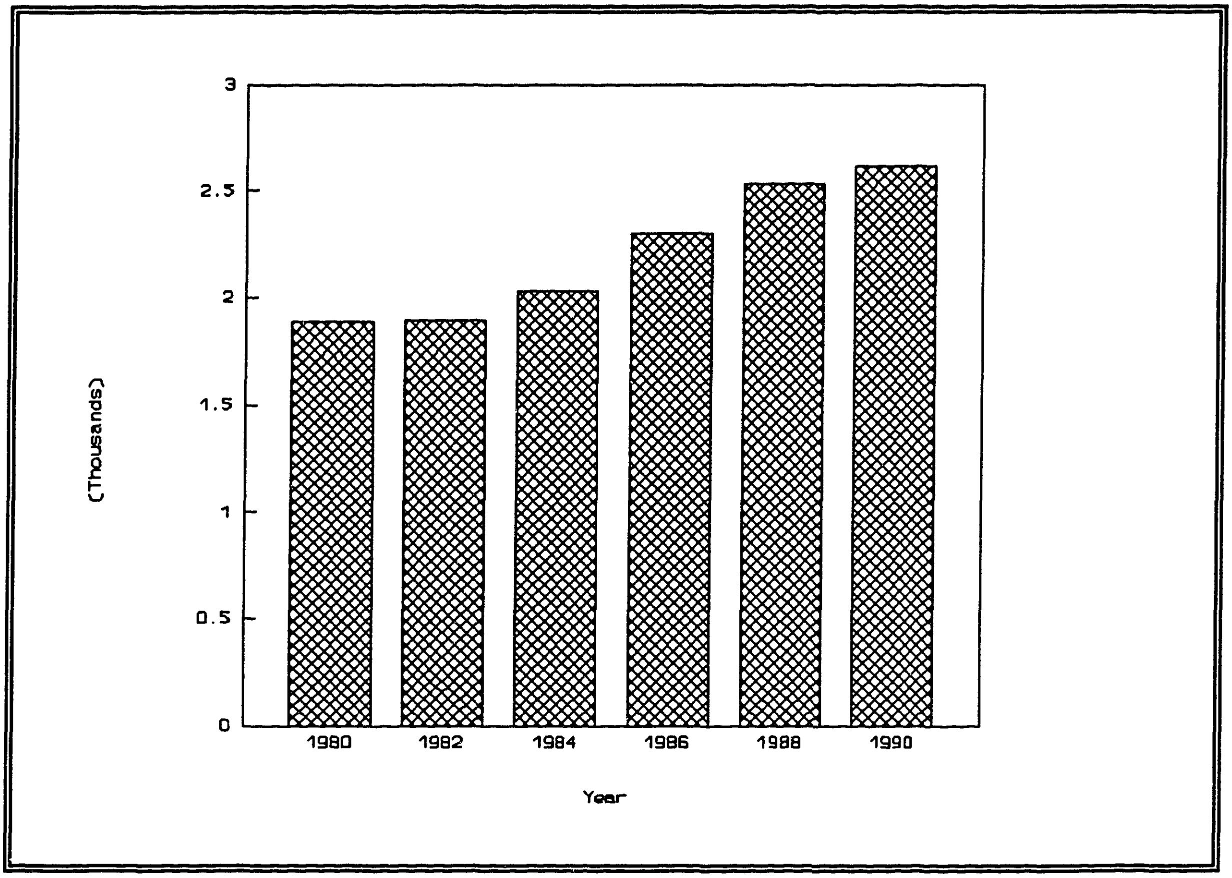

Fig. 3.1: Aircraft Fleet Aggregate for Sample Airlines

There has been a steady growth from a low of 1,886 aircraft in 1980 to a high of 2,618 aircraft in 1990.

[4]1978 data has not been included in this overview analysis because it cannot be compared to aircraft deliveries, and removals data which starts in 1980

Figure 3.2 depicts the aggregate number of aircraft delivered by the sample airlines from 1980 to 1990. While the percentages fluctuate throughout these years, it is apparent that there has been a tendency towards a higher number of aircraft deliveries.

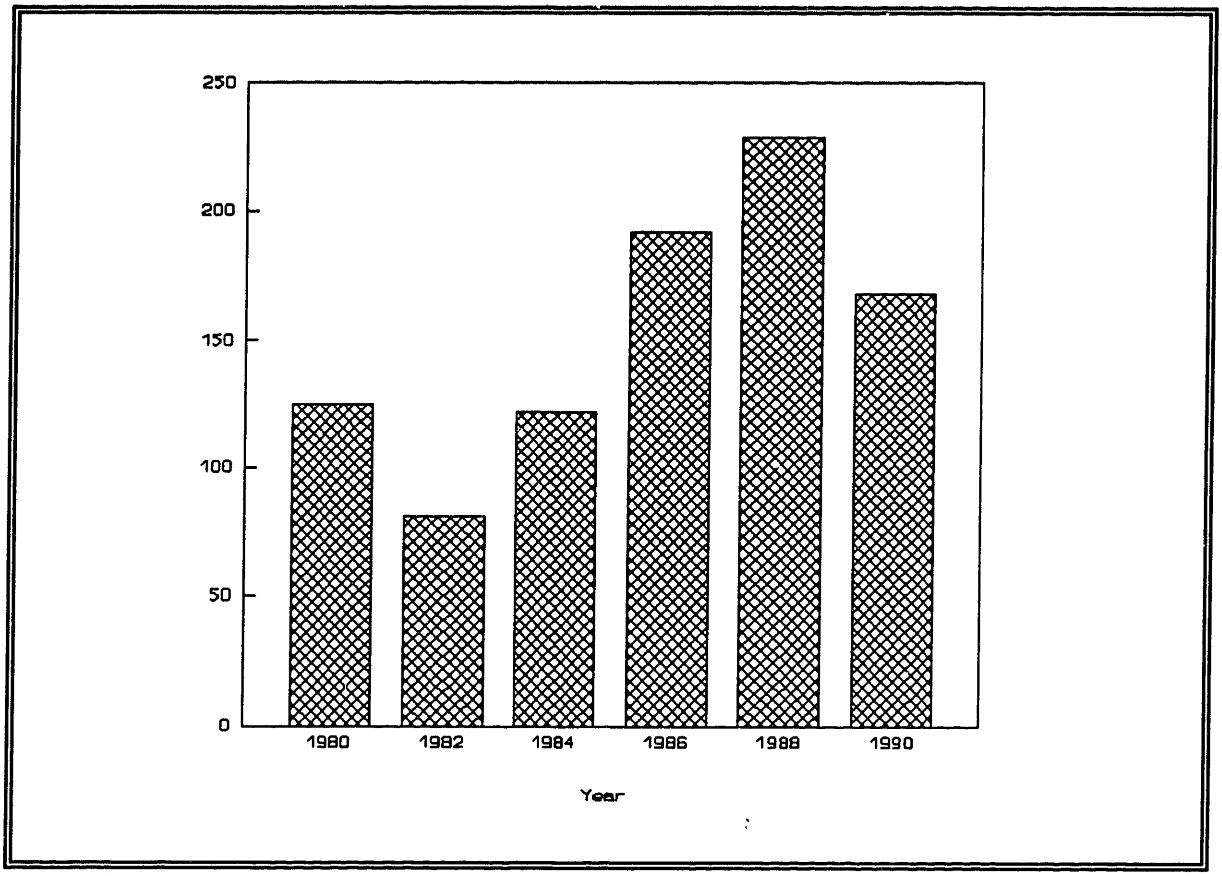

Fig. 3.2: Aggregate Aircraft Deliveries for Sample Airlines

Figure 3.3 depicts the aggregate number of aircraft removals for the sample airlines from 1980 to 1990. Except for 1988, it is evident that there has been a tendency for decreasing aircraft removal. This tendency is probably a consequence of the increasing high prices of aircraft and the fact that the older models are lasting longer than anticipated. As with merging with other airlines, keeping the older aircraft longer is an effective way to expand without having the burden of the immense expenses triggered by new aircraft purchases.

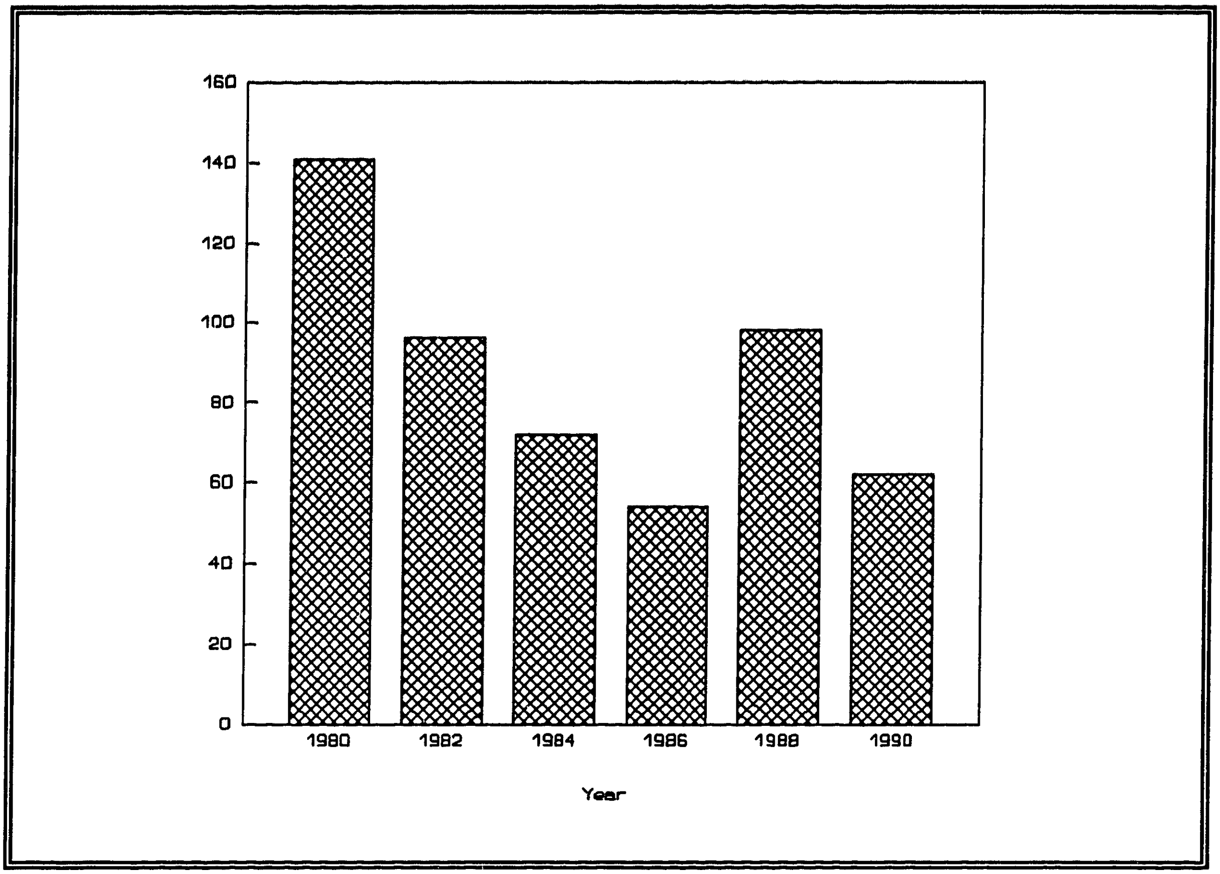

Fig. 3.3: Aggregate Aircraft Removals for Sample Airlines

It can therefore be concluded that the aggregate of aircraft fleet for the sample airlines has been increasing since deregulation. Figure 3.4 depicts the net difference between deliveries and removals from 1980 to 1990.

The remainder of this section presents a discussion of how aircraft characteristics have been changing since deregulation.

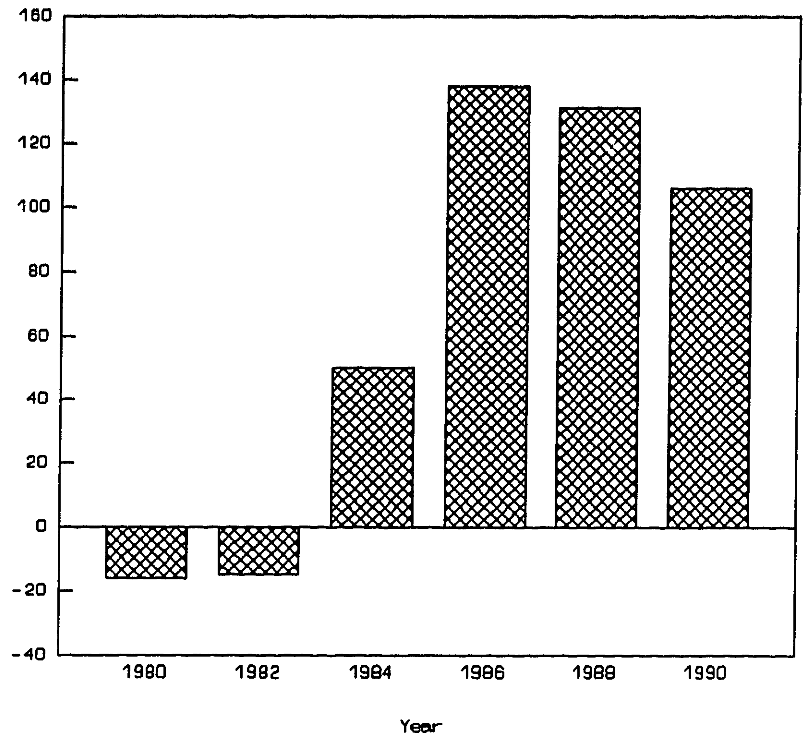

Fig. 3.4: Aggregate Difference between Aircraft Deliveries and Removals for Sample Airlines

3.3.3.1 Aircraft Manufacturers

Airbus Industrie started with a 0.4% share of the total existing sample airlines fleet in 1978 and has steadily grown to 3.6% in 1990, as depicted in Figure 3.5.

However, it is shown in Figure 3.6 that Airbus Industrie secured 5.6% (7 aircraft) of the total number of aircraft delivered in 1980, a figure which will have increased to

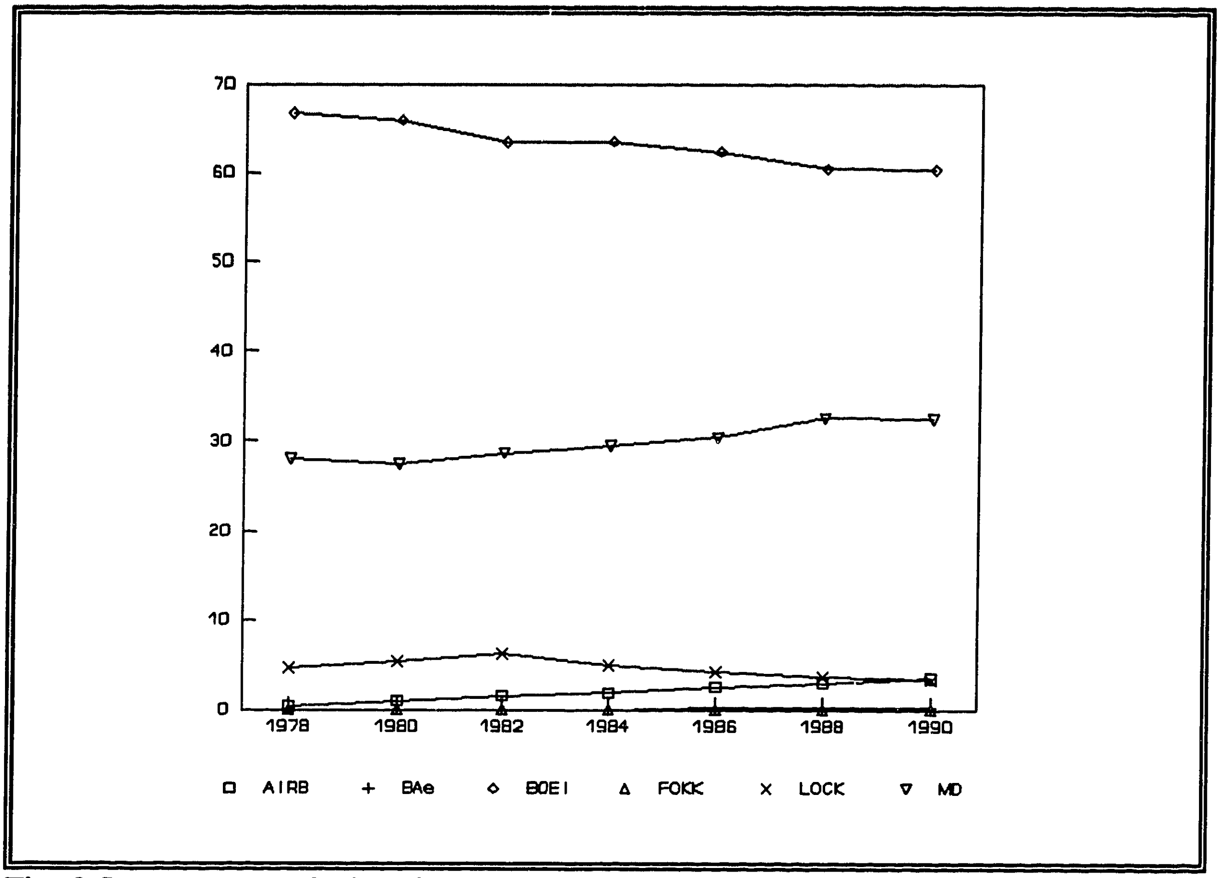

Fig. 3.5: Percentage of Aircraft Fleet by Manufacturer

14.5% (21 aircraft) by 1992.

Airbus Industrie has had a hard time breaking into the American market, with many airlines hesitating to buy its aircraft because they wanted to see whether it would provide enough support in terms of spare parts and maintenance. After Eastern Air Lines bought its first A300s, this manufacturer began to be taken seriously. Through an often aggressive and always controversial salesmanship, Airbus Industrie made its way into the US Major

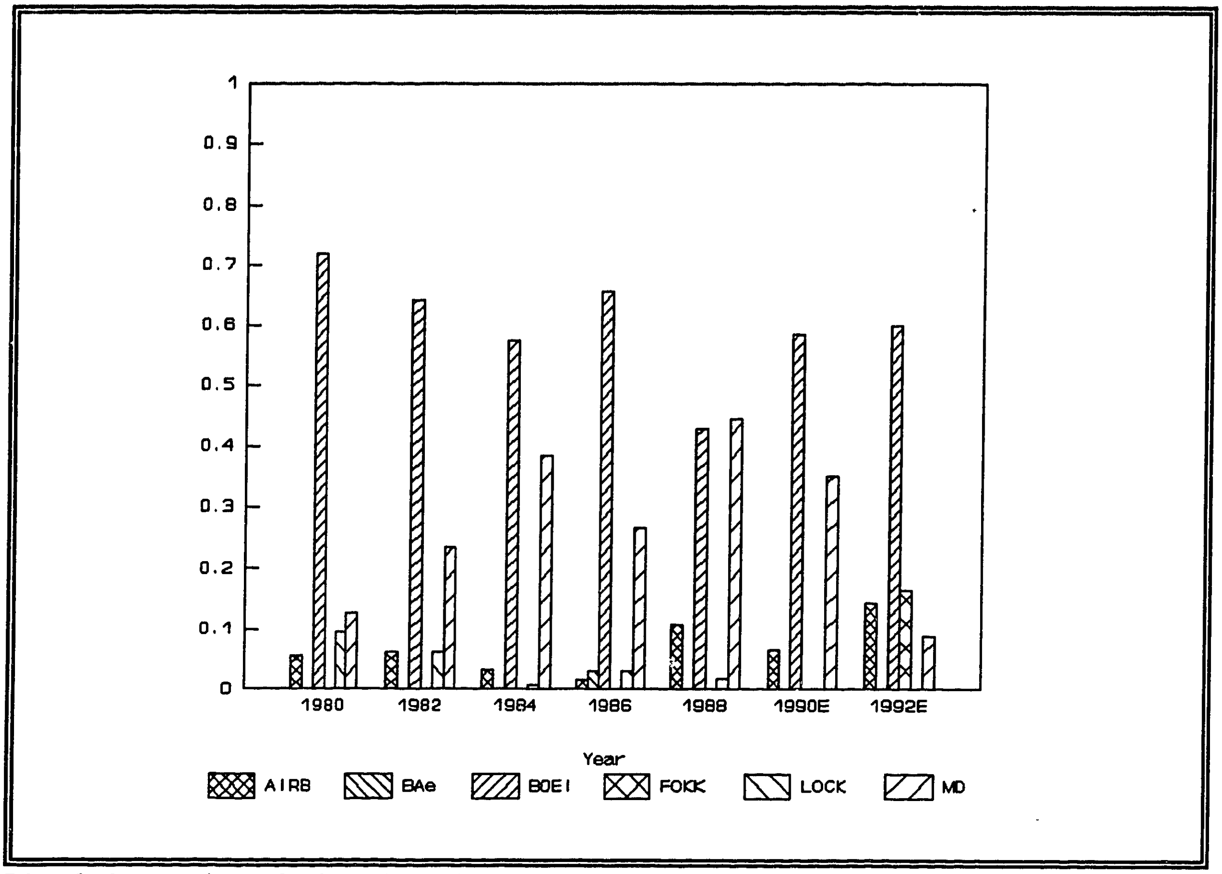

Fig. 3.6: Fraction of Aircraft Deliveries by Manufacturer

airlines[5]. More specifically, there are numerous questions as to how and why Airbus Industrie has consistently taken peculiar interpretations of international trade agreements which have ultimately led to questions about the legality of subsidies and unusual sales practices.

The reason for the Airbus success can be attributed to the fact that this mixture of multi-national, state-owned, and private shareholders --which constitutes the Airbus Industrie consortium-- provides considerable benefits to the consumer airline. First, the customer

[5]With the exception of Delta Air Lines and United Airlines

airlines are better protected than when dealing with a normal limited liability company because, in general, state-owned companies can temper the need to show immediate return on investments; therefore, they can assure their customers the delivery of high quality products at a competitive price. Second, through these subsidies, Airbus Industrie has been able to expand and it now has in production and/or development a *family* of aircraft: A300, A310, A320, A321, A330, and A340. This aircraft family allows for low, medium, and high capacity aircraft for short, medium, and large ranges.

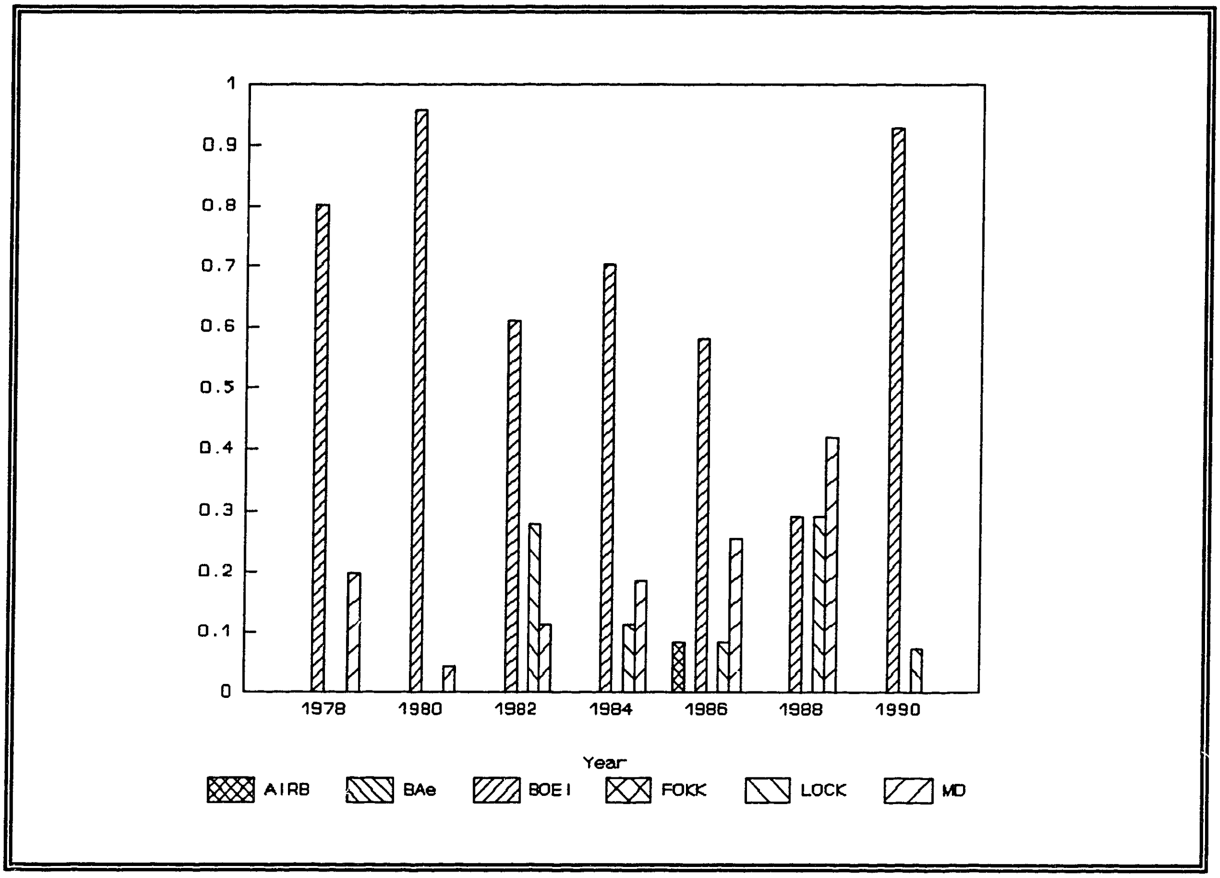

Fig. 3.7: Fraction of Aircraft Removals by Manufacturer

Today, Airbus Industrie has become a true competitor for Boeing and, in the process, is putting the life of McDonnell-Douglas commercial aircraft division in jeopardy. As for the removal pattern of Airbus aircraft, it was in hands of its first customer, Eastern Air Lines, which removed 8 A300s (refer to Figure 3.7). These aircraft have been the first and only Airbus Industrie aircraft to be discarded since deregulation was enacted.

With the introduction of the A310 in 1986, and the A320 in 1990, the Airbus Industrie aircraft are new and are expected to remain in service throughout the 1990s and possibly beyond. As older Boeing, Lockheed, and McDonnell Douglas aircraft are beginning to be phased out, the Airbus Industrie fraction of the sample airlines fleet can only grow.

British Aerospace started to make its presence in 1986 with a 0.3% share, but it has since declined to a 0.2% in 1990. While the 1986 figure actually represented a 3.1% share of the total aircraft delivered in that year, these aircraft were acquired through a merger. British Aerospace has since not been able to make any other sale to the sample airlines. Contrary to Airbus Industrie, British Aerospace has not expanded its family of aircraft and cannot possibly compete with the bigger aircraft selection of its competitors.

While Boeing's share of the sample airlines' fleet has steadily declined from 66.8% in 1978 to 60.5% in 1990, it there has nevertheless been a growth of 1,225 to 1,584 Boeing aircraft in service for the sample airlines since deregulation. Boeing has established itself as the single most important civil aircraft manufacturer. It provides the most extensive and versatile family of aircraft, not just by aircraft type but by the number of versions made available. This supremacy is confirmed by the percentage of total aircraft deliveries to the sample airlines, 72.0% in 1978 and about 60.0% by 1992. It is interesting to note that in 1978, 64% of the total deliveries were B727; in 1986, this trend was shifted in favor of the B733 which averaged a 23% of the total deliveries for the sample airlines; the B757 totaled 31% of the deliveries in 1990, a trend which is expected to continue up to 1992. Only the MD80 has been able to achieve these high percentages for a single aircraft type. On the other hand, the Boeing aircraft have represented an average of about 70% of all aircraft removals since deregulation was enacted. This comes as no surprise since, after all, most of the aircraft utilized throughout these years were Boeing. The phasing out of the B707, B727, and B737 are responsible for this figure. All in all, the future of Boeing appears well secured despite the increasing challenges from its closer competitors, particularly Airbus Industrie.

Fokker has had no representation in the sample airlines fleets during the time frame considered here. However, the F100 aircraft type may well be a promising opportunity for this manufacturer to make an entrance in the US Major airlines. This idea is supported by the fact that Fokker is expected to have a 16.6% of the total deliveries booked for 1992. With only one aircraft type, the F100 introduction is quite a remarkable achievement.

Lockheed had a peak 6.2% aircraft share of the sample airlines' fleet in 1982, but has since declined to a 3.3% low in 1990. Much like British Aerospace, Lockheed has offered only one aircraft type, the L1011. Its deliveries reached a maximum 9.6% share in 1978 and have declined to 0%, the reason being that Lockheed is no longer in the commercial aircraft business. As for removals, the aging L1011 began to be phased out in

1982 and have averaged 17% of the total aircraft removed since deregulation.

McDonnell Douglas has managed to increase its 28.1% share of the aggregate fleet in 1978 to 32.5% in 1990. It is currently the second most represented aircraft manufacturer but it is starting to lose ground to Airbus Industrie. As for deliveries, its share has fluctuated a great deal since deregulation. It started with 12.8% in 1978, peaked to 44.5% in 1988 -- thereby surpassing Boeing's 42.8% share-- but is expected to have a very low 9% of expected deliveries in 1992 (behind Boeing, Airbus Industrie, and Fokker). There is no doubt that the F100 is directly competing against the MD80, McDonnell Douglas' bestseller. Following the steps of Boeing, McDonnell Douglas' share in aircraft removals have been proportional to the actual aircraft fleet share. It is second in percentage of aircraft being removed, averaging about 17%. Even its newest aircraft types[6] are based on older projects, namely, the DC9 and the DC10 aircraft types.

In conclusion, this study suggests that the *aircraft family*[7] concept appears to be the key to the success for aircraft manufacturers in order to gain market share. It explains why Boeing and McDonnell Douglas have dominated in the past, and why Airbus Industrie may take McDonnell's place in the foreseeable future.

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[6]MD80, MD90, MD11, and MD12

[7]An aircraft manufacturer is said to offer a family of aircraft if it can provide with a wide range of aircraft types and (possibly) several versions

3.3.3.2 Country of Origin

Even though US aircraft manufacturers have experienced a steady share decrease in terms of the sample airlines fleets from 99.6% in 1978 to 96.3% in 1990 (refer to Figure 3.8), this nonetheless represents an increase from 1,827 to 2,521 of American-made aircraft in the aggregate fleet of the sample airlines.

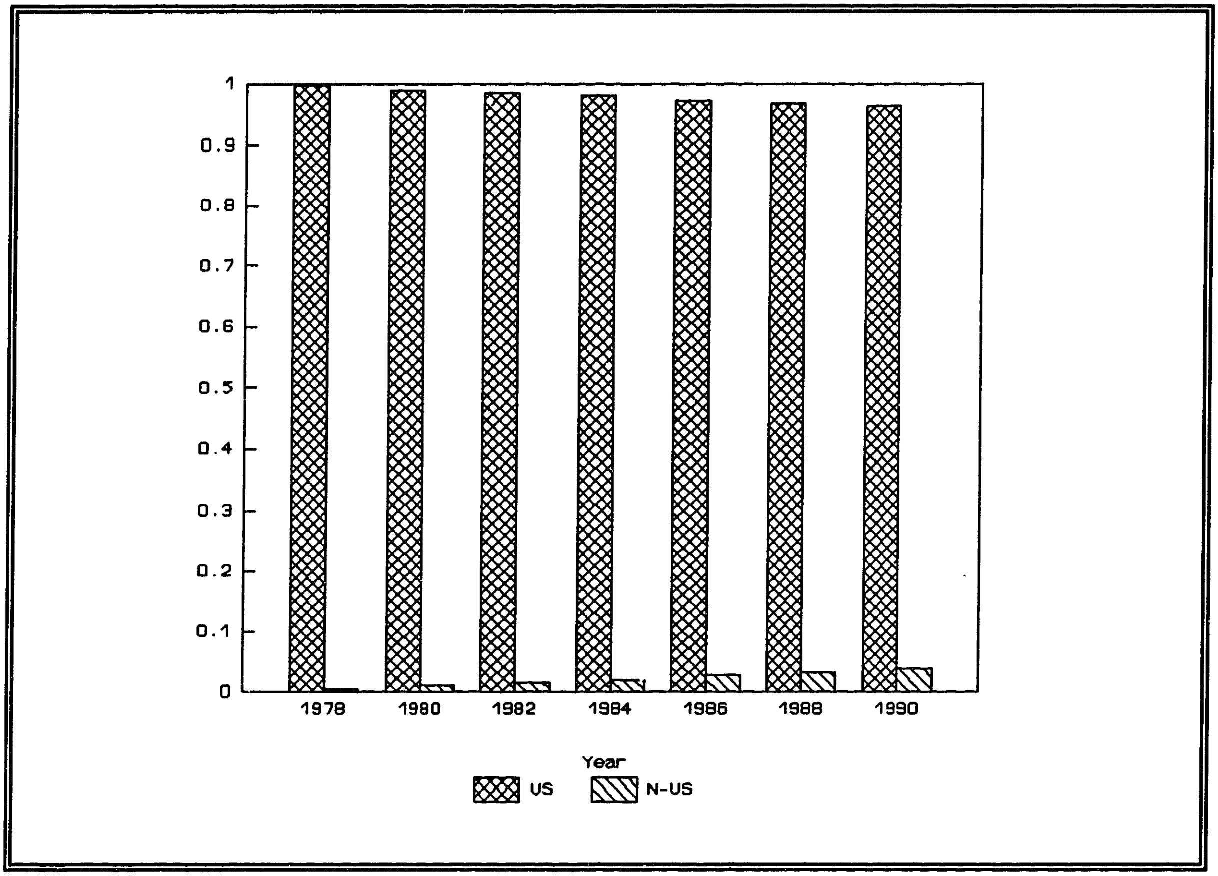

Fig. 3.8: Fraction of Aircraft Fleet by Country of Origin

US aircraft manufacturers have overwhelmingly dominated the aircraft representation in US Major airline fleets and they are expected to do so for quite a number of years. The reason for this situation is, again, related to the number of aircraft types offered to the airlines throughout the years. Today, American-made aircraft account for 15 of the 21 aircraft types considered in this thesis, but it must also be remembered that the composition of these fleets was determined decades earlier, when the B707s, DC8s, B727s, and B737s were introduced and formed the fleet backbone of the sample airlines. At the time, no aircraft manufacturer ever seriously challenged the capability of Boeing or McDonnell Douglas to design and develop any type of aircraft. As other manufacturers began to introduce new competitive aircraft types, particularly Airbus Industrie, the American giants started to lose market share. Today, 7 of the 13 aircraft types currently in production are American-made, which is a dramatic decrease from the virtually 100% share at the beginning of deregulation.

Indeed, the data show that by 1992 one of every three aircraft delivered to the sample airlines will be European made (refer to Figure 3.9). Airbus Industrie appears to be the manufacturer with the greatest potential but if Fokker's F100 remains popular, it has the possibility to fit in the most important niche, namely, the low capacity/short range aircraft.

As for aircraft removal, with the exception of the previously mentioned 8 A300s in 1986, all other aircraft phased out since deregulation by the sample airlines were American-made. This is simply explained by the fact that US manufacturers have been in the business longer and some of their aircraft are at the end of their operating life.

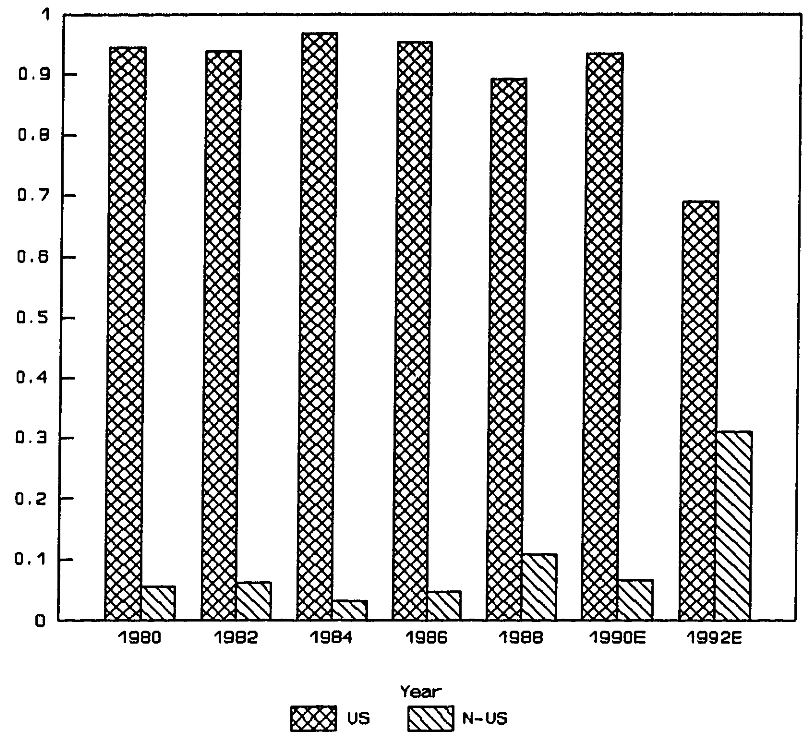

Fig. 3.9: Fraction of Aircraft Deliveries by Country of Origin

3.3.3.3 Number of Crew

From 76.3% of the sample airlines aggregate fleet aircraft being flown with a three-crew member configuration in 1978, this percentage has decreased to its low of 50.2% in 1990. There were 435 two-crew member aircraft at the beginning of deregulation, and today there are 1,306 (refer to Figure 3.10).

This can only mean that airlines find the introduction of the new flight decks

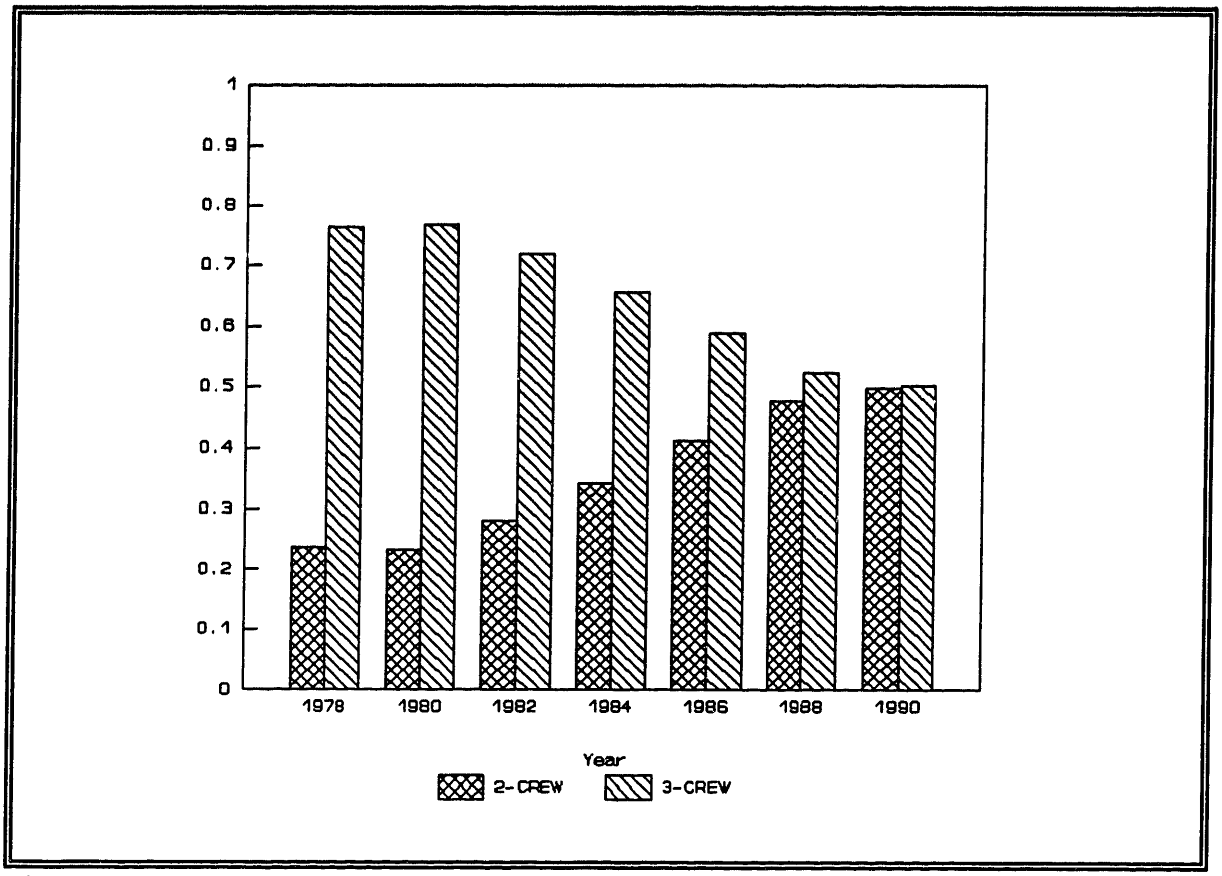

Fig. 3.10: Fraction of Aircraft Fleet by Number of Crew

attractive. As discussed in Chapter 2, these cockpits not only have eliminated the need for a flight engineer, but have the potential of reducing the workload of the remaining two pilots. In addition, digital equipment increases efficiency both in flight and on the ground.

The two-crew configuration trend is most obvious by studying the aircraft deliveries (refer to Figure 3.11); 91.2% of the aircraft delivered in 1978 had three-crew member cockpits, figure that has decreased to a low 0.6% in 1990.

