THE MARKET DEMAND FOR AIR TRANSPORTATION

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Abstract

Although the presentation will touch upon the areas of market for air transportation, the theoretical foundations of the demand function, the demand models, and model selection and evaluation, the emphasis of the presentation will be on a qualitative description of the factors affecting the demand for air transportation. The presentation will rely heavily on the results of market surveys carried out by the Port of New York Authority, the University of Michigan, and Census of Transportation.

The purpose of this paper is to present a basic analysis of the demand for air transportation. The presentation is divided into five areas: the market for air transportation, the factors affecting the demand for air transportation, the theoretical foundation of the demand function, air travel demand models, and model selection and evaluation.

The Market For Air Transportation

At the global level approximately 383 million passengers were carried on the scheduled domestic and international services of 120 airlines of the ICAO Contracting States during the year 1970. This includes the USSR traffic which accounted for almost 58 million passengers in 1970 and most of which was carried on the domestic routes. Of the total world traffic, 170 million passengers or 44.4 percent was carried by the airlines of the United States. Reliable statistics are not available for total world non-scheduled traffic, a bulk of which is generated in Europe and the United States.

The statistics taken from ICAO in Table 1 show the regional distribution of the total world traffic measured in percentage ton-km. performed on scheduled services. This table shows that almost 86% of the world air traffic was accounted for by North America and Europe (including the USSR).

Table 1

Regional Percentage Distribution of Total Ton-km Performed on Scheduled Airlines of ICAO States

1970

REGION	SERVICES		
	Domestic	International	All
North America[1]	62.9	33.2	51.1
Europe	28.8	44.1	34.9
East and South Asia and the Pacific[2]	5.6	11.2	7.8
South America	1.7	4.2	2.7
Africa	0.7	3.8	1.9
Middle East	0.3	3.5	1.6
Total ICAO World[3]	100	100	100

1. Includes Panama and all countries to the north as well as the Caribbean States and territories.

2. Including New Zealand, Australia and neighboring islands.

3. Including USSR statistics for Aeroflot.

Source: ICAO Bulletin, May 1972

These two areas account for almost 30% of the world's population and almost 80% of the world's economic activity. If we measure economic activity by Gross National Product, then the United States accounts for roughly thirty percent of the total world's GNP and almost 45% of the world's air passenger traffic.

The North Atlantic market represents the largest international air traffic flow in the world, accounting for almost a quarter of the total international passengers. In 1970, approximately ten million passengers traveled on this route with roughly three-quarters of these using scheduled airlines. Roughly a third of the passengers using non-scheduled services were transported by the charter operations of the scheduled carriers.

From the statistics collected by the Civil Aeronautics Board on the passenger traffic carried on United States scheduled air system in 1970, 153 million or a little over 90 percent were carried in the domestic operations. Table 2 shows the percentage distribution of the revenue passenger originations by carrier group. Over 70% of the passengers were carried by the eleven domestic trunk carriers and over 46% were accounted for by the Big Four Carriers. The revenue passenger miles of the United States domestic air system represents less than ten percent of the total for all modes.

Table 2

U.S. Scheduled Air Passenger Traffic & Distribution

Carrier Group	Scheduled Service - 1970 Revenue Passenger Originations: Passengers (000)	Percent
Domestic Operations		
Trunks	122,866	72.4%
Local Service	26,472	15.6
Helicopter	573	0.3
Intra-Alaska	351	0.2
Intra-Hawaii	2,643	1.6
Other*	503	0.3
	153,408	90.4%
International and Territorial Operations	16,260	9.6%
Total	169,668	100.0%

* Alaska, Aspen, Tag.

Source: CAB Handbook of Airline Statistics, 1971 Edition, Tables 46 and 47.

Although private automobile accounts for almost 85 percent of intercity passenger traffic in terms of passenger miles, the air carriers are the largest form of common carrier transportation.

For passenger travel on the scheduled domestic air system, the 1970 CAB data shows that 42.8 percent of the passengers traveled a distance less than 499 miles while 99.0 percent of the passengers' trip length was 2749 miles or less. The reader is cautioned that these statistics do not include traffic data for the intra-state carriers. These statistics would change significantly if we were including PSA's traffic on the Los Angeles - San Francisco market, the world's largest passenger market.