As for aircraft removal, it is worthwhile to note the fairly high percentages of two-

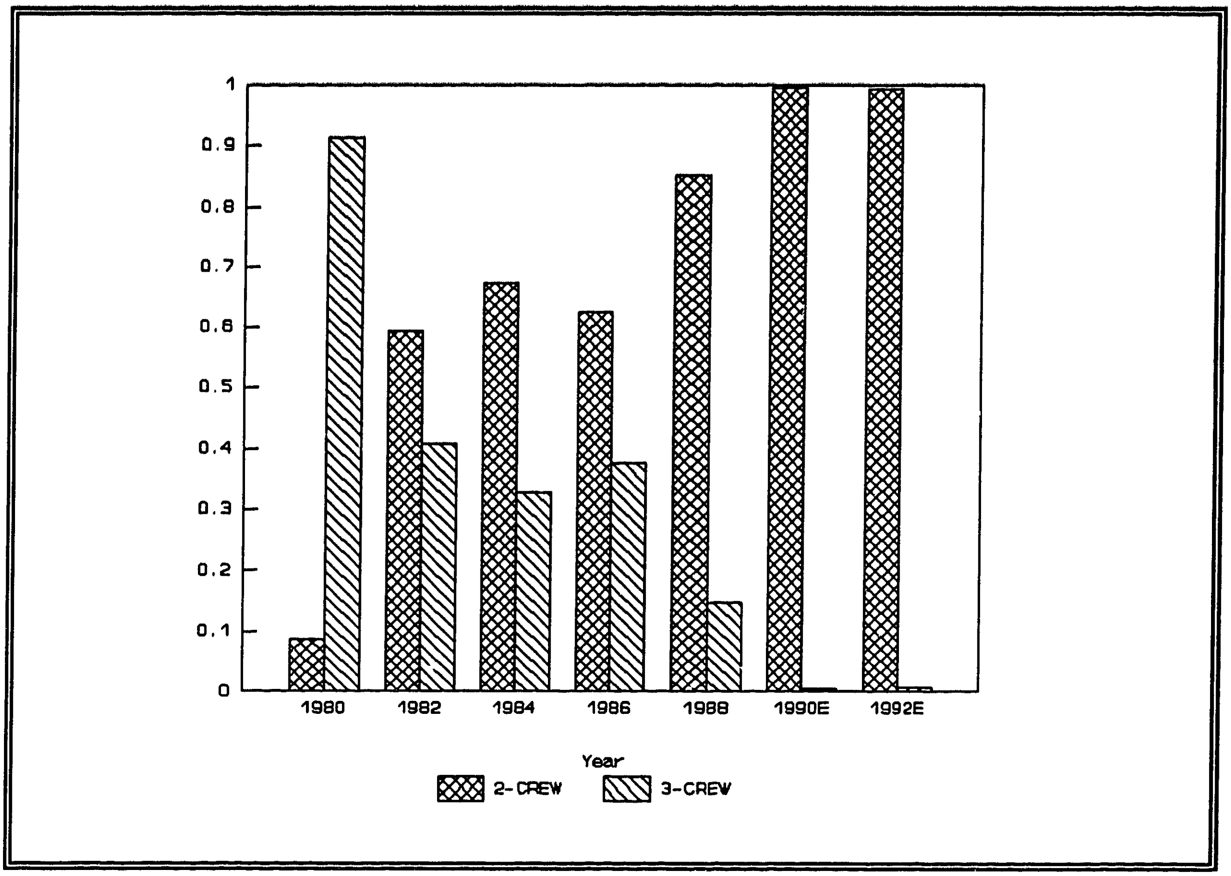

Fig. 3.11: Fraction of Aircraft Deliveries by Number of Crew

crew member aircraft (refer to Figure 3.12). This is explained by the fact that the B737s and DC9s are being phased out. Still, the highest removal percentage is, as expected, the now obsolete aircraft with three-crew member cockpits.

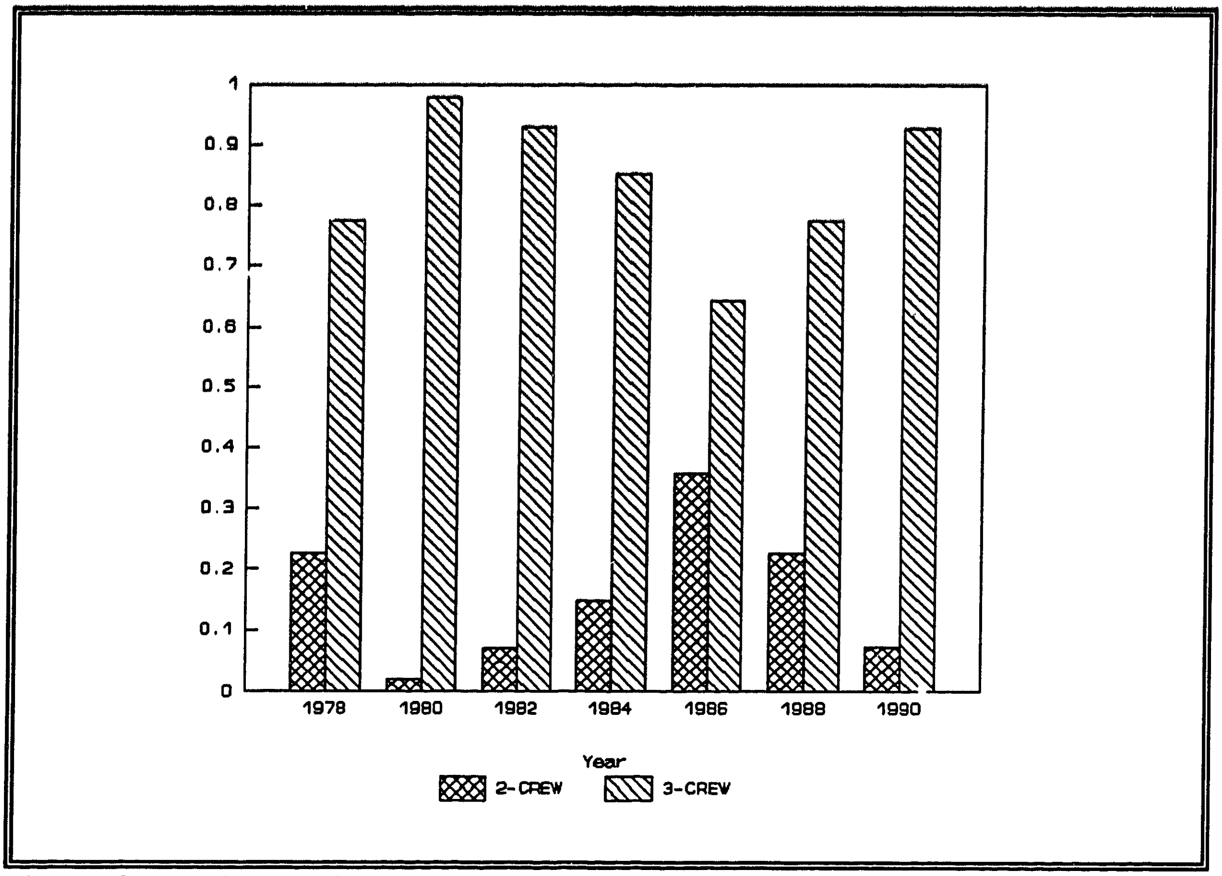

Fig. 3.12: Fraction of Aircraft Removals by Number of Crew

3.3.3.4 Technology Level

Representation for the Technology Level 1 aircraft in the aggregate sample has steadily dropped from 15.9% to 0.9% since deregulation was enacted. (refer to Figure 3.13).

This percentage can only be reduced further because aircraft in this category are no longer in production. Moreover, if it had not been for the re-engining programs, these aircraft would be completely extinct today. From a peak 73.5% in 1982, Technology Level

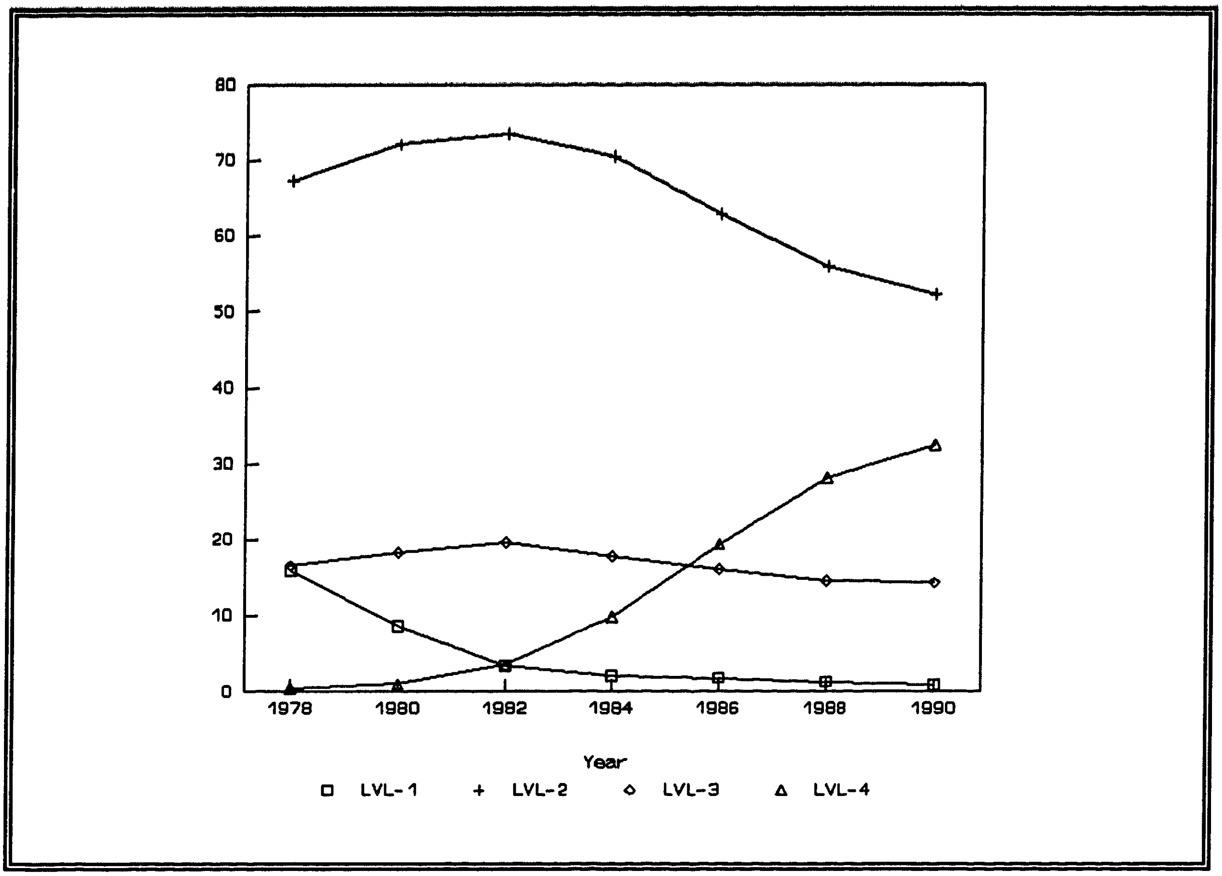

Fig. 3.13: Percentage of Aircraft Fleet by Technology Level

2 aircraft have decreased to a low of 52.3% in 1990. It has been the most influential category since deregulation. As with the Technology Level 1 aircraft, this percentage will continue to decrease because the aircraft in this category are no longer in production. Technology Level 3 aircraft have had a fairly constant representation throughout these years, with an average of about 17%. Again, this category is expected to lose its share because aircraft belonging to it are no longer in production. The share for Technology Level 4 aircraft has grown from a 0.4% in 1978 to a 32.6% in 1990. This represents a total increase from 7 to 853 aircraft. As opposed to the other levels, this category can only grow in the future, particularly as older aircraft are removed. Thus, airlines respond positively to the

products offered by the aircraft manufacturers, who do their best to incorporate the latest technology. This trend is confirmed by studying the deliveries of aircraft since deregulation.

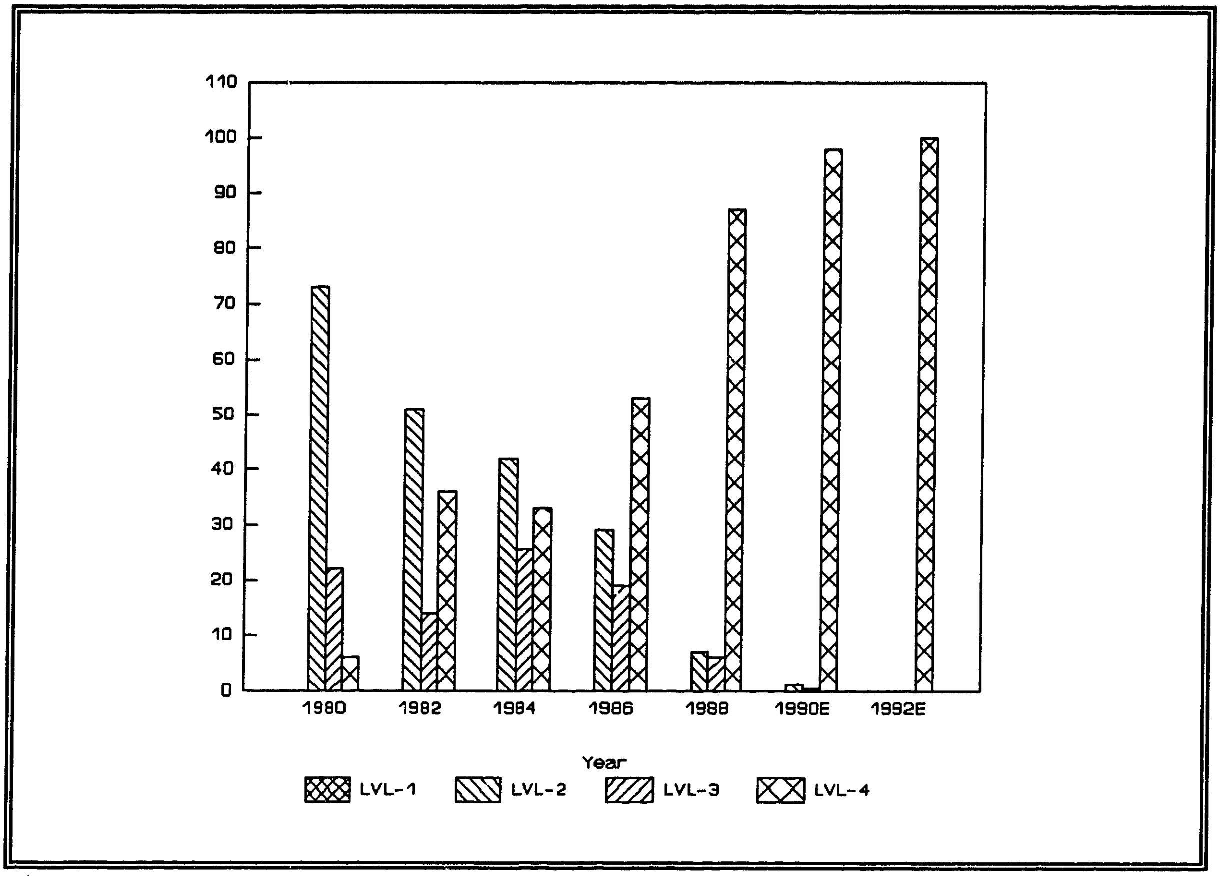

Fig. 3.14: Percentage of Aircraft Deliveries by Technology Level

As shown in Figure 3.14, no Technology Level 1 aircraft have been delivered since 1978. From a peak 72.8% in 1982, the Technology Level 2 aircraft share of deliveries has dropped to 0% today. Technology Level 3 aircraft deliveries peaked at 25.4% in 1984 but have since dropped to 0%, as well. Technology Level 4 aircraft deliveries will have grown from a 5.6% in 1980 to a 100% by 1992.

Aircraft removal, depicted in Figure 3.15, is also well correlated to the technology level, and the percentages are proportional to the number of aircraft in the fleets.

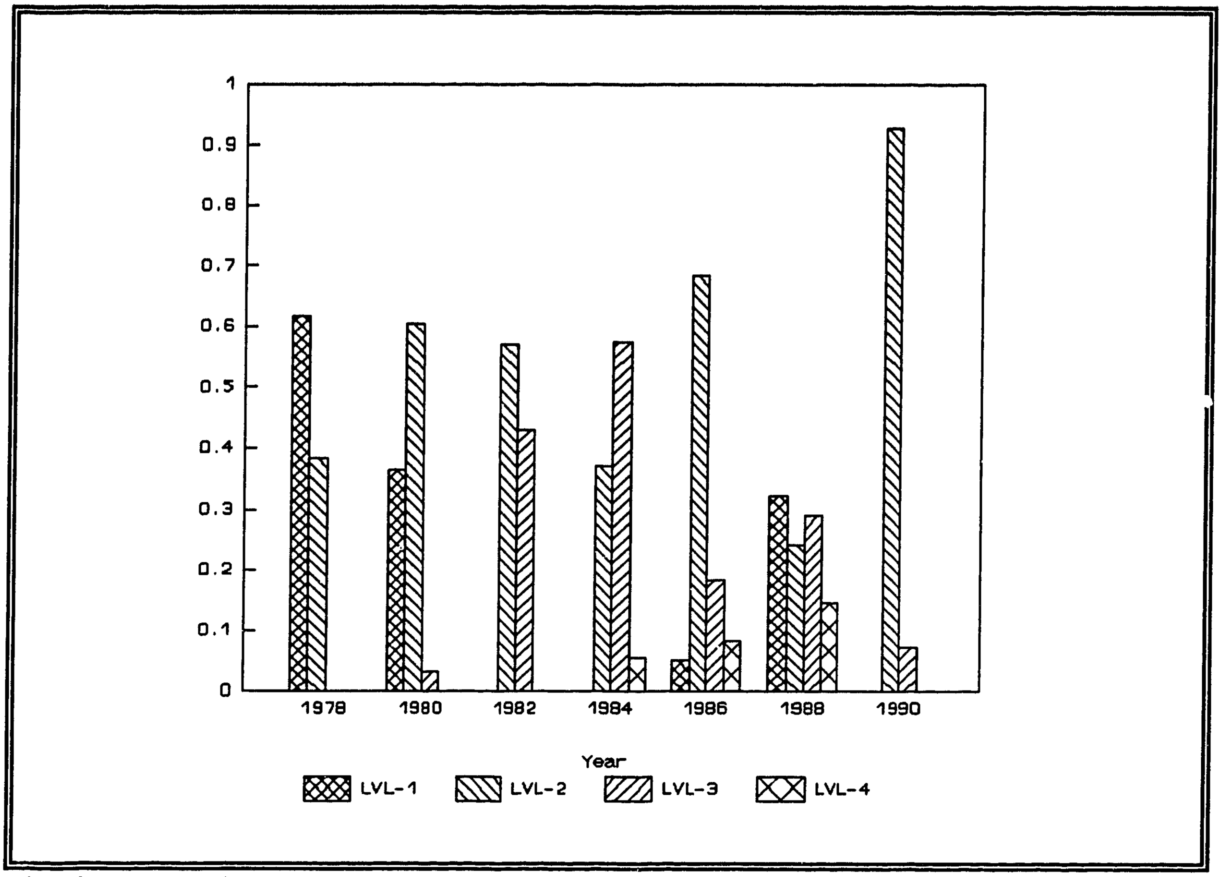

Fig. 3.15: Fraction of Aircraft Removals by Technology Level

As shown in Figure 3.15, the Technology Level 1 aircraft were removed first, followed by levels 2, 3, and 4, respectively. The largest removal percentages belong to the Technology Level 2 aircraft because they were the most popular aircraft in the first place. They have averaged 54% of the total removed aircraft during this period; Technology Level 1 aircraft have averaged about 19% over the years; Technology Level 3 aircraft have averaged 23%, and Technology Level 4 aircraft have averaged 4%.

3.3.3.5 Aircraft Capacity

Low capacity aircraft have averaged about 72% of the total sample airlines' aircraft fleet share since deregulation, followed by the medium capacity aircraft at about 22%, and the high capacity aircraft with the remaining 6%. As depicted on Figure 3.16, the distribution of aircraft by capacity has not fluctuated much throughout these years.

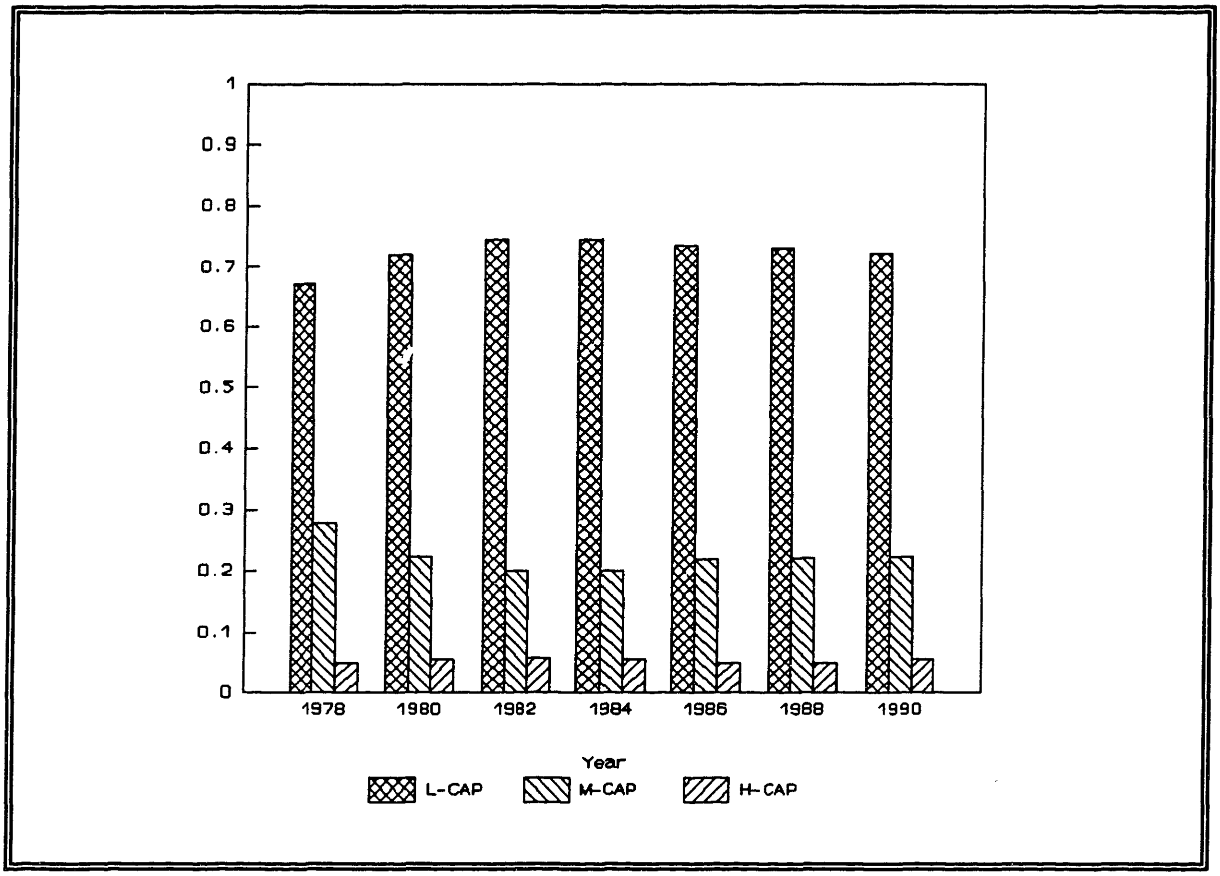

Fig. 3.16: Fraction of Aircraft Fleet by Number of Seats

This result suggests that the sample airlines have been typically operated flights in markets where frequency of service is highly relevant, such as domestic markets.

From the deliveries perspective (see Figure 3.17), low capacity aircraft have averaged 60%. Medium capacity aircraft appear to be increasingly popular, with delivery shares increasing from 22.4% in 1980 to 37.9% by 1992. The high capacity aircraft remains the least popular option among the sample airlines with an average of about 7% of deliveries throughout these years, but with an expected increase by 1992.

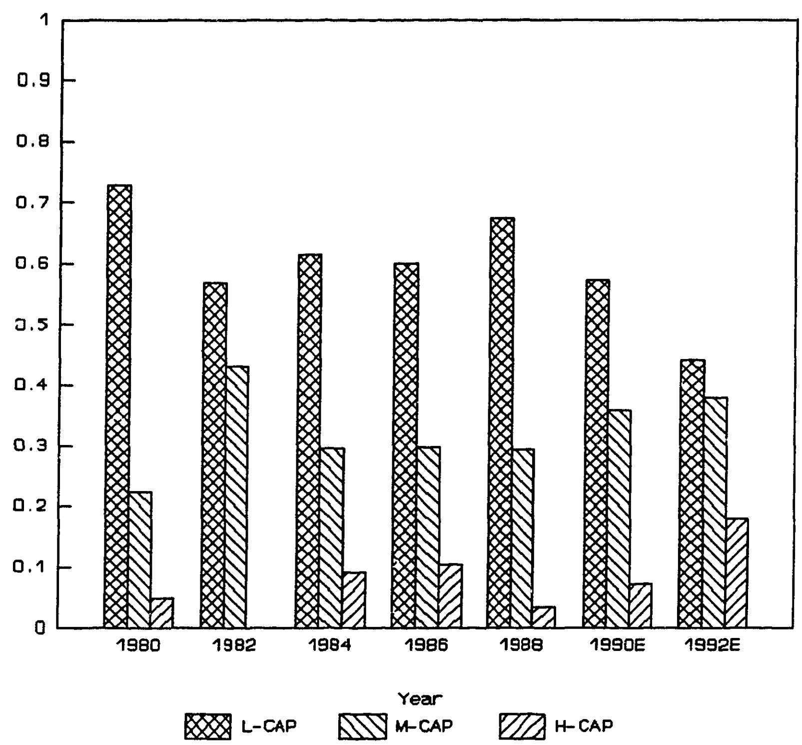

Fig. 3.17: Fraction of Aircraft Deliveries by Number of Seats

As for aircraft removals, depicted in Figure 3.18, low capacity aircraft have averaged the greatest percentage at 57% because they represent the largest percentage of the existing fleet. Removals of low capacity aircraft are increasing as a percentage of the total aircraft removed, and will reach a maximum 92.8% of the total aircraft removed by 1992. Medium

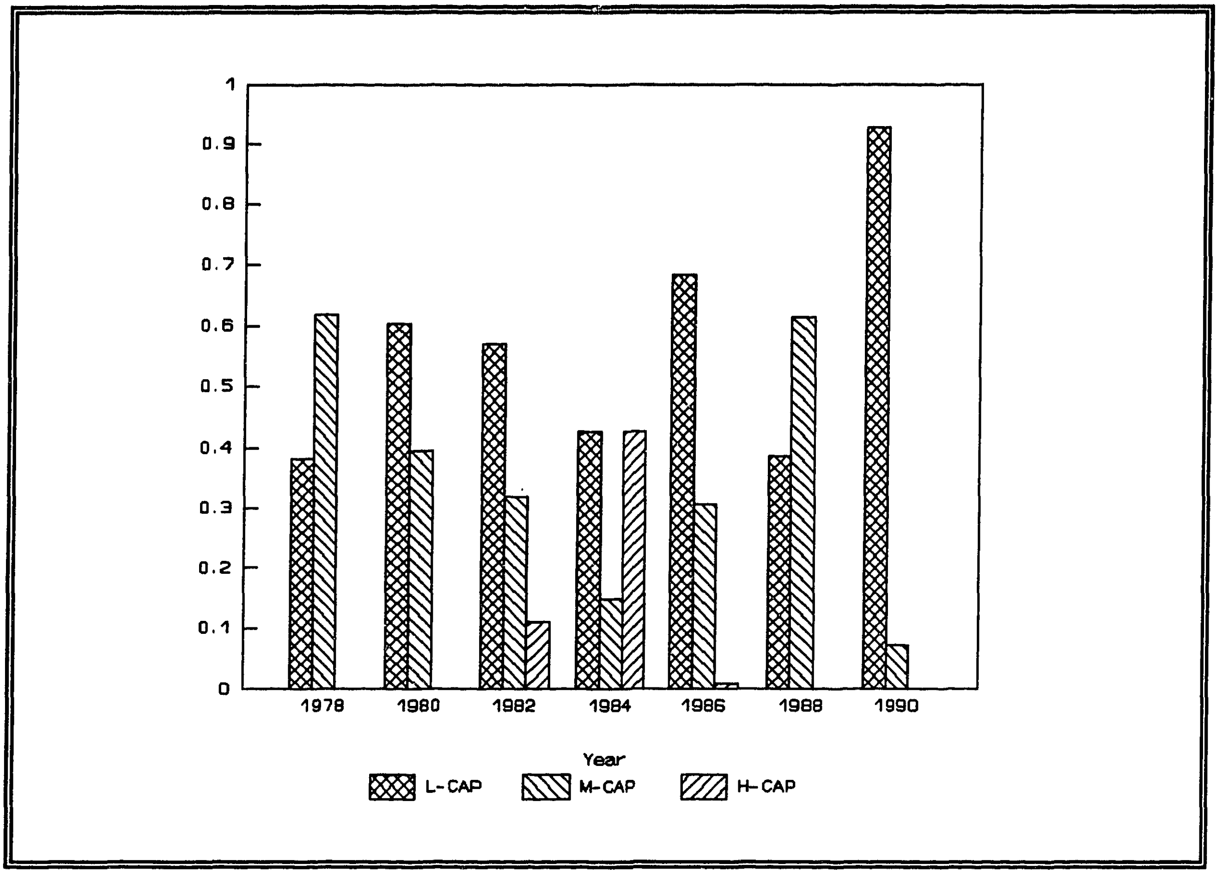

Fig. 3.18: Fraction of Aircraft Removals by Number of Seats

capacity, the second most popular capacity configuration is also second in removals, at 35% average throughout the sample period. Its removal rates have fluctuated and will reach a minimum by 1990 with 7.2% of the aircraft removed. High capacity aircraft have the lowest removal percentage, averaging 8%, thus maintaining a balance between deliveries and removals. In conclusion, the results suggest that aircraft capacity mix has remained almost constant since deregulation.

3.3.3.6 Aircraft Range

Short range aircraft have averaged a 72% of the total aircraft share in the sample airlines' fleets since deregulation (refer to Figure 3.19).

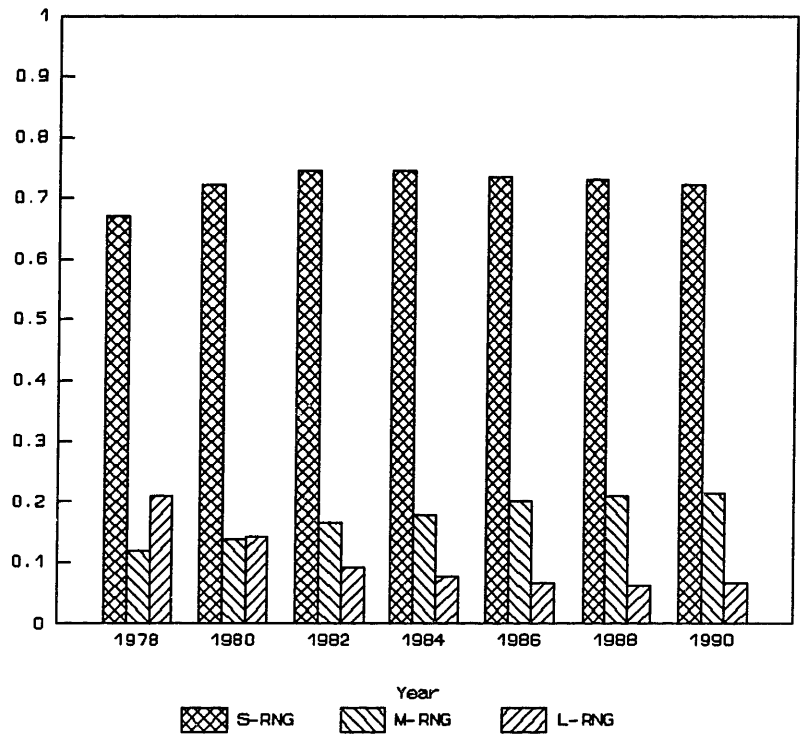

Fig. 3.19: Fraction of Aircraft Fleet by Maximum Range

This result further supports the previously suggested idea that the sample airlines must be focusing their operations on domestic markets, particularly in the hub/spoke configuration. The next most popular category corresponds to that of the medium range aircraft with about 17%. With a 11.9% share in 1978, this category has steadily risen to 21.4% in 1990. Airlines seem to be increasingly interested in having aircraft that fly further, which in principle indicates an increase in transcontinental and international operations. In contrast, long range aircraft have consistently lost share, from a 20.9% in 1978 to a 6.5% in 1990. The reason for this result can be attributed to the fact that the B707 and DC8 aircraft types constituted the 16% of the total aircraft fleet for the sample airlines; as most of them are being phased out, the percentage has dropped. Moreover, the routes formerly flown by these old aircraft are being substituted by not only the newer long range aircraft such as the B747, but by the medium range aircraft such as the DC10 and L1011, and later by the A300, and B767.

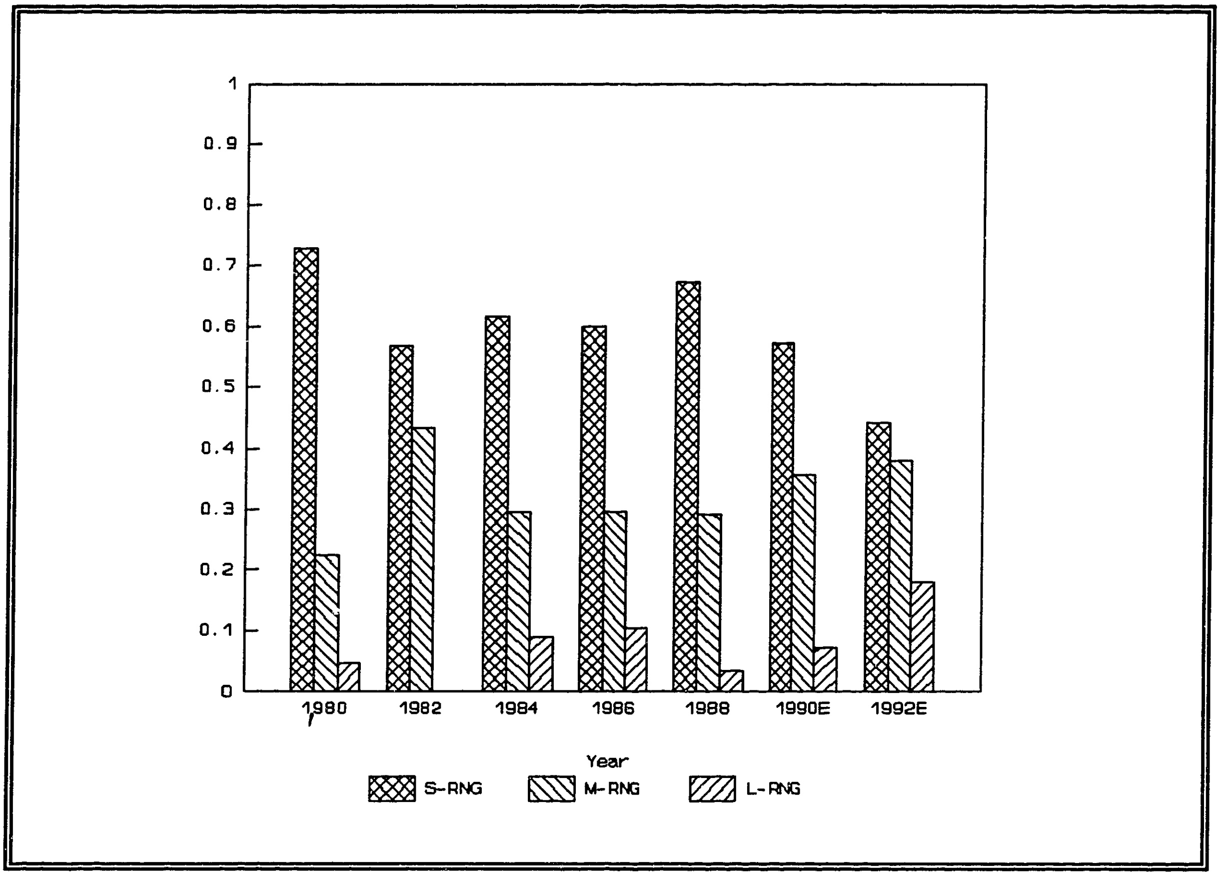

Fig. 3.20: Fraction of Aircraft Deliveries by Maximum Range

As for aircraft deliveries, depicted in Figure 3.20, it is interesting to note that the results are exactly the same as for the capacity analysis; in other words, the deliveries and orders of low, medium, and high capacity aircraft correlate well to those of short, medium, and long range aircraft, respectively. It appears that medium range aircraft share will continue to grow, while both short and long range aircraft share are expected to decrease. This implies that airlines are moving towards the acquisition of medium range aircraft.

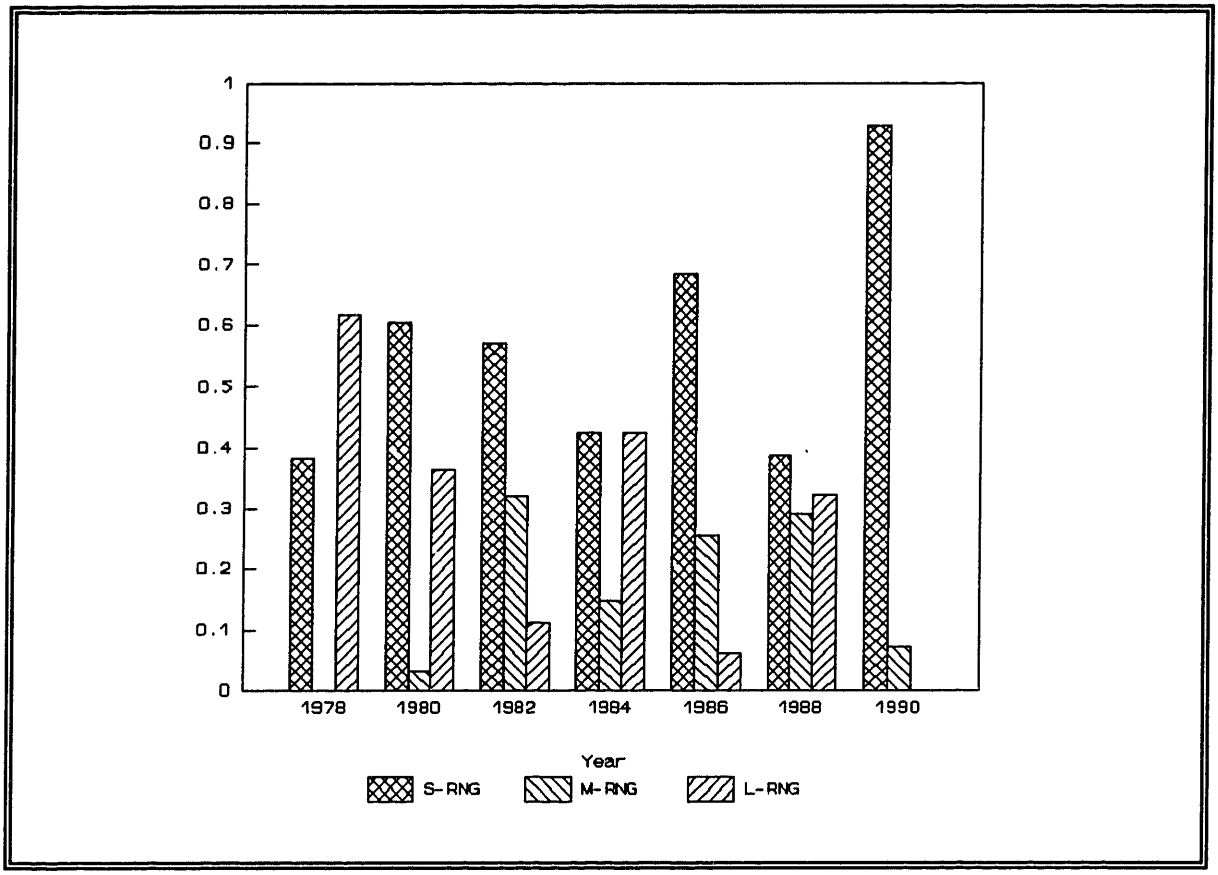

Fig. 3.21: Fraction of Aircraft Removals by Maximum Range

The study of aircraft removals is depicted in Figure 3.21 and it indicates that short range aircraft have had the greatest percentage, about 57%. Medium range aircraft have a 16% share and long range aircraft have the remaining 27% of removals. This fact further reinforces the idea of the increasing medium range aircraft representation in the fleets of the sample airlines.

3.3.3.7 Number of Engines

The fleet share for the twin-engined aircraft has grown dramatically (refer to Figure 3.22).

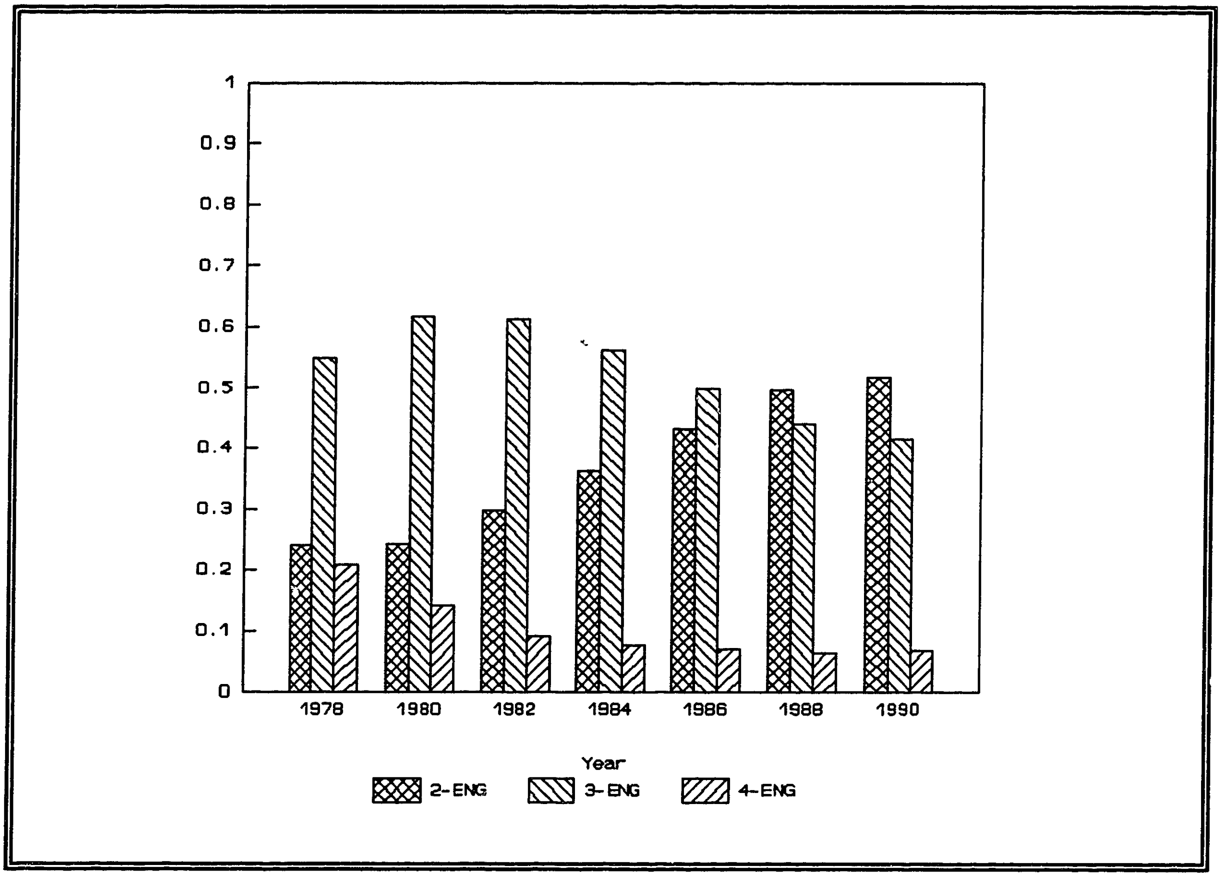

Fig. 3.22: Fraction of Aircraft Fleet by Number of Engines

In 1978, 24.1% of the aircraft were twins (442 aircraft) and by 1990 this figure had risen to 51.8% (1,356 aircraft). The trijet remains a fairly popular choice but has been losing its share continuously from a 61.7% peak in 1980 (mostly because of the popularity of the B727) to a low of 41.5% in 1990. Also, share for the four-engined aircraft has decreased since deregulation from a 20.9% in 1978 to 6.7% in 1990. This result suggests that there is an eagerness to increase the fleet mix with twins. In fact, if ETOPS were to be established to be increased from the current 180 minutes, it is quite conceivable that the tendency would be even more dramatic.

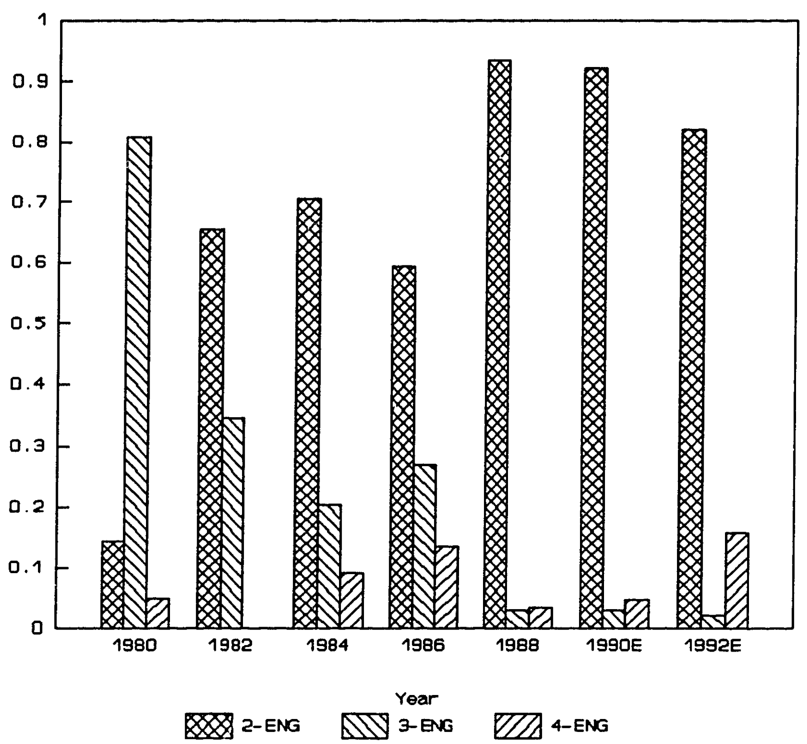

Fig. 3.23: Fraction of Aircraft Deliveries by Number of Engines

This trend is even more obvious when the behavior of deliveries is studied (refer to Figure 3.23). In 1978, 14.4% of the aircraft deliveries were twins and in 1990 this figure had risen to 92.3%. In contrast, the trijet has gone from an 80.8% share of deliveries in

1980 to a 3.0% in 1990. Four-engined aircraft deliveries have averaged about 7% throughout these years with great fluctuations from a low 0% in 1982 to an estimated 15.9% in 1992, with purchases of the B744 and A334.

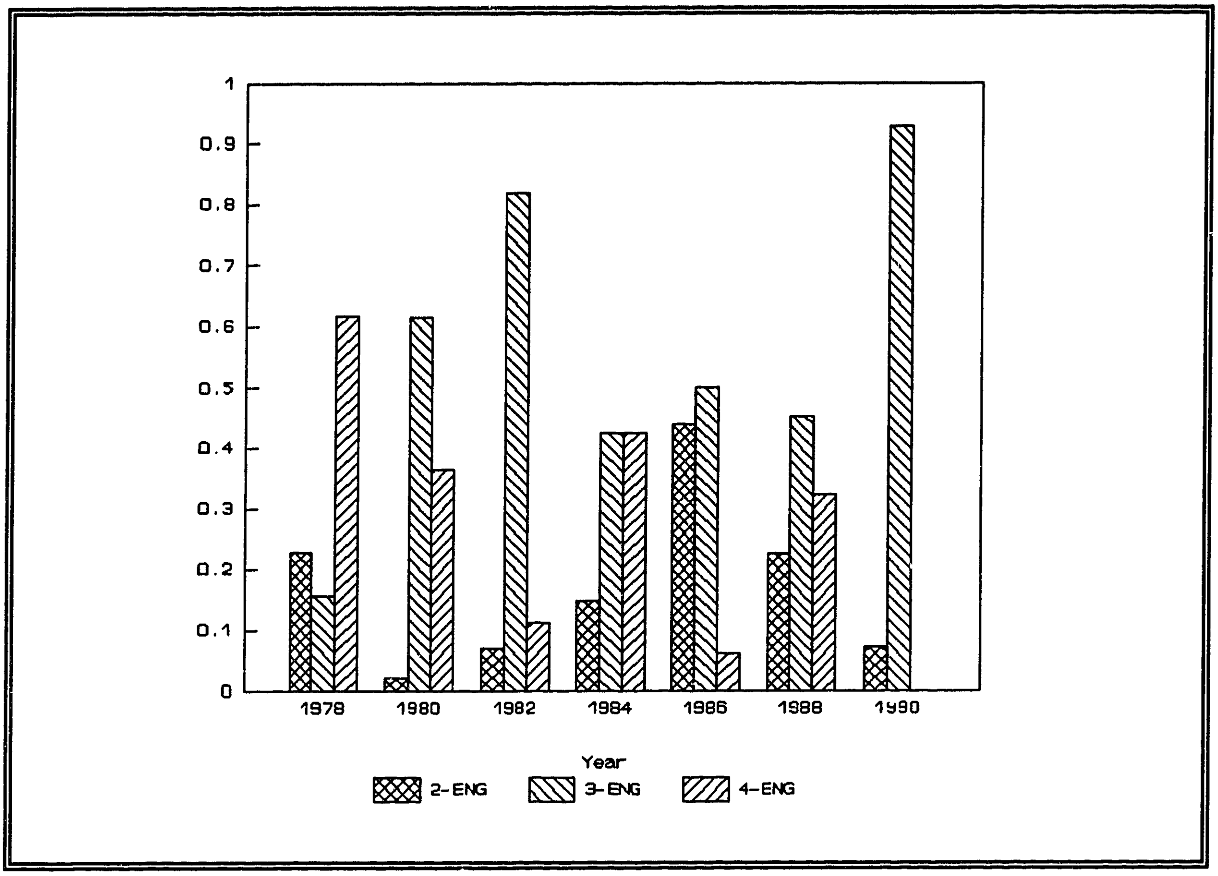

Fig. 3.24: Fraction of Aircraft Removals by Number of Engines

Aircraft removals are depicted in Figure 3.24. The twin engine aircraft has averaged 17% of removals in the years studied. This means that there are proportionally more twins now than at the beginning of deregulation. The trijet has had the largest removal percentage, averaging about 56% and is hence the fastest disappearing group by engine. Four-engined aircraft removals have averaged 27%, mostly due to the phasing out of B707s and DC8s.

3.3.3.8 FAA Noise Stage

Share for the Stage 3 aircraft in the sample airlines fleets has grown dramatically. In 1978, 16.9% aircraft were Stage 3 (310 aircraft), and by 1990 this figure had risen to 46.9% (1,228 aircraft).

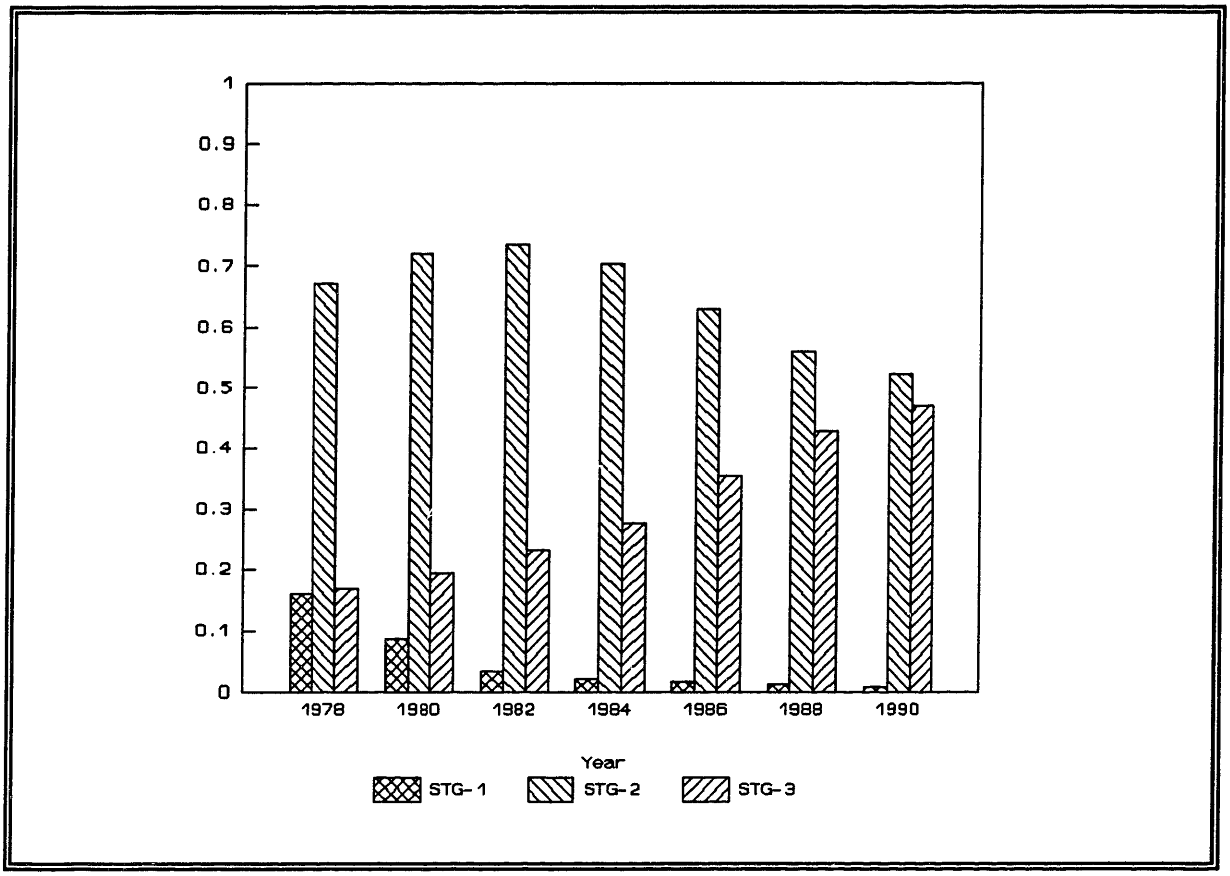

Fig. 3.25: Fraction of Aircraft Fleet by FAA Noise Stage

In fact, no other aircraft characteristic treated in this thesis has gone through such a dramatic increase.

The pattern of noise stage aircraft shares is similar to that of the number of engines (refer to Figure 3.25). Noise Stage 2 aircraft have had the largest share but it has been decreasing continuously since 1982, from a 73.5% peak to a low 52.3% in 1990. Today, no single aircraft in the sample of airlines flies Stage 1 aircraft. However, the graph shows that Stage 1 aircraft have decreased since deregulation from 15.9% in 1978 to 0.9% in 1990. This is because the remaining aircraft have undergone re-engining programs that allow them to fly under FAA noise Stage 2. In any case, their share can only decrease in the future because these are economically obsolete aircraft to fly.

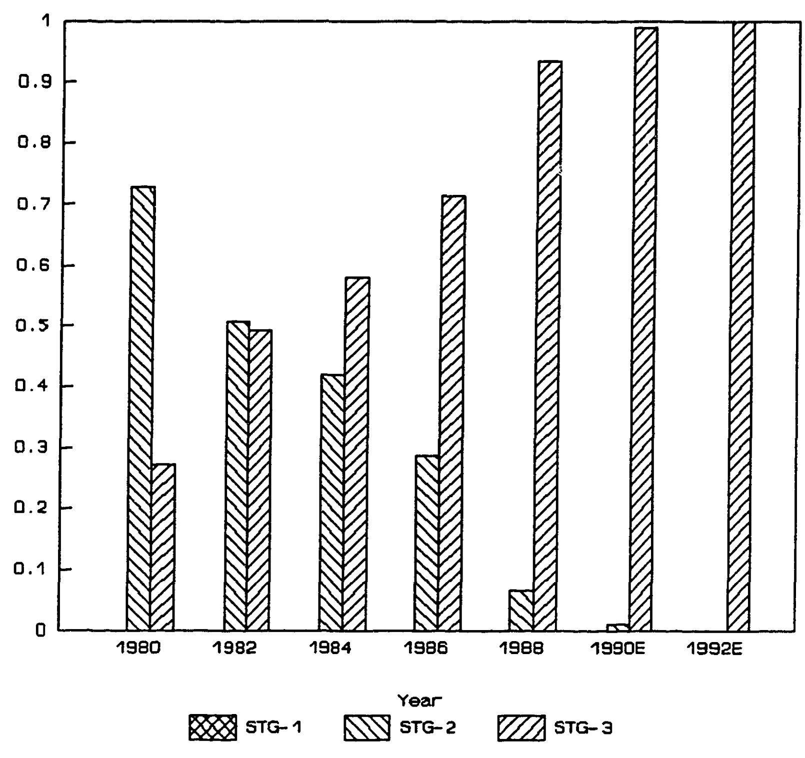

Fig. 3.26: Fraction of Aircraft Deliveries by FAA Noise Stage

As for deliveries, depicted in Figure 3.26, 27.2% of the aircraft delivered in 1980 were Stage 3. By 1992, all aircraft delivered will be under this category. Noise Stage 2 aircraft had the largest share of deliveries up until 1982, averaging 62%, but have since declined to 0%. No single aircraft delivered since 1978 has been Stage 1.

Aircraft removals have been proportional to their time of introduction. By 1990, noise Stage 1 aircraft have been removed almost entirely (refer to Figure 3.27).

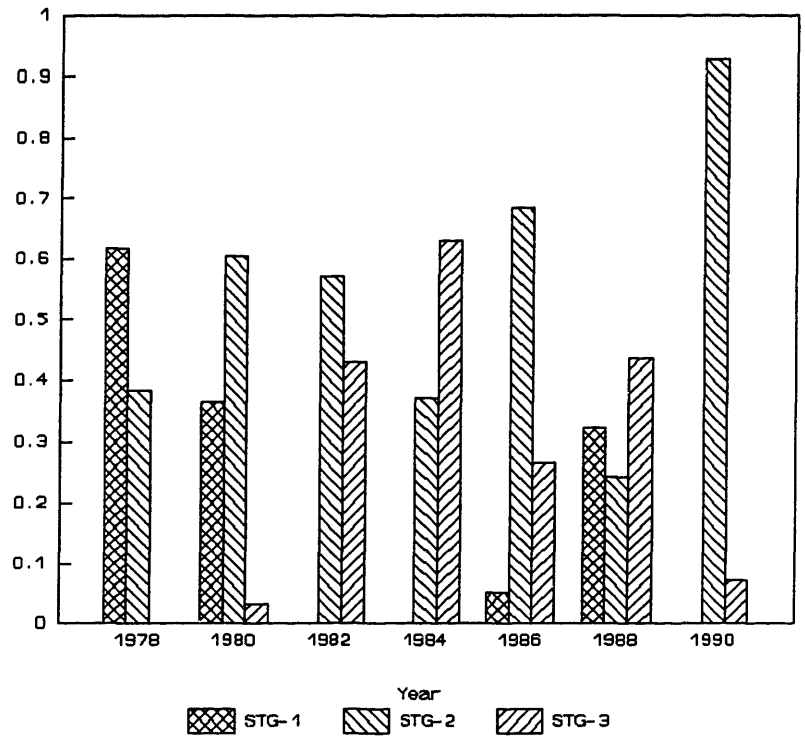

Fig. 3.27: Fraction of Aircraft Removals by FAA Noise Stage

However, the largest percentage of aircraft removals from 1980 to today has been in Stage 2 category because they are the most numerous. Stage 3 aircraft have had the lowest removal percentage. They were introduced last and hence are expected to be phased out in later years.

3.3.3.9 Category

Fleet share for aircraft category 1ML (technology level 1, medium capacity, long range) has decreased from 15.9% in 1978, the second most popular category, to 0.9% in 1990, the second least popular category (refer to Figure 3.28).

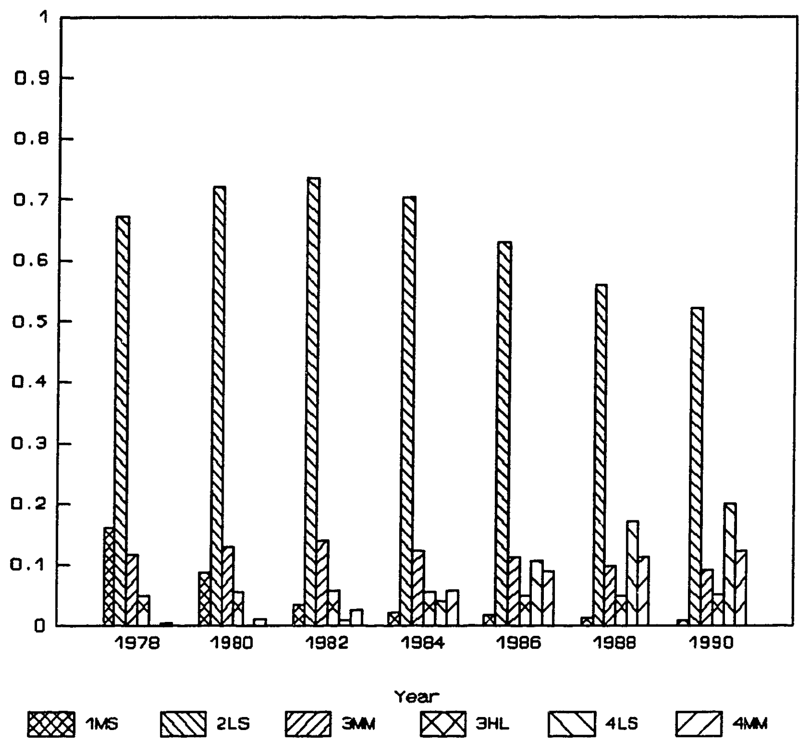

Fig. 3.28: Fraction of Aircraft Fleet by Category

Category 2LS (technology level 2, low capacity, short range) has been decreasing from a high 73.5% in 1982 to a 52.3% in 1990. Category 3MM (technology level 3, medium capacity, medium range) has had a quite steady percentage since 1978, with an average 11.5%. Category 3HL (technology level 3, high capacity, long range) has also maintained a fairly regular share of about 5.2%. Category 4LS (technology level 4, low capacity, short range) has grown dramatically from a 1.0% in 1982 to a 19.9% in 1990. The aircraft represented here are clearly the substitutes of the 2LS category which is, by far, the most popular capacity/range arrangement. Category 4MM (technology level 4, medium capacity, medium range) has steadily grown from a 0.4% in 1978 to a 12.2% in 1990. The aircraft under this category are substituting for the 3MM aircraft. Category 4HL (technology level 4, high capacity, long range) is the latest introduction; these aircraft became operational in 1990, and represented 0.4% of the total fleet mix.

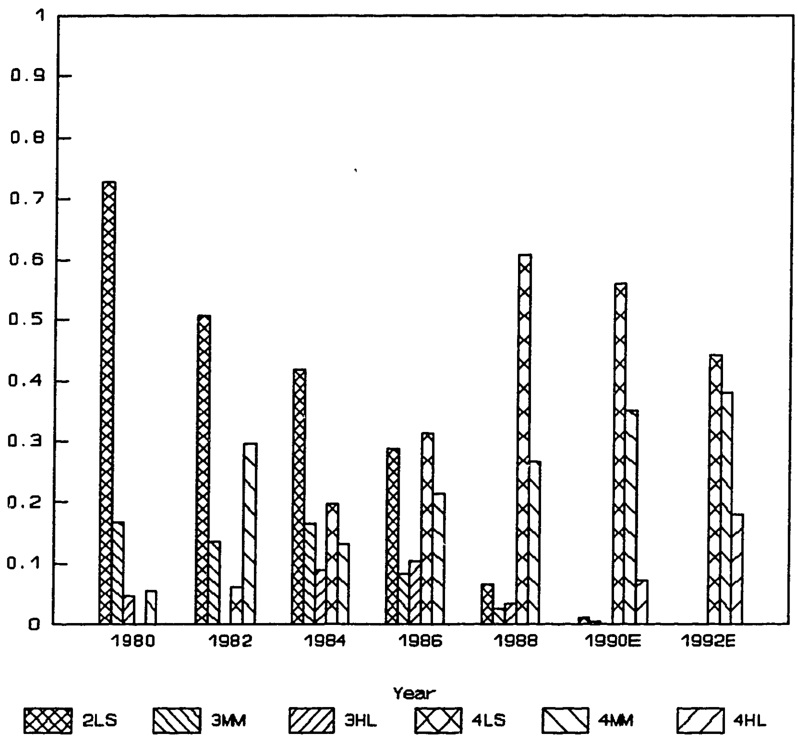

Fig. 3.29: Fraction of Aircraft Deliveries by Category

(Note that this category is not included in the graph because 0.4% would not appear).

As for deliveries, depicted in Figure 3.29, there are no category 1ML aircraft listed, and thus are not shown in the corresponding graph. Share for category 2LS aircraft has decreased from a high 72.8% in 1980 to 0% in 1990. Category 3MM aircraft decreased from 16.8% in 1980 to 0% by 1992. Category 3HL peaked in 1986 with 10.4% of all deliveries, but will have fallen to 0% by 1992. Category 4LS has grown dramatically from 5.6% in 1980 to 56.0% in 1988. Category 4MM has steadily grown from a 5.6% in 1980 to a 37.9% in 1990. Category 4HL had 7.1% of the total deliveries in their year of introduction, a figure which is expected to grow to 17.9% by 1992.

Aircraft removals are depicted in Figure 3.30, the 1ML category experienced the greatest removal percentage up until 1980 with an average 49%. The remaining aircraft were re-engined and had not been started to be phased out until 1988, when 32% of the total aircraft removed belonged to this category. Percentage removal of category 2LS aircraft has been the highest since deregulation with an average 54%. Again, this can be explained by noting that most of the aircraft belong to this now aging category. Category 3MM aircraft started to be phased out in 1982 and have averaged a 17% of aircraft removed since then. Category 3HL aircraft started to be phased out in 1982, peaked with a 42.6% of the total aircraft removed by the sample airlines in 1984, and had a low 1% total removal in 1986; since then, no further removals have been observed. Removals for aircraft Category 4LS, 4MM, and 4HL are naturally very low, as they represent the latest aircraft introduced.

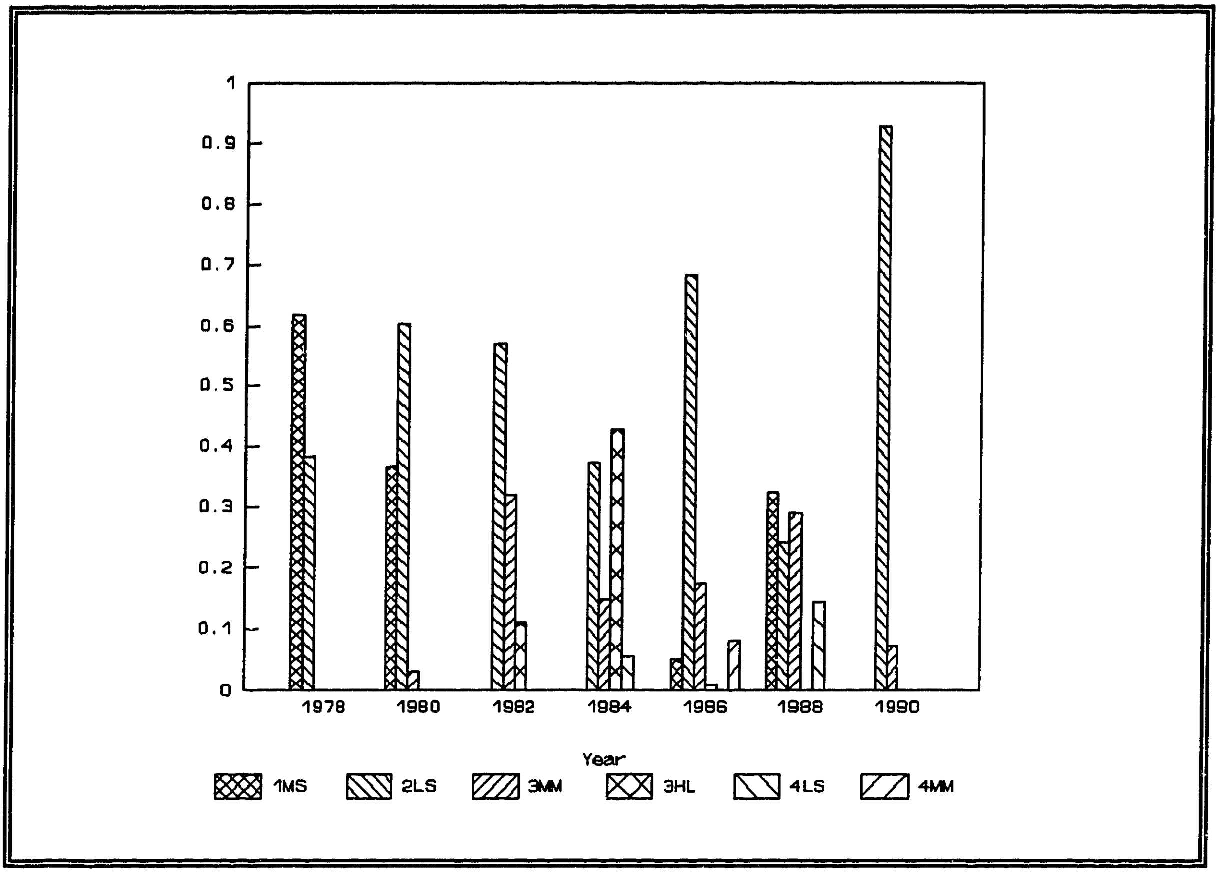

Fig. 3.30: Fraction of Aircraft Removal by Category

Combined, they only represent a 7% average since 1984 of the total aircraft removed in the sample airlines.

3.4 Conclusions

This third chapter has dealt with how the aircraft fleet mix for the sample airlines has been changing since deregulation. As an overview, it was observed that the aggregate of aircraft in the sample fleets has steadily increased from 1,886 in 1980 to 2,618 in 1990.

As for aircraft characteristics, the study of aircraft manufacturers suggests that the aircraft family concept may be the key to the success for aircraft manufacturers. It appears to be a very successful tool to gain market share and it explains why Boeing and McDonnell Douglas have dominated in the past, and why Airbus Industrie can be expected to become a key player in the near future.

The study of country of origin of aircraft indicates that US aircraft manufacturers have overwhelmingly dominated the market and are expected to do so for quite a number of years in spite of the increasing presence of European aircraft manufacturers, particularly of Airbus Industrie.

Airlines responded very favorably to the introduction of the two-crew member cockpits. These cockpits have a true potential of increasing efficiency both in-flight and on the ground. In fact, all aircraft types designed today have this desirable configuration. This is further confirmed in the study of technology level of the fleet mix in which it was found that airlines respond positively to new technology. Since deregulation, the older aircraft are being phased out while the newer aircraft are being delivered.

The study of aircraft capacity shows that the sample airlines fleets are primarily made up of low capacity aircraft. It is therefore suggested that these airlines are primarily involved in flights where frequency of service is critical or where demand is low (e.g. domestic operations). Furthermore, it is inferred that sample airlines are reluctant to change this operational feature in the foreseeable future.

The study of aircraft range further supports the previously suggested idea that the sample airlines must be focusing their operations on domestic markets because aircraft with short range have been overwhelmingly popular for the sample airlines. However, from a deliveries standpoint it has been found that there is an increasing appeal for the medium range aircraft.

The study of the number of engines arrangement in the fleet mix clearly shows that the popularity of twins has grown dramatically and that twin-engined aircraft will become even more popular in the years to come. While economics seem to encourage this configuration, aviation policy through ETOPS and in some instances engineering constraints might restrict this otherwise highly appealing alternative.

No other aircraft characteristic treated in this thesis has gone through such a dramatic change as the shift towards FAA noise Stage 3. Noise Stage 2 aircraft have had the largest share but they are no longer in production and are starting to be phased out. Noise Stage 1 aircraft which were not phased out in the early years after deregulation were re-engined to meet the legal requirement for at least noise Stage 2. Indeed, partly because of aviation policy, there appears to be no future for any aircraft types other than those in Stage 3 (or higher).

Finally, the results of the aircraft category study (which embodies technology level, capacity, and range) has been dominated by the technology level. As discussed, capacity and range have not changed dramatically during these years, as opposed to technology level. Thus, while Technology Level 2 aircraft with low capacity and short range remains the most popular aircraft, these are being replaced by the Technology Level 4 aircraft with similar capacity and range. Again, this suggests that the fleet mix of the sample airlines will be primarily involved in domestic operations.

Chapter 4

Analysis of Aircraft Fleet Operations

4.1 Introduction

This fourth chapter presents an analysis of aircraft operations by the sample airlines. Measures of aircraft operation include: total aircraft miles flown, total aircraft block hours, total aircraft days assigned to service, miles flown per day, block hours per day, and block hours to hours ratio. This study forms the basis for understanding how these airlines have been operating their fleets, in the time interval which roughly corresponds to the first decade of airline industry deregulation in the United States, from 1978 to 1990.

Section 4.2 presents a survey of aircraft operations, in aggregate terms. Section 4.3 contains the methodology, presentation of results, and discussion of the analysis, which relates the aircraft characteristics discussed in the previous chapters with the aircraft operation data introduced in Section 4.2. Finally, Section 4.4 provides a chapter summary and conclusions.

4.2 Aircraft Operations

This section presents a survey of the aircraft operations for the sample airlines in aggregate form, from 1978 to 1990 at two year intervals. The source of information is the CAB Form 41, schedule T-2(b). This schedule contains the information provided by each airline to the U.S. Department of Transportation. about miles, hours, block hours, and assigned days, by entity, year, quarter, and aircraft type. *Miles* refers to the number of revenue aircraft miles flown, or the number of miles an aircraft is flown carrying revenue passengers. *Hours* refers to the number of revenue airborne hours, or the number of hours an aircraft is flown carrying revenue passengers. *Block hours* refers to the number of ramp-to-ramp hours, the sum of flight and taxiing times, or the number of hours elapsed from the time the aircraft doors are closed to the time they are opened. *Assigned days* refers to the number of days an aircraft is assigned to service. *Entity* refers to the region of aircraft operations, which is divided in four sectors: Domestic, Atlantic, Latin America, and Pacific.

The detailed data of aircraft operations is located in Appendix G. This appendix includes the aggregate of total domestic and international operations (i.e. aggregate of Atlantic, Latin America, and Pacific entities). Aggregate refers to the sum of all sample airlines' data considered in this thesis. Abbreviations used in this appendix are: **A/C T**, which refers to aircraft types (refer to Table 2.1 for formal definitions); **QX-YYY**, which refers to operation parameter YYY (410, 610, 630, or 810) for quarter X (1,2,3, or 4). (Z)410, (Z)610, (Z)630, and (Z)810 are the codes used in Form 41, Schedule T-2(b) for the measures of revenue aircraft miles flown, revenue aircraft hours (airborne), aircraft hours (ramp-to-ramp), and aircraft days assigned to service, respectively. For example, Q3-810 refers to the number of aircraft days assigned to service during quarter 3.

4.3 Aircraft Operations Analysis

This section contains the methodology, presentation of results, and discussion of the aircraft operation analysis, which relates the aircraft characteristics discussed in the previous chapters with the aggregate aircraft operation data introduced in Section 4.2. The study is intended to show how the airlines have been operating their fleets since deregulation in both domestic and international markets.

4.3.1 Analysis Method

Using the data obtained from Form 41, an *operations aggregate* for the domestic and international markets has been computed for each *aircraft characteristic*, by year. *Operations* *aggregate* refers to eight distinct variables. The first four (miles, hours, block hours, and assigned days of service) were introduced in Section 4.2; in addition, miles per day, hours per day, block hours per day, and hours to block hours ratio have also been calculated.

Miles per day, MPD^l, is defined by equation 4.1,

$$MPD^l = \frac{\sum_i \sum_j M^l}{\sum_i \sum_j D^l} \qquad \textbf{(Eqn.4.1)}$$

where,

i: (sample airlines:) AA,...,UA

j: (quarters:) 1,2,3, and 4

M^l: revenue miles flown by aircraft type l

D^l: days assigned for service to aircraft type l

MPD is thus a function of the total number of miles flown and the total number of a assigned days to service, for a given aircraft type. An increase in MPD implies that this aircraft type is flown, on average, further distances per day. Note that because the total number of miles is not only a function of actual distance but also of frequency, a higher MPD value does not necessarily mean that this aircraft type flies longer routes per day.

Hours per day, HPD^l, is defined by equation 4.2,

$$HPD^l = \frac{\sum_i \sum_j H^l}{\sum_i \sum_j D^l} \quad \textbf{(Eqn.4.2)}$$

where,

i: (sample airlines:) AA,...,UA

j: (quarters:) 1,2,3, and 4

H^l: revenue hours (airborne) by aircraft type l

D^l: days assigned for service to aircraft type l

HPD is a useful parameter to compute the *block hours to hours ratio*, which is discussed later in this section.

Block hours per day, $BHPD^l$, is defined by equation 4.3,

$$BHPD^l = \frac{\sum_i \sum_j BH^l}{\sum_i \sum_j D^l} \quad \textbf{(Eqn.4.3)}$$

where,

i: (sample airlines:) AA,...,UA

j: (quarters:) 1,2,3, and 4

BH^l: block hours by aircraft type l

D^l: days assigned for service to aircraft type l

BH can be written in terms of H. Refer to Equation 4.4,

$$BH = B + \alpha \tag{Eqn.4.4}$$

where,

α: taxiing time

Therefore, BHPD is a measure of daily aircraft utilization. A high BHPD means that the aircraft type is flown more hours per day (due to greater distances or flying to more congested airspaces, or both) and/or the aircraft taxiing time has grown --thereby suggesting increase in congestion of airport ground operations.

Block hours to hours ratio, $BHPH^l$, is defined by equation 4.5,

$$BHPH^l = \frac{\sum_i \sum_j BH^l}{\sum_i \sum_j H^l} \tag{Eqn.4.5}$$

where,

i: (sample airlines:) AA,...,UA

j: (quarters:) 1,2,3, and 4

BH^l: block hours for aircraft type l

H^l: hours for aircraft type l

This ratio is a good measure for detecting general trends on the level of congestion at airports; for example, higher BHPH values imply greater taxiing times and therefore higher airport congestion on the ground.

Finally, *aircraft characteristic* refers to each technical features introduced in Chapter 2, namely, aircraft manufacturers, country of origin, number of crew members, technology level, capacity, range, number of engines, FAA noise stage, and category.

4.3.2 Presentation of Results

The results of the analysis proposed in the previous section are presented in detail in Appendix H. Each table is organized by a given *operation aggregate variable*, expressed in terms of all *aircraft characteristics* pertinent to this thesis, by entity, and by year. For example, Appendix H.1 lists the number of miles flown (***operation aggregate variable***) in terms of aircraft manufacturers, country of origin, number of crew members, technology level, capacity, range, number of engines, FAA noise stage, and category (***aircraft characteristics***), for the domestic market (***entity***), from 1978 to 1990 at two year intervals (***year***).

These tables are prepared for immediate use in the discussion contained in Section 4.3.3. On the other hand, the discussion of Section 4.3.4 makes use of these tables indirectly; this section deals with percentages instead of total volumes. For example, Section 4.3.4.2, which deals with aircraft miles versus technology level, states that 17.5% of all aircraft miles flown on domestic routes were under the Technology Level 1 category, in 1978. This result can be readily obtained by referring to Appendix H.1; LVL1 lists a total number of miles of 271,971; because the total sum of the miles under LVL1, 2, 3, and 4 is 1,557,284, the percentage must be 17.5%.

4.3.3 Discussion: Operation Parameters

The discussion of how airlines have utilized their aircraft fleets is arranged in two parts. The first part of this discussion, contained in Section 4.3.3, deals with changes in the aircraft operation parameters from 1978 to 1990, and its purpose is to provide the reader with an overall picture of how the volume of operations has grown since deregulation was enacted. A detailed study of the variation of total number of aircraft miles flown, block hours, days assigned to service, miles flown per day, block hours per day, and block hours to hours ratio throughout these years is presented. Such study is carried out in a comparative form between the domestic and international markets. Results correspond to the aggregate of the sample airlines. The second part of this discussion, contained in Section 4.3.4, presents the study of aircraft operation parameters versus aircraft technical characteristics.

4.3.3.1 Aircraft Miles

Figure 4.1 depicts the total number of aircraft miles (in thousands) operated by the sample airlines for both domestic and international markets. By simple inspection, it can be inferred that the sample US major airlines have been focusing their operations in the domestic arena. Almost 1,600 billion aircraft miles were flown at the beginning of deregulation in the domestic markets, a figure that has steadily increased to almost 2,700 billion by 1990; only in 1982 was there a slight decline. All in all, this represents an increase of almost 70% in aircraft miles flown domestically over these first ten years of deregulation.

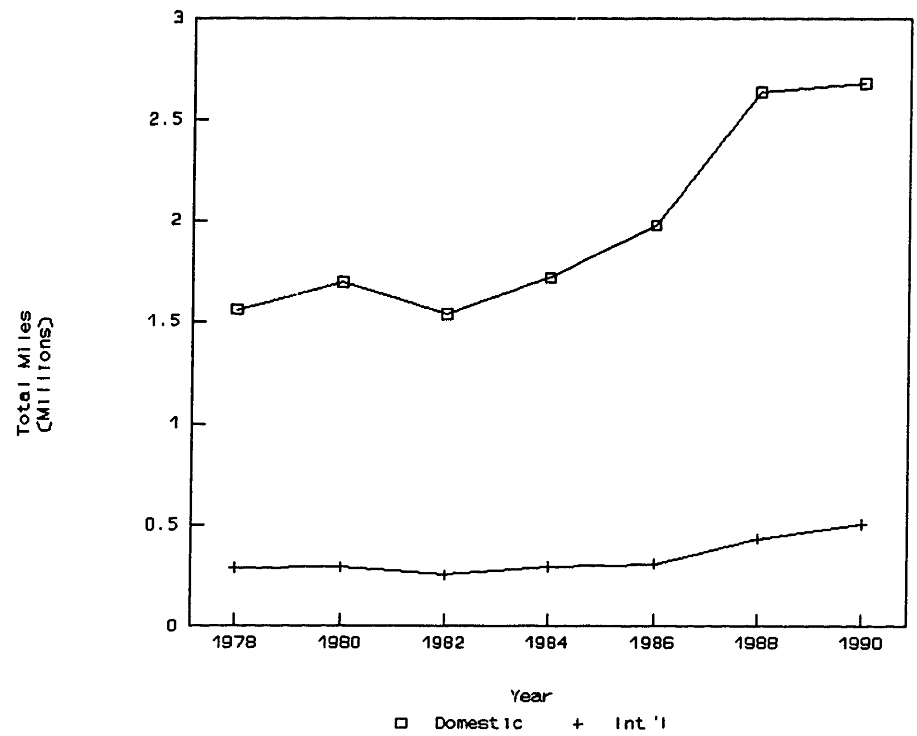

Fig. 4.1: Total Miles in Domestic and International Markets

In the international markets, about 290 billion miles were flown in 1978. Again, with the exception of 1982, this figure has grown steadily to 507 billion miles by 1990, which represents an increase of 75% in total miles flown. Thus it can be concluded that international operations by these US airlines have increased at a greater rate than the domestic operations, in terms of total aircraft miles flown. This is further confirmed by the fact that the percentage of international aircraft miles flown with respect to the total (aggregate of domestic and international aircraft miles flown) was 15.4% in 1978 and has increased to 15.9% in 1990.

The cause for the growth of total miles flown can be attributed to a number of reasons. Perhaps the most critical reason is that there have been very significant mergers in the industry. For example, Frontier was bought by People Express which later became part of Texas Air Corp., a conglomerate made up of EA, Texas International, and CO (after filing for bankruptcy). Western merged with DL, while Republic became part of NW. Ozark was bought by TW, and Allegheny became USAir, which later merged with Piedmont. Therefore, the sample airlines considered in this thesis have become larger through mergers, thereby causing operation expansions which have led to a growth of miles flown.