The distribution of domestic scheduled air passenger traffic is shown in Table 3 for 1970. The top 100 city-pairs account for 33.4 percent of the total traffic while the top 1000 city-pairs accounts for 72.9 percent of the traffic. According to the CAB data, New York - Boston ranks as number one city-pair with a little over two million passengers in 1970. If we include intra-state operations, then a DOT[1] Study, based on a ten percent sample similiar to the CAB data, indicates that a total of 5.3 million passengers travelled on the Los Angeles - San Francisco route.

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1. Statistical Compilation of Airline Passenger Markets. Domestic FY 1972. U.S. Department of Transportation. November, 1971. Page 10.

TABLE 3

U.S. Scheduled Domestic Air Passengers

Cumulative Distribution Among City-Pairs

1970

Number of Top City - Pairs In Order of Passengers Rank	Cumulative Percent
1	1.9
10	11.1
50	24.6
100	33.4
200	44.2
500	60.4
1000	72.9
ALL	100.0

Source: CAB's Handbook of Airline Statistics. 1971 Edition

The seasonality of air travel is a very important characteristic. Figures 1 and 2 show the monthly seasonality of the traffic moving through New York. The months of July and August represent peaks for both domestic and overseas travel. The effect of seasonality is more pronounced if we analyze an individual market. Figure 3 shows that on the North Atlantic, the eastbound traffic was almost four and a half times greater in July than in February. Air travel even changes with the day of the week and hour of the day. The peaks in the hourly variation can be explained partially by the preference of the business traveler. The somewhat heavier demand on Thursday and Friday can be partially explained by the preference of the traveler on personal business or pleasure to travel at the end of the week. These demand patterns are seen in Figures 4 and 5.

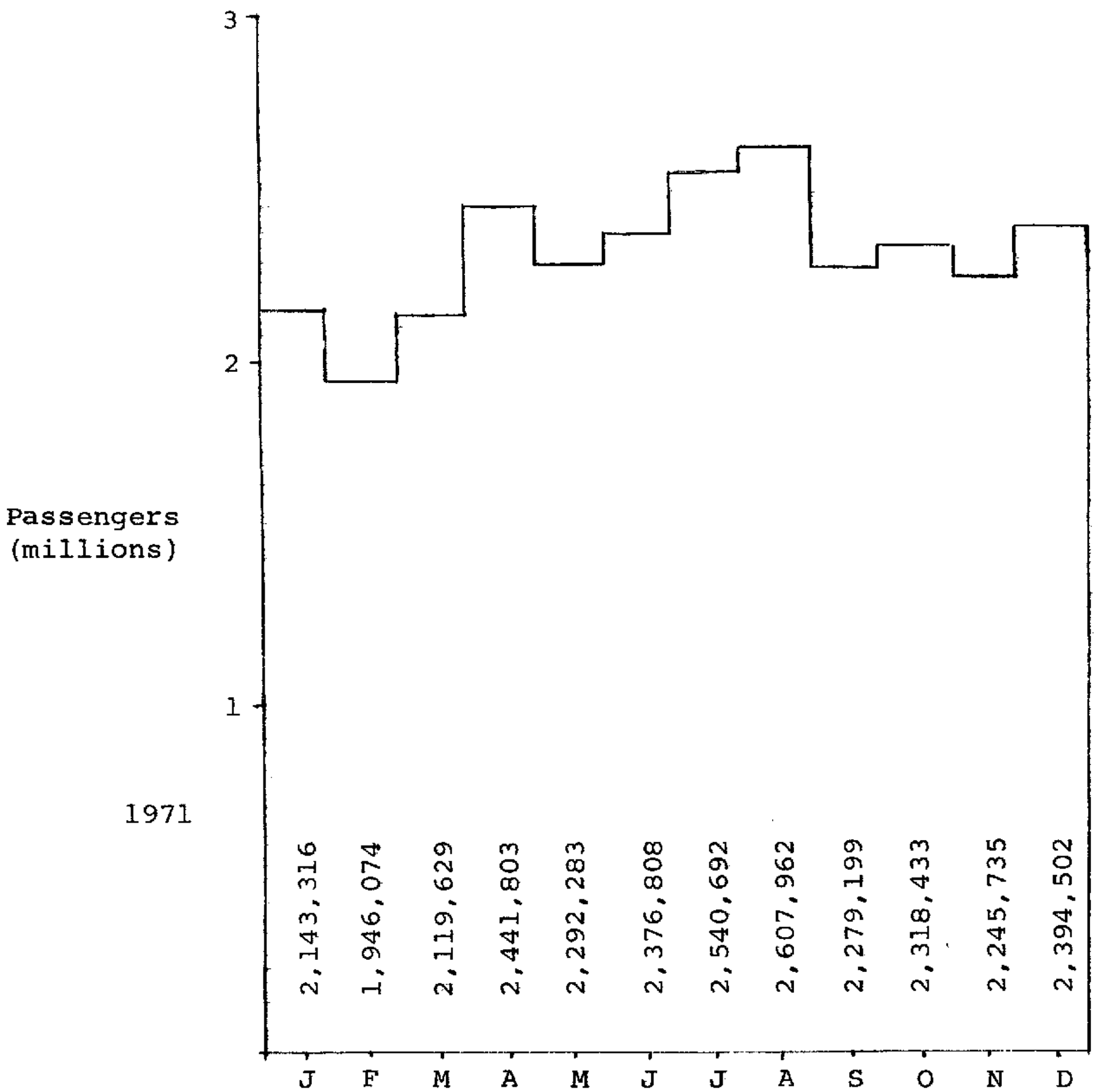
Part of the seasonality pattern may be artificial. Orginally, excursion or discount fares were introduced by the carriers to shift demand from the peaks to the slack periods. However, the black out periods established to reduce peaking have created their own peaking problems.