Another cause of growth was triggered by the expansion of most US major airlines to the international arena, in search of new markets. For example, AA started operations across the Atlantic in 1982, and across the Pacific in 1988. CO started operations in Latin America and Pacific in 1980, and started service across the Atlantic in 1986. DL started operations in the Pacific in 1988. NW started service across the Atlantic in 1980, and UA started services in the Pacific in 1984, and the Atlantic in 1990. Only three carriers have been reluctant to expand: EA tried to start Atlantic operations in 1986 but withdrew the following year. TW has only been active in the Atlantic and Domestic operations; finally, PA actually lost operations in the Pacific, in 1986.

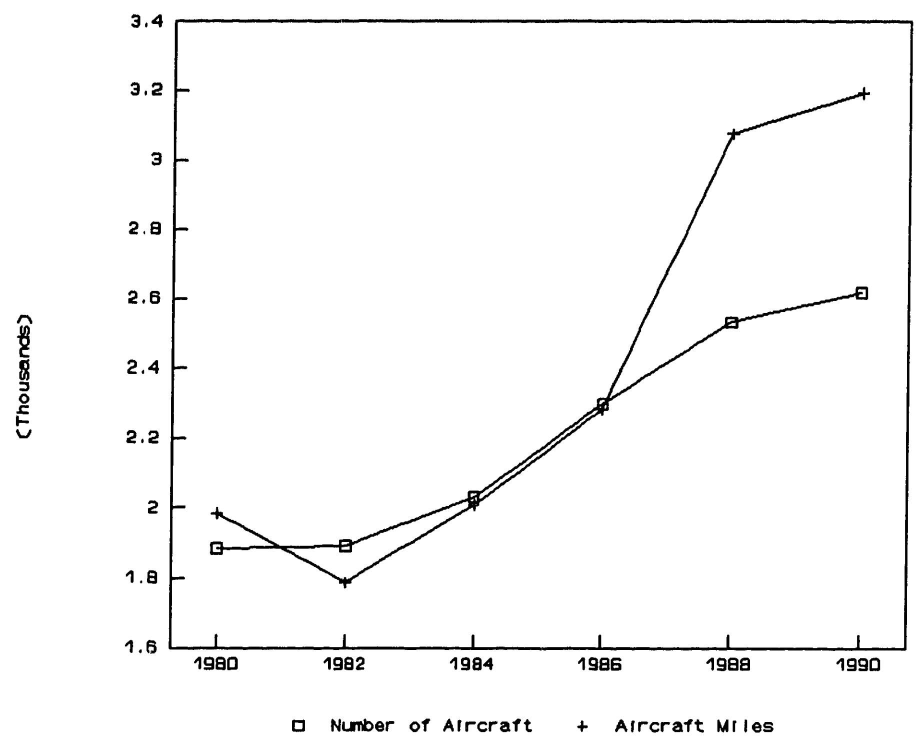

Fig. 4.2: Total Number of Aircraft Versus Total Number of Miles Flown

As discussed in Section 3.3.3, the number of aircraft in the sample has grown from 1,886 in 1980 to 2,618 in 1990 (about a 40% increase). Because the increase on the number of aircraft miles has expanded 70% and 75% in the domestic and international markets, respectively, it can be concluded that airlines are flying their aircraft more miles because airlines are expanding their operations at a greater rate that they are expanding their fleets, particularly in the international markets. Figure 4.2 shows the growth of the total number of aircraft versus the total number of aircraft miles flown. Note that the total number of aircraft miles has been scaled down, after dividing by 10^6. As shown, the greatest growth in the number of aircraft miles occurred from 1986 to 1990.

4.3.3.2 Block Hours

Figure 4.3 depicts the total number of aircraft block hours in the domestic and international markets.

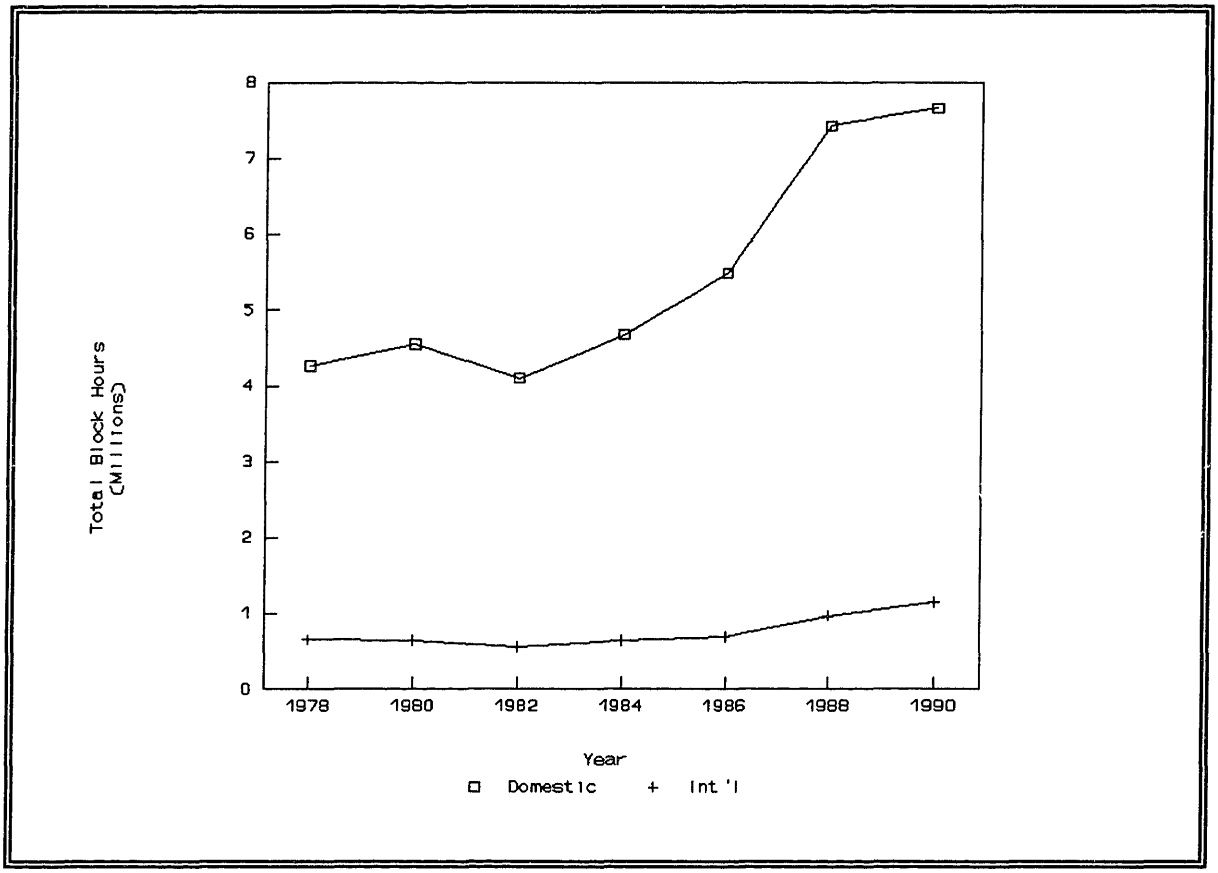

Fig. 4.3: Total Block Hours for Domestic and International Markets

In 1978, aircraft operating in the domestic market logged a total of 4.3 billion block hours, and by 1990 this figure had increased to 7.7 billion, or about an 80% increase. On the other hand, aircraft operating in the international routes logged a total of 659 million block hours in 1978, which increased to 1.15 billion by 1990, a 74% increase.

As previously discussed, the total number of aircraft miles has risen 70% since deregulation in the domestic market. Thus, if the number of aircraft block hours in this entity has risen 80%, this implies that the number of logged block hours is increasing at a greater rate than the number of miles flown. This can be due to two reasons. First, aircraft are scheduled for more cycles per day and therefore the taxiing times, which are part of the block hour equation, become more significant. Second, air traffic congestion may have increased since deregulation; aircraft operating in congested routes have greater block times for the same amount of miles flown, because the latter parameter is computed in terms of absolute distance between the city pairs.

As for the international markets, it was previously found that the total number of aircraft miles flown has increased 75%, whereas the increase in aircraft block hours has been of 74%. Naturally, the same arguments suggested above still apply. However, the change of number of cycles per day is less plausible in the international arena because aircraft assigned to these routes cover much longer legs. Since there is such a little variation between the growth of total aircraft miles flown and total aircraft block hours, it means that aircraft operated in these routes are less susceptible to air traffic congestion. This does not imply that aircraft operating in international routes are flown between airports that are not congested; it only means that, because the flight time in these routes is so much greater than the taxiing times (even when they are operated at congested times), the "congestion" factor is far less critical than for aircraft operated in domestic routes, which typically involve much shorter distances.

4.3.3.3 Assigned Days

Figure 4.4 depicts the total number of assigned aircraft days in both domestic and international markets. In 1978, the total number of aircraft days assigned to service was 475,701 in the domestic market (or 1,303 aircraft assigned to service on average over the year), and by 1990 this figure had risen to almost 800,000 (or 2,192 aircraft assigned to service per year). This represents an increase of 67%.

On the other hand, there were about 71,000 aircraft days assigned to service on international routes in 1978 (or 195 aircraft assigned to service per year), a figure which has grown to just over 101,000 by 1990 (or 277 aircraft assigned to service per year), or a 42% increase. This means that in 1978 airlines assigned 13% of the total number of days to international operations. By 1990 this figure decreased to 11%. This result is a good indication to demonstrate the importance of the domestic market as compared to the international one, for the sample airlines. Not only have the domestic operations been far more extensive than the international ones, but they have proportionally grown at a faster rate as well since deregulation was enacted.

If the total number of aircraft days assigned to service is not increasing as fast as the number of total miles flown, this implies that aircraft must be flying further each day, or that airlines are scheduling aircraft to perform more cycles per day, a situation which would be consistent with the fact that block hours have risen more rapidly than the number of miles

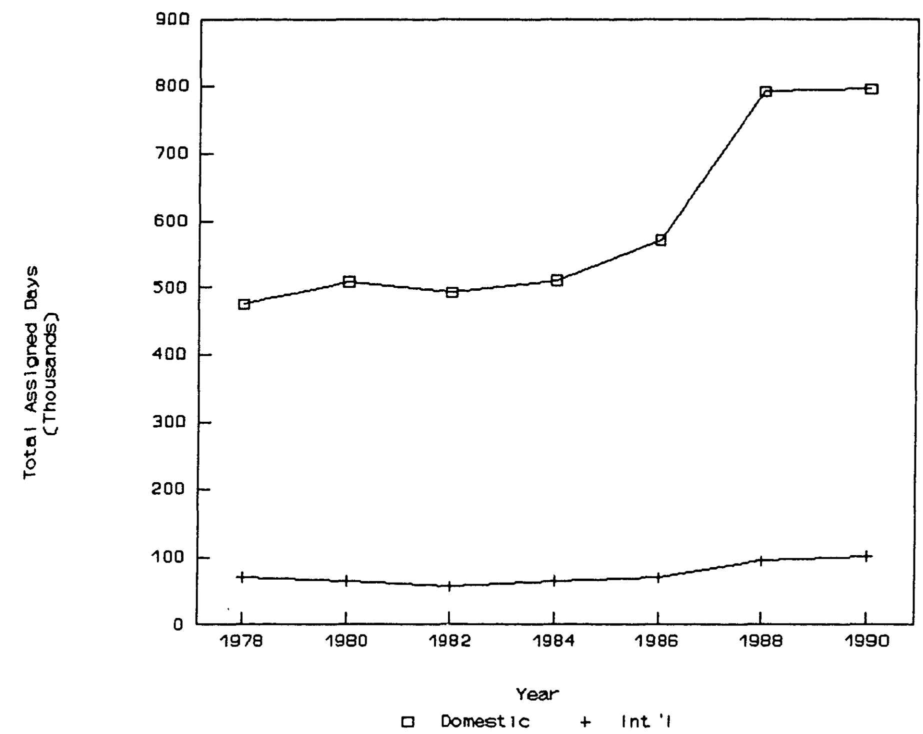

Fig. 4.4: Total Assigned Days for Domestic and International Markets

flown (refer to Section 4.3.3.2). Yet another possibility is that there must be a number of aircraft that are not being used as frequently as they used to but they are flown further when they are scheduled; this situation would apply to older aircraft that are more expensive to fly, particularly on shorter flights.

4.3.3.4 Miles Per Day

The average aircraft miles per day for both domestic and international services is depicted in Figure 4.5.

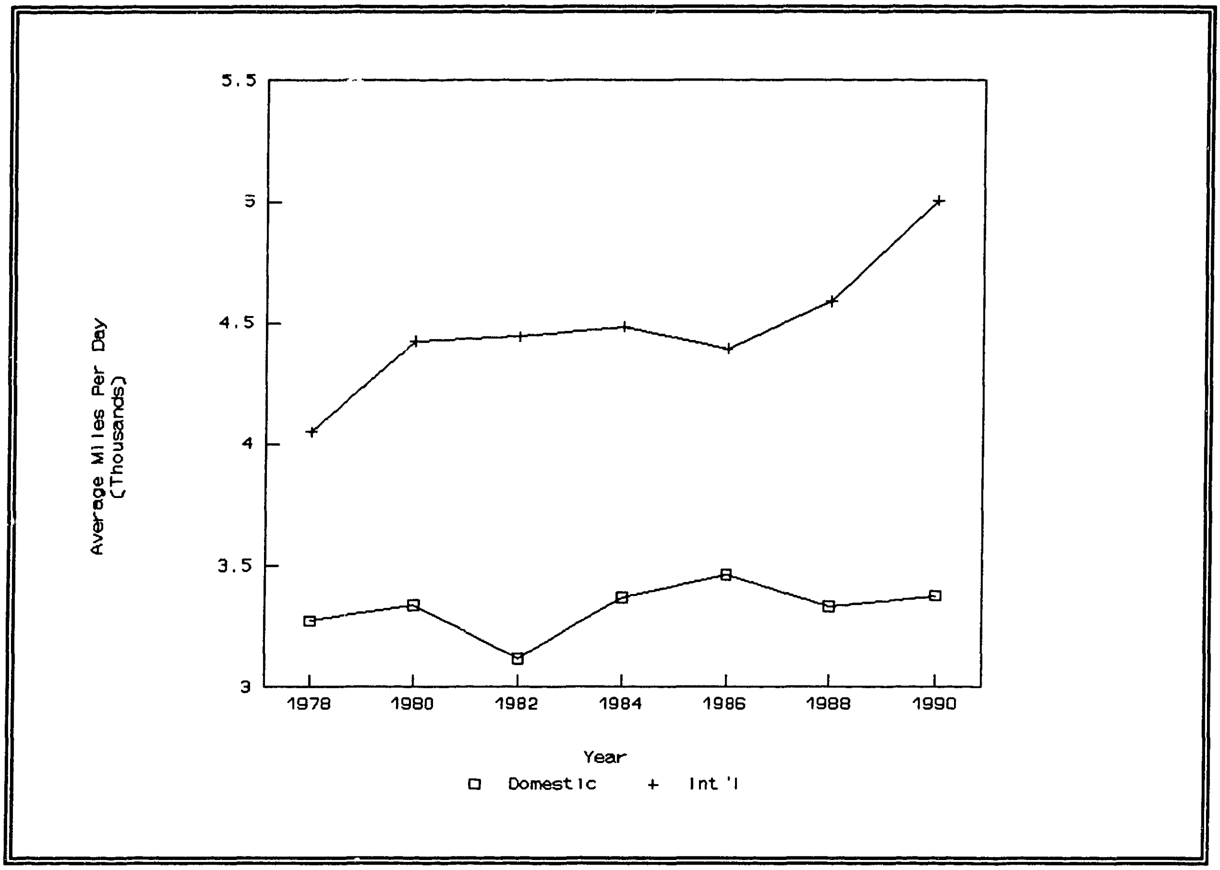

Fig. 4.5: Average Miles Per Day in Domestic and International Markets

As previously discussed, MPD (miles per day) is a function of the total number of miles flown and the total number of a assigned days to service, for a given aircraft type. Therefore, an increase in MPD implies that this aircraft type is flown, on average, further distances per day. Because the total number of miles is not only a function of actual distance but also of frequency, a higher MPD value can also imply an increase of cycles per day, and not necessarily longer routes. Of course, a combination of both is also possible.

From Figure 4.5, there is no clear evidence that aircraft assigned to service in the domestic routes are being flown more miles per day, since deregulation was enacted. The average aircraft miles per day from 1978 to 1990 is 3,325. Earlier in this thesis, it was suggested that a higher growth in block hours with respect to aircraft miles could be due to the fact that aircraft are scheduled for more cycles per day and therefore the taxiing times, become more significant, or that air traffic congestion may have increased since deregulation because aircraft operating in congested routes have greater block times for the same amount of miles flown. But if aircraft are not being flown more miles per day, then it is apparent that congestion must be a greater factor than the increase in the number of cycles.

The international market presents a completely different situation. From a low of 4,050 miles flown per day per aircraft in 1978, this figure has increased to 5,006 miles per day average by 1990. Clearly, aircraft in international operations are being flown to substantially greater distances. This is consistent with the expansion of this airlines to new longer haul markets, particularly in the Pacific routes. It is interesting to note the great increase of miles flown per day in the later years, from 1988 to 1990.

4.3.3.5 Block Hours Per Day

Figure 4.6 depicts the average blocks hours per day, BHPD, in the domestic and international markets. As has been stated, BHPD is a measure of daily aircraft utilization. A high BHPD means that the aircraft type is flown to greater distances or flying to more congested airspaces, or both; in addition, a high BHPD can be due to an increase in congestion of airport ground operations.

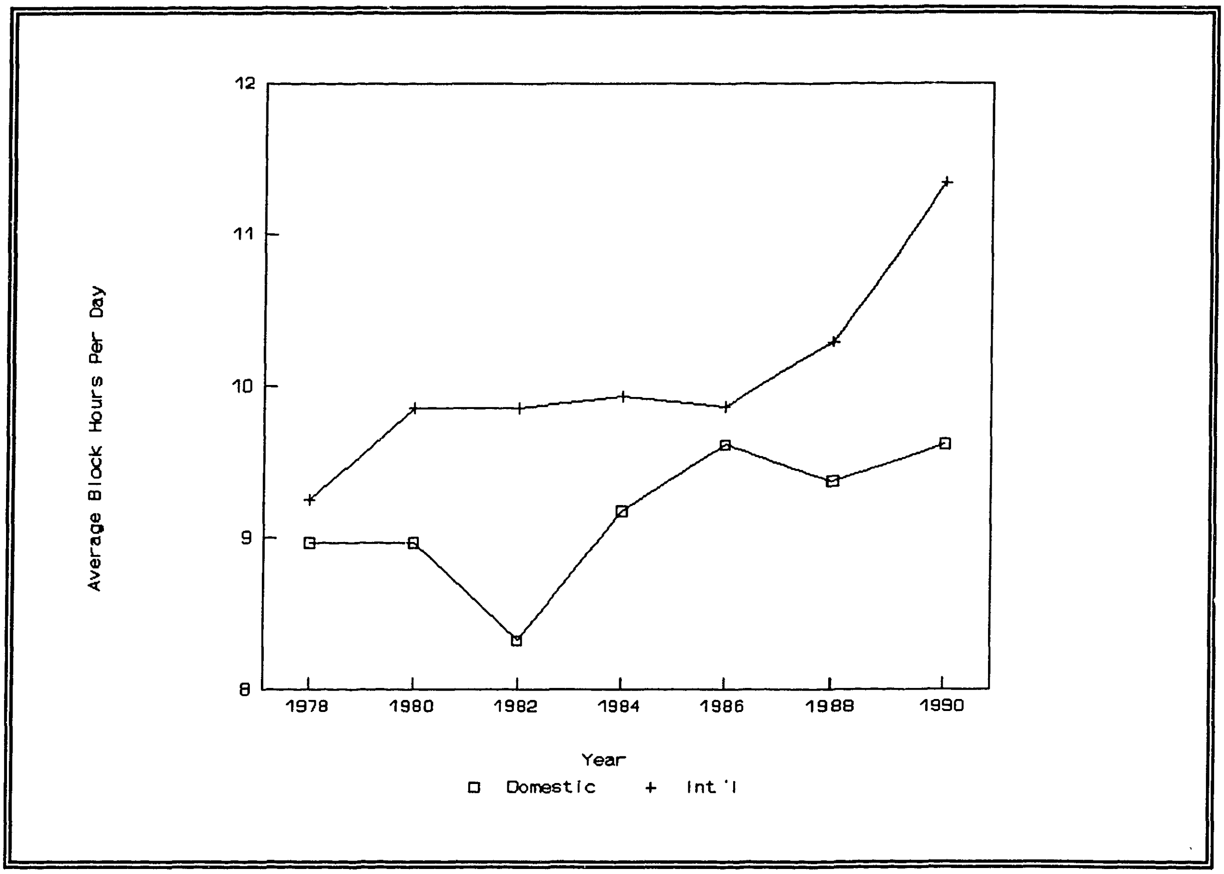

Fig. 4.6: Average Block Hours Per Day Versus Domestic and International Markets

With the exception of 1982, the number of block hours per day has increased in a fairly steady fashion in the domestic markets, from 8.97 in 1978 to 9.63 in 1990. Because aircraft are not flying further per day (refer to previous section), an increase of block hours per day can be due to an increase of air traffic congestion and/or airport congestion, more cycles, shorter stage lengths, or some combination of these factors.

On the other hand, block hours in the international markets have been increasing at an almost identical rate as the number of international miles flown per day. With this, it can be concluded that air traffic congestion and/or airport congestion plays a less important role in the international markets; higher block hours must therefore be attributed mainly to longer routes. This fact is consistent with the findings of the previous section.

4.3.3.6 Aircraft Block Hours to Aircraft Hours Ratio

The block hours to hours ratio, BHPH, is a measure for detecting any variation over time in the level of congestion at airports insofar as ground operations are concerned. Consider Equation 4.6, a modified version of Equation 4.5,

$$BHPH^{l} = \frac{\sum_{i}\sum_{j} BH^{l}}{\sum_{i}\sum_{j} H^{l}} = \frac{\sum_{i}\sum_{j} (H+\alpha)^{l}}{\sum_{i}\sum_{j} H^{l}} \qquad \textbf{(Eqn.4.6)}$$

Clearly, higher BHPH values can only mean greater taxiing times and therefore increased airport congestion on the ground. Alternatively, an increase in this ratio could be due to an increase in cycles per day because there would be more α's (taxiing times) per day to account for. This impact would be particularly noticeable on shorter flights because taxiing times are proportionally greater with respect to total block hours. Naturally, a better method to determine air traffic congestion would have been to include the cycle information. Unfortunately, this information only appears in the last year of the data available in Form 41, Schedule T-2(b).

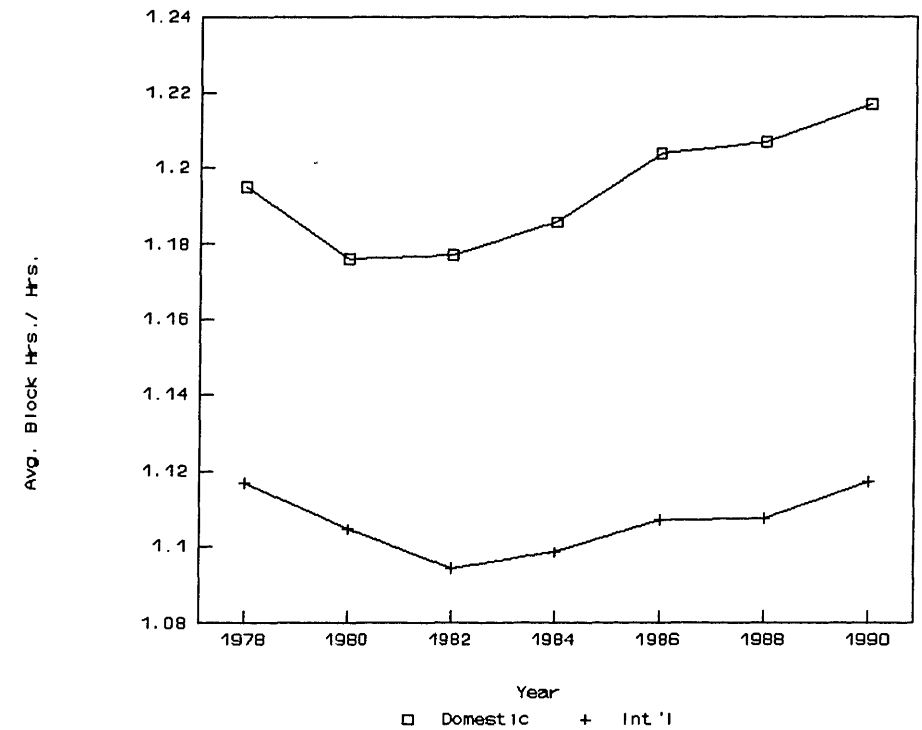

Fig. 4.7: Average Block Hours to Hours Ratio Versus Domestic and International Markets

With these limitations in mind, consider Figure 4.7. Block hours to hours ratio in the domestic markets has steadily increased from a low of 1.18 in 1980 to a high 1.22 in 1990. Note that in 1978, the ratio had a surprisingly high 1.19 value. It has already been speculated that airport congestion may be a factor in the domestic arena. In addition, the number of cycles per day could well have increased since deregulation due to the growth of hub/spoke operations which generally involve more frequent but shorter-haul flights.

On the other hand, the block hours to hours ratio has been fairly constant in the international arena with an average 1.11, from 1978 to 1990. Because it is less conceivable to have an increase of cycles in the international routes, particularly in the longer ones, it can be concluded that congestion is not as serious as factor as it may be in the domestic markets.

4.3.4 Discussion: Aircraft Miles Versus Technical Characteristics

This section includes the second part of the aircraft operation analysis discussion. It deals with the study of the aircraft operation parameters as a function of the technical characteristics of the aircraft. The purpose of this section is to provide insight on how aircraft are operated as a function of their technical features. Questions such as whether there is a correlation between aircraft that are flown further with the number of crew, aircraft technology level, aircraft capacity, aircraft range, number of engines, FAA noise stage, and category are addressed in this section.

This discussion only deals with one operation parameter, namely, *total aircraft miles flown*. It is shown that the study of *block hours* and *assigned days* should yield almost identical results than *total aircraft miles*. This fact is proven by using the statistical procedures introduced in Chapter 2 (and presented below). For this reason, only the discussion of total miles has been included in this thesis and it is hereafter implicitly assumed that similar arguments hold for block hours and assigned days. Much in the same fashion as in the previous discussion, this part is carried out in a comparative form between the domestic and international markets. Again, results correspond to the aggregate of the sample airlines.

A descriptive statistic used to summarize the relationships among the variables of interest in terms of their degree of linearity is called Product-Moment Correlation Coefficient, r, and it is defined by Eqn. 2.1. As previously discussed, the larger the absolute value of r is, the stronger the linear relationship is. A value of $r=1$ or $r=-1$ implies perfect correlation between the two variables. Likewise, r near zero indicates there is no linear relationship between the two variables. The correlation values of total aircraft miles flown with respect to block hours and assigned days to service for the domestic routes have been found to be equal to 0.998 and 0.995, respectively. As for the international routes, the correlation values of total aircraft miles flown with respect to block hours and assigned days to service have been found to be equal to 0.997 and 0.978, respectively. This values have been computed by using all the data values from 1978 to 1990.

In addition to the calculation of the correlation coefficient, it is desirable to find whether there is sufficient evidence as to conclude with reasonable confidence that there exists a significant relationship between the two variables. Consider again the following two hypothesis:

H_0: *no linear relationship exists between x and y*

H_a: *linear relationship exists between x and y*

Then, H_0 is rejected if $|t| > t_{\alpha/2,n-2}$, where t is defined by Eqn. 2.2. This method provides a way to conclude with reasonable confidence that either a positive linear relationship exists between x and y, or that H_0 cannot be rejected and therefore no linear relationship exists between x and y. For the purposes of this analysis, reasonable confidence is defined as a 95% statistical confidence level, or $\alpha=0.05$; note that $n=231$. Therefore, $t_{\alpha/2,n-2}=t_{0.025,229}=2.0$. The values of $|t|$ are 238.9, 150.8, 194.9, and 70.95, respectively. Thus, all four correlations are indeed (very) significant.

4.3.4.1 Number of Crew

Figure 4.8 depicts the percentage distribution of miles flown in terms of the number of crew for the domestic market. Airlines are increasingly operating aircraft with the two-member configuration. At the beginning of deregulation most of the two-crew member aircraft were B737s and DC9s, but this configuration has become standard even for transcontinental aircraft such as the Airbus widebody models, B757, and B767.

The percentage of domestic aircraft miles flown with two-crew aircraft has grown from about 10% in the early years of deregulation to about 54% share in 1990. The trend can only grow, as the B727s are replaced by newer two-crew aircraft of similar capacity and range.

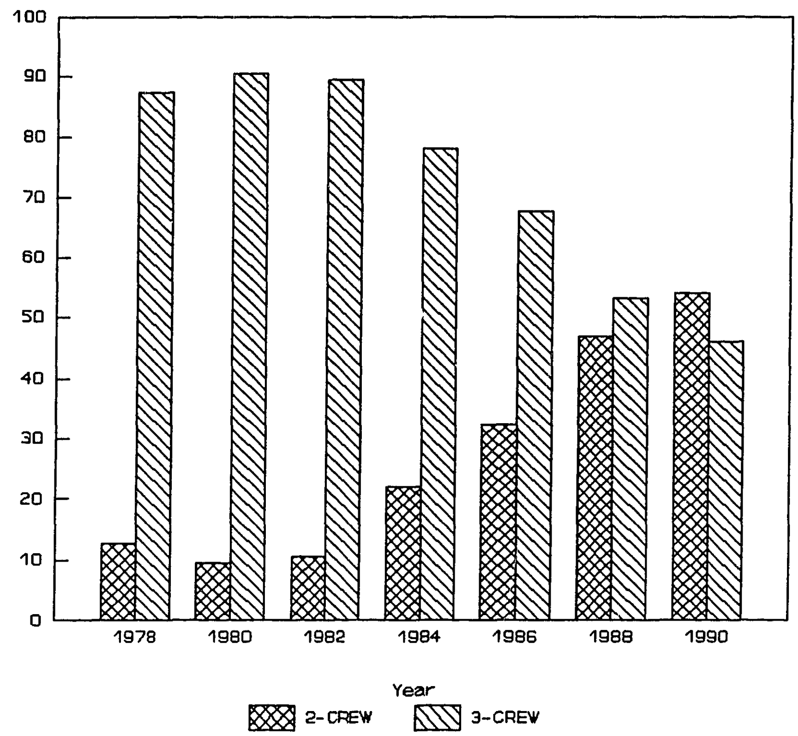

Fig. 4.8: Percentage Distribution of Miles Flown Versus Number of Crew in the Domestic Market

Figure 4.9 shows the same percentage distribution, but for the international market. Again, the appeal of using the two-crew member cockpits is apparent, despite the fact that the transition to this configuration has been notably slower than in the domestic market. At the beginning of deregulation, most of the international routes were flown by the B747s, DC8s, DC10s, and L1011s, all of which have three-crew member configurations. As the Airbus aircraft, B757s and B767s proved their capability to be utilized in the international routes, particularly in those of lower traffic density, airlines found them more economic to operate.

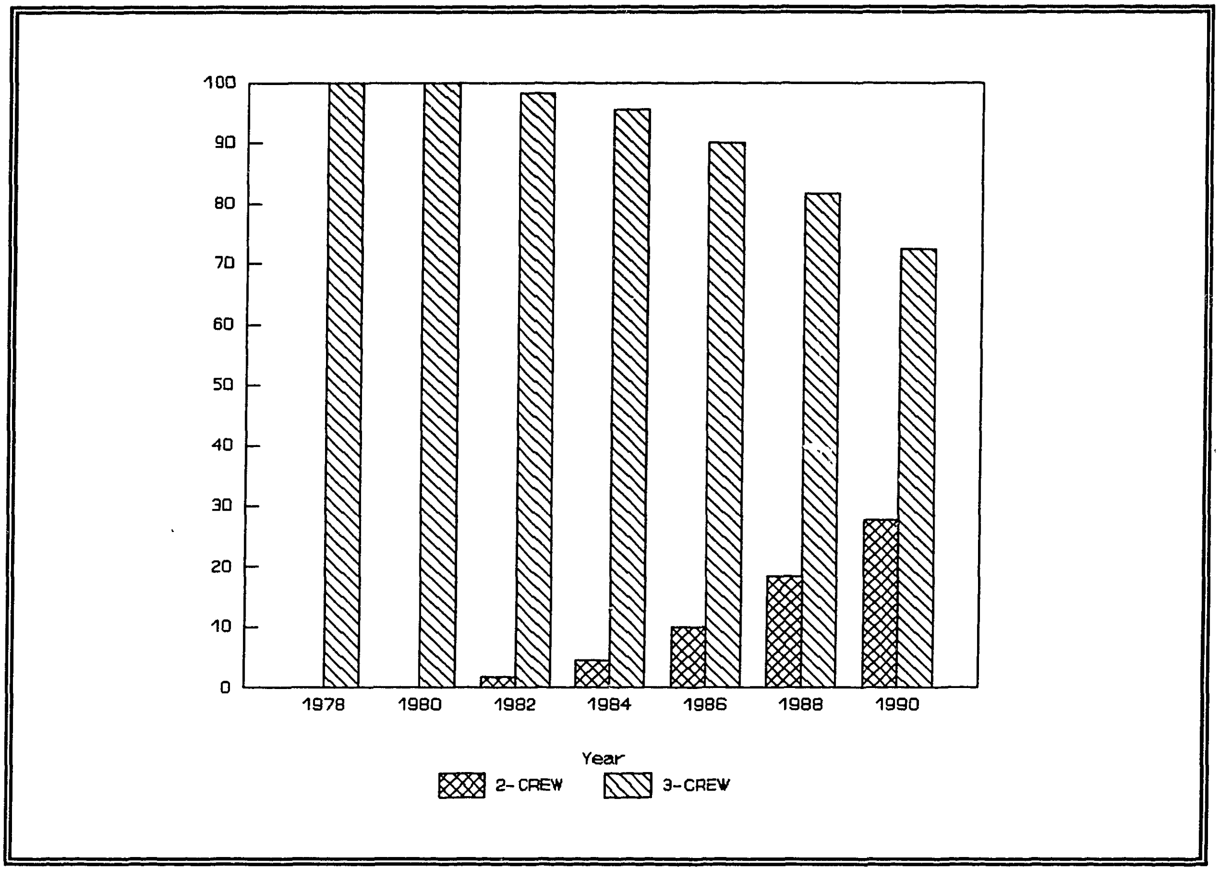

Fig. 4.9: Percentage Distribution of Miles Flown Versus Number of Crew in the International Market

The percentage of two-crew member cockpits operation has risen from a minute 0.2% in 1978 to a high of 28% in 1990 in terms of aircraft miles flown. The trend is obvious and it will increase further because all new aircraft are being manufactured only with the two-crew member configuration, including the larger aircraft such as the B744, MD-11, and A334.

4.3.4.2 Technology Level

The number of miles flown as a function of technology level is depicted in figures 4.10 and 4.11 for the domestic and international markets, respectively.

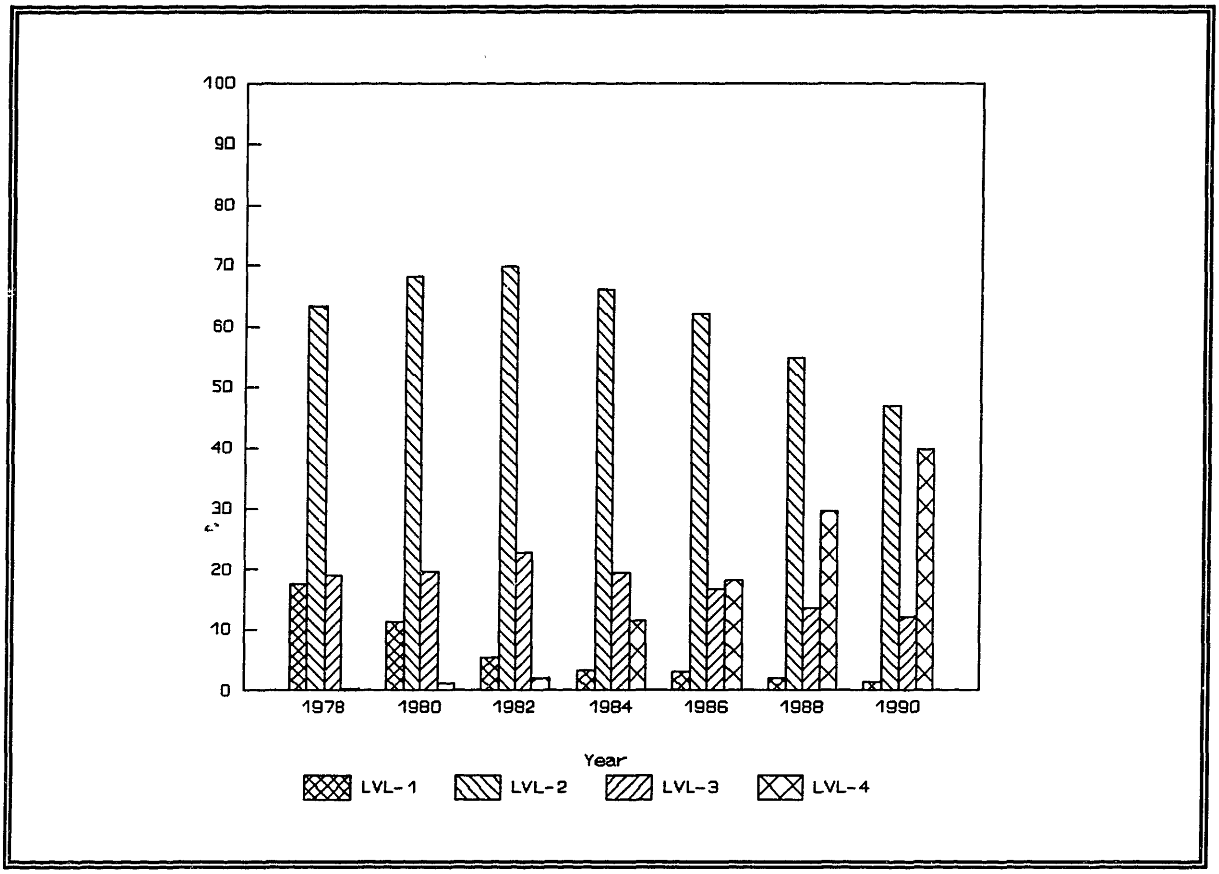

Fig. 4.10: Percentage Distribution of Miles Flown Versus Technology Level in the Domestic Market

There have been a number of changing trends in both markets. In the domestic arena, the near extinction of the Level 1 aircraft is obvious: from a high 17.5% in 1978 to a low 3.0% in 1990. As these aircraft are being phased out, this percentage can only become smaller. Level 2 aircraft have remained the most popular throughout these years, particularly due to the B727. They reached a high 70% in 1982 but have since then decreased their percentage to a low 47%. Level 3 aircraft have had a fairly constant share since deregulation, averaging about 18% of all miles flown in the domestic routes. Level 4 aircraft have undergone the most dramatic percentage change, from a low 0.3% in 1978 to a high 40% in 1990. All percentages are expected to decrease in the future except that of Level 4 because they are the only aircraft currently being manufactured.

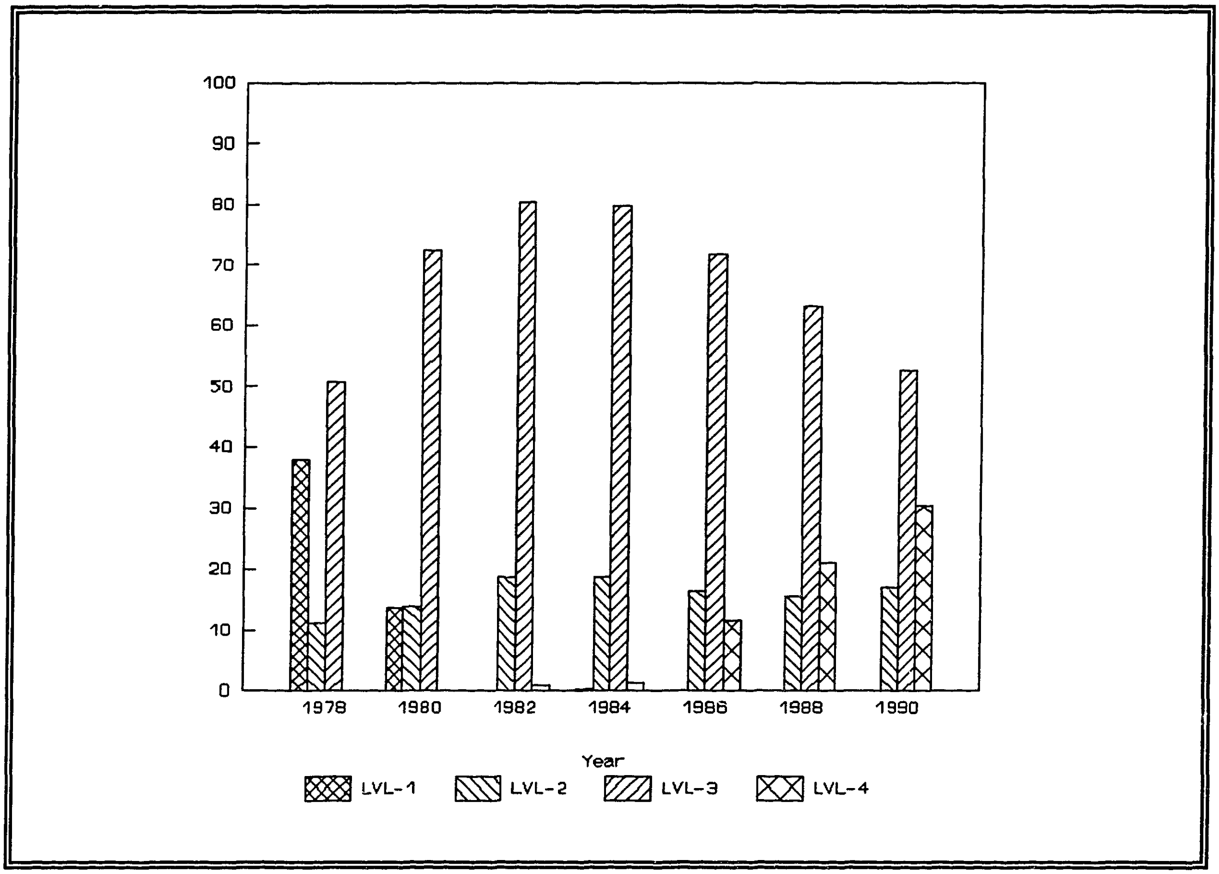

Fig. 4.11: Percentage Distribution of Miles Flown Versus Technology Level in the International Market

As for the international market, similar arguments apply. The difference in this arena is that the popular aircraft used were those in the technology Level 3 category, the B747s, DC10s, and L1011s. Back in 1982, the percentage of miles flown by these aircraft were as high as 80%, but have since then dropped to about 53% in 1990. Level 4 planes already account for 30.3% of the total share of miles flown. Again, this percentage is expected to grow while the rest are expected to decrease.