433

Figure 1

Seasonality of Air Travel Demand

U.S. Domestic at New York



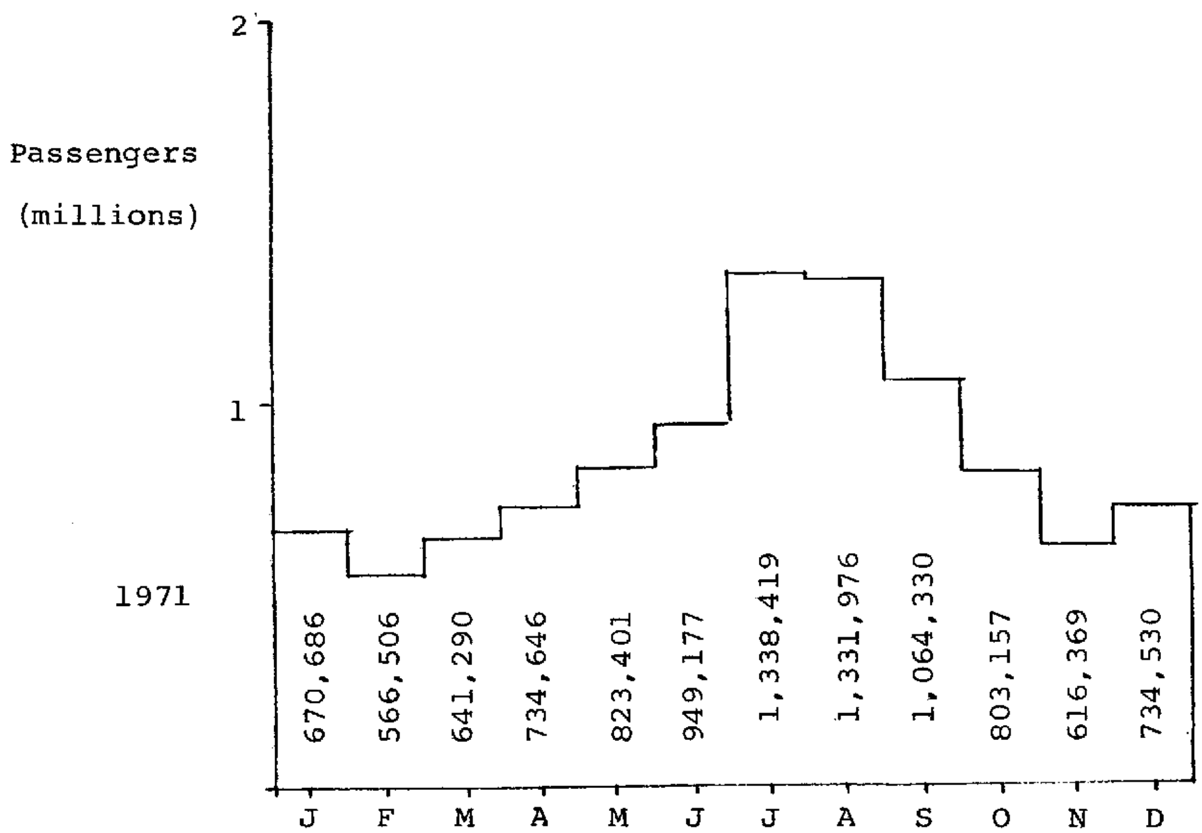
Total Domestic Passenger Revenue Traffic Handled by New York Airports - by Month

Source: PONYA, Monthly Airport Traffic, January-December 1971

Figure 2

Seasonality of Air Travel Demand

U.S. Overseas at New York



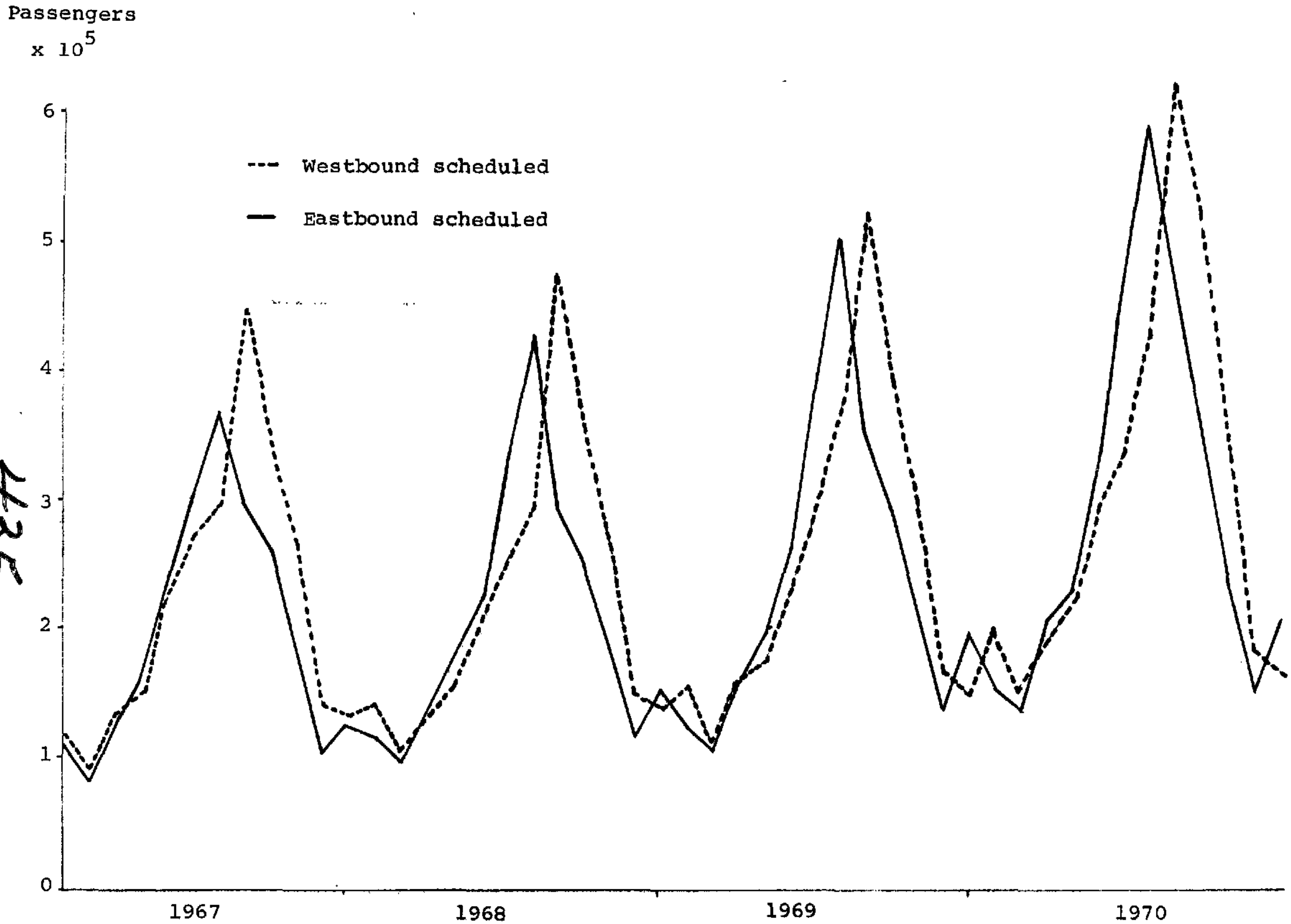
Total Overseas Passenger Revenue Traffic Handled by New York Airports - by Month