4.3.4.3 Aircraft Capacity

Figure 4.12 shows the percentage distribution of total miles flown as a function of aircraft capacity, for the domestic market.

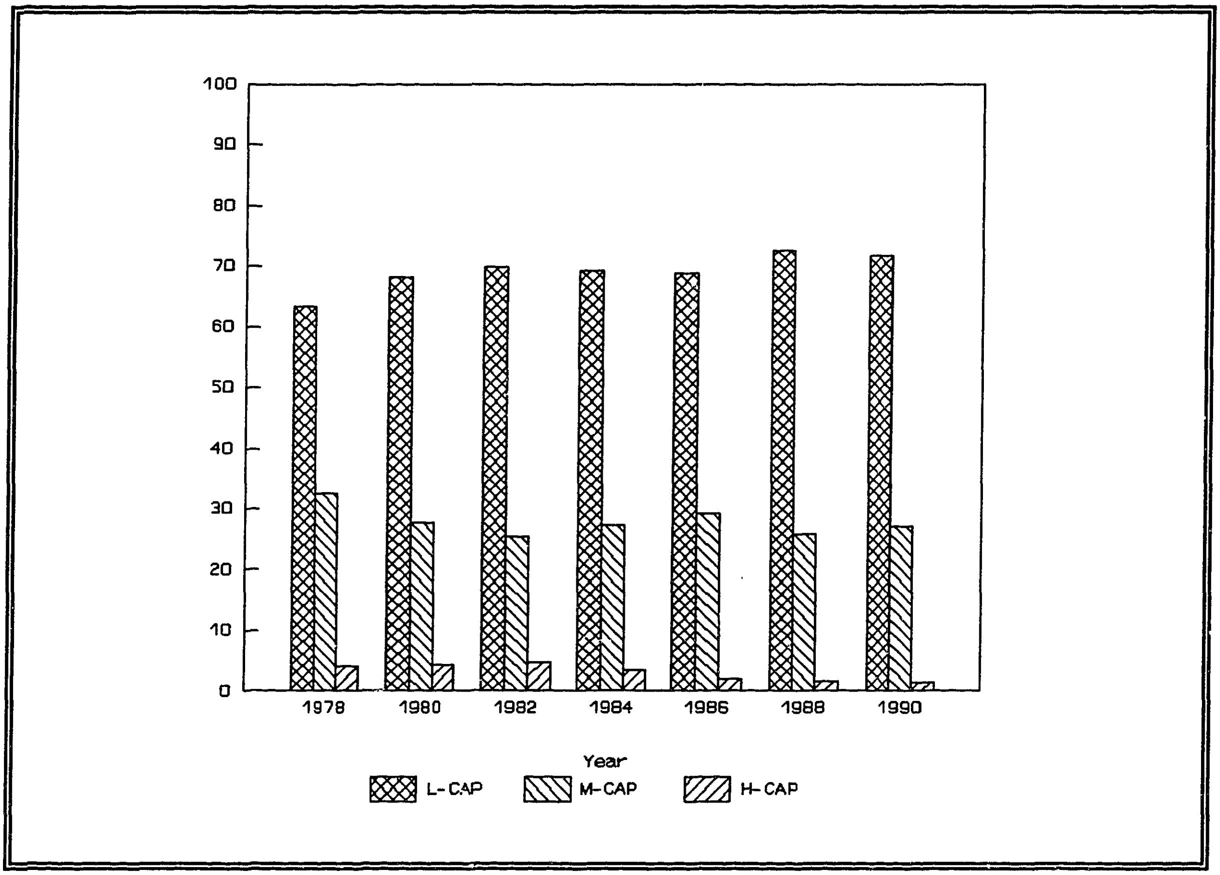

Fig. 4.12: Percentage Distribution of Miles Flown Versus Aircraft Capacity in the Domestic Market

The low capacity aircraft have had the largest share, averaging almost 70% of all miles flown, and this share has increased slightly in recent years. The medium capacity aircraft have had an average 28% share, and the high capacity aircraft about 2%. Overall, there appears to be a trend towards the increased usage of low capacity aircraft. For instance, medium capacity aircraft had a 33% share in 1978 which decreased to 27% in 1990; likewise, high capacity aircraft share decreased from 4.2% in 1978 to 1.3% in 1990.

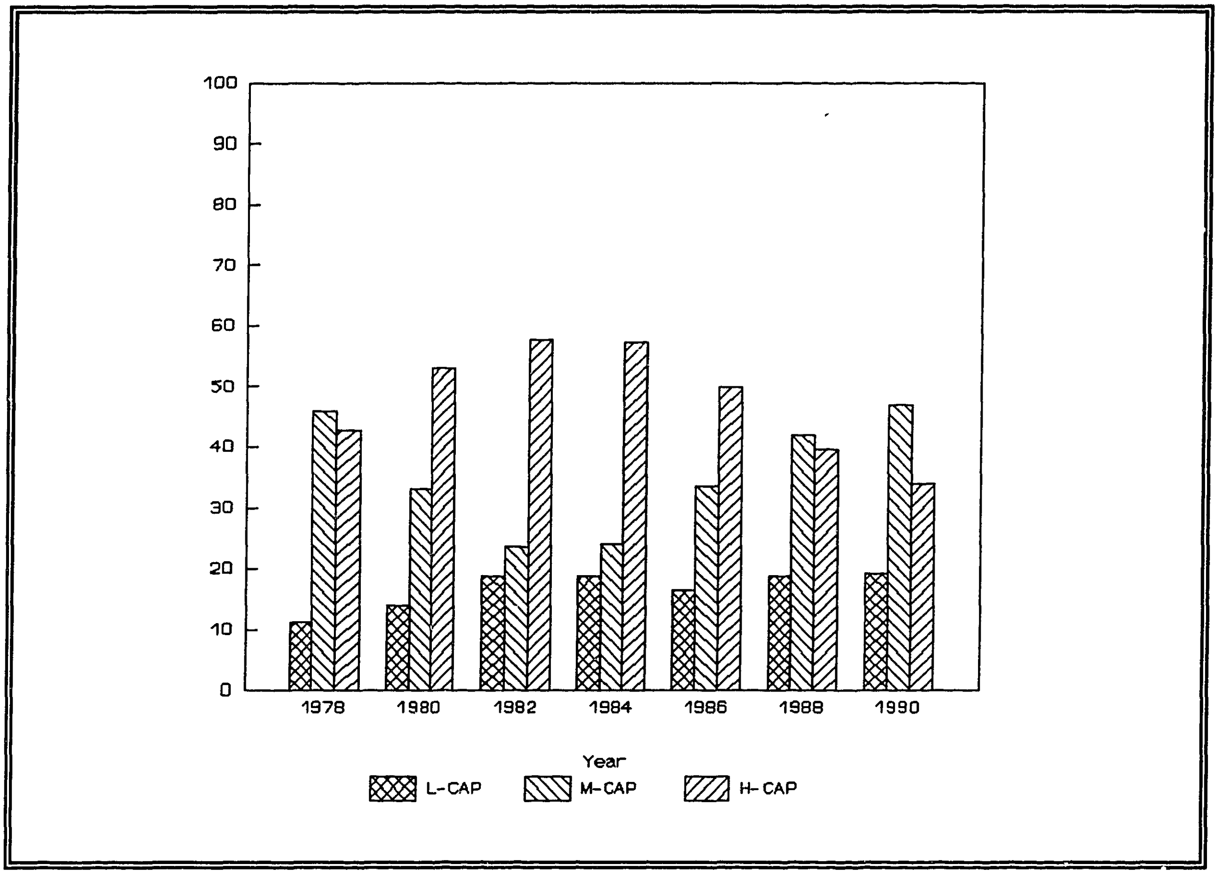

Fig. 4.13: Percentage Distribution of Miles Flown Versus Aircraft Capacity in the International Market

Figure 4.13 depicts the same variables, but for the international market. Low capacity appears to have been increasingly popular since deregulation. From a low of 11.2% in 1978, this figure has risen to a high 19.3% in 1990. The medium capacity aircraft show a less obvious pattern; from a high 46% in 1978, this figure dropped to a low 24% in 1982 but has since then grown back to a high 47% in 1990. High capacity aircraft have had the highest share in miles flown internationally, for most of the time since deregulation; however, the results seem to indicate that this trend is changing. From a high of almost 58%, achieved in 1982, this percentage has dropped to a low of 34% in 1990. This is due to the increasing popularity of the B757 and B767 in the international arena.

4.3.4.4 Aircraft Range

Figure 4.14 depicts the percentage of number of miles flown as a function of aircraft range, for the domestic market. Short range aircraft are, by far, the most popular. In fact this percentage has increased from a low of 63% in 1978 to a high 73% in 1988. The medium range aircraft configuration has also experienced a percentage increase from a low 15% to a high 26% in 1990. On the other hand, long range aircraft have been losing their share from a high 22% at the beginning of deregulation to a low 3% in 1990. This is due to the increasing removal of the then popular B707s and DC8s, which were formerly utilized in transcontinental routes. Nowadays, these routes are increasingly operated with Airbus, B757s, and B767s.

Figure 4.15 shows the same parameters, but for the international market. The short range aircraft have had an increasingly important role since deregulation. From a low 11% in 1978, this figure has been raised to a high 19% in 1990. More flights to Canada, the

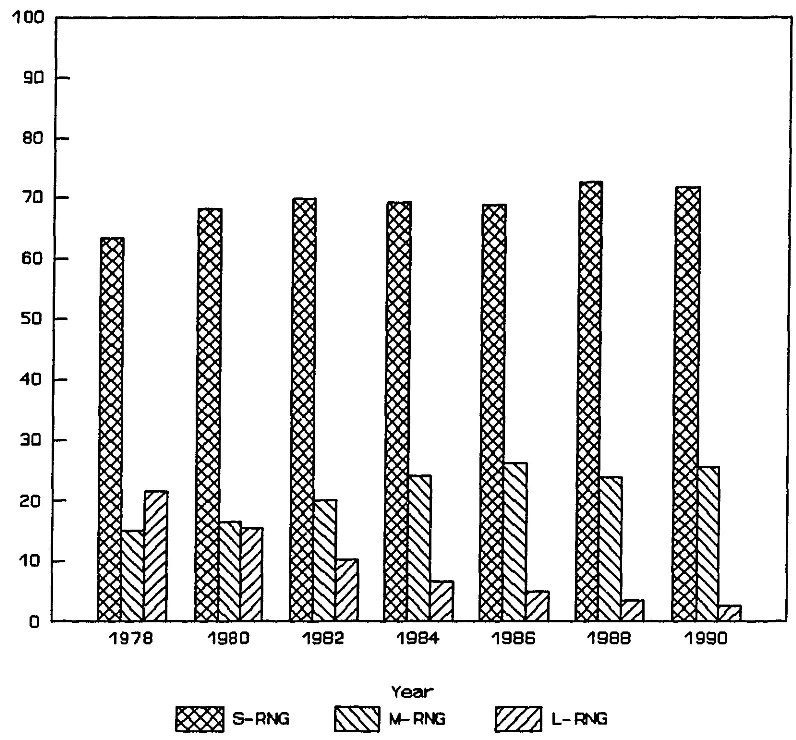

Fig. 4.14: Percentage Distribution of Miles Flown Versus Aircraft Range in the Domestic Market

Caribbean, and Mexico have triggered such increase. Medium range aircraft have also gained a substantial share in the total number of miles flown. As seen on the graph, the 8% figure has increased to 47% in 1990. This is due to the fact that Atlantic flights are increasingly being flown by the Airbus 300/310 and B767 aircraft types.

The greatest percentage change has been for the long range aircraft, which have undergone a dramatic decrease from 81% share in 1978 to 34% in 1990. Most of the aircraft used internationally were DC8s and B707s at the beginning of deregulation. As these aircraft started to be phased out, the percentage share of miles flown decreased.

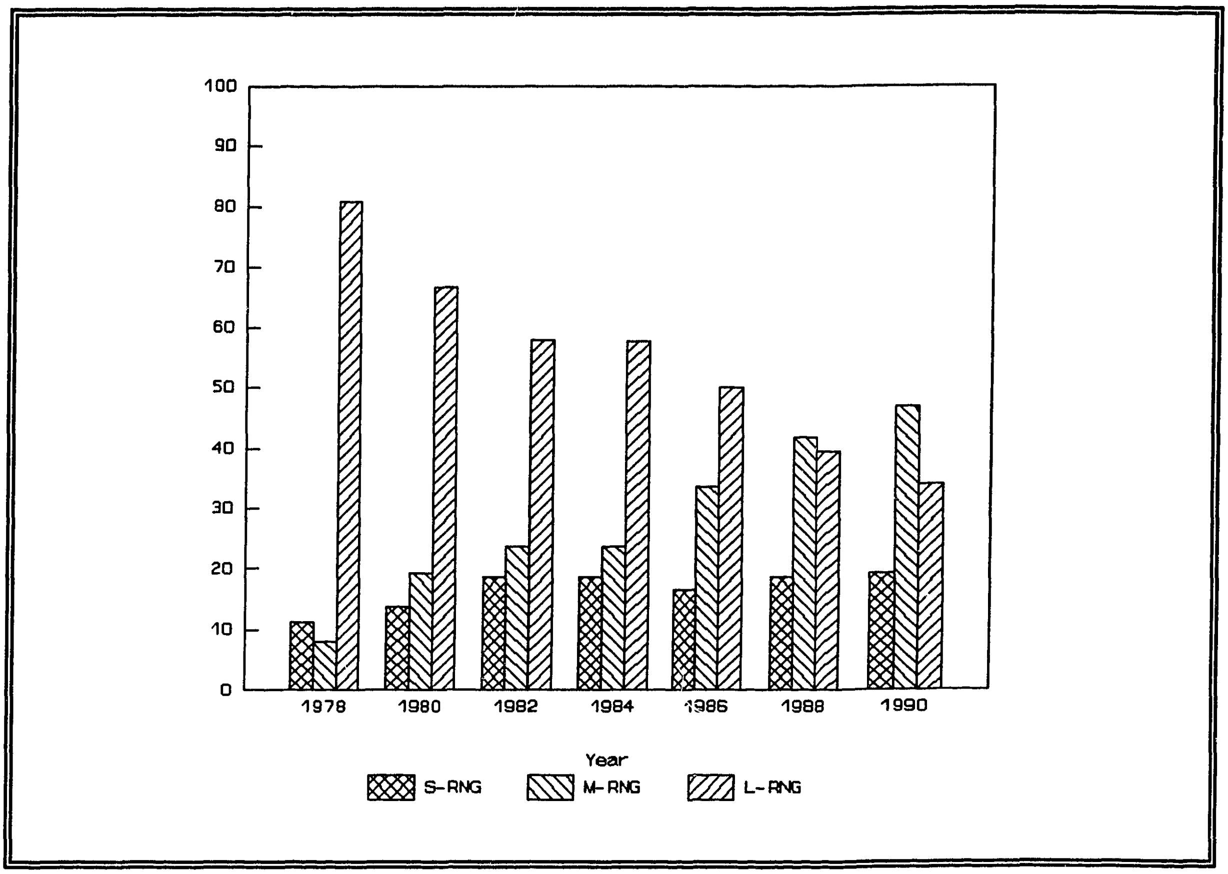

Fig. 4.15: Percentage Distribution of Miles Flown Versus Aircraft Range in the International Market

4.3.4.5 Number of Engines

Figure 4.16 depicts the percentage share of the total miles flown versus the number of engines for aircraft operated in the domestic market.

The share for the two-engine configuration has risen from a low 13% at the beginning

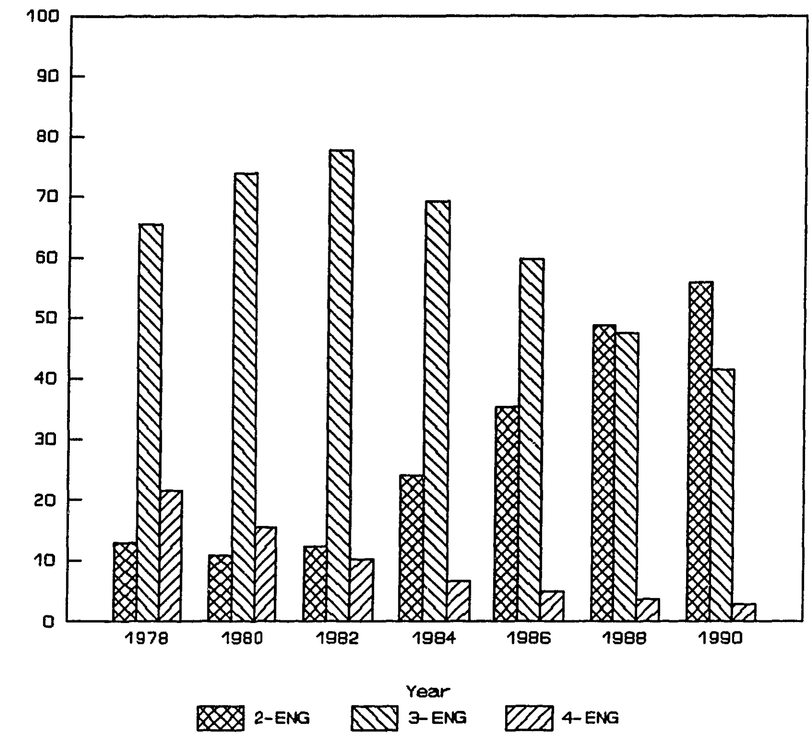

Fig. 4.16: Percentage Distribution of Miles Flown Versus Number of Engines in the Domestic Market

of deregulation to a high 56% in 1990. In fact, its share became greater than the popular three-engine configuration by 1988. The three-engine aircraft representation has dropped from a peak 78% in 1982, to a low 41% in 1990. This decrease is due to the aging B727. With no foreseeable three-engine aircraft to replace the B727, this percentage is expected to decrease even further in the nearby future, for the more economically sound two-engine aircraft. Not surprisingly, the four-engine configuration has also become less popular in domestic operations, and its representation has been decreasing ever since deregulation was enacted. From a high of 22% in 1978, this percentage has decreased to a low of 3% in 1990.

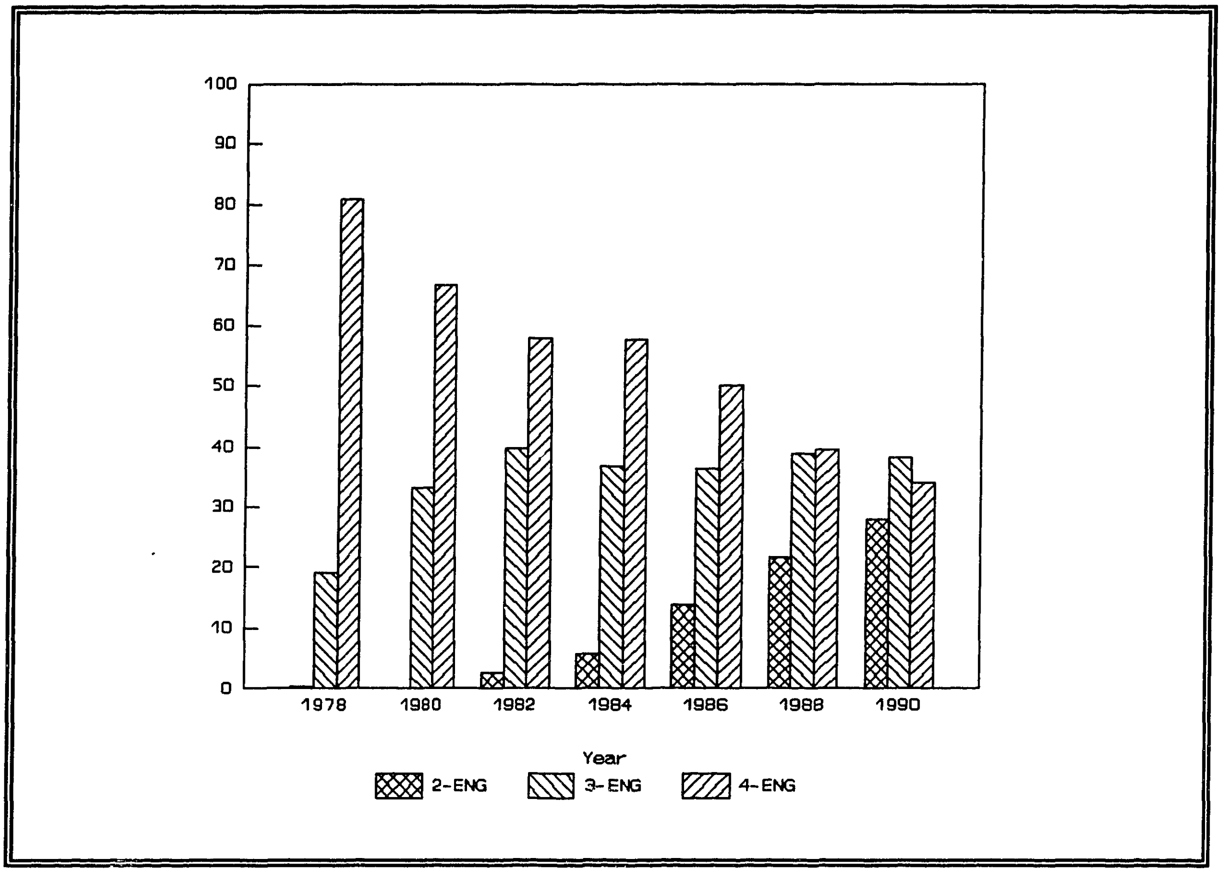

Fig. 4.17: Percentage Distribution of Miles Flown Versus Number of Engines in the International Market

Figure 4.17 depicts the percentage share of aircraft miles by number of engines for the international market. The two-engine share has increased dramatically, from a 0.2% in 1978 to a high 28% in 1990. Again, this is due to the increasingly popular A310, B757 and B767 aircraft. The four-engine configuration has lost a substantial share, from about 81% in 1978 to a low 34% in 1990. Overall, airlines prefer the usage of aircraft with fewer number of engines regardless of the market.

4.3.4.6 FAA Noise Stage

Figure 4.18 shows the percentage share of the total miles flown as a function of the FAA noise stage for the domestic market.

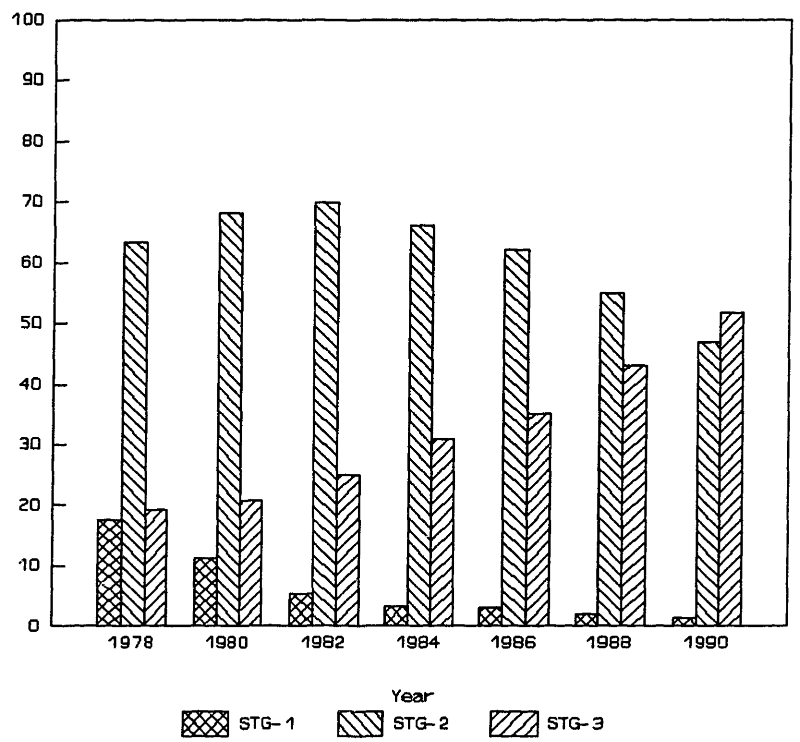

Fig. 4.18: Percentage Distribution of Miles Flown Versus FAA Noise Stage in the Domestic Market

Stage 1 aircraft share has been decreasing ever since deregulation was enacted. From a 17.5% share in 1978, this figure has decreased to a low 1.4% in 1990. In fact, no aircraft flies today under Stage 1 regulations and this remaining percentage corresponds to those aircraft that were re-engined to meet the FAA noise Stage 2 regulations. As for the Stage 2 aircraft, its percentage has also been decreasing ever since it reached its peak of 70% in

1982 to a low of 47% in 1990. Stage 3 aircraft have increased their share from a low 19% at the beginning of deregulation to a high of 52% in 1990. This figure can only increase in the future, as all newer aircraft meet the requirements for the FAA noise stage 3, partly dictated by new aviation policies regarding noise pollution.

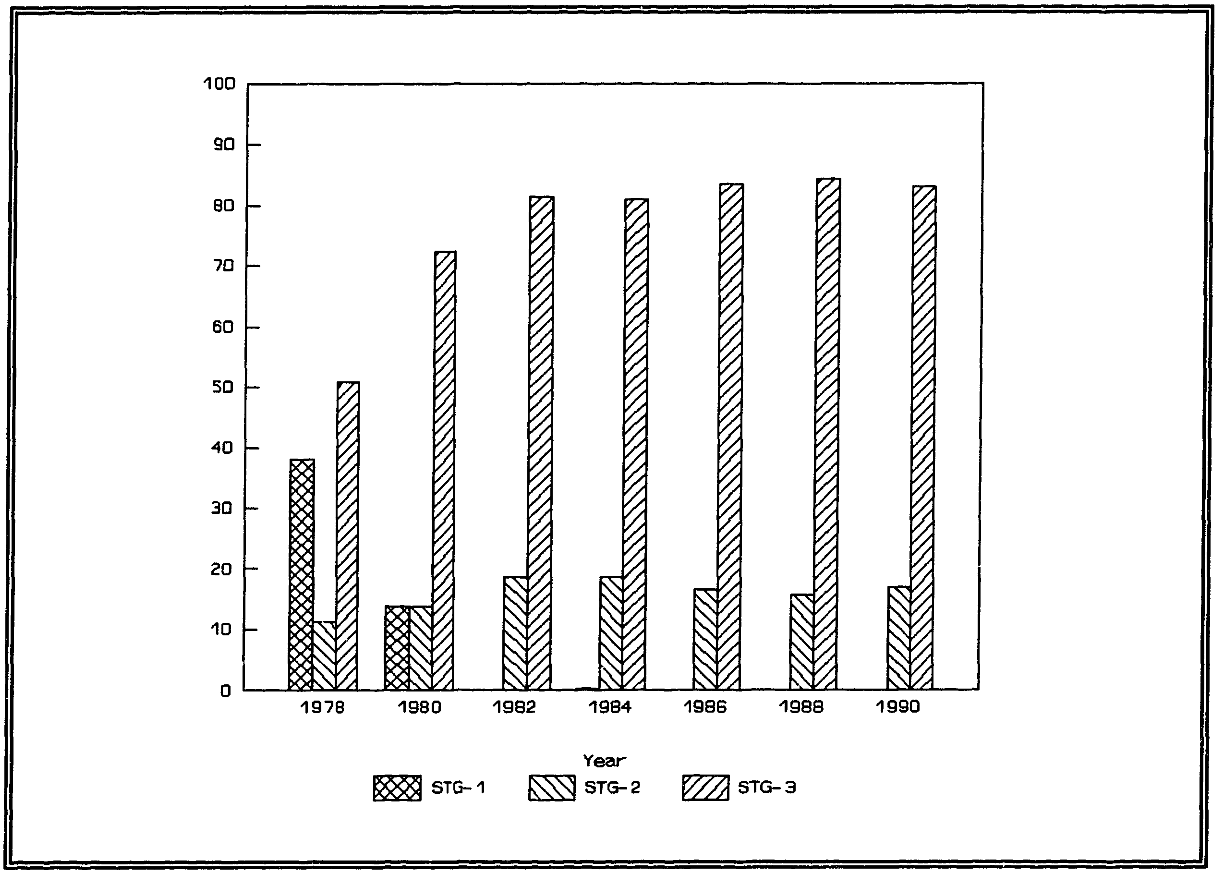

Fig. 4.19: Percentage Distribution of Miles Flown Versus FAA Noise Stage in the International Market

Figure 4.19 depicts the percentage distribution by noise stage, but for the international market. Stage 1 aircraft were only present during the first years of deregulation. From a 38% share in 1978 it decreased to virtually 0% in 1982. Stage 2 aircraft representation has remained fairly constant throughout these years, with an average of 16%. The most popular configuration for international routes has been the Stage 3 aircraft. From a 51% in 1978, this percentage has been increasing to a 83% in 1990. As with the domestic markets, this category is expected to grow in the future because aircraft listed under Stage 1 or 2 are no longer in production, and are starting to be phased out.

4.3.4.7 Category

Figure 4.20 depicts the percentage of total miles flown versus aircraft category for the domestic markets.

The 1ML category representation has been decreasing since deregulation, from a high 38% in 1978 to 1% in 1990. The 2LS category percentage has also been decreasing after peaking 70% in 1982; nevertheless, with a low 47% share in the total miles flown, it remains the most popular category of aircraft, still primarily represented by the B727 aircraft. While the 3MM category shows a tendency to reduce its representation, it still has averaged about 14% throughout these years. On the other hand, the 3HL representation has been decreasing since 1978, from a 4.2% to 1.3% in 1990. The 4LS category has become the substitute for the 2LS category, and it shows a dramatic growth from 0% in 1982 to a high of 25% in 1990; together with the 2LS configuration, their total share of miles flown is almost 72%, thereby confirming the popularity of the low capacity/short range aircraft. The 4MM category has also increased its share, from a low 0.3% in 1978, to a high 15% in 1990. The 4HL category representation is negligible as compared to the other categories.

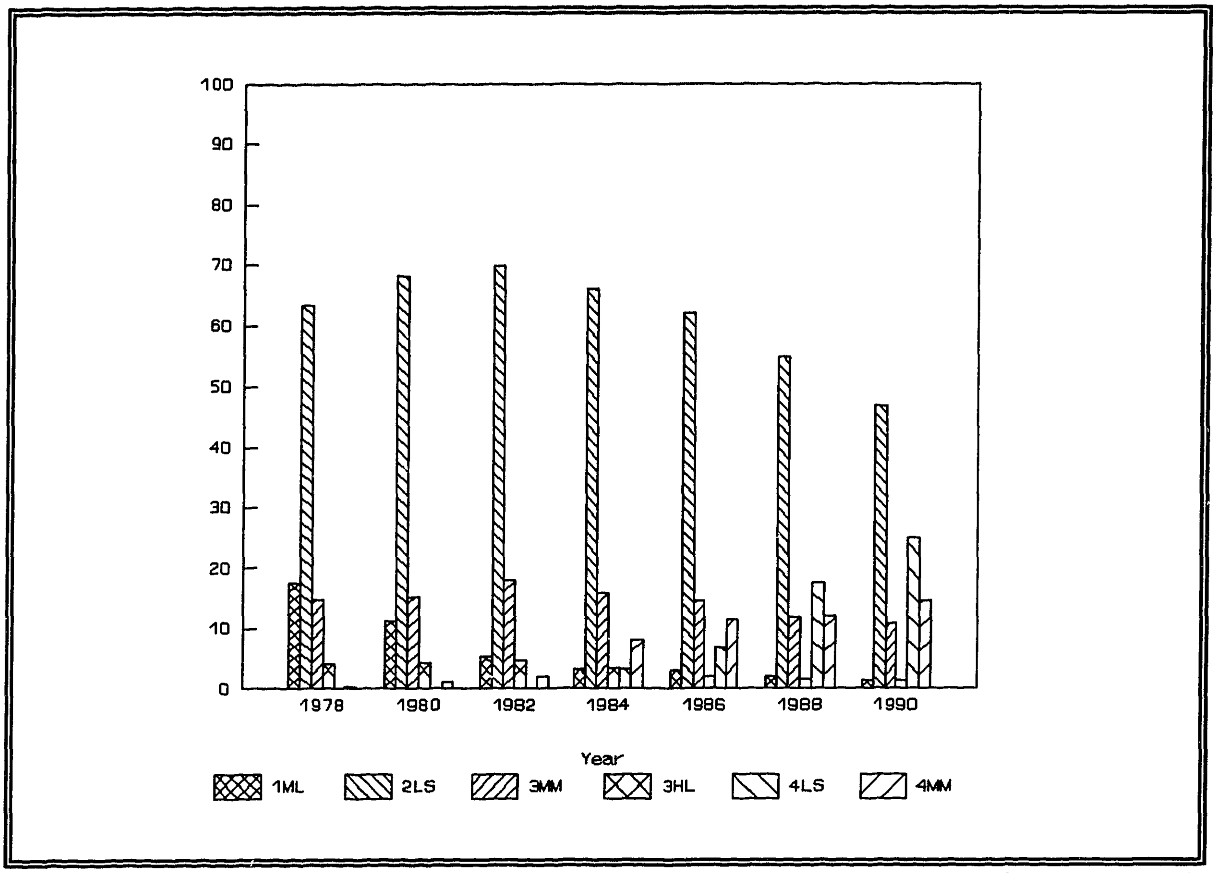

Fig. 4.20: Percentage Distribution of Miles Flown Versus Aircraft Category in the Domestic Market

Figure 4.21 shows the percentage for the international market. Again, the 1ML representation has decreased dramatically, from 38% in 1978 to 0% in 1982. The 2LS category has had an increasing share trend throughout these years, from an 11% in 1978 to a 17% in 1990. Even though the representation of the 3MM category aircraft was only 8% at the beginning of deregulation, it has maintained a fairly uniform share since then of about 22%. The largest share for international routes corresponds to those aircraft under the 3HL category; they have consistently averaged the largest representation, even though the trend indicates an overall decrease of their usage, from a high 58% in 1982 to a low 31% in 1990. The 4LS category aircraft has not been significant, with an overall average of 2% since

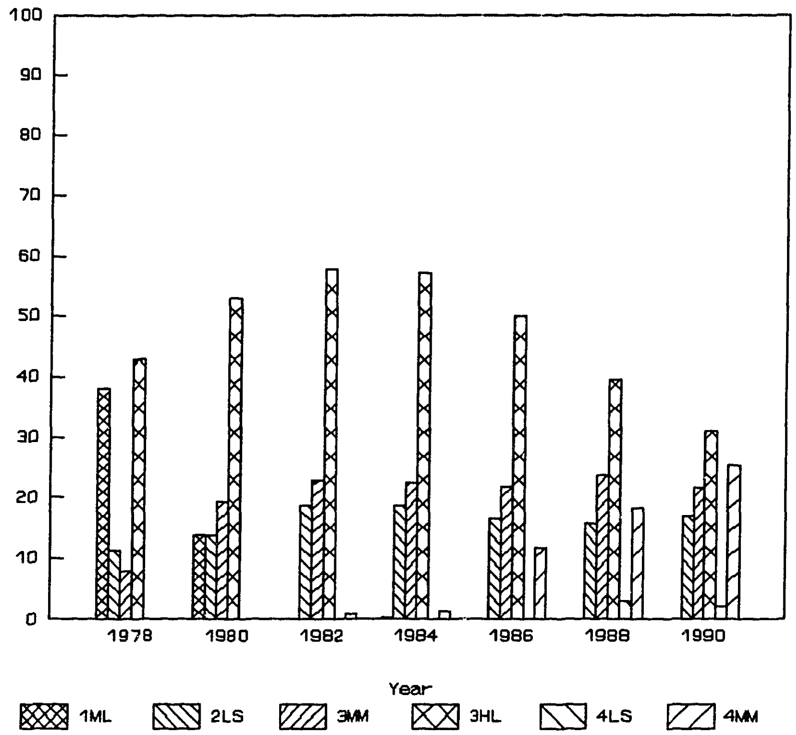

Fig. 4.21: Percentage Distribution of Miles Flown Versus Aircraft Category in the International Market

1988. Yet, the 4MM category has experienced an increase from a 0.1% in 1978 to a high 25.3% in 1990. Again, the 4HL category representation is negligible.

4.4 Conclusion

This fourth chapter has dealt with how the sample airlines have utilized their aircraft fleets. The study was carried out in a comparative form between the domestic and international markets. Results correspond to the aggregate operation of the sample airlines.

The sample US major airlines have been focusing their operations mostly in the domestic arena, with 84.6% share of the total miles flown at the beginning of deregulation in 1978 and down to 84.1% by 1990. In this market, the number of miles flown has grown almost 70% since deregulation. Operations in the international arena have increased even more, about 75%. The cause for the growth of miles flown can be attributed to mergers, and the expansion of most US major airlines to the international arena, in search of new markets. Because aircraft fleets have grown about 40%, it can be concluded that airlines are flying their aircraft a greater number of miles per day.

There has been a parallel increase in block hours, of 80% in the domestic markets and 74% in the international ones. Because the total number of miles figure has risen to 70% and the number of block hours figure has risen to 80%, it can be concluded that aircraft are scheduled for more cycles per day and/or that air traffic congestion has been increasing since deregulation. For the domestic arena, it is quite possible that both arguments apply. As for the international markets, the total miles flown increase of 75% together with a 74% increase in block hours can only mean that aircraft operated in these routes are less susceptible to air traffic congestion, and that the number of cycles has remained relatively stable.

The number of aircraft assigned days to service has increased 67% since deregulation for the domestic markets, and 42% to the international ones. This is a good parameter to demonstrate the importance of the domestic market as compared to the international one. Not only have the domestic operations been far more extensive than the international routes, but they have proportionally grown larger as well.

With an average 3,325 miles flown per day per aircraft operating in domestic markets, since deregulation was enacted, there is no clear evidence that aircraft are being flown more miles per day. However, the international market presents a completely different situation. With a low of 4,050 miles flown per day per aircraft, it has reached to a 5,006 miles per day average by 1990. Thus, aircraft in international operations are being flown to substantially greater distances. This is consistent with the expansion of this airlines, particularly in the Pacific routes.

With the exception of 1982, the number of block hours per day has increased steadily in the domestic markets, from 8.97 in 1978 to 9.63 in 1990. Because aircraft are not being flown further in this arena, it can only mean that this is due to increasing air traffic congestion and/or more scheduled cycles. On the other hand, block hours in the international markets have been increasing at an almost identical rate than the number of miles flown per day. With this, it can be concluded that there is little air traffic congestion in the international markets.

The block hours to hours ratio has steadily increased from a low 1.18 in 1980 to a high 1.22 in 1990. This can be due to an increase of cycles per day and/or increase in airport traffic congestion. On the other hand, this ratio has been fairly constant in the international arena, since deregulation, with an average 1.11. Because it is less conceivable to have an increase of cycles in the international routes, particularly, the longer ones, it can be concluded that congestion is not as serious as factor as in the domestic markets.

The study of miles flown versus the number of crew members suggests that airlines are increasingly operating aircraft with the two-member configuration in both domestic and international markets. This configuration has grown from about 10% of domestic aircraft miles in the early years of deregulation to about 54%, and from 0.2% to 28% for international services. This trend can only grow because all new aircraft are being manufactured only with the two-crew member configuration.

The study of number of miles flown as a function of technology level has unveiled a number of changing trends of aircraft operation in both markets, as well. In the domestic arena, Level 1 aircraft are no longer operational. Level 2 aircraft have remained the most popular option throughout these years, from a high 70% in 1982 which has steadily declined to 47%. Level 3 aircraft have had a fairly constant share since deregulation, averaging about 18% of all miles flown. Level 4 aircraft have undergone the most dramatic percentage change, from a low 0.3% in 1978 to a high 40% in 1990. As for the international market, similar arguments apply. The difference in this arena is that the popular aircraft used were those in the technology Level 3 category; while still the most used aircraft, the Level 4 planes have accounted for 30.3% of the total share of miles flown. All percentages are expected to decrease in the future except that of Level 4 because they are the only aircraft currently being manufactured.

The study of aircraft capacity suggests that there have not been major changes in the domestic arena. The low capacity aircraft have had the largest share, averaging almost 70% of all miles flown. The medium capacity aircraft have had a 28% share, and the high capacity aircraft about 2%. However there appears to be a trend towards the increase usage of low capacity aircraft. As for the international markets, low capacity appears to have been increasingly popular since deregulation from 11.2% to 19.3%. The medium capacity aircraft show a less obvious pattern; from a high 46% in 1978, this figure dropped to a low 24% in 1982 but has since then grow back to a high 47% in 1990. Due to the increasing popularity of the B757, and B767, high capacity aircraft, which have had the highest share in miles flown for most of the time since deregulation, have undergone a percentage change of a high of almost 58% in 1982 to a low 34% in 1990.

Short range aircraft are, by far, the most popular configuration in the domestic arena; in fact their share of domestic aircraft miles increased from a low 63% in 1978 to a high 73% in 1988. The medium range aircraft configuration has also seen a percentage increase from a low 15% to a high 26% in 1990. On the other hand, long range aircraft have been losing their share from a high 22% at the beginning of deregulation to a low 3% in 1990, in part due to the increasing removal of the then popular B707s and DC8s. For the international market, the short range aircraft have had an increasingly important role since deregulation. From a low 11% in 1978, this figure almost doubled by 1990. Medium range aircraft have also gained a substantial share in the total number of miles flown, from 8% in 1978 to 47% in 1990. The greatest percentage change has been for the long range aircraft. It has undergone a dramatic decrease from 81% in 1978 share to a 34% in 1990 in international operations.