Source: PONYA, Monthly Airport Traffic, January-December 1971

434

Figure 3

Seasonality of the North Atlantic Traffic - by Month

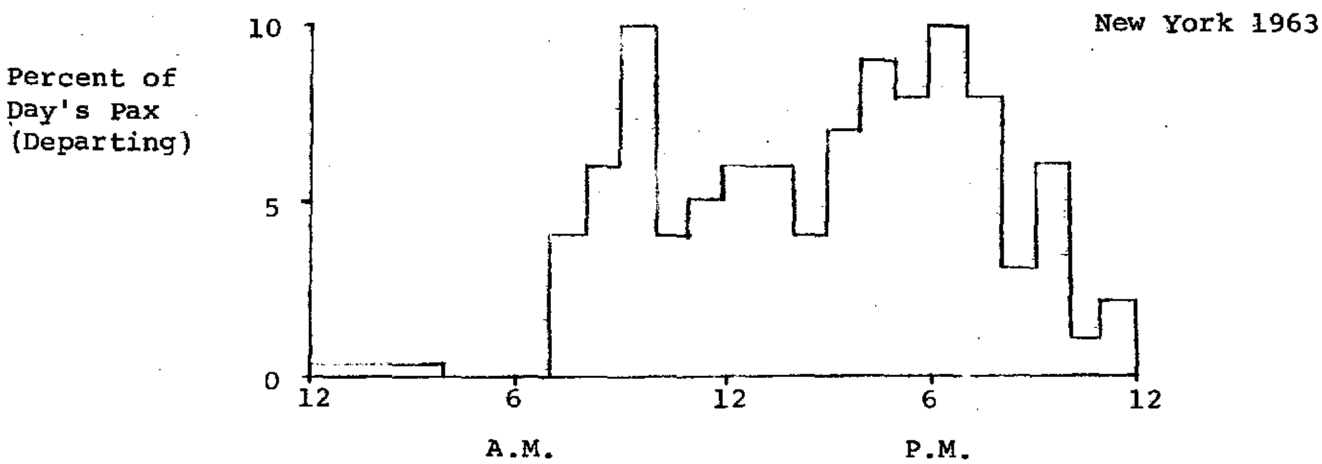


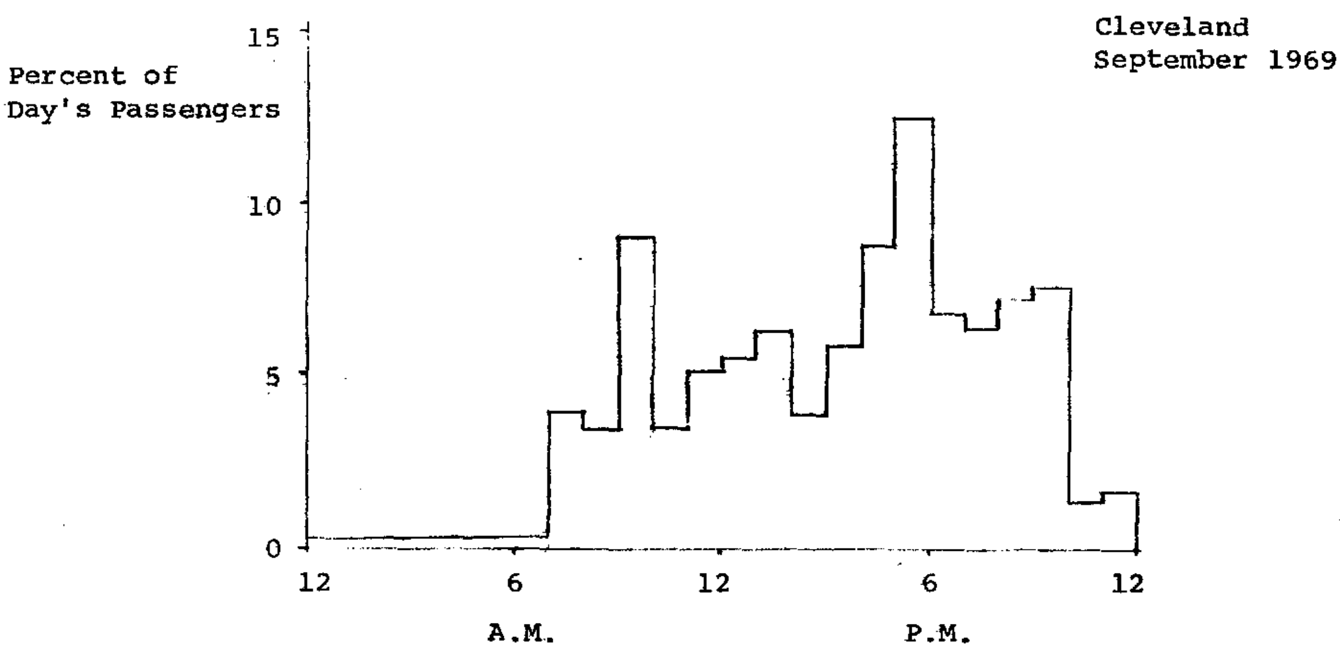
Source: IATA World Air Transport Statistics

Figure 4

Daily Air Travel Demand

by Hour



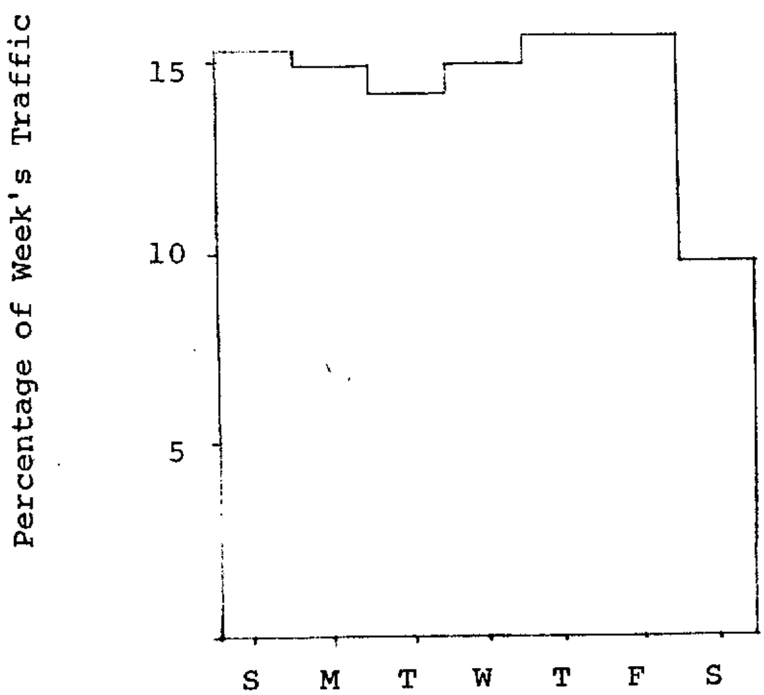


Sources: New York's Domestic Air Passenger Market, PONYA May 1965
Cleveland-Hopkins Airport Access Study
Survey Results, Regional Planning Commission, Cleveland, Ohio
June 1970