The share of aircraft miles flown for the two-engine configuration has risen dramatically in both domestic and international markets. For domestic operations, it has grown from a low 13% at the beginning of deregulation to a high 56% in 1990. The three-engine aircraft representation has dropped from a peak 78% in 1982, to a low 41% in 1990, primarily due to the aging B727. The four-engine configuration has also become less popular, and its representation has been decreasing ever since deregulation was enacted. From a high 22% in 1978, this percentage has decreased to a low 3% in 1990. For the international markets, twins have experienced an increase from 0.2% in 1978 to a high 28% in 1990. There seems to be a trend to a slight increase in the three-engine configuration in international routes, from about 19% in 1978 to a about 38% in the later years (1988 to 1990). Also, the four-engine configuration has lost a substantial share, from about 81% in 1978 to a low 34% in 1990. All in all, airlines prefer the usage of aircraft with fewer number of engines regardless of the market.

As for FAA noise stage, share for aircraft under Stage 1 has been decreasing ever since deregulation was enacted to extinction. As for the Stage 2 aircraft, its percentage has also been decreasing ever since it reached its peak of 70% in 1982 to a low of 47% in 1990; in the international arena, its representation has remained at a fairly constant 16%. Stage 3 aircraft have increased their share from a low 19% at the beginning of deregulation to a high of 52% in 1990. The most popular configuration for international routes has been the Stage 3 aircraft. From a 51% in 1978, this percentage has been increasing to a 83% in 1990. As with the domestic markets, this category is expected to grow in the future because aircraft listed under Stage 1 or 2 are no longer in production, and are starting to be phased out.

The 2LS category has been the most popular category for the domestic markets; from a peak 70% in 1982 to a low 47% in 1990 it still remains the most popular category of aircraft. The 4LS category has become the substitute for the 2LS category, and it shows a dramatic growth from 0% in 1982 to a high of 25% in 1990; together with the 2LS configuration, their total share of miles flown is almost 72%, thereby confirming the popularity of the low capacity/short range aircraft. The largest share for international routes corresponds to those aircraft under the 3HL category; they have consistently averaged the largest representation, even though the trend indicates an overall decrease of their usage, from a high 58% in 1982 to a low 31% in 1990. On the other hand, the 4MM category has experienced an increase from a 0.1% in 1978 to a high 25.3% in 1990, and it is conceivable that it will become the substitute for the 3MM category.

Chapter 5

Conclusions

The objective of this study has been to relate the use of aircraft by U.S. Major airlines to changing aviation policy (such as U.S. Airline Deregulation Act, and noise pollution controls) and technology in terms of aircraft characteristics (such as aircraft type, number of crew, capacity, range, number of engines, and fuel consumption). This thesis considers only the US airlines that have been US Major airlines throughout the entire period from 1978 to 1990; therefore, the results presented in this study reflect general trends followed by the North American megacarriers and not necessarily the rest of the airline industry.

First, an analysis of the aircraft used by the sample airlines was carried out, as a necessary step before attempting to understand how these airlines compose and utilize their fleets. It was found that as technology advances, more cockpit tasks become automated which ultimately lead to the elimination of the flight engineer. Bigger aircraft are, in general, designed to have greater range because it is economically desirable to offer less frequency of service and consequently higher capacity aircraft for the longer haul routes. While there is an economically sound tendency to design aircraft with fewer engines --and most aircraft manufacturers have followed this approach-- there are instances in which the lack of high-thrust engine availability leaves no option but to add more engines to the aircraft. Additional technological advances together with stricter noise pollution aviation policies have led to the introduction of more environmentally preferable engines. Overall, new technologies have been applied to new aircraft in order to make them easier and more economical to fly.

Second, a study of the airlines aircraft mix in terms of the aircraft technical characteristics was presented in order to understand how these airlines have been composing their fleets in the past and how they are preparing for the future. Airlines responded very favorably to the introduction of the two-crew member cockpits because of their potential for increasing efficiency both in-flight and on the ground. The results of aircraft capacity and range show that the sample airlines fleets are primarily made up of low capacity/short range aircraft, thereby suggesting that these airlines are primarily involved in flights where frequency of service is critical or where demand is low, such as domestic operations particularly of the hub/spoke kind. The study of the number of engines arrangement in the fleet mix shows that the popularity of twins has grown dramatically and that twin-engined aircraft will become even more popular in the years to come. As for aircraft noise stage, there appears to be no future for any aircraft types other than those in Stage 3 (or higher).

Third, a comparative analysis of the aircraft fleet operation in both domestic and international markets was presented, in order to understand how these airlines have been operating their fleets. The analysis focused on relating the aircraft characteristics discussed in the previous chapters with the pertinent aircraft operation data: miles flown, hours flown, block hours flown, and aircraft days assigned to service. The sample airlines have grown 70% in terms of the number of miles flown since deregulation. Operations in the international arena have increased even more, about 75%. Nevertheless, these airlines have been focusing their operations mostly in the domestic arena, with 84.6% share of the total miles flown at the beginning of deregulation in 1978 and down only to 84.1% by 1990. The cause for the growth of miles flown can be attributed to mergers, and the expansion of most US major airlines to the international arena, in search of new markets.

Because aircraft fleets have grown about 40% during this period, it can be concluded that airlines are flying their aircraft a greater number of miles per day. Since the increase of block hours has been slightly greater, it can be concluded that aircraft are scheduled for more cycles per day and/or that air traffic congestion has been increasing since deregulation. There is clear evidence that aircraft are being flown more miles per day in the international arena; with a low of 4,050 miles flown per day per aircraft at the beginning of deregulation, it has reached to a 5,006 miles per day average by 1990. This is consistent with the expansion of this airlines, particularly in the Pacific routes. The block hours to hours ratio has steadily increased from a low 1.18 in 1980 to a high 1.22 in 1990. This can be due to an increase of cycles per day and/or increase in airport traffic congestion. On the other hand, this ratio has been fairly constant in the international arena, since deregulation, with an average 1.11.

In addition, airlines are increasingly operating aircraft with the two-member configuration in both domestic and international markets. This configuration has grown from about 10% in the early years of deregulation to about 54%, and from 0.2% to 28% for the international one. The study of aircraft capacity suggests that there have not been major changes in the domestic arena. The low capacity aircraft have had the largest share, averaging almost 70% of all miles flown. Short range aircraft are, by far, the most popular configuration in the domestic arena; in fact its percentage has been increasing from a low 63% in 1978 to a high 73% in 1988. For the international market, the short range aircraft have had an increasingly important role since deregulation.

Share for the two-engine configuration has risen in both domestic and international markets because of its economic benefits. For domestic operations, it has grown from a low 13% at the beginning of deregulation to a high 56% in 1990 in terms of total miles flown. For the international markets, twins have experienced an increase from 0.2% in 1978 to a high 28% in 1990. Overall, airlines prefer the usage of aircraft with fewer number of engines regardless the market.

Finally, low capacity/short range aircraft account for 72% of the total share of miles flown. The largest share of miles flown for international routes corresponds to those aircraft under the 3HL category; they have consistently averaged the largest representation, even though the trend indicates an overall decrease of their usage, from a high 58% in 1982 to a low 31% in 1990.

In retrospect, the real value of a study of this nature is perhaps to provide the airline industry analyst with a tool for understanding the relationships between aviation policies and technological advances on the one hand and the composition and utilization of aircraft fleets by airlines on the other. Furthermore, there exist interrelationships between various aircraft technical characteristics which also have important economic implications for airlines, particularly in a deregulated environment. This thesis has covered in detail all these aspects but the results are indisputably limited by the number of sample airlines. For this reason, further research might be undertaken in the future to cover the remaining airlines. Conclusions from these future studies could be used to further understand the dynamics of airline fleet structure within deregulated environments.

Appendix A.1: AA Aircraft Fleet by Year

	1978	1980	1982	1984	1986	1988	1990
A300	0	0	0	0	0	13	25
A310	0	0	0	0	0	0	0
A320	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0
BA146	0	0	0	0	6	6	6
B707	82	34	0	0	0	0	0
B727	136	158	177	164	164	164	164
B737	11	16	15	18	24	25	13
B733	0	0	0	0	8	8	8
B734	0	0	0	0	0	0	0
B747	8	8	8	0	2	2	2
B744	0	0	0	0	0	0	0
B757	0	0	0	0	0	0	10
B767	0	0	3	10	22	45	45
DC8	0	0	0	0	0	0	0
DC9	0	0	0	0	0	0	0
MD80	0	0	7	40	88	157	186
DC10	28	34	37	53	59	60	59
MD11	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0
L1011	0	0	0	0	0	0	0
TOTAL	265	250	247	285	373	480	518

Appendix A.2: CO Aircraft Fleet by Year

	1978	1980	1982	1984	1986	1988	1990
A300	0	0	0	0	6	12	16
A310	0	0	0	0	0	0	0
A320	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0
B707	0	0	0	0	0	0	0
B727	50	52	59	98	106	106	113
B737	32	43	70	73	47	44	43
B733	0	0	0	0	39	55	55
B734	0	0	0	4	8	8	0
B747	0	0	0	0	0	0	8
B744	0	0	0	0	0	0	0
B757	0	0	0	0	0	0	0
B767	0	0	0	0	0	0	0
DC8	0	0	0	0	0	0	0
DC9	27	38	52	48	47	41	35
MD80	0	0	5	15	45	65	66
DC10	15	14	13	13	15	15	15
MD11	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0
L1011	0	0	0	0	0	0	0
TOTAL	124	147	199	251	313	346	351

Appendix A.3: DL Aircraft Fleet by Year

	1978	1980	1982	1984	1986	1988	1990
A300	0	0	0	0	0	0	0
A310	0	0	0	0	0	0	0
A320	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0
B707	14	0	0	0	0	0	0
B727	139	168	169	147	138	130	129
B737	22	15	14	50	65	61	59
B733	0	0	0	0	13	13	13
B734	0	0	0	0	0	0	0
B747	0	0	0	0	0	0	0
B744	0	0	0	0	0	0	0
B757	0	0	0	4	22	42	56
B767	0	0	4	15	20	30	30
DC8	23	17	13	13	13	5	0
DC9	49	39	36	36	36	36	36
MD80	0	0	0	0	0	31	55
DC10	9	12	11	10	9	2	0
MD11	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0
L1011	26	34	42	34	35	39	40
TOTAL	282	285	289	309	351	389	418

Appendix A.4: EA Aircraft Fleet by Year

	1978	1980	1982	1984	1986	1988	1990
A300	7	19	30	34	34	20	14
A310	0	0	0	0	0	0	0
A320	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0
B707	0	0	0	0	0	0	0
B727	125	142	121	128	122	117	68
B737	0	0	0	0	0	0	0
B733	0	0	0	0	0	0	0
B734	0	0	0	0	0	0	0
B747	0	0	0	0	0	0	0
B744	0	0	0	0	0	0	0
B757	0	0	2	19	25	25	22
B767	0	0	0	0	0	0	0
DC8	0	0	0	0	0	0	0
DC9	84	75	79	79	79	80	69
MD80	0	0	0	0	0	0	0
DC10	0	0	0	0	2	2	2
MD11	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0
L1011	34	34	31	25	24	21	14
TOTAL	250	270	263	285	286	265	189

Appendix A.5: NW Aircraft Fleet by Year

	1978	1980	1982	1984	1986	1988	1990
A300	0	0	0	0	0	0	0
A310	0	0	0	0	0	0	0
A320	0	0	0	0	0	0	6
A334	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0
B707	0	0	0	0	0	0	0
B727	67	79	76	80	80	71	73
B737	0	0	0	0	0	0	0
B733	0	0	0	0	0	0	0
B734	0	0	0	0	0	0	0
B747	17	24	24	28	32	32	40
B744	0	0	0	0	0	0	7
B757	0	0	0	0	26	33	33
B767	0	0	0	0	0	0	0
DC8	0	0	0	0	0	0	0
DC9	104	124	126	121	126	139	139
MD80	0	0	6	8	8	8	8
DC10	22	22	22	20	20	20	21
MD11	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0
L1011	0	0	0	0	0	0	0
TOTAL	210	249	254	257	292	303	327

Appendix A.6: PA Aircraft Fleet by Year

	1978	1980	1982	1984	1986	1988	1990
A300	0	0	0	4	12	12	13
A310	0	0	0	0	7	19	19
A320	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0
B707	31	0	0	0	0	0	0
B727	53	60	57	41	48	56	93
B737	0	0	10	16	12	5	5
B733	0	0	0	0	0	0	0
B734	0	0	0	0	0	0	0
B747	37	39	39	48	35	37	35
B744	0	0	0	0	0	0	0
B757	0	0	0	0	0	0	0
B767	0	0	0	0	0	0	0
DC8	0	0	0	0	0	0	0
DC9	0	0	0	0	0	0	0
MD80	0	0	0	0	0	0	0
DC10	15	15	16	1	0	0	0
MD11	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0
L1011	0	6	12	9	0	0	0
TOTAL	136	120	134	119	114	129	165

Appendix A.7: TW Aircraft Fleet by Year

	1978	1980	1982	1984	1986	1988	1990
A300	0	0	0	0	0	0	0
A310	0	0	0	0	0	0	0
A320	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0
B707	87	65	23	0	0	0	0
B727	74	90	82	82	78	72	69
B737	0	0	0	0	0	0	0
B733	0	0	0	0	0	0	0
B734	0	0	0	0	0	0	0
B747	11	15	18	19	17	19	19
B744	0	0	0	0	0	0	0
B757	0	0	0	0	0	0	0
B767	0	0	3	10	10	11	11
DC8	0	0	0	0	0	0	0
DC9	47	39	44	46	46	46	48
MD80	0	0	0	17	23	33	33
DC10	0	0	0	0	0	0	0
MD11	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0
L1011	26	28	32	33	33	33	33
TOTAL	245	237	202	207	207	214	213

Appendix A.8: UA Aircraft Fleet by Year

	1978	1980	1982	1984	1986	1988	1990
A300	0	0	0	0	0	0	0
A310	0	0	0	0	0	0	0
A320	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0
B707	0	0	0	0	0	0	0
B727	153	173	154	154	154	148	138
B737	59	48	49	49	74	74	74
B733	0	0	0	0	3	49	86
B734	0	0	0	0	0	0	0
B747	18	18	18	18	24	31	31
B744	0	0	0	0	0	0	4
B757	0	0	0	0	0	0	7
B767	0	0	7	19	19	19	19
DC8	55	47	29	29	29	29	23
DC9	0	0	0	0	0	0	0
MD80	0	0	0	0	0	0	0
DC10	37	42	47	50	55	55	55
MD11	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0
L1011	0	0	0	0	6	0	0
TOTAL	322	328	304	319	364	405	437

Appendix A.9: Aggregate Aircraft Fleet by Year

	1978	1980	1982	1984	1986	1988	1990
A300	7	19	30	38	52	57	68
A310	0	0	0	0	7	19	19
A320	0	0	0	0	0	0	6
A334	0	0	0	0	0	0	0
BA146	0	0	0	0	6	6	6
B707	214	99	23	0	0	0	0
B727	797	922	895	894	890	864	847
B737	124	122	158	206	222	209	194
B733	0	0	0	0	63	125	162
B734	0	0	0	4	8	8	0
B747	91	104	107	113	110	121	135
B744	0	0	0	0	0	0	11
B757	0	0	2	23	73	100	128
B767	0	0	17	54	71	105	105
DC8	78	64	42	42	42	34	23
DC9	311	315	337	330	334	342	327
MD80	0	0	18	80	164	294	348
DC10	126	139	146	147	160	154	152
MD11	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0
L1011	86	102	117	101	98	93	87
TOTAL	1,834	1,886	1,892	2,032	2,300	2,531	2,618

Appendix B.1: AA Aircraft Deliveries and Orders by Year

	1980	1982	1984	1986	1988	1990E	1992E
A300	0	0	0	0	13	0	1
A310	0	0	0	0	0	0	0
A320	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0
BA146	0	0	0	6	0	0	0
B707	0	0	0	0	0	0	0
B727	14	0	0	0	0	0	0
B737	4	0	3	0	0	0	0
B733	0	0	0	3	0	0	0
B734	0	0	0	0	0	0	0
B747	0	0	0	2	0	0	0
B744	0	0	0	0	0	0	0
B757	0	0	0	0	0	20	22
B767	0	3	2	7	16	0	6
DC8	0	0	0	0	0	0	0
DC9	0	0	0	0	0	0	0
MD80	0	2	13	32	39	36	10
DC10	3	3	16	3	0	0	0
MD11	0	0	0	0	0	4	0
F100	0	0	0	0	0	0	24
L1011	0	0	0	0	0	0	0
TOTAL	21	8	34	53	68	60	63

Appendix B.2: CO Aircraft Deliveries and Orders by Year

	1980	1982	1984	1986	1988	1990E	1992E
A300	0	0	0	6	0	0	0
A310	0	0	0	0	0	0	0
A320	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0
B707	0	0	0	0	0	0	0
B727	2	0	26	0	0	0	0
B737	4	11	0	0	0	0	10
B733	0	0	0	19	0	0	0
B734	0	0	0	0	0	0	0
B747	0	0	3	2	0	0	0
B744	0	0	0	0	0	0	0
B757	0	0	0	0	0	0	0
B767	0	0	0	0	0	0	0
DC8	0	0	0	0	0	0	0
DC9	5	3	0	5	0	0	0
MD80	0	5	9	24	0	0	0
DC10	2	0	2	2	0	0	0
MD11	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0
L1011	0	0	0	0	0	0	0
TOTAL	13	19	40	58	0	0	10

Appendix B.3: DL Aircraft Deliveries and Options by Year

	1980	1982	1984	1986	1988	1990E	1992E
A300	0	0	0	0	0	0	0
A310	0	0	0	0	0	0	0
A320	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0
B707	0	0	0	0	0	0	0
B727	15	0	0	0	0	0	0
B737	0	2	28	4	0	0	0
B733	0	0	0	7	0	0	0
B734	0	0	0	0	0	0	0
B747	0	0	0	0	0	0	0
B744	0	0	0	0	0	0	0
B757	0	0	4	10	9	11	0
B767	0	4	2	5	6	5	0
DC8	0	0	0	0	0	0	0
DC9	0	0	0	0	0	0	0
MD80	0	0	0	0	19	16	0
DC10	2	0	0	0	0	0	0
MD11	0	0	0	0	0	0	3
F100	0	0	0	0	0	0	0
L1011	4	5	1	0	4	0	0
TOTAL	21	11	35	26	38	32	3

Appendix B.4: EA Aircraft Deliveries and Options by Year

	1980	1982	1984	1986	1988	1990E	1992E
A300	7	5	0	0	0	0	0
A310	0	0	0	0	0	0	0
A320	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0
B707	0	0	0	0	0	0	0
B727	15	4	2	0	0	0	0
B737	0	0	0	0	0	0	0
B733	0	0	0	0	0	0	0
B734	0	0	0	0	0	0	0
B747	0	0	0	0	0	0	0
B744	0	0	0	0	0	0	0
B757	0	2	4	3	0	0	0
B767	0	0	0	0	0	0	0
DC8	0	0	0	0	0	0	0
DC9	0	1	0	0	0	0	0
MD80	0	0	0	0	0	0	0
DC10	0	0	0	1	0	0	0
MD11	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0
L1011	0	0	0	0	0	0	0
TOTAL	22	12	6	4	0	0	0

Appendix B.5: NW Aircraft Deliveries and Options by Year

	1980	1982	1984	1986	1988	1990E	1992E
A300	0	0	0	0	0	0	0
A310	0	0	0	0	0	0	0
A320	0	0	0	0	0	9	0
A334	0	0	0	0	0	0	20
BA146	0	0	0	0	0	0	0
B707	0	0	0	0	0	0	0
B727	11	5	0	0	0	0	0
B737	0	0	0	0	0	0	0
B733	0	0	0	0	0	0	0
B734	0	0	0	0	0	0	0
B747	2	0	4	3	0	0	0
B744	0	0	0	0	0	4	0
B757	0	0	0	13	5	0	0
B767	0	0	0	0	0	0	0
DC8	0	0	0	0	0	0	0
DC9	6	0	0	0	9	2	0
MD80	0	3	0	0	0	0	0
DC10	0	0	0	0	0	0	0
MD11	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0
L1011	0	0	0	0	0	0	0
TOTAL	19	8	4	16	14	15	20

Appendix B.6: PA Aircraft Deliveries and Options by Year

	1980	1982	1984	1986	1988	1990E	1992E
A300	0	0	4	0	0	0	0
A310	0	0	0	3	6	2	0
A320	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0
B707	0	0	0	0	0	0	0
B727	3	6	3	10	1	0	0
B737	0	10	0	0	0	0	0
B733	0	0	0	0	0	0	0
B734	0	0	0	0	0	0	0
B747	0	0	5	1	0	0	0
B744	0	0	0	0	0	0	0
B757	0	0	0	0	0	0	0
B767	0	0	0	0	0	0	0
DC8	0	0	0	0	0	0	0
DC9	0	0	0	0	0	0	0
MD80	0	0	0	0	0	0	0
DC10	0	0	0	0	0	0	0
MD11	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0
L1011	6	0	0	0	0	0	0
TOTAL	9	16	12	14	7	2	0

Appendix B.7: TW Aircraft Deliveries and Options by Year

	1980	1982	1984	1986	1988	1990E	1992E
A300	0	0	0	0	0	0	0
A310	0	0	0	0	0	0	0
A320	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0
B707	0	0	0	0	0	0	0
B727	10	0	0	0	0	0	0
B737	0	0	0	0	0	0	0
B733	0	0	0	0	0	0	0
B734	0	0	0	0	0	0	0
B747	4	0	2	0	1	0	0
B744	0	0	0	0	0	0	0
B757	0	0	0	0	0	0	0
B767	0	3	0	0	0	0	0
DC8	0	0	0	0	0	0	0
DC9	1	2	1	0	0	0	0
MD80	0	0	6	0	4	0	0
DC10	0	0	0	0	0	0	0
MD11	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0
L1011	2	0	0	0	0	0	0
TOTAL	17	5	9	0	5	0	0

Appendix B.8: UA Aircraft Deliveries and Options by Year

	1980	1982	1984	1986	1988	1990E	1992E
A300	0	0	0	0	0	0	0
A310	0	0	0	0	0	0	0
A320	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0
B707	0	0	0	0	0	0	0
B727	12	0	0	0	0	0	0
B737	0	0	0	15	0	0	0
B733	0	0	0	3	34	33	0
B734	0	0	0	0	0	0	30
B747	0	0	0	11	5	0	0
B744	0	0	0	0	0	4	3
B757	0	0	0	0	0	21	24
B767	0	7	0	0	0	0	2
DC8	0	0	0	0	0	0	0
DC9	0	0	0	0	0	0	0
MD80	0	0	0	0	0	0	0
DC10	4	1	3	4	0	1	0
MD11	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0
L1011	0	0	0	6	0	0	0
TOTAL	16	8	3	39	39	59	59

Appendix B.9: Aggregate Aircraft Deliveries and Options by Year

	1980	1982	1984	1986	1988	1990E	1992E
A300	7	5	4	0	19	0	1
A310	0	0	0	3	6	2	0
A320	0	0	0	0	0	9	0
A334	0	0	0	0	0	0	20
BA146	0	0	0	6	0	0	0
B707	0	0	0	0	0	0	0
B727	80	17	5	36	1	0	0
B737	4	16	42	19	0	0	0
B733	0	0	0	13	53	33	0
B734	0	0	0	0	0	0	30
B747	6	0	11	20	8	0	0
B744	0	0	0	0	0	8	3
B757	0	2	8	26	14	52	46
B767	0	17	4	12	22	5	8
DC8	0	0	0	0	0	0	0
DC9	7	8	4	0	14	2	0
MD80	0	5	24	41	86	52	10
DC10	9	6	19	10	2	1	0
MD11	0	0	0	0	0	4	3
F100	0	0	0	0	0	0	24
L1011	12	5	1	6	4	0	0
TOTAL	125	81	122	192	229	168	145

Appendix C.1: AA Aircraft Removals by Year

	1980	1982	1984	1986	1988	1990E	1992E
A300	0	0	0	0	0	0	0
A310	0	0	0	0	0	0	0
A320	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0
B707	38	0	0	0	0	0	0
B727	1	2	2	0	0	0	24
B737	0	1	0	0	0	0	0
B733	0	0	0	0	0	8	0
B734	0	0	0	0	0	0	0
B747	0	0	7	0	0	0	0
B744	0	0	0	0	0	0	0
B757	0	0	0	0	0	0	0
B767	0	0	0	0	0	0	0
DC8	0	0	0	0	0	0	0
DC9	0	0	0	0	0	0	0
MD80	0	0	0	3	0	0	0
DC10	0	0	0	0	0	0	0
MD11	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0
L1011	0	0	0	0	0	0	0
TOTAL	39	3	9	3	0	8	24

Appendix C.2: CO Aircraft Removals by Year

	1980	1982	1984	1986	1988	1990E	1992E
A300	0	0	0	0	0	0	0
A310	0	0	0	0	0	0	0
A320	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0
B707	0	0	0	0	0	0	0
B727	1	0	0	8	0	0	0
B737	0	0	0	13	0	0	0
B733	0	0	0	0	0	0	0
B734	0	0	0	0	0	0	0
B747	0	0	0	0	0	0	0
B744	0	0	0	0	0	0	0
B757	0	0	0	0	0	0	0
B767	0	0	0	0	0	0	0
DC8	0	0	0	0	0	0	0
DC9	1	0	5	7	5	0	0
MD80	0	0	0	0	1	0	0
DC10	3	0	0	2	0	0	0
MD11	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0
L1011	0	0	0	0	0	0	0
TOTAL	5	0	5	30	6	0	0

Appendix C.3: DL Aircraft Removals by Year

	1980	1982	1984	1986	1988	1990E	1992E
A300	0	0	0	0	0	0	0
A310	0	0	0	0	0	0	0
A320	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0
B707	5	0	0	0	0	0	0
B727	0	7	15	3	2	0	15
B737	6	0	0	0	9	0	0
B733	0	0	0	0	0	0	0
B734	0	0	0	0	0	0	0
B747	0	0	0	0	0	0	0
B744	0	0	0	0	0	0	0
B757	0	0	0	0	0	0	0
B767	0	0	0	0	0	0	0
DC8	4	0	0	0	5	0	0
DC9	4	0	0	0	0	0	0
MD80	0	0	0	0	0	0	0
DC10	0	0	1	1	7	0	0
MD11	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0
L1011	0	0	9	0	0	0	5
TOTAL	19	7	25	4	23	0	20

Appendix C.4: EA Aircraft Removals by Year

	1980	1982	1984	1986	1988	1990E	1992E
A300	0	0	0	0	8	0	0
A310	0	0	0	0	0	0	0
A320	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0
B707	0	0	0	0	0	0	0
B727	7	21	1	5	5	0	0
B737	0	0	0	0	0	0	0
B733	0	0	0	0	0	0	0
B734	0	0	0	0	0	0	0
B747	0	0	0	0	0	0	0
B744	0	0	0	0	0	0	0
B757	0	0	0	0	0	0	0
B767	0	0	0	0	0	0	0
DC8	0	0	0	0	0	0	0
DC9	1	0	0	0	4	0	0
MD80	0	0	0	0	0	0	0
DC10	0	0	0	1	0	0	0
MD11	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0
L1011	0	0	6	0	2	18	0
TOTAL	8	21	7	6	19	18	0

Appendix C.5: NW Aircraft Removals by Year

	1980	1982	1984	1986	1988	1990E	1992E
A300	0	0	0	0	0	0	0
A310	0	0	0	0	0	0	0
A320	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0
B707	0	0	0	0	0	0	0
B727	0	6	0	3	5	0	10
B737	0	0	0	0	0	0	0
B733	0	0	0	0	0	0	0
B734	0	0	0	0	0	0	0
B747	0	0	0	0	0	0	0
B744	0	0	0	0	0	0	0
B757	0	0	0	0	0	0	0
B767	0	0	0	0	0	0	0
DC8	0	0	0	0	0	0	0
DC9	7	0	5	0	0	0	0
MD80	0	0	0	0	0	0	0
DC10	0	0	2	0	0	0	0
MD11	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0
L1011	0	0	0	0	0	0	0
TOTAL	7	6	7	3	5	0	10

Appendix C.6: PA Aircraft Removals by Year

	1980	1982	1984	1986	1988	1990E	1992E
A300	0	0	0	0	0	0	0
A310	0	0	0	0	0	0	0
A320	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0
B707	22	0	0	0	0	0	0
B727	0	7	18	0	0	0	0
B737	0	0	0	0	2	0	0
B733	0	0	0	0	0	0	0
B734	0	0	0	0	0	0	0
B747	0	0	0	19	1	0	0
B744	0	0	0	0	0	0	0
B757	0	0	0	0	0	0	0
B767	0	0	0	0	0	0	0
DC8	0	0	0	0	0	0	0
DC9	0	0	0	0	0	0	0
MD80	0	0	0	0	0	0	0
DC10	0	0	0	0	0	0	0
MD11	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0
L1011	0	0	3	6	0	0	0
TOTAL	22	7	21	25	3	0	0

Appendix C.7: TW Aircraft Removals by Year

	1980	1982	1984	1986	1988	1990E	1992E
A300	0	0	0	0	0	0	0
A310	0	0	0	0	0	0	0
A320	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0
B707	13	35	0	0	0	0	0
B727	1	8	0	4	6	0	0
B737	0	0	0	0	0	0	0
B733	0	0	0	0	0	0	0
B734	0	0	0	0	0	0	0
B747	0	0	1	4	0	0	0
B744	0	0	0	0	0	0	0
B757	0	0	0	0	0	0	0
B767	0	0	0	0	0	0	0
DC8	0	0	0	0	0	0	0
DC9	7	0	0	0	0	0	0
MD80	0	0	0	0	0	0	0
DC10	0	0	0	0	0	0	0
MD11	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0
L1011	0	0	2	0	0	0	0
TOTAL	21	43	3	8	6	0	0

Appendix C.8: UA Aircraft Removals by Year

	1980	1982	1984	1986	1988	1990E	1992E
A300	0	0	0	0	0	0	0
A310	0	0	0	0	0	0	0
A320	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0
B707	0	0	0	0	0	0	0
B727	13	4	0	0	6	10	10
B737	7	0	0	0	0	0	5
B733	0	0	0	0	0	0	0
B734	0	0	0	0	0	0	0
B747	0	0	0	0	0	0	0
B744	0	0	0	0	0	0	0
B757	0	0	0	0	0	0	0
B767	0	0	0	0	0	0	0
DC8	5	0	0	0	0	20	0
DC9	0	0	0	0	0	0	0
MD80	0	0	0	0	0	0	0
DC10	0	0	0	0	0	0	0
MD11	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0
L1011	0	0	0	0	6	0	0
TOTAL	25	4	0	0	12	30	15

Appendix C.9: Aggregate Aircraft Removals by Year

	1980	1982	1984	1986	1988	1990E	1992E
A300	0	0	0	0	8	0	0
A310	0	0	0	0	0	0	0
A320	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0
B707	78	35	0	0	0	0	0
B727	22	56	36	15	32	10	59
B737	13	1	0	0	24	0	5
B733	0	0	0	0	0	8	0
B734	0	0	0	0	0	0	0
B747	0	0	8	23	1	0	0
B744	0	0	0	0	0	0	0
B757	0	0	0	0	0	0	0
B767	0	0	0	0	0	0	0
DC8	9	0	0	0	5	20	0
DC9	19	1	5	5	11	5	0
MD80	0	0	0	3	0	1	0
DC10	0	3	3	2	9	0	0
MD11	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0
L1011	0	0	20	6	8	18	5
TOTAL	141	96	72	54	98	62	69

Appendix D: Aggregate Aircraft Fleet Analysis by Year

	1978	1980	1982	1984	1986	1988	1990
# A/C	1,834	1,886	1,892	2,032	2,300	2,531	2,618
A300	0.4%	1.0%	1.6%	1.9%	2.3%	2.3%	2.6%
A310	0.0%	0.0%	0.0%	0.0%	0.3%	0.8%	0.7%
A320	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%
A334	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
BA146	0.0%	0.0%	0.0%	0.0%	0.3%	0.2%	0.2%
B707	11.7%	5.2%	1.2%	0.0%	0.0%	0.0%	0.0%
B727	43.5%	48.9%	47.3%	44.0%	38.7%	34.1%	32.4%
B737	6.8%	6.5%	8.4%	10.1%	9.7%	8.3%	7.4%
B733	0.0%	0.0%	0.0%	0.0%	2.7%	4.9%	6.2%
B734	0.0%	0.0%	0.0%	0.2%	0.3%	0.3%	0.0%
B747	5.0%	5.5%	5.7%	5.6%	4.8%	4.8%	5.2%
B744	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%
B757	0.0%	0.0%	0.1%	1.1%	3.2%	4.0%	4.9%
B767	0.0%	0.0%	0.9%	2.7%	3.1%	4.1%	4.0%
DC8	4.3%	3.4%	2.2%	2.1%	1.8%	1.3%	0.9%
DC9	17.0%	16.7%	17.8%	16.2%	14.5%	13.5%	12.5%
MD80	0.0%	0.0%	1.0%	3.9%	7.1%	11.6%	13.3%
DC10	6.9%	7.4%	7.7%	7.2%	7.0%	6.1%	5.8%
MD11	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
F100	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
L1011	4.7%	5.4%	6.2%	5.0%	4.3%	3.7%	3.3%
AIRBS	0.4%	1.0%	1.6%	1.9%	2.6%	3.0%	3.6%
BAe	0.0%	0.0%	0.0%	0.0%	0.3%	0.2%	0.2%
BOEIN	66.8%	66.1%	63.6%	63.7%	62.5%	60.5%	60.5%
FOKK	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
LOCKH	4.7%	5.4%	6.2%	5.0%	4.3%	3.7%	3.3%
MD	28.1%	27.5%	28.7%	29.5%	30.4%	32.6%	32.5%
US	99.6%	99.0%	98.5%	98.1%	97.2%	96.8%	96.3%
N-US	0.4%	1.0%	1.6%	1.9%	2.8%	3.2%	3.8%

2CREW	23.7%	23.2%	28.1%	34.3%	41.2%	47.7%	49.9%
3CREW	76.3%	76.8%	71.9%	65.7%	58.8%	52.3%	50.2%
LVL1	15.9%	8.6%	3.4%	2.1%	1.8%	1.3%	0.9%
LVL2	67.2%	72.1%	73.5%	70.4%	62.9%	55.9%	52.3%
LVL3	16.5%	18.3%	19.6%	17.8%	16.0%	14.6%	14.3%
LVL4	0.4%	1.0%	3.5%	9.8%	19.3%	28.2%	32.6%
L CAP	67.2%	72.1%	74.4%	74.5%	73.3%	73.0%	72.2%
M CAP	27.9%	22.4%	19.9%	19.9%	21.9%	22.2%	22.2%
H CAP	5.0%	5.5%	5.7%	5.6%	4.8%	4.8%	5.6%
S RNG	67.2%	72.1%	74.4%	74.5%	73.3%	73.0%	72.2%
M RNG	11.9%	13.8%	16.5%	17.9%	20.0%	20.9%	21.4%
L RNG	20.9%	14.1%	9.1%	7.6%	6.6%	6.1%	6.5%
2-ENG	24.1%	24.2%	29.7%	36.2%	43.2%	49.7%	51.8%
3-ENG	55.0%	61.7%	61.2%	56.2%	49.9%	43.9%	41.5%
4-ENG	20.9%	14.1%	9.1%	7.6%	6.9%	6.4%	6.7%
STG-1	15.9%	8.6%	3.4%	2.1%	1.8%	1.3%	0.9%
STG-2	67.2%	72.1%	73.5%	70.4%	62.9%	55.9%	52.3%
STG-3	16.9%	19.3%	23.1%	27.5%	35.3%	42.8%	46.9%
1ML	15.9%	8.6%	3.4%	2.1%	1.8%	1.3%	0.9%
2LS	67.2%	72.1%	73.5%	70.4%	62.9%	55.9%	52.3%
3MM	11.6%	12.8%	13.9%	12.2%	11.2%	9.8%	9.1%
3HL	5.0%	5.5%	5.7%	5.6%	4.8%	4.8%	5.2%
4LS	0.0%	0.0%	1.0%	4.1%	10.5%	17.1%	19.9%
4MM	0.4%	1.0%	2.6%	5.7%	8.8%	11.1%	12.2%
4HL	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%

Appendix E: Aggregate Aircraft Deliveries Analysis by Year

	1980	1982	1984	1986	1988	1990E	1992E
# A/C	125	81	122	192	229	168	145
A300	5.6%	6.2%	3.3%	0.0%	8.3%	0.0%	0.7%
A310	0.0%	0.0%	0.0%	1.6%	2.6%	1.2%	0.0%
A320	0.0%	0.0%	0.0%	0.0%	0.0%	5.4%	0.0%
A334	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	13.8%
BA146	0.0%	0.0%	0.0%	3.1%	0.0%	0.0%	0.0%
B707	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
B727	64.0%	21.0%	4.1%	18.8%	0.4%	0.0%	0.0%
B737	3.2%	19.8%	34.4%	9.9%	0.0%	0.0%	0.0%
B733	0.0%	0.0%	0.0%	6.8%	23.1%	19.6%	0.0%
B734	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	20.7%
B747	4.8%	0.0%	9.0%	10.4%	3.5%	0.0%	0.0%
B744	0.0%	0.0%	0.0%	0.0%	0.0%	4.8%	2.1%
B757	0.0%	2.5%	6.6%	13.5%	6.1%	31.0%	31.7%
B767	0.0%	21.0%	3.3%	6.3%	9.6%	3.0%	5.5%
DC8	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
DC9	5.6%	9.9%	3.3%	0.0%	6.1%	1.2%	0.0%
MD80	0.0%	6.2%	19.7%	21.4%	37.6%	31.0%	6.9%
DC10	7.2%	7.4%	15.6%	5.2%	0.9%	0.6%	0.0%
MD11	0.0%	0.0%	0.0%	0.0%	0.0%	2.4%	2.1%
F100	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	16.6%
L1011	9.6%	6.2%	0.8%	3.1%	1.7%	0.0%	0.0%
AIRBS	5.6%	6.2%	3.3%	1.6%	10.9%	6.5%	14.5%
BAe	0.0%	0.0%	0.0%	3.1%	0.0%	0.0%	0.0%
BOEIN	72.0%	64.2%	57.4%	65.6%	42.8%	58.3%	60.0%
FOKK	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	16.6%
LOCKH	9.6%	6.2%	0.8%	3.1%	1.7%	0.0%	0.0%
MD	12.8%	23.5%	38.5%	26.6%	44.5%	35.1%	9.0%
US	94.4%	93.8%	96.7%	95.3%	89.1%	93.5%	69.0%
N-US	5.6%	6.2%	3.3%	4.7%	10.9%	6.5%	31.0%

2CREW	8.8%	59.3%	67.2%	62.5%	85.2%	99.4%	99.3%
3CREW	91.2%	40.7%	32.8%	37.5%	14.8%	0.6%	0.7%
LVL1	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
LVL2	72.8%	50.6%	41.8%	28.6%	6.6%	1.2%	0.0%
LVL3	21.6%	13.6%	25.4%	18.8%	6.1%	0.6%	0.0%
LVL4	5.6%	35.8%	32.8%	52.6%	87.3%	98.2%	100.0%
L CAP	72.8%	56.8%	61.5%	59.9%	67.2%	57.1%	44.1%
M CAP	22.4%	43.2%	29.5%	29.7%	29.3%	35.7%	37.9%
H CAP	4.8%	0.0%	9.0%	10.4%	3.5%	7.1%	17.9%
S RNG	72.8%	56.8%	61.5%	59.9%	67.2%	57.1%	44.1%
M RNG	22.4%	43.2%	29.5%	29.7%	29.3%	35.7%	37.9%
L RNG	4.8%	0.0%	9.0%	10.4%	3.5%	7.1%	17.9%
2-ENG	14.4%	65.4%	70.5%	59.4%	93.4%	92.3%	82.1%
3-ENG	80.8%	34.6%	20.5%	27.1%	3.1%	3.0%	2.1%
4-ENG	4.8%	0.0%	9.0%	13.6%	3.5%	4.8%	15.9%
STG-1	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
STG-2	72.8%	50.6%	41.8%	28.6%	6.6%	1.2%	0.0%
STG-3	27.2%	49.4%	58.2%	71.4%	93.4%	98.8%	100.0%
1ML	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2LS	72.8%	50.6%	41.8%	28.6%	6.6%	1.2%	0.0%
3MM	16.8%	13.6%	16.4%	8.3%	2.6%	0.6%	0.0%
3HL	4.8%	0.0%	9.0%	10.4%	3.5%	0.0%	0.0%
4LS	0.0%	6.2%	19.7%	31.3%	60.7%	56.0%	44.1%
4MM	5.6%	29.6%	13.1%	21.4%	26.6%	35.1%	37.9%
4HL	0.0%	0.0%	0.0%	0.0%	0.0%	7.1%	17.9%