436

Figure 5

Weekly Air Travel Demand
by Day



Source: Phase II Survey (September 8-14, 1969)
Cleveland-Hopkins Airport Access Study
Survey Results, June 1970 - Regional
Planning Commission - Cleveland, Ohio

437

Factors Influencing The Demand For Air Travel

Factors affecting the air travel demand can be grouped into two broad categories: market related and trip related. The market related variables, also called the socio-economic variables, are those inherent to the general economic, geographic, social and political environment. This group can be further divided into characteristics related to the traveler (income, age, occupation, etc.) and demographic characteristics (population, industrial activity, tourism, etc.). The trip related variables, on the other hand, are those inherent to the transport mode, that is cost, travel time, comfort, safety and convenience. The demand for air travel is influenced by a complex interaction of one or more of these variables. This section contains a qualitative description of some of these factors.

The demand for air travel can be analyzed in two parts: personal travel and business travel. Table 4 shows the distribution of air travel by purpose of trip. In 1967, based on the survey carried out by the Census of Transportation, personal and business travel each accounted for about 50 percent of the air travel market.

Table 4

Percentage Distribution of Air Travel by Purpose of Trip (1967)

	person-trips	person-miles
business	45.8	40.8
conventions	5.5	6.5
visits to friends & relatives	23.9	26.0
outdoor recreation	2.4	2.5
entertainment	3.4	3.6
sightseeing	7.6	7.6
other pleasure	2.2	2.3
personal & family	9.1	10.7
	100%	100%

Source: 1967 Census of Transportation

Market Related Factors

Income: Air travel is strongly determined by income,personal income in the case of personal travel and national income in the case of business travel. The ability to pay however, has to be accompanied by the willingness or the desire to spend. The demand for air travel is unlikely to change,if for example, an increase in income is accompanied by an exact increase in savings. Table 5, taken from Port of New York Authority's survey data for 1967 shows that 94 percent of the passengers surveyed had an annual family income higher than $5000. The data implies that the higher the income, the higher the percentage of travel. A similar survey carried out by the University of Michigan in 1962 showed that in a sample of 5093 respondents, 28 percent of the respondents had family income less than $4000 and accounted for 6 percent of the airtrips, while 17 percent of the respondents with family income of $10,000 and above accounted for 60 percent of the air travel.

There are at least three forms of per capita income that can be used to explain the demand for air travel: national income is equal to domestic product at factor cost plus net factor income from abroad; disposable income is defined as personal income less taxes; discretionary income is that portion of disposable income in excess of the amount necessary to maintain a defined or historical standard of living.

Table 5

Average Family Income of New York's
Domestic Air Passenger Market

Family Income	Percent of the Survey Population 1956	1963	1967
Under $5,000	12%	6%	6%
$5,000 - $9,999	32	19	16
$10,000 - $14,999	21	25	21
$15,000 - $19,999	10	16	17
$20,000 and over	25	34	40
(Median)	$11,400	$15,000	$17,000

Source: Port of New York Authority Reference 2.

441

This last type of income may be saved or spent with no immediate impairment of living standards. Thus, it would appear that discretionary income would be a better and more consistent predictor of air travel growth than either disposable or national income. However, most studies employ disposable income for the following reasons:

1. unavailability of consistent data for discretionary income.
2. difficulty of quantification of discretionary income.
3. subjective definitions as to the size of discretionary income.

Although data on disposable income per capita for the United States is readily available, similar and consistent data for other countries is not available. For international travel, one can use the data on national income which is published by the United Nations in consistent form for many countries including the United States.