Appendix F: Aggregate Aircraft Removals Analysis by Year

	1978	1980	1982	1984	1986	1988	1990
# A/C	141	96	72	54	98	62	69
A300	0.0%	0.0%	0.0%	0.0%	8.2%	0.0%	0.0%
A310	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
A320	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
A334	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
BA146	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
B707	55.3%	36.5%	0.0%	0.0%	0.0%	0.0%	0.0%
B727	15.6%	58.3%	50.0%	27.8%	32.7%	16.1%	85.5%
B737	9.2%	1.0%	0.0%	0.0%	24.5%	0.0%	7.2%
B733	0.0%	0.0%	0.0%	0.0%	0.0%	12.9%	0.0%
B734	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
B747	0.0%	0.0%	11.1%	42.6%	1.0%	0.0%	0.0%
B744	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
B757	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
B767	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
DC8	6.4%	0.0%	0.0%	0.0%	5.1%	32.3%	0.0%
DC9	13.5%	1.0%	6.9%	9.3%	11.2%	8.1%	0.0%
MD80	0.0%	0.0%	0.0%	5.6%	0.0%	1.6%	0.0%
DC10	0.0%	3.1%	4.2%	3.7%	9.2%	0.0%	0.0%
MD11	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
F100	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
L1011	0.0%	0.0%	27.8%	11.1%	8.2%	29.0%	7.2%
AIRBS	0.0%	0.0%	0.0%	0.0%	8.2%	0.0%	0.0%
BAe	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
BOEIN	80.1%	95.8%	61.1%	70.4%	58.2%	29.0%	92.8%
FOKK	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
LOCKH	0.0%	0.0%	27.8%	11.1%	8.2%	29.0%	7.2%
MD	19.9%	4.2%	11.1%	18.5%	25.5%	41.9%	0.0%
US	100.0%	100.0%	100.0%	100.0%	91.8%	100.0%	100.0%
N-US	0.0%	0.0%	0.0%	0.0%	8.2%	0.0%	0.0%

2CREW	22.7%	2.1%	6.9%	14.8%	35.7%	22.6%	7.2%
3CREW	77.3%	97.9%	93.0%	85.2%	64.3%	77.4%	92.8%
LVL1	61.7%	36.5%	0.0%	0.0%	5.1%	32.3%	0.0%
LVL2	38.3%	60.4%	56.9%	37.0%	68.4%	24.2%	92.8%
LVL3	0.0%	3.1%	43.0%	57.4%	18.4%	29.0%	7.2%
LVL4	0.0%	0.0%	0.0%	5.6%	8.2%	14.5%	0.0%
L CAP	38.3%	60.4%	56.9%	42.6%	68.4%	38.7%	92.8%
M CAP	61.7%	39.6%	31.9%	14.8%	30.6%	61.3%	7.2%
H CAP	0.0%	0.0%	11.1%	42.6%	1.0%	0.0%	0.0%
S RNG	38.3%	60.4%	56.9%	42.6%	68.4%	38.7%	92.8%
M RNG	0.0%	3.1%	31.9%	14.8%	25.5%	29.0%	7.2%
L RNG	61.7%	36.5%	11.1%	42.6%	6.1%	32.3%	0.0%
2-ENG	22.7%	2.1%	6.9%	14.8%	43.9%	22.6%	7.2%
3-ENG	15.6%	61.5%	81.9%	42.6%	50.0%	45.2%	92.8%
4-ENG	61.7%	36.5%	11.1%	42.6%	6.1%	32.3%	0.0%
STG-1	61.7%	36.5%	0.0%	0.0%	5.1%	32.3%	0.0%
STG-2	38.3%	60.4%	56.9%	37.0%	68.4%	24.2%	92.8%
STG-3	0.0%	3.1%	43.0%	63.0%	26.5%	43.5%	7.2%
1ML	61.7%	36.5%	0.0%	0.0%	5.1%	32.3%	0.0%
2LS	38.3%	60.4%	56.9%	37.0%	68.4%	24.2%	92.8%
3MM	0.0%	3.1%	31.9%	14.8%	17.3%	29.0%	7.2%
3HL	0.0%	0.0%	11.1%	42.6%	1.0%	0.0%	0.0%
4LS	0.0%	0.0%	0.0%	5.6%	0.0%	14.5%	0.0%
4MM	0.0%	0.0%	0.0%	0.0%	8.2%	0.0%	0.0%
4HL	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Appendix G.1: Domestic Operations Aggregate for 1978

A/C T	Q1-410	Q1-610	Q1-630	Q1-810	Q2-410	Q2-610	Q2-630	Q2-810
A300	1,196	2,704	3,230	346	1,120	2,538	3,136	341
A310	0	0	0	0	0	0	0	0
A320	0	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0	0
B707	38,979	85,735	99,685	12,090	38,384	77,814	97,336	11,484
B727	185,696	440,483	530,532	59,261	190,224	444,698	535,911	60,537
B737	9,102	26,055	33,303	5,310	10,284	28,816	36,918	5,369
B733	0	0	0	0	0	0	0	0
B734	0	0	0	0	0	0	0	0
B747	16,904	34,211	39,058	3,696	15,222	30,433	34,683	3,674
B744	0	0	0	0	0	0	0	0
B757	0	0	0	0	0	0	0	0
B767	0	0	0	0	0	0	0	0
DC8	28,763	63,068	72,631	8,539	28,561	62,275	71,852	8,303
DC9	38,343	101,276	124,951	13,637	38,910	101,919	126,315	13,603
MD80	0	0	0	0	0	0	0	0
DC10	34,865	73,589	84,486	9,015	32,020	66,268	75,504	9,084
MD11	0	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0	0
L1011	21,104	45,431	54,339	6,120	22,733	48,059	57,180	5,931

A/C T	Q3-410	Q3-610	Q3-630	Q3-810	Q4-410	Q4-610	Q4-630	Q4-810
A300	1,020	2,284	2,885	340	1,268	2,806	3,475	429
A310	0	0	0	0	0	0	0	0
A320	0	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0	0
B707	39,579	85,056	98,645	10,872	37,192	81,123	93,537	11,352
B727	203,821	465,141	557,724	61,527	206,923	482,783	577,890	62,655
B737	12,265	33,293	42,515	5,428	12,022	33,538	42,422	5,428
B733	0	0	0	0	0	0	0	0
B734	0	0	0	0	0	0	0	0
B747	17,045	33,750	38,394	3,692	16,140	32,529	37,050	3,490
B744	0	0	0	0	0	0	0	0
B757	0	0	0	0	0	0	0	0
B767	0	0	0	0	0	0	0	0
DC8	30,707	65,624	74,882	8,351	29,806	64,746	73,803	8,298
DC9	38,779	100,779	125,474	13,447	38,229	100,976	125,502	13,506
MD80	0	0	0	0	0	0	0	0
DC10	35,612	72,430	82,560	9,238	36,591	76,629	87,813	9,129
MD11	0	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0	0
L1011	24,650	51,163	60,496	5,999	23,225	49,392	59,102	6,180

Appendix G.2: Domestic Operations Aggregate for 1980

A/C T	Q1-410	Q1-610	Q1-630	Q1-810	Q2-410	Q2-610	Q2-630	Q2-810
A300	4,413	10,087	12,270	1,214	4,386	9,892	12,022	1,285
A310	0	0	0	0	0	0	0	0
A320	0	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0	0
B707	34,034	75,294	85,886	10,231	29,583	64,865	74,339	9,752
B727	246,971	580,524	684,828	71,249	247,800	572,029	676,515	72,993
B737	8,186	23,335	29,792	4,657	8,302	21,893	27,625	4,278
B733	0	0	0	0	0	0	0	0
B734	0	0	0	0	0	0	0	0
B747	18,170	36,441	40,908	3,933	17,936	35,455	39,591	3,779
B744	0	0	0	0	0	0	0	0
B757	0	0	0	0	0	0	0	0
B767	0	0	0	0	0	0	0	0
DC8	20,536	45,319	51,344	6,690	18,618	40,838	46,793	6,727
DC9	33,623	89,611	110,016	11,184	33,003	85,246	104,741	10,763
MD80	0	0	0	0	0	0	0	0
DC10	36,980	77,866	88,783	9,703	38,615	79,813	90,874	10,112
MD11	0	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0	0
L1011	27,439	58,909	69,787	6,787	27,738	58,125	68,392	6,393

A/C T	Q3-410	Q3-610	Q3-630	Q3-810	Q4-410	Q4-610	Q4-630	Q4-810
A300	4,775	10,459	12,749	1,364	5,184	11,545	13,722	1,481
A310	0	0	0	0	0	0	0	0
A320	0	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0	0
B707	30,634	66,388	76,303	10,329	24,691	54,030	61,842	9,971
B727	254,706	585,357	694,792	74,787	239,947	558,747	655,058	75,698
B737	8,082	20,977	26,077	4,256	7,296	19,226	23,779	4,166
B733	0	0	0	0	0	0	0	0
B734	0	0	0	0	0	0	0	0
B747	18,650	36,610	41,060	3,722	17,196	34,205	38,457	3,911
B744	0	0	0	0	0	0	0	0
B757	0	0	0	0	0	0	0	0
B767	0	0	0	0	0	0	0	0
DC8	17,863	39,036	44,865	5,759	14,770	33,032	37,829	5,538
DC9	32,660	83,331	102,444	10,665	32,149	83,161	99,811	10,626
MD80	0	0	0	0	0	0	0	0
DC10	40,676	83,576	95,477	10,376	34,022	70,429	79,945	10,381
MD11	0	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0	0
L1011	29,024	59,900	69,844	6,427	25,951	54,655	63,346	6,459

Appendix G.3: Domestic Operations Aggregate for 1982

A/C T	Q1-410	Q1-610	Q1-630	Q1-810	Q2-410	Q2-610	Q2-630	Q2-810
A300	6,943	15,980	19,074	2,118	6,602	14,851	17,752	2,051
A310	0	0	0	0	0	0	0	0
A320	0	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0	0
B707	7,871	17,938	20,936	4,284	8,414	18,970	22,402	4,155
B727	219,056	511,797	606,190	72,649	223,406	512,936	608,060	73,204
B737	10,053	25,995	32,052	4,410	9,808	24,840	30,632	4,459
B733	0	0	0	0	0	0	0	0
B734	0	0	0	0	0	0	0	0
B747	18,990	38,057	42,671	4,626	17,749	35,107	39,351	4,113
B744	0	0	0	0	0	0	0	0
B757	0	0	0	0	0	0	0	0
B767	0	0	0	0	0	0	0	0
DC8	12,792	28,603	33,237	4,683	13,310	29,520	34,102	4,647
DC9	25,229	66,201	80,018	10,320	27,082	69,150	83,202	10,420
MD80	0	0	0	0	0	0	0	0
DC10	36,243	75,588	86,106	9,961	38,162	78,156	88,883	10,664
MD11	0	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0	0
L1011	31,772	68,260	79,414	8,474	30,977	65,468	76,184	8,043

A/C T	Q3-410	Q3-610	Q3-630	Q3-810	Q4-410	Q4-610	Q4-630	Q4-810
A300	7,158	15,814	18,829	2,121	7,332	16,582	19,596	2,246
A310	0	0	0	0	0	0	0	0
A320	0	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0	0
B707	7,823	17,407	20,512	3,534	5,018	11,349	13,371	2,441
B727	239,804	545,359	644,648	74,628	230,730	532,043	626,918	73,741
B737	9,460	23,849	29,701	4,508	9,419	24,354	30,125	4,508
B733	0	0	0	0	0	0	0	0
B734	0	0	0	0	0	0	0	0
B747	18,971	37,159	41,614	3,929	17,988	35,631	39,808	4,217
B744	0	0	0	0	0	0	0	0
B757	0	0	0	0	0	0	0	0
B767	185	400	682	68	2,391	5,145	6,508	782
DC8	13,074	28,654	33,220	4,776	12,820	28,433	32,749	4,959
DC9	28,813	73,064	87,882	10,515	39,390	100,839	120,990	13,960
MD80	0	0	0	0	0	0	0	0
DC10	41,969	85,271	97,114	10,809	36,845	75,725	85,976	10,885
MD11	0	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0	0
L1011	31,353	65,238	75,629	8,049	30,129	64,167	74,462	8,504

Appendix G.4: Domestic Operations Aggregate for 1984

A/C T	Q1-410	Q1-610	Q1-630	Q1-810	Q2-410	Q2-610	Q2-630	Q2-810
A300	9,689	21,841	25,431	2,844	9,266	20,757	24,552	2,764
A310	0	0	0	0	0	0	0	0
A320	0	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0	0
B707	0	0	0	0	0	0	0	0
B727	218,444	513,517	609,544	69,062	227,386	528,876	632,294	69,197
B737	12,349	33,060	42,006	5,233	15,480	40,767	52,186	5,987
B733	0	0	0	0	0	0	0	0
B734	0	0	0	0	0	0	0	0
B747	18,255	36,567	41,082	4,133	15,182	30,228	34,114	3,568
B744	0	0	0	0	0	0	0	0
B757	4,597	10,922	12,687	1,332	5,127	11,913	13,910	1,351
B767	17,857	39,365	45,611	4,578	19,147	42,140	49,495	4,756
DC8	13,929	30,747	35,426	4,915	14,201	31,278	36,249	4,941
DC9	36,462	94,778	113,681	12,877	38,188	97,898	118,201	12,853
MD80	11,077	25,828	29,948	2,825	12,147	28,220	33,013	3,115
DC10	38,093	79,146	90,512	9,831	40,815	83,761	95,608	10,009
MD11	0	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0	0
L1011	28,199	61,496	71,648	8,196	26,224	55,968	65,053	7,123

A/C T	Q3-410	Q3-610	Q3-630	Q3-810	Q4-410	Q4-610	Q4-630	Q4-810
A300	9,341	20,684	24,469	2,889	10,271	22,865	26,744	3,021
A310	0	0	0	0	0	0	0	0
A320	0	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0	0
B707	0	0	0	0	0	0	0	0
B727	237,469	544,020	649,721	69,933	229,823	537,429	641,969	69,758
B737	19,019	49,064	62,398	6,650	21,038	55,608	69,913	7,252
B733	0	0	0	0	0	0	0	0
B734	0	0	0	0	0	0	0	0
B747	13,405	26,558	29,929	3,093	12,286	24,711	27,946	2,910
B744	0	0	0	0	0	0	0	0
B757	5,636	12,869	14,854	1,380	5,911	13,878	16,180	1,637
B767	21,315	46,255	53,980	4,968	20,915	45,574	52,047	4,910
DC8	14,360	31,299	36,498	4,968	13,308	29,650	34,596	4,553
DC9	38,896	99,046	119,683	13,180	37,862	97,676	118,451	13,166
MD80	14,680	33,611	39,155	3,724	18,726	43,626	51,033	4,695
DC10	45,980	92,920	105,985	10,495	45,935	94,928	109,748	11,287
MD11	0	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0	0
L1011	25,436	53,269	61,641	6,811	23,108	49,177	56,963	6,693

Appendix G.5: Domestic Operations Aggregate for 1986

A/C T	Q1-410	Q1-610	Q1-630	Q1-810	Q2-410	Q2-610	Q2-630	Q2-810
A300	13,795	30,643	35,761	3,506	13,348	29,372	34,805	3,580
A310	0	0	0	0	0	0	0	0
A320	0	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0	0
B707	0	0	0	0	0	0	0	0
B727	199,102	470,644	570,203	62,815	226,786	530,633	646,069	69,014
B737	23,515	61,285	77,095	8,314	34,225	85,694	106,347	10,870
B733	0	0	0	0	0	0	0	0
B734	0	0	0	0	0	0	0	0
B747	10,397	20,937	23,552	2,285	9,222	18,436	21,004	1,822
B744	0	0	0	0	0	0	0	0
B757	16,304	37,449	43,704	4,269	18,929	42,960	50,349	4,790
B767	21,790	46,738	52,865	4,926	22,181	47,393	53,850	4,745
DC8	12,994	28,678	33,794	3,720	14,128	30,732	36,135	3,819
DC9	27,773	73,576	90,415	10,348	40,284	96,005	125,948	13,811
MD80	27,504	64,474	75,813	7,121	31,328	72,711	86,335	7,965
DC10	40,336	84,344	96,751	10,106	47,959	98,749	113,354	11,202
MD11	0	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0	0
L1011	24,034	51,263	59,720	6,902	24,920	52,054	60,873	6,521

A/C T	Q3-410	Q3-610	Q3-630	Q3-810	Q4-410	Q4-610	Q4-630	Q4-810
A300	14,889	32,592	38,707	3,895	14,640	33,019	39,540	4,089
A310	0	0	0	0	360	762	882	100
A320	0	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0	0
B707	0	0	0	0	0	0	0	0
B727	230,317	536,685	658,233	69,705	233,633	548,843	666,571	70,988
B737	39,319	96,665	118,877	11,844	41,016	102,520	125,482	12,822
B733	0	0	0	0	113	279	487	59
B734	0	0	0	0	0	0	0	0
B747	11,005	21,936	25,365	2,047	10,108	20,437	23,417	2,127
B744	0	0	0	0	0	0	0	0
B757	21,583	48,723	57,364	5,230	24,370	55,840	65,905	6,230
B767	22,536	48,042	55,001	4,749	22,915	49,479	56,478	4,914
DC8	15,752	33,924	39,864	3,864	15,675	34,185	39,971	3,864
DC9	42,365	107,116	132,198	14,287	87,664	226,323	279,478	31,750
MD80	34,581	79,080	94,053	8,627	39,399	92,213	109,684	10,738
DC10	50,756	103,578	118,989	11,148	49,768	102,718	117,852	11,132
MD11	0	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0	0
L1011	26,741	55,184	64,895	6,709	25,414	53,176	62,118	6,902

Appendix G.6: Domestic Operations Aggregate for 1988

A/C T	Q1-410	Q1-610	Q1-630	Q1-810	Q2-410	Q2-610	Q2-630	Q2-810
A300	14,229	31,694	37,436	4,023	13,516	29,349	34,633	3,859
A310	190	431	548	54	436	975	1,338	106
A320	0	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0	0
BA146	1,227	3,731	4,668	606	1,242	3,818	4,822	546
B707	0	0	0	0	0	0	0	0
B727	241,409	569,400	689,045	74,524	238,585	555,504	677,134	74,042
B737	53,961	138,832	172,746	19,153	50,653	128,594	161,018	18,653
B733	29,353	69,962	82,065	7,827	30,939	72,012	85,032	8,291
B734	0	0	0	0	0	0	0	0
B747	12,047	24,086	27,017	2,515	10,249	20,306	23,075	2,069
B744	0	0	0	0	0	0	0	0
B757	30,603	69,846	82,102	7,919	31,712	71,257	83,897	8,141
B767	28,781	62,470	71,613	5,601	31,128	67,071	77,421	6,774
DC8	13,231	28,969	33,796	3,430	12,576	27,021	31,677	3,287
DC9	77,014	203,155	253,578	30,677	77,386	198,211	248,127	30,431
MD80	75,529	180,638	215,570	21,359	80,496	188,811	226,586	22,120
DC10	54,783	112,854	128,240	12,363	54,580	110,757	126,263	11,968
MD11	0	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0	0
L1011	25,048	52,801	61,746	6,223	24,454	50,203	58,510	5,743

A/C T	Q3-410	Q3-610	Q3-630	Q3-810	Q4-410	Q4-610	Q4-630	Q4-810
A300	13,305	28,417	33,485	3,905	13,025	28,151	32,642	3,873
A310	537	1,177	1,543	116	1,250	2,755	3,402	301
A320	0	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0	0
BA146	1,284	3,917	4,972	552	1,237	3,845	4,930	622
B707	0	0	0	0	0	0	0	0
B727	236,222	547,094	671,284	73,515	224,191	530,705	647,309	72,178
B737	49,472	124,604	156,685	18,586	47,315	122,174	152,711	18,262
B733	32,942	76,350	90,632	9,018	37,549	89,045	104,800	10,329
B734	0	0	0	0	0	0	0	0
B747	10,059	19,775	22,419	1,887	9,679	19,319	21,910	2,061
B744	0	0	0	0	0	0	0	0
B757	33,978	75,291	88,601	8,400	35,194	78,647	91,668	8,659
B767	34,213	73,056	84,294	7,159	35,736	77,759	89,266	7,555
DC8	12,943	27,464	32,057	3,243	11,524	25,016	28,708	3,098
DC9	78,593	201,491	254,330	30,638	75,024	197,239	247,102	30,747
MD80	85,179	198,161	239,399	23,657	87,759	210,997	255,726	25,498
DC10	55,617	112,126	129,172	12,279	51,749	106,710	122,351	12,129
MD11	0	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0	0
L1011	23,781	47,718	55,246	5,428	24,179	49,318	56,652	5,543

Appendix G.7: Domestic Operations Aggregate for 1990

A/C T	Q1-410	Q1-610	Q1-630	Q1-810	Q2-410	Q2-610	Q2-630	Q2-810
A300	9,141	20,487	24,509	2,550	10,267	22,889	26,750	2,798
A310	6,564	13,852	15,815	1,590	7,072	14,808	16,798	1,709
A320	2,156	5,022	5,905	540	2,757	6,356	7,584	667
A334	0	0	0	0	0	0	0	0
BA146	814	2,510	3,423	540	901	2,794	3,959	546
B707	0	0	0	0	0	0	0	0
B727	206,410	489,839	598,514	64,287	209,983	494,200	606,227	64,434
B737	35,698	92,142	114,833	13,731	37,525	96,095	120,653	14,184
B733	46,666	112,516	133,562	13,506	49,864	120,030	143,056	14,273
B734	0	0	0	0	0	0	0	0
B747	10,955	22,071	25,044	2,371	9,423	18,797	21,338	1,782
B744	110	263	352	25	88	222	296	23
B757	44,049	99,777	117,731	10,682	48,372	108,404	128,164	11,612
B767	31,564	68,723	79,150	6,885	31,746	68,802	79,564	6,923
DC8	9,347	19,856	22,624	2,311	9,880	20,789	23,587	2,286
DC9	72,198	192,732	244,623	29,270	74,034	194,727	248,397	29,176
MD80	104,917	254,602	312,119	30,086	111,924	268,727	328,621	31,769
DC10	48,696	101,364	117,049	11,319	50,941	104,735	121,073	11,400
MD11	0	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0	0
L1011	24,061	50,082	58,309	5,417	22,529	46,025	53,425	4,997

A/C T	Q3-410	Q3-610	Q3-630	Q3-810	Q4-410	Q4-610	Q4-630	Q4-810
A300	16,872	35,909	42,190	4,240	14,909	31,680	36,747	3,908
A310	1,750	3,652	4,211	294	0	0	0	0
A320	3,130	7,052	8,352	736	3,750	8,577	9,955	916
A334	0	0	0	0	0	0	0	0
BA146	978	2,987	4,202	552	351	1,074	1,526	210
B707	0	0	0	0	0	0	0	0
B727	214,098	497,845	616,039	65,204	187,991	442,573	541,451	60,393
B737	38,869	98,371	124,537	14,159	37,062	95,492	119,663	14,344
B733	51,705	122,530	148,912	14,982	54,801	132,084	157,468	15,796
B734	0	0	0	0	292	724	891	122
B747	8,184	16,001	18,287	1,401	6,176	12,249	13,918	1,334
B744	88	221	327	24	91	231	327	24
B757	53,839	119,452	141,779	12,798	59,155	132,222	155,947	14,252
B767	30,314	64,869	75,326	6,425	29,372	63,702	73,284	6,399
DC8	10,414	21,478	24,509	2,200	7,516	16,016	18,275	1,820
DC9	73,758	192,777	248,651	29,417	70,656	185,048	236,291	29,691
MD80	117,944	277,288	342,062	33,313	115,802	279,242	344,726	34,591
DC10	52,451	106,142	123,253	11,253	49,658	102,188	118,109	11,271
MD11	0	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0	0
L1011	22,050	44,011	50,842	4,668	21,777	44,332	50,912	4,909

Appendix G.8: International Operations Aggregate for 1978

A/C T	Q1-410	Q1-610	Q1-630	Q1-810	Q2-410	Q2-610	Q2-630	Q2-810
A300	30	92	129	14	48	145	206	23
A310	0	0	0	0	0	0	0	0
A320	0	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0	0
B707	23,816	50,141	57,326	7,841	28,199	58,581	66,184	8,040
B727	7,964	18,830	22,123	2,798	8,221	19,444	22,822	2,765
B737	48	158	166	90	46	152	159	91
B733	0	0	0	0	0	0	0	0
B734	0	0	0	0	0	0	0	0
B747	28,772	56,094	60,996	5,247	28,509	55,271	59,817	5,323
B744	0	0	0	0	0	0	0	0
B757	0	0	0	0	0	0	0	0
B767	0	0	0	0	0	0	0	0
DC8	607	1,244	1,360	158	585	1,179	1,287	160
DC9	105	287	344	38	82	228	274	30
MD80	0	0	0	0	0	0	0	0
DC10	92	198	237	41	350	750	902	165
MD11	0	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0	0
L1011	3,965	8,054	9,154	1,031	5,404	10,807	12,147	1,351

A/C T	Q3-410	Q3-610	Q3-630	Q3-810	Q4-410	Q4-610	Q4-630	Q4-810
A300	55	164	233	28	48	149	218	30
A310	0	0	0	0	0	0	0	0
A320	0	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0	0
B707	32,069	65,961	73,715	8,049	22,495	46,805	53,346	6,818
B727	8,117	19,123	22,551	2,704	7,547	18,082	21,324	2,738
B737	44	156	163	92	41	135	141	92
B733	0	0	0	0	0	0	0	0
B734	0	0	0	0	0	0	0	0
B747	32,124	61,959	66,987	5,688	34,015	65,916	71,332	5,976
B744	0	0	0	0	0	0	0	0
B757	0	0	0	0	0	0	0	0
B767	0	0	0	0	0	0	0	0
DC8	710	1,415	1,532	206	849	1,693	1,846	254
DC9	94	257	310	35	70	194	226	25
MD80	0	0	0	0	0	0	0	0
DC10	483	1,003	1,188	122	692	1,380	1,529	166
MD11	0	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0	0
L1011	6,356	12,499	13,934	1,534	5,630	11,204	12,492	1,417

Appendix G.9: International Operations Aggregate for 1980

A/C T	Q1-410	Q1-610	Q1-630	Q1-810	Q2-410	Q2-610	Q2-630	Q2-810
A300	0	0	0	0	0	0	0	0
A310	0	0	0	0	0	0	0	0
A320	0	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0	0
B707	14,137	29,972	33,594	4,571	10,941	22,992	25,950	3,875
B727	9,440	22,231	26,021	3,204	10,068	23,543	27,558	3,251
B737	45	145	153	91	47	152	153	91
B733	0	0	0	0	0	0	0	0
B734	0	0	0	0	0	0	0	0
B747	34,763	67,124	72,073	6,088	38,930	74,443	80,156	6,555
B744	0	0	0	0	0	0	0	0
B757	0	0	0	0	0	0	0	0
B767	0	0	0	0	0	0	0	0
DC8	195	443	459	57	152	355	414	44
DC9	116	368	597	49	64	202	271	29
MD80	0	0	0	0	0	0	0	0
DC10	5,543	10,944	11,905	1,130	4,968	9,757	10,612	1,019
MD11	0	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0	0
L1011	6,516	12,988	14,429	1,283	8,352	16,481	18,401	1,761

A/C T	Q3-410	Q3-610	Q3-630	Q3-810	Q4-410	Q4-610	Q4-630	Q4-810
A300	0	0	0	0	0	0	0	0
A310	0	0	0	0	0	0	0	0
A320	0	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0	0
B707	8,697	18,299	20,835	2,942	5,484	11,611	13,306	2,122
B727	10,351	23,946	27,799	3,260	9,888	22,884	26,497	3,392
B737	56	181	191	92	63	204	214	92
B733	0	0	0	0	0	0	0	0
B734	0	0	0	0	0	0	0	0
B747	43,734	83,779	90,365	7,080	36,067	69,686	75,332	6,688
B744	0	0	0	0	0	0	0	0
B757	0	0	0	0	0	0	0	0
B767	0	0	0	0	0	0	0	0
DC8	125	288	343	35	128	300	342	41
DC9	13	38	50	6	42	128	172	18
MD80	0	0	0	0	0	0	0	0
DC10	5,081	9,959	10,877	1,012	4,744	9,251	10,096	1,076
MD11	0	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0	0
L1011	10,889	21,414	23,885	2,197	10,010	19,948	22,105	2,305

Appendix G.10: International Operations Aggregate for 1982

A/C T	Q1-410	Q1-610	Q1-630	Q1-810	Q2-410	Q2-610	Q2-630	Q2-810
A300	398	962	1,210	132	722	1,640	1,976	224
A310	0	0	0	0	0	0	0	0
A320	0	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0	0
B707	0	0	0	0	0	0	0	0
B727	10,214	24,039	28,048	3,611	11,235	25,879	29,810	3,722
B737	40	126	170	90	486	1,568	1,993	321
B733	0	0	0	0	0	0	0	0
B734	0	0	0	0	0	0	0	0
B747	33,324	66,983	69,909	6,534	39,726	76,364	81,898	7,122
B744	0	0	0	0	0	0	0	0
B757	0	0	0	0	0	0	0	0
B767	0	0	0	0	0	0	0	0
DC8	0	0	0	0	0	0	0	0
DC9	0	0	0	0	106	283	354	44
MD80	0	0	0	0	0	0	0	0
DC10	5,432	10,868	12,113	1,592	4,651	9,234	10,286	1,069
MD11	0	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0	0
L1011	5,959	11,801	12,838	1,411	11,690	22,768	24,601	2,240

A/C T	Q3-410	Q3-610	Q3-630	Q3-810	Q4-410	Q4-610	Q4-630	Q4-810
A300	593	1,352	1,642	179	505	1,170	1,429	161
A310	0	0	0	0	0	0	0	0
A320	0	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0	0
B707	0	0	0	0	0	0	0	0
B727	11,510	25,410	29,057	3,577	9,756	21,493	24,638	3,317
B737	1,383	4,561	5,528	804	1,534	4,925	5,974	965
B733	0	0	0	0	0	0	0	0
B734	0	0	0	0	0	0	0	0
B747	34,188	65,537	70,277	5,821	38,598	74,721	80,201	7,038
B744	0	0	0	0	0	0	0	0
B757	0	0	0	0	0	0	0	0
B767	0	0	0	0	0	0	0	0
DC8	0	0	0	0	0	0	0	0
DC9	176	438	534	64	679	1,585	1,821	207
MD80	0	0	0	0	0	0	0	0
DC10	5,935	11,679	13,151	1,221	4,646	9,141	10,158	1,269
MD11	0	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0	0
L1011	10,544	20,515	22,135	1,952	8,667	17,085	18,711	2,167

Appendix G.11: International Operations Aggregate for 1984

A/C T	Q1-410	Q1-610	Q1-630	Q1-810	Q2-410	Q2-610	Q2-630	Q2-810
A300	845	1,909	2,278	250	1,103	2,496	2,966	330
A310	0	0	0	0	0	0	0	0
A320	0	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0	0
B707	0	0	0	0	0	0	0	0
B727	10,567	23,023	26,190	3,113	10,145	22,058	25,135	2,929
B737	2,371	7,261	8,743	1,502	2,973	8,950	10,755	1,456
B733	0	0	0	0	0	0	0	0
B734	0	0	0	0	0	0	0	0
B747	36,219	70,119	75,068	6,765	41,642	79,816	85,490	7,338
B744	0	0	0	0	0	0	0	0
B757	113	262	309	33	44	102	120	14
B767	0	0	0	0	0	0	0	0
DC8	196	449	516	58	203	454	520	64
DC9	554	1,318	1,520	209	497	1,168	1,329	188
MD80	0	0	0	0	0	0	0	0
DC10	4,938	9,898	11,126	1,165	4,995	9,861	10,891	1,173
MD11	0	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0	0
L1011	8,034	16,040	17,651	2,125	12,585	24,673	27,062	2,796

A/C T	Q3-410	Q3-610	Q3-630	Q3-810	Q4-410	Q4-610	Q4-630	Q4-810
A300	1,145	2,587	3,078	239	377	873	1,043	121
A310	0	0	0	0	0	0	0	0
A320	0	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0	0
B707	0	0	0	0	0	0	0	0
B727	10,667	23,130	26,398	3,140	10,438	22,502	25,792	3,032
B737	2,986	8,851	10,557	1,472	2,716	8,391	10,096	1,472
B733	0	0	0	0	0	0	0	0
B734	0	0	0	0	0	0	0	0
B747	47,951	91,808	98,609	8,131	41,286	79,551	85,309	7,841
B744	0	0	0	0	0	0	0	0
B757	0	0	0	0	164	386	453	47
B767	0	0	0	0	0	0	0	0
DC8	269	600	692	92	107	239	277	38
DC9	341	798	898	96	365	859	1,012	174
MD80	0	0	0	0	55	125	150	21
DC10	5,283	10,230	11,169	1,008	4,503	8,677	9,602	875
MD11	0	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0	0
L1011	14,227	27,643	30,177	3,085	11,028	21,631	23,781	2,695

Appendix G.12: International Operations Aggregate for 1986

A/C T	Q1-410	Q1-610	Q1-630	Q1-810	Q2-410	Q2-610	Q2-630	Q2-810
A300	2,431	5,229	6,040	634	3,155	6,739	7,747	847
A310	857	2,666	3,521	481	1,571	4,113	5,034	667
A320	0	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0	0
B707	0	0	0	0	0	0	0	0
B727	6,237	13,939	16,326	1,992	11,727	26,120	30,375	3,487
B737	1,609	4,802	5,860	1,077	1,753	5,061	6,195	1,090
B733	0	0	0	0	0	0	0	0
B734	0	0	0	0	0	0	0	0
B747	36,811	71,358	76,730	7,519	40,070	77,232	83,354	7,577
B744	0	0	0	0	0	0	0	0
B757	53	149	203	18	44	110	132	13
B767	3,965	8,330	9,262	963	3,750	7,533	8,030	721
DC8	191	427	501	60	9	19	22	3
DC9	0	0	0	0	239	565	662	69
MD80	0	0	0	0	160	375	448	42
DC10	5,626	10,936	11,849	1,026	9,501	18,258	19,537	1,592
MD11	0	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0	0
L1011	6,482	12,901	14,307	1,628	9,006	17,622	19,358	1,973

A/C T	Q3-410	Q3-610	Q3-630	Q3-810	Q4-410	Q4-610	Q4-630	Q4-810
A300	3,347	7,124	8,287	889	2,451	5,219	6,064	695
A310	2,177	5,462	6,515	644	1,358	3,727	4,607	544
A320	0	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0	0
B707	0	0	0	0	0	0	0	0
B727	12,660	27,947	32,583	3,680	13,821	31,654	37,301	4,602
B737	1,912	5,451	6,692	1,093	532	1,417	1,812	417
B733	0	0	0	0	0	0	0	0
B734	0	0	0	0	0	0	0	0
B747	41,740	80,164	86,859	7,686	35,176	68,362	73,792	7,342
B744	0	0	0	0	0	0	0	0
B757	0	0	0	0	0	0	0	0
B767	5,258	10,600	11,345	966	5,306	10,790	11,515	1,050
DC8	0	0	0	0	0	0	0	0
DC9	173	391	456	45	153	345	401	40
MD80	0	0	0	0	0	0	0	0
DC10	10,707	20,457	21,939	1,734	8,900	17,189	18,516	1,624
MD11	0	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0	0
L1011	9,642	18,758	20,698	1,939	7,455	14,699	16,263	1,593

Appendix G.13: International Operations Aggregate for 1988

A/C T	Q1-410	Q1-610	Q1-630	Q1-810	Q2-410	Q2-610	Q2-630	Q2-810
A300	1,130	2,473	2,934	311	3,078	6,665	7,863	858
A310	3,461	7,735	8,633	883	6,147	13,294	14,764	1,280
A320	0	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0	0
B707	0	0	0	0	0	0	0	0
B727	15,540	36,523	43,271	5,445	16,832	39,268	47,003	5,808
B737	171	405	462	58	243	575	678	86
B733	2,605	5,888	6,511	641	2,446	5,398	6,030	578
B734	0	0	0	0	0	0	0	0
B747	36,110	69,680	75,189	7,374	43,809	84,168	90,900	8,009
B744	0	0	0	0	0	0	0	0
B757	271	608	671	60	258	595	673	61
B767	7,996	16,356	17,566	2,183	9,274	18,638	20,020	1,640
DC8	0	0	0	0	0	0	0	0
DC9	33	109	148	18	205	484	555	98
MD80	376	891	1,056	91	567	1,285	1,536	182
DC10	10,761	21,109	23,032	2,092	12,358	24,223	26,083	2,294
MD11	0	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0	0
L1011	9,816	18,970	20,608	2,035	13,701	26,299	28,730	2,660

A/C T	Q3-410	Q3-610	Q3-630	Q3-810	Q4-410	Q4-610	Q4-630	Q4-810
A300	4,585	9,803	11,463	1,307	4,729	10,161	11,763	1,357
A310	8,414	18,103	19,882	1,630	6,491	14,304	15,860	1,447
A320	0	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0	0
B707	0	0	0	0	0	0	0	0
B727	16,783	39,201	46,926	5,924	17,206	40,434	48,382	6,171
B737	401	910	1,040	131	222	523	611	80
B733	3,232	7,182	8,182	834	2,524	5,593	6,353	645
B734	0	0	0	0	0	0	0	0
B747	50,054	95,364	103,057	8,319	41,851	80,787	87,127	7,854
B744	0	0	0	0	0	0	0	0
B757	219	527	591	57	453	997	1,138	108
B767	11,242	22,281	23,888	1,975	11,316	22,870	24,485	2,009
DC8	0	0	0	0	0	0	0	0
DC9	323	757	869	134	147	382	483	52
MD80	635	1,418	1,698	184	585	1,351	1,622	184
DC10	12,505	23,853	25,729	2,152	10,107	19,544	21,166	1,790
MD11	0	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0	0
L1011	18,071	34,480	37,498	3,080	15,453	27,870	30,189	2,573

Appendix G.14: International Operations Aggregate for 1990

A/C T	Q1-410	Q1-610	Q1-630	Q1-810	Q2-410	Q2-610	Q2-630	Q2-810
A300	2,347	4,977	5,720	614	2,779	5,847	6,741	722
A310	9,990	21,764	24,244	2,002	10,820	22,840	25,516	2,066
A320	0	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0	0
B707	0	0	0	0	0	0	0	0
B727	22,261	51,599	61,860	7,305	22,459	51,930	62,078	7,524
B737	161	367	405	47	164	368	406	49
B733	1,741	3,911	4,381	415	1,954	4,393	4,947	492
B734	0	0	0	0	0	0	0	0
B747	38,247	73,917	80,479	6,789	44,097	84,508	91,508	7,262
B744	2,709	5,180	5,498	515	2,713	5,197	5,514	523
B757	1,294	2,786	5,152	299	1,417	2,991	4,878	325
B767	14,796	30,098	32,446	2,511	15,958	31,969	34,258	2,587
DC8	0	0	0	0	0	0	0	0
DC9	115	283	345	35	183	449	538	62
MD80	776	1,773	2,085	180	821	1,894	2,179	209
DC10	10,995	21,360	23,131	2,046	12,025	23,209	25,002	2,059
MD11	0	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0	0
L1011	13,871	26,865	29,001	2,101	16,180	31,167	33,851	2,402

A/C T	Q3-410	Q3-610	Q3-630	Q3-810	Q4-410	Q4-610	Q4-630	Q4-810
A300	6,550	14,106	16,484	1,739	3,474	7,571	8,958	954
A310	9,486	19,268	21,034	1,438	0	0	0	0
A320	0	0	0	0	0	0	0	0
A334	0	0	0	0	0	0	0	0
BA146	0	0	0	0	0	0	0	0
B707	0	0	0	0	0	0	0	0
B727	23,852	54,997	66,416	7,805	16,295	36,254	43,310	4,842
B737	169	384	427	52	100	228	252	31
B733	2,580	5,733	6,465	539	1,986	4,478	5,026	424
B734	0	0	0	0	0	0	0	0
B747	48,624	92,817	102,045	7,694	26,951	52,047	57,904	5,108
B744	3,617	6,951	7,410	712	4,824	9,274	9,858	892
B757	2,079	4,500	5,441	513	2,235	4,818	5,966	515
B767	23,114	46,103	49,332	3,648	21,900	44,075	47,042	3,772
DC8	0	0	0	0	0	0	0	0
DC9	205	504	615	69	262	564	688	78
MD80	840	1,890	2,222	201	793	1,799	2,095	199
DC10	12,789	24,549	26,639	2,095	12,417	24,048	26,078	2,135
MD11	0	0	0	0	0	0	0	0
F100	0	0	0	0	0	0	0	0
L1011	17,443	33,434	36,518	2,527	13,559	26,273	28,380	2,159

Appendix H.1: Domestic Miles Aggregate

	1978	1980	1982	1984	1986	1988	1990
AIRBS	4,604	18,758	28,035	38,567	57,032	56,488	78,368
BAE	0	0	0	0	0	4,990	3,044
BOEIN	1,049,782	1,212,184	1,057,136	1,140,641	1,239,366	1,575,970	1,534,490
FOKK	0	0	0	0	0	0	0
LOCKH	91,712	110,152	124,231	102,967	101,109	97,462	90,417
MD	411,186	353,515	325,729	434,659	578,266	903,983	980,136
US	1,552,680	1,675,851	1,507,096	1,678,267	1,918,741	2,577,415	2,605,043
N-US	4,604	18,758	28,035	38,567	57,032	61,478	81,412
2CREW	197,934	163,301	161,830	376,429	640,054	1,237,912	1,452,726
3CREW	1,359,350	1,531,308	1,373,301	1,340,405	1,335,719	1,400,981	1,233,729
LVL1	271,971	190,729	81,122	55,798	58,549	50,274	37,157
LVL2	984,598	1,152,725	1,072,250	1,132,416	1,225,999	1,449,825	1,258,282
LVL3	296,111	332,397	351,148	332,918	330,660	356,225	326,901
LVL4	4,604	18,758	30,611	195,702	360,565	782,569	1,064,115
L CAP	984,598	1,152,725	1,072,250	1,189,046	1,358,924	1,914,561	1,927,034
M CAP	507,375	469,932	389,183	468,660	576,117	682,298	724,306
H CAP	65,311	71,952	73,698	59,128	40,732	42,034	35,115
S RNG	984,598	1,152,725	1,072,250	1,189,046	1,358,924	1,914,561	1,927,034
M RNG	235,404	279,203	308,061	412,862	517,568	632,024	687,149
L RNG	337,282	262,681	154,820	114,926	99,281	92,308	72,272
2-ENG	202,538	182,059	189,865	414,996	696,726	1,286,997	1,500,494
3-ENG	1,017,464	1,249,869	1,190,446	1,186,912	1,179,766	1,254,598	1,110,645
4-ENG	337,282	262,681	154,820	114,926	99,281	97,298	75,316
STG-1	271,971	190,729	81,122	55,798	58,549	50,274	37,157
STG-2	984,598	1,152,725	1,072,250	1,132,416	1,225,999	1,449,825	1,258,282
STG-3	300,715	351,155	381,759	528,620	691,225	1,138,794	1,391,016
1ML	271,971	190,729	81,122	55,798	58,549	50,274	37,157
2LS	984,598	1,152,725	1,072,250	1,132,416	1,225,999	1,449,825	1,258,282
3MM	230,800	260,445	277,450	273,790	289,928	314,191	292,163
3HL	65,311	71,952	73,698	59,128	40,732	42,034	34,738
4LS	0	0	0	56,630	132,925	464,736	668,752
4MM	4,604	18,758	30,611	139,072	227,640	317,833	394,986
4HL	0	0	0	0	0	0	377

Appendix H.2: Domestic Hours Aggregate

	1978	1980	1982	1984	1986	1988	1990
AIRBS	10,332	41,983	63,227	86,147	126,388	122,949	170,284
BAE	0	0	0	0	0	15,311	9,365
BOEIN	2,415,458	2,785,376	2,418,336	2,643,321	2,891,618	3,683,159	3,590,447
FOKK	0	0	0	0	0	0	0
LOCKH	194,045	231,589	263,133	219,910	211,677	200,040	184,450
MD	949,579	811,258	739,204	994,412	1,328,406	2,129,620	2,337,711
US	3,559,082	3,828,223	3,420,673	3,857,643	4,431,701	6,012,819	6,112,608
N-US	10,332	41,983	63,227	86,147	126,388	138,260	179,649
2CREW	526,652	426,780	413,837	922,098	1,535,327	2,996,322	3,510,699
3CREW	3,042,762	3,443,426	3,070,063	3,021,692	3,022,762	3,154,757	2,781,558
LVL1	585,441	418,802	180,874	122,974	127,519	108,470	78,139
LVL2	2,359,757	2,723,437	2,510,427	2,691,739	2,935,989	3,517,003	3,071,841
LVL3	613,884	685,984	723,827	688,729	682,812	725,973	667,997
LVL4	10,332	41,983	68,772	440,348	811,769	1,799,633	2,474,280
L CAP	2,359,757	2,723,437	2,510,427	2,823,024	3,244,746	4,618,290	4,675,956
M CAP	1,078,734	1,004,058	827,519	1,002,702	1,231,597	1,449,303	1,546,246
H CAP	130,923	142,711	145,954	118,064	81,746	83,486	70,055
S RNG	2,359,757	2,723,437	2,510,427	2,823,024	3,244,746	4,618,290	4,675,956
M RNG	493,293	585,256	646,645	879,728	1,104,078	1,340,833	1,468,107
L RNG	716,364	561,513	326,828	241,038	209,265	191,956	148,194
2-ENG	536,984	468,763	477,064	1,008,245	1,660,953	3,098,622	3,611,362
3-ENG	2,316,066	2,839,930	2,680,008	2,694,507	2,687,871	2,845,190	2,523,336
4-ENG	716,364	561,513	326,828	241,038	209,265	207,267	157,559
STG-1	585,441	418,802	180,874	122,974	127,519	108,470	78,139
STG-2	2,359,757	2,723,437	2,510,427	2,691,739	2,935,989	3,517,003	3,071,841
STG-3	624,216	727,967	792,599	1,129,077	1,494,581	2,525,606	3,142,277
1ML	585,441	418,802	180,874	122,974	127,519	108,470	78,139
2LS	2,359,757	2,723,437	2,510,427	2,691,739	2,935,989	3,517,003	3,071,841
3MM	482,961	543,273	577,873	570,665	601,066	642,487	598,879
3HL	130,923	142,711	145,954	118,064	81,746	83,486	69,118
4LS	0	0	0	131,285	308,757	1,101,287	1,604,115
4MM	10,332	41,983	68,772	309,063	503,012	698,346	869,228
4HL	0	0	0	0	0	0	937

Appendix H.3: Domestic Block Hours Aggregate

	1978	1980	1982	1984	1986	1988	1990
AIRBS	12,726	50,763	75,251	101,196	149,695	145,027	198,816
BAE	0	0	0	0	0	19,392	13,110
BOEIN	2,895,603	3,276,852	2,856,181	3,151,866	3,498,218	4,453,744	4,356,640
FOKK	0	0	0	0	0	0	0
LOCKH	231,117	271,369	305,689	255,305	247,606	232,154	213,488
MD	1,125,773	952,922	863,479	1,167,787	1,590,634	2,572,682	2,873,969
US	4,252,493	4,501,143	4,025,349	4,574,958	5,336,458	7,258,580	7,444,097
N-US	12,726	50,763	75,251	101,196	149,695	164,419	211,926
2CREW	657,400	524,285	501,792	1,108,432	1,858,610	3,641,192	4,303,042
3CREW	3,607,819	4,027.621	3,598,808	3,567,722	3,627,543	3,781,807	3,352,981
LVL1	682,371	479,201	210,529	142,769	149,764	126,238	88,995
LVL2	2,859,457	3,235,478	2,980,418	3,230,047	3,596,916	4,331,069	3,819,879
LVL3	710,665	786,464	827,212	790,229	787,890	832,601	771,559
LVL4	12,726	50,763	82,441	513,109	951,583	2,133,091	2,975,590
L CAP	2,859,457	3,235,478	2,980,418	3,383,196	3,963,288	5,650,271	5,776,202
M CAP	1,256,577	1,156,412	956,738	1,159,887	1,429,527	1,678,307	1,799,932
H CAP	149,185	160,016	163,444	133,071	93,338	94,421	79,889
S RNG	2,859,457	3,235,478	2,980,418	3,383,196	3,963,288	5,650,271	5,776,202
M RNG	574,206	677,211	746,209	1,017,118	1,279,763	1,552,069	1,710,937
L RNG	831,556	639,217	373,973	275,840	243,102	220,659	168,884
2-ENG	670,126	575,048	577,043	1,209,628	2,007,423	3,759,996	4,418,826
3-ENG	2,763,537	3,337,641	3,149,584	3,190,686	3,235,628	3,422,952	3,055,203
4-ENG	831,556	639,217	373,973	275,840	243,102	240,051	181,994
STG-1	682,371	479,201	210,529	142,769	149,764	126,238	88,995
STG-2	2,859,457	3,235,478	2,980,418	3,230,047	3,596,916	4,331,069	3,819,879
STG-3	723,391	837,227	909,653	1,303,338	1,739,473	2,965,692	3,747,149
1ML	682,371	479,201	210,529	142,769	149,764	126,238	88,995
2LS	2,859,457	3,235,478	2,980,418	3,230,047	3,596,916	4,331,069	3,819,879
3MM	561,480	626,448	663,768	657,158	694,552	738,180	692,972
3HL	149,185	160,016	163,444	133,071	93,338	94,421	78,587
4LS	0	0	0	153,149	366,372	1,319,202	1,956,323
4MM	12,726	50,763	82,441	359,960	585,211	813,889	1,017,965
4HL	0	0	0	0	0	0	1,302

Appendix H.4: Domestic Days Aggregate

	1978	1980	1982	1984	1986	1988	1990
AIRBS	1,456	5,344	8,536	11,518	15,170	16,237	19,948
BAE	0	0	0	0	0	2,326	1,848
BOEIN	325,865	367,712	344,256	341,688	364,565	473,118	452,375
FOKK	0	0	0	0	0	0	0
LOCKH	24,230	26,066	33,070	28,823	27,034	22,937	19,991
MD	124,150	108,524	106,599	127,434	163,502	276,924	301,173
US	474,245	502,302	483,925	497,945	555,101	772,979	773,539
N-US	1,456	5,344	8,536	11,518	15,170	18,563	21,796
2CREW	75,728	60,595	63,950	116,469	188,509	388,357	446,782
3CREW	399,973	447,051	428,511	392,994	381,762	403,185	348,553
LVL1	79,289	64,997	33,479	19,377	15,267	13,058	8,617
LVL2	319,708	355,322	357,322	355,148	386,568	491,406	428,290
LVL3	75,248	81,983	92,274	84,149	78,903	80,208	72,122
LVL4	1,456	5,344	9,386	50,789	89,533	206,870	286,306
L CAP	319,708	355,322	357,322	369,507	421,078	621,831	621,435
M CAP	141,441	136,979	118,254	126,252	140,912	161,179	166,916
H CAP	14,552	15,345	16,885	13,704	8,281	8,532	6,984
S RNG	319,708	355,322	357,322	369,507	421,078	621,831	621,435
M RNG	62,152	71,982	84,775	106,875	125,645	148,121	158,299
L RNG	93,841	80,342	50,364	33,081	23,548	21,590	15,601
2-ENG	77,184	65,939	72,486	127,987	203,579	401,691	458,334
3-ENG	304,676	361,365	369,611	348,395	343,144	365,935	319,552
4-ENG	93,841	80,342	50,364	33,081	23,548	23,916	17,449
STG-1	79,289	64,997	33,479	19,377	15,267	13,058	8,617
STG-2	319,708	355,322	357,322	355,148	386,568	491,406	428,290
STG-3	76,704	87,327	101,660	134,938	168,436	287,078	358,428
1ML	79,289	64,997	33,479	19,377	15,267	13,058	8,617
2LS	319,708	355,322	357,322	355,148	386,568	491,406	428,290
3MM	60,696	66,638	75,389	70,445	70,622	71,676	65,234
3HL	14,552	15,345	16,885	13,704	8,281	8,532	6,888
4LS	0	0	0	14,359	34,510	130,425	193,145
4MM	1,456	5,344	9,386	36,430	55,023	76,445	93,065
4HL	0	0	0	0	0	0	96

Appendix H.5: Domestic Miles Per Day Aggregate

	1978	1980	1982	1984	1986	1988	1990
AIRBS	3,162	3,510	3,284	3,348	3,760	3,479	3,929
BAE	N/A	N/A	N/A	N/A	N/A	2,145	1,647
BOEIN	3,222	3,297	3,071	3,338	3,400	3,331	3,392
FOKK	N/A	N/A	N/A	N/A	N/A	N/A	N/A
LOCKH	3,785	4,226	3,757	3,572	3,740	4,249	4,523
MD	3,312	3,257	3,056	3,411	3,537	3,264	3,254
US	3,274	3,336	3,114	3,370	3,457	3,334	3,368
N-US	3,162	3,510	3,284	3,348	3,760	3,312	3,735
2CREW	2,614	2,695	2,531	3,232	3,395	3,188	3,252
3CREW	3,399	3,425	3,205	3,411	3,499	3,475	3,540
LVL1	3,430	2,934	2,423	2,880	3,835	3,850	4,312
LVL2	3,080	3,244	3,001	3,189	3,171	2,950	2,938
LVL3	3,935	4,054	3,805	3,956	4,191	4,441	4,533
LVL4	3,162	3,510	3,261	3,853	4,027	3,783	3,717
L CAP	3,080	3,244	3,001	3,218	3,227	3,079	3,101
M CAP	3,587	3,431	3,291	3,712	4,088	4,233	4,339
H CAP	4,488	4,689	4,365	4,315	4,919	4,927	5,028
S RNG	3,080	3,244	3,001	3,218	3,227	3,079	3,101
M RNG	3,788	3,879	3,634	3,863	4,119	4,267	4,341
L RNG	3,594	3,270	3,074	3,474	4,216	4,275	4,633
2-ENG	2,624	2,761	2,619	3,242	3,422	3,204	3,274
3-ENG	3,339	3,459	3,221	3,407	3,438	3,428	3,476
4-ENG	3,594	3,270	3,074	3,474	4,216	4,068	4,316
STG-1	3,430	2,934	2,423	2,880	3,835	3,850	4,312
STG-2	3,080	3,244	3,001	3,189	3,171	2,950	2,938
STG-3	3,920	4,021	3,755	3,918	4,104	3,967	3,881
1ML	3,430	2,934	2,423	2,880	3,835	3,850	4,312
2LS	3,080	3,244	3,001	3,189	3,171	2,950	2,938
3MM	3,803	3,908	3,680	3,887	4,105	4,383	4,479
3HL	4,488	4,689	4,365	4,315	4,919	4,927	5,043
4LS	N/A	N/A	N/A	3,944	3,852	3,563	3,462
4MM	3,162	3,510	3,261	3,818	4,137	4,158	4,244
4HL	N/A	N/A	N/A	N/A	N/A	N/A	3,927

Appendix H.6: Domestic Hours Per Day Aggregate

	1978	1980	1982	1984	1986	1988	1990
AIRBS	7.10	7.86	7.41	7.48	8.33	7.57	8.54
BAE	N/A	N/A	N/A	N/A	N/A	6.58	5.07
BOEIN	7.41	7.57	7.02	7.74	7.93	7.78	7.94
FOKK	N/A	N/A	N/A	N/A	N/A	N/A	N/A
LOCKH	8.01	8.88	7.96	7.63	7.83	8.72	9.23
MD	7.65	7.48	6.93	7.80	8.12	7.69	7.76
US	7.50	7.62	7.07	7.75	7.98	7.78	7.90
N-US	7.10	7.86	7.41	7.48	8.33	7.45	8.24
2CREW	6.95	7.04	6.47	7.92	8.14	7.72	7.86
3CREW	7.61	7.70	7.16	7.69	7.92	7.82	7.98
LVL1	7.38	6.44	5.40	6.35	8.35	8.31	9.07
LVL2	7.38	7.66	7.03	7.58	7.60	7.16	7.17
LVL3	8.16	8.37	7.84	8.18	8.65	9.05	9.26
LVL4	7.10	7.86	7.33	8.67	9.07	8.70	8.64
L CAP	7.38	7.66	7.03	7.64	7.71	7.43	7.52
M CAP	7.63	7.33	7.00	7.94	8.74	8.99	9.26
H CAP	9.00	9.30	8.64	8.62	9.87	9.79	10.03
S RNG	7.38	7.66	7.03	7.64	7.71	7.43	7.52
M RNG	7.94	8.13	7.63	8.23	8.79	9.05	9.27
L RNG	7.63	6.99	6.49	7.29	8.89	8.89	9.50
2-ENG	6.96	7.11	6.58	7.88	8.16	7.71	7.88
3-ENG	7.60	7.86	7.25	7.73	7.83	7.78	7.90
4-ENG	7.63	6.99	6.49	7.29	8.89	8.67	9.03
STG-1	7.38	6.44	5.40	6.35	8.35	8.31	9.07
STG-2	7.38	7.66	7.03	7.58	7.60	7.16	7.17
STG-3	8.14	8.34	7.80	8.37	8.87	8.80	8.77
1ML	7.38	6.44	5.40	6.35	8.35	8.31	9.07
2LS	7.38	7.66	7.03	7.58	7.60	7.16	7.17
3MM	7.96	8.15	7.67	8.10	8.51	8.96	9.18
3HL	9.00	9.30	8.64	8.62	9.87	9.79	10.03
4LS	N/A	N/A	N/A	9.14	8.95	8.44	8.31
4MM	7.10	7.86	7.33	8.48	9.14	9.14	9.34
4HL	N/A	N/A	N/A	N/A	N/A	N/A	9.76

Appendix H.7: Domestic Block Hours Per Day Aggregate

	1978	1980	1982	1984	1986	1988	1990
AIRBS	8.74	9.50	8.82	8.79	9.87	8.93	9.97
BAE	N/A	N/A	N/A	N/A	N/A	8.34	7.09
BOEIN	8.89	8.91	8.30	9.22	9.60	9.41	9.63
FOKK	N/A	N/A	N/A	N/A	N/A	N/A	N/A
LOCKH	9.54	10.41	9.24	8.86	9.16	10.12	10.68
MD	9.07	8.78	8.10	9.16	9.73	9.29	9.54
US	8.97	8.96	8.32	9.19	9.61	9.39	9.62
N-US	8.74	9.50	8.82	8.79	9.87	8.86	9.72
2CREW	8.68	8.65	7.85	9.52	9.86	9.38	9.63
3CREW	9.02	9.01	8.40	9.08	9.50	9.38	9.62
LVL1	8.61	7.37	6.29	7.37	9.81	9.67	10.33
LVL2	8.94	9.11	8.34	9.09	9.30	8.81	8.92
LVL3	9.44	9.59	8.96	9.39	9.99	10.38	10.70
LVL4	8.74	9.50	8.78	10.10	10.63	10.31	10.39
L CAP	8.94	9.11	8.34	9.16	9.41	9.09	9.29
M CAP	8.88	8.44	8.09	9.19	10.14	10.41	10.78
H CAP	10.25	10.43	9.68	9.71	11.27	11.07	11.44
S RNG	8.94	9.11	8.34	9.16	9.41	9.09	9.29
M RNG	9.24	9.41	8.80	9.52	10.19	10.48	10.81
L RNG	8.86	7.96	7.43	8.34	10.32	10.22	10.83
2-ENG	8.68	8.72	7.96	9.45	9.86	9.36	9.64
3-ENG	9.07	9.24	8.52	9.16	9.43	9.35	9.56
4-ENG	8.86	7.96	7.43	8.34	10.32	10.04	10.43
STG-1	8.61	7.37	6.29	7.37	9.81	9.67	10.33
STG-2	8.94	9.11	8.34	9.09	9.30	8.81	8.92
STG-3	9.43	9.59	8.95	9.66	10.33	10.33	10.45
1ML	8.61	7.37	6.29	7.37	9.81	9.67	10.33
2LS	8.94	9.11	8.34	9.09	9.30	8.81	8.92
3MM	9.25	9.40	8.80	9.33	9.83	10.30	10.62
3HL	10.25	10.43	9.68	9.71	11.27	11.07	11.41
4LS	N/A	N/A	N/A	10.67	10.62	10.11	10.13
4MM	8.74	9.50	8.78	9.88	10.64	10.65	10.94
4HL	N/A	N/A	N/A	N/A	N/A	N/A	13.56

Appendix H.8: Domestic Hours to Block Hours Ratio

	1978	1980	1982	1984	1986	1988	1990
AIRBS	1.23	1.21	1.19	1.17	1.18	1.18	1.17
BAE	N/A	N/A	N/A	N/A	N/A	1.27	1.40
BOEIN	1.20	1.18	1.18	1.19	1.21	1.21	1.21
FOKK	N/A	N/A	N/A	N/A	N/A	N/A	N/A
LOCKH	1.19	1.17	1.16	1.16	1.17	1.16	1.16
MD	1.19	1.17	1.17	1.17	1.20	1.21	1.23
US	1.19	1.18	1.18	1.19	1.20	1.21	1.22
N-US	1.23	1.21	1.19	1.17	1.18	1.19	1.18
2CREW	1.25	1.23	1.21	1.20	1.21	1.22	1.23
3CREW	1.19	1.17	1.17	1.18	1.20	1.20	1.21
LVL1	1.17	1.14	1.16	1.16	1.17	1.16	1.14
LVL2	1.21	1.19	1.19	1.20	1.23	1.23	1.24
LVL3	1.16	1.15	1.14	1.15	1.15	1.15	1.16
LVL4	1.23	1.21	1.20	1.17	1.17	1.19	1.20
L CAP	1.21	1.19	1.19	1.20	1.22	1.22	1.24
M CAP	1.16	1.15	1.16	1.16	1.16	1.16	1.16
H CAP	1.14	1.12	1.12	1.13	1.14	1.13	1.14
S RNG	1.21	1.19	1.19	1.20	1.22	1.22	1.24
M RNG	1.16	1.16	1.15	1.16	1.16	1.16	1.17
L RNG	1.16	1.14	1.14	1.14	1.16	1.15	1.14
2-ENG	1.25	1.23	1.21	1.20	1.21	1.21	1.22
3-ENG	1.19	1.18	1.18	1.18	1.20	1.20	1.21
4-ENG	1.16	1.14	1.14	1.14	1.16	1.16	1.16
STG-1	1.17	1.14	1.16	1.16	1.17	1.16	1.14
STG-2	1.21	1.19	1.19	1.20	1.23	1.23	1.24
STG-3	1.16	1.15	1.15	1.15	1.16	1.17	1.19
1ML	1.17	1.14	1.16	1.16	1.17	1.16	1.14
2LS	1.21	1.19	1.19	1.20	1.23	1.23	1.24
3MM	1.16	1.15	1.15	1.15	1.16	1.15	1.16
3HL	1.14	1.12	1.12	1.13	1.14	1.13	1.14
4LS	N/A	N/A	N/A	1.17	1.19	1.20	1.22
4MM	1.23	1.21	1.20	1.16	1.16	1.17	1.17
4HL	N/A	N/A	N/A	N/A	N/A	N/A	1.39

Appendix H.9: International Miles Aggregate

	1978	1980	1982	1984	1986	1988	1990
AIRBS	181	0	2,218	3,470	17,347	38,035	45,446
BAE	0	0	0	0	0	0	0
BOEIN	262,027	232,711	191,994	220,282	222,424	291,058	348,297
FOKK	0	0	0	0	0	0	0
LOCKH	21,355	35,767	36,860	45,874	32,585	57,041	61,053
MD	4,719	21,171	21,625	22,306	35,659	48,602	52,221
US	288,101	289,649	250,479	288,462	290,668	396,701	461,571
N-US	181	0	2,218	3,470	17,347	38,035	45,446
2CREW	530	446	4,404	13,179	30,870	80,257	139,802
3CREW	287,752	289,203	248,293	278,753	277,145	354,479	367,215
LVL1	109,330	39,859	0	775	200	0	0
LVL2	32,379	40,193	47,119	54,620	50,816	68,106	86,226
LVL3	146,392	209,597	203,360	232,691	221,116	274,596	267,198
LVL4	181	0	2,218	3,846	35,883	92,034	153,593
L CAP	32,379	40,193	47,119	54,675	50,976	81,076	97,717
M CAP	132,483	95,962	59,742	70,159	103,242	181,836	237,518
H CAP	123,420	153,494	145,836	167,098	153,797	171,824	171,782
S RNG	32,379	40,193	47,119	54,675	50,976	81,076	97,717
M RNG	23,153	56,103	59,742	69,384	103,042	181,836	237,518
L RNG	232,750	193,353	145,836	167,873	153,997	171,824	171,782
2-ENG	711	446	6,622	16,649	42,254	93,779	141,089
3-ENG	54,821	95,850	100,239	107,410	111,764	169,133	194,146
4-ENG	232,750	193,353	145,836	167,873	153,997	171,824	171,782
STG-1	109,330	39,859	0	775	200	0	0
STG-2	32,379	40,193	47,119	54,620	50,816	68,106	86,226
STG-3	146,573	209,597	205,578	236,537	256,999	366,630	420,791
1ML	109,330	39,859	0	775	200	0	0
2LS	32,379	40,193	47,119	54,620	50,816	68,106	86,226
3MM	22,972	56,103	57,524	65,593	67,319	102,772	109,279
3HL	123,420	153,494	145,836	167,098	153,797	171,824	157,919
4LS	0	0	0	55	160	12,970	11,491
4MM	181	0	2,218	3,791	35,723	79,064	128,239
4HL	0	0	0	0	0	0	13,863

Appendix H.10: International Hours Aggregate

	1978	1980	1982	1984	1986	1988	1990
AIRBS	550	0	5,124	7,865	40,279	82,538	96,373
BAE	0	0	0	0	0	0	0
BOEIN	536,808	471,192	391,606	446,210	451,019	594,771	711,873
FOKK	0	0	0	0	0	0	0
LOCKH	42,564	70,831	72,169	89,987	63,980	107,619	117,739
MD	9,828	42,033	43,228	44,676	68,962	95,406	102,322
US	589,200	584,056	507,003	580,873	583,961	797,796	931,934
N-US	550	0	5,124	7,865	40,279	82,538	96,373
2CREW	1,567	1,418	13,486	38,471	71,887	169,459	286,832
3CREW	588,183	582,638	498,641	550,267	552,353	710,875	741,475
LVL1	227,019	84,260	0	1,742	446	0	0
LVL2	77,046	94,022	110,307	128,309	117,692	159,571	197,927
LVL3	285,135	405,774	396,696	449,947	427,936	526,347	514,194
LVL4	550	0	5,124	8,740	78,166	194,416	316,186
L CAP	77,046	94,022	110,307	128,434	118,067	188,577	223,798
M CAP	273,464	195,002	118,215	139,010	209,057	361,758	474,618
H CAP	239,240	295,032	283,605	321,294	297,116	329,999	329,891
S RNG	77,046	94,022	110,307	128,434	118,067	188,577	223,798
M RNG	46,445	110,742	118,215	137,268	208,611	361,758	474,618
L RNG	466,259	379,292	283,605	323,036	297,562	329,999	329,891
2-ENG	2,117	1,418	18,610	46,336	96,198	198,561	292,731
3-ENG	121,374	203,346	209,912	219,366	230,480	351,774	405,685
4-ENG	466,259	379,292	283,605	323,036	297,562	329,999	329,891
STG-1	227,019	84,260	0	1,742	446	0	0
STG-2	77,046	94,022	110,307	128,309	117,692	159,571	197,927
STG-3	285,685	405,774	401,820	458,687	506,102	720,763	830,380
1ML	227,019	84,260	0	1,742	446	0	0
2LS	77,046	94,022	110,307	128,309	117,692	159,571	197,927
3MM	45,895	110,742	113,091	128,653	130,820	196,348	210,905
3HL	239,240	295,032	283,605	321,294	297,116	329,999	303,289
4LS	0	0	0	125	375	29,006	25,871
4MM	550	0	5,124	8,615	77,791	165,410	263,713
4HL	0	0	0	0	0	0	26,602

Appendix H.11: International Block Hours Aggregate

	1978	1980	1982	1984	1986	1988	1990
AIRBS	786	0	6,257	9,365	47,815	93,162	108,697
BAE	0	0	0	0	0	0	0
BOEIN	599,152	520,197	427,503	489,024	498,366	660,754	800,704
FOKK	0	0	0	0	0	0	0
LOCKH	47,727	78,820	78,285	98,671	70,626	117,025	127,750
MD	11,035	46,138	48,417	49,702	74,331	103,977	111,617
US	657,914	645,155	554,205	637,397	643,323	881,756	1,040,071
N-US	786	0	6,257	9,365	47,815	93,162	108,697
2CREW	1,783	1,801	16,374	45,942	82,690	186,005	316,665
3CREW	656,917	643,354	544,088	600,820	608,448	788,913	832,103
LVL1	256,596	95,243	0	2,005	523	0	0
LVL2	90,603	109,676	127,927	148,425	138,663	190,428	237,340
LVL3	310,715	440,236	426,278	485,935	463,202	569,308	560,536
LVL4	786	0	6,257	10,397	88,750	215,182	350,892
L CAP	90,603	109,676	127,927	148,575	139,111	223,416	266,740
M CAP	308,965	217,553	130,250	153,711	231,292	395,229	521,812
H CAP	259,132	317,926	302,285	344,476	320,735	356,273	360,216
S RNG	90,603	109,676	127,927	148,575	139,111	223,416	266,740
M RNG	52,369	122,310	130,250	151,706	230,769	395,229	521,812
L RNG	515,728	413,169	302,285	346,481	321,258	356,273	360,216
2-ENG	2,569	1,801	22,631	55,307	110,828	220,028	326,288
3-ENG	140,403	230,185	235,546	244,974	259,052	398,617	462,264
4-ENG	515,728	413,169	302,285	346,481	321,258	356,273	360,216
STG-1	256,596	95,243	0	2,005	523	0	0
STG-2	90,603	109,676	127,927	148,425	138,663	190,428	237,340
STG-3	311,501	440,236	432,535	496,332	551,952	784,490	911,428
1ML	256,596	95,243	0	2,005	523	0	0
2LS	90,603	109,676	127,927	148,425	138,663	190,428	237,340
3MM	51,583	122,310	123,993	141,459	142,467	213,035	228,600
3HL	259,132	317,926	302,285	344,476	320,735	356,273	331,936
4LS	0	0	0	150	448	32,988	29,400
4MM	786	0	6,257	10,247	88,302	182,194	293,212
4HL	0	0	0	0	0	0	28,280

Appendix H.12: International Days Aggregate

	1978	1980	1982	1984	1986	1988	1990
AIRBS	95	0	696	940	5,401	9,073	9,535
BAE	0	0	0	0	0	0	0
BOEIN	64,352	53,394	42,922	48,285	51,293	66,050	73,190
FOKK	0	0	0	0	0	0	0
LOCKH	5,333	7,546	7,770	10,701	7,133	10,348	9,189
MD	1,400	4,516	5,466	5,161	6,235	9,271	9,368
US	71,085	65,456	56,158	64,147	64,661	85,669	91,747
N-US	95	0	696	940	5,401	9,073	9,535
2CREW	493	468	2,495	6,684	9,940	17,329	25,400
3CREW	70,687	64,988	54,359	58,403	60,122	77,413	75,882
LVL1	31,526	13,687	0	252	63	0	0
LVL2	11,498	13,575	16,722	18,783	17,592	24,005	27,899
LVL3	28,061	38,194	39,436	44,997	43,233	50,232	44,377
LVL4	95	0	696	1,055	9,174	20,505	29,006
L CAP	11,498	13,575	16,722	18,804	17,634	27,344	30,558
M CAP	37,448	25,470	13,617	16,208	22,304	35,842	41,229
H CAP	22,234	26,411	26,515	30,075	30,124	31,556	29,495
S RNG	11,498	13,575	16,722	18,804	17,634	27,344	30,558
M RNG	5,922	11,783	13,617	15,956	22,241	35,842	41,229
L RNG	53,760	40,098	26,515	30,327	30,187	31,556	29,495
2-ENG	588	468	3,191	7,624	13,005	21,162	26,787
3-ENG	16,832	24,890	27,148	27,136	26,870	42,024	45,000
4-ENG	53,760	40,098	26,515	30,327	30,187	31,556	29,495
STG-1	31,526	13,687	0	252	63	0	0
STG-2	11,498	13,575	16,722	18,783	17,592	24,005	27,899
STG-3	28,156	38,194	40,132	46,052	52,407	70,737	73,383
1ML	31,526	13,687	0	252	63	0	0
2LS	11,498	13,575	16,722	18,783	17,592	24,005	27,899
3MM	5,827	11,783	12,921	14,922	13,109	18,676	17,524
3HL	22,234	26,411	26,515	30,075	30,124	31,556	26,853
4LS	0	0	0	21	42	3,339	2,659
4MM	95	0	696	1,034	9,132	17,166	23,705
4HL	0	0	0	0	0	0	2,642

Appendix H.13: International Miles Per Day Aggregate

	1978	1980	1982	1984	1986	1988	1990
AIRBS	1,905	N/A	3,187	3,691	3,212	4,192	4,766
BAE	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BOEIN	4,072	4,358	4,473	4,562	4,336	4,407	4,759
FOKK	N/A	N/A	N/A	N/A	N/A	N/A	N/A
LOCKH	4,004	4,740	4,744	4,287	4,568	5,512	6,644
MD	3,371	4,688	3,956	4,322	5,719	5,242	5,574
US	4,053	4,425	4,460	4,497	4,495	4,631	5,031
N-US	1,905	N/A	3,187	3,691	3,212	4,192	4,766
2CREW	1,075	953	1,765	1,972	3,106	4,631	5,504
3CREW	4,071	4,450	4,568	4,773	4,610	4,579	4,839
LVL1	3,468	2,912	N/A	3,075	3,175	N/A	N/A
LVL2	2,816	2,961	2,818	2,908	2,889	2,837	3,091
LVL3	5,217	5,488	5,157	5,171	5,115	5,467	6,021
LVL4	1,905	N/A	3,187	3,645	3,911	4,488	5,295
L CAP	2,816	2,961	2,818	2,908	2,891	2,965	3,198
M CAP	3,538	3,768	4,387	4,329	4,629	5,073	5,761
H CAP	5,551	5,812	5,500	5,556	5,105	5,445	5,824
S RNG	2,816	2,961	2,818	2,908	2,891	2,965	3,198
M RNG	3,910	4,761	4,387	4,348	4,633	5,073	5,761
L RNG	4,329	4,822	5,500	5,535	5,101	5,445	5,824
2-ENG	1,209	953	2,075	2,184	3,249	4,431	5,267
3-ENG	3,257	3,851	3,692	3,958	4,159	4,025	4,314
4-ENG	4,329	4,822	5,500	5,535	5,101	5,445	5,824
STG-1	3,468	2,912	N/A	3,075	3,175	N/A	N/A
STG-2	2,816	2,961	2,818	2,908	2,889	2,837	3,091
STG-3	5,206	5,488	5,123	5,136	4,904	5,183	5,734
1ML	3,468	2,912	N/A	3,075	3,175	N/A	N/A
2LS	2,816	2,961	2,818	2,908	2,889	2,837	3,091
3MM	3,942	4,761	4,452	4,396	5,135	5,503	6,236
3HL	5,551	5,812	5,500	5,556	5,105	5,445	5,881
4LS	N/A	N/A	N/A	2,619	3,810	3,884	4,322
4MM	1,905	N/A	3,187	3,666	3,912	4,606	5,410
4HL	N/A	N/A	N/A	N/A	N/A	N/A	5,247

Appendix H.14: International Hours Per Day Aggregate

	1978	1980	1982	1984	1986	1988	1990
AIRBS	5.79	N/A	7.36	8.37	7.46	9.10	10.11
BAE	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BOEIN	8.34	8.82	9.12	9.24	8.79	9.00	9.73
FOKK	N/A	N/A	N/A	N/A	N/A	N/A	N/A
LOCKH	7.98	9.39	9.29	8.41	8.97	10.40	12.81
MD	7.02	9.31	7.91	8.66	11.06	10.29	10.92
US	8.29	8.92	9.03	9.06	9.03	9.31	10.16
N-US	5.79	N/A	7.36	8.37	7.46	9.10	10.11
2CREW	3.18	3.03	5.41	5.76	7.23	9.78	11.29
3CREW	8.32	8.97	9.17	9.42	9.19	9.18	9.77
LVL1	7.20	6.16	N/A	6.91	7.08	N/A	N/A
LVL2	6.70	6.93	6.60	6.83	6.69	6.65	7.09
LVL3	10.16	10.62	10.06	10.00	9.90	10.48	11.59
LVL4	5.79	N/A	7.36	8.28	8.52	9.48	10.90
L CAP	6.70	6.93	6.60	6.83	6.70	6.90	7.32
M CAP	7.30	7.66	8.68	8.58	9.37	10.09	11.51
H CAP	10.76	11.17	10.70	10.68	9.86	10.46	11.18
S RNG	6.70	6.93	6.60	6.83	6.70	6.90	7.32
M RNG	7.84	9.40	8.68	8.60	9.38	10.09	11.51
L RNG	8.67	9.46	10.70	10.65	9.86	10.46	11.18
2-ENG	3.60	3.03	5.83	6.08	7.40	9.38	10.93
3-ENG	7.21	8.17	7.73	8.08	8.58	8.37	9.02
4-ENG	8.67	9.46	10.70	10.65	9.86	10.46	11.18
STG-1	7.20	6.16	N/A	6.91	7.08	N/A	N/A
STG-2	6.70	6.93	6.60	6.83	6.69	6.65	7.09
STG-3	10.15	10.62	10.01	9.96	9.66	10.19	11.32
1ML	7.20	6.16	N/A	6.91	7.08	N/A	N/A
2LS	6.70	6.93	6.60	6.83	6.69	6.65	7.09
3MM	7.88	9.40	8.75	8.62	9.98	10.51	12.04
3HL	10.76	11.17	10.70	10.68	9.86	10.46	11.29
4LS	N/A	N/A	N/A	5.95	8.93	8.69	9.73
4MM	5.79	N/A	7.36	8.33	8.52	9.64	11.12
4HL	N/A	N/A	N/A	N/A	N/A	N/A	10.07

Appendix H.15: International Block Hours Per Day Aggregate

	1978	1980	1982	1984	1986	1988	1990
AIRBS	8.27	N/A	8.99	9.96	8.85	10.27	11.40
BAE	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BOEIN	9.31	9.74	9.96	10.13	9.72	10.00	10.94
FOKK	N/A	N/A	N/A	N/A	N/A	N/A	N/A
LOCKH	8.95	10.45	10.08	9.22	9.90	11.31	13.90
MD	7.88	10.22	8.86	9.63	11.92	11.22	11.91
US	9.26	9.86	9.87	9.94	9.95	10.29	11.34
N-US	8.27	N/A	8.99	9.96	8.85	10.27	11.40
2CREW	3.62	3.85	6.56	6.87	8.32	10.73	12.47
3CREW	9.29	9.90	10.01	10.29	10.12	10.19	10.97
LVL1	8.14	6.96	N/A	7.96	8.30	N/A	N/A
LVL2	7.88	8.08	7.65	7.90	7.88	7.93	8.51
LVL3	11.07	11.53	10.81	10.80	10.71	11.33	12.63
LVL4	8.27	N/A	8.99	9.85	9.67	10.49	12.10
L CAP	7.88	8.08	7.65	7.90	7.89	8.17	8.73
M CAP	8.25	8.54	9.57	9.48	10.37	11.03	12.66
H CAP	11.65	12.04	11.40	11.45	10.65	11.29	12.21
S RNG	7.88	8.08	7.65	7.90	7.89	8.17	8.73
M RNG	8.84	10.38	9.57	9.51	10.38	11.03	12.66
L RNG	9.59	10.30	11.40	11.42	10.64	11.29	12.21
2-ENG	4.37	3.85	7.09	7.25	8.52	10.40	12.18
3-ENG	8.34	9.25	8.68	9.03	9.64	9.49	10.27
4-ENG	9.59	10.30	11.40	11.42	10.64	11.29	12.21
STG-1	8.14	6.96	N/A	7.96	8.30	N/A	N/A
STG-2	7.88	8.08	7.65	7.90	7.88	7.93	8.51
STG-3	11.06	11.53	10.78	10.78	10.53	11.09	12.42
1ML	8.14	6.96	N/A	7.96	8.30	N/A	N/A
2LS	7.88	8.08	7.65	7.90	7.88	7.93	8.51
3MM	8.85	10.38	9.60	9.48	10.87	11.41	13.04
3HL	11.65	12.04	11.40	11.45	10.65	11.29	12.36
4LS	N/A	N/A	N/A	7.14	10.67	9.88	11.06
4MM	8.27	N/A	8.99	9.91	9.67	10.61	12.37
4HL	N/A	N/A	N/A	N/A	N/A	N/A	10.70

Appendix H.16: International Hours to Block Hours Ratio

	1978	1980	1982	1984	1986	1988	1990
AIRBS	1.43	N/A	1.22	1.19	1.19	1.13	1.13
BAE	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BOEIN	1.12	1.10	1.09	1.10	1.10	1.11	1.12
FOKK	N/A	N/A	N/A	N/A	N/A	N/A	N/A
LOCKH	1.12	1.11	1.08	1.10	1.10	1.09	1.09
MD	1.12	1.10	1.12	1.11	1.08	1.09	1.09
US	1.12	1.10	1.09	1.10	1.10	1.11	1.12
N-US	1.43	N/A	1.22	1.19	1.19	1.13	1.13
2CREW	1.14	1.27	1.21	1.19	1.15	1.10	1.10
3CREW	1.12	1.10	1.09	1.09	1.10	1.11	1.12
LVL1	1.13	1.13	N/A	1.15	1.17	N/A	N/A
LVL2	1.18	1.17	1.16	1.16	1.18	1.19	1.20
LVL3	1.09	1.08	1.07	1.08	1.08	1.08	1.09
LVL4	1.43	N/A	1.22	1.19	1.14	1.11	1.11
L CAP	1.18	1.17	1.16	1.16	1.18	1.18	1.19
M CAP	1.13	1.12	1.10	1.11	1.11	1.09	1.10
H CAP	1.08	1.08	1.07	1.07	1.08	1.08	1.09
S RNG	1.18	1.17	1.16	1.16	1.18	1.18	1.19
M RNG	1.13	1.10	1.10	1.11	1.11	1.09	1.10
L RNG	1.11	1.09	1.07	1.07	1.08	1.08	1.09
2-ENG	1.21	1.27	1.22	1.19	1.15	1.11	1.11
3-ENG	1.16	1.13	1.12	1.12	1.12	1.13	1.14
4-ENG	1.11	1.09	1.07	1.07	1.08	1.08	1.09
STG-1	1.13	1.13	N/A	1.15	1.17	N/A	N/A
STG-2	1.18	1.17	1.16	1.16	1.18	1.19	1.20
STG-3	1.09	1.08	1.08	1.08	1.09	1.09	1.10
1ML	1.13	1.13	N/A	1.15	1.17	N/A	N/A
2LS	1.18	1.17	1.16	1.16	1.18	1.19	1.20
3MM	1.12	1.10	1.10	1.10	1.09	1.08	1.08
3HL	1.08	1.08	1.07	1.07	1.08	1.08	1.09
4LS	N/A	N/A	N/A	1.20	1.19	1.14	1.14
4MM	1.43	N/A	1.22	1.19	1.14	1.10	1.11
4HL	N/A	N/A	N/A	N/A	N/A	N/A	1.06

Biography

Education

MASSACHUSETTS INSTITUTE OF TECHNOLOGY (Cambridge, MA)

Master of Science in Aeronautics & Astronautics, February 1992. Master Thesis on airline fleet analysis since deregulation.

Background in international air transportation, airline management, air transportation economics, planning and design of airport systems, and statistics.

PENNSYLVANIA STATE UNIVERSITY (State College, PA)

Bachelor of Science in Aerospace Engineering with High Distinction, May 1990.

Background in materials science, thermodynamics, system dynamics, stability and control, astronautics, aerodynamics, aerospace structures, aero/space propulsion, V/STOL aircraft, aircraft design, and air transportation design.

Member of the National Engineering Honor Society (Tau Beta Pi), National Honor Society in Aerospace Engineering (Sigma Gamma Tau), The Golden Key National Honor Society, and The Honor Society of Phi Kappa Phi.

WEST CHESTER UNIVERSITY (West Chester, PA)

Bachelor of Science in Physics, Summa Cum Laude.

Background in theoretical mechanics, atomic physics and quantum mechanics, computer science, engineering graphics, chemistry, and economics.

Member of the National Physics Society (Sigma Pi Sigma), National Honorary Mathematics Society (Pi Mu Epsilon), and Who's Who Among Students in American Universities & Colleges.