Various studies have shown that a factor which is even more important than the level of personal income is the distribution of family income. Some analysts prefer to use the distribution of family income above a certain base level to explain the demand for air travel. Asher[3] uses a base of $7,500 for international travel; in other words, the traveler's annual income is greater than or equal to $7,500 and the greater the income (above $7,500) the greater the chances of his taking the trip. The use of such a districution should be viewed with caution since:

1. The base level is a subjective measure and analysts differ in their views of its numerical value. Furthermore, the level would vary by geographic region.

2. The data is very sketchy on the distribution of income in the United States and almost non-existent for some of the foreign countries.

3. The variation in the income distribution is fairly difficult to forecast accurately.

It has been shown previously that the level of income is an explanatory variable which partially explains the pleasure demand for air travel. While higher income families are more likely to travel, it is not income alone that influences them to travel. Now, we will introduce other variables related to income which also influence the pleasure travel demand. Given the relationship between income and the demand for air travel, the relationship between occupation, education, social status, etc., is fairly easy to predict. Travelers in the higher status occupations are usually educated to a higher level, belong to a higher social class and earn a higher income.

Table 6 shows the relationship between occupation and air travel. In 1967, the survey of the pleasure air travelers in New York shows that 19 percent were in the professional and technical category.

Table 6

Occupation By Broad Purpose of Trip

New York's Domestic Air Passenger Market

1967

Occupation	Personal			
	Visiting Friends or Relatives	Sightseeing or Visiting Resort	Other	Total
Technical, Professional	21	20	10	19
Manager, Official	14	17	6	12
Salesman	3	4	1	3
Secretary, Clerk	11	12	3	9
Mechanic, Craftsman, Factory Worker	4	4	2	3
Armed Forces	2	1	24	7
Housewife	22	23	19	21
Student	17	12	32	20
Retired	5	5	2	4
Other	1	2	1	2

Source: Port of New York Authority. Reference 2.

444

Further, the 1967 Travel Survey shows that for 56 percent of the trips taken, the occupation of the household head was either professional or managerial. The category of factory workers and service workers accounted for only 3% of the sample population.

The level of education attained has a high correlation with income, occupation, social status, human wants, buying habits and attitudes. The educated generally travel more. Even when income is held constant, the better educated population tends to outspend the lesser educated for all goods and services. In addition, the better educated respond strongly to innovations. Therefore, the amount of education is increasingly important in estimating the demand for certain products.

Higher education inspires an interest in and a desire to see other places, and thus affects demand for air travel. Today, there is a phenomenon which is not so much a pressure against heavy spending as a pressure to spend money as educated men are supposed to spend it. This is shown in the National Travel Survey by the fact that in 1967, 66 percent of the air travelers had some college education and 94 percent had high school training. The vital role education plays in the air travel demand is substantiated by many other surveys

For example, in a 1955 survey of United States Tourists in Europe, 57% were found to be college and university graduates. Life magazine, in a survey in 1960, found that 72 percent of the respondents sampled had some college education (19 October 1960).

Knowledge of the social class with which a comsumer affiliates and/or to which he aspires also provides an indication of the likelihood of his traveling. The middle class considers non-business air travel prestigious and a middle class person normally aspires to develop purchasing habits and attitudes similar to those of persons with higher social status.

This phenomenon also takes place within the same social class. For example, having relatives, friends or business associates who traveled and enjoyed their trips appears to be an important determinant of a person's decision to travel. As a result of social pressures such as status-seeking and a desire to conform, the travel decision of the individual may be a reflection of his friends' and associates' spending preferences.[4]

While rising incomes account for part of the increase in the demand for air travel, changes in taste also account for part of the growth. For example, a reduction in income may not be accompanied by a proportionate reduction in travel and visa versa. Tastes change with time and the availability of other goods and services will continually influence the demand for air travel.

It appears that business travel is not sensitive to personal income. Business reasons are not self-selected, and although highly paid senior management executives travel more than middle and lower level staff, income of the business traveler seldom seems to directly influence the frequency or, in some cases, the class of travel.

Business travel in general appears to depend, among other things, on the state of the economy. In individual city-pairs, the demand for business travel will depend on the type and extent of the business activity in each city. On the other hand, the demand for international travel may depend on the level of exports, imports, investment abroad, balance of payments, etc.

Since the economy is correlated to the demand for business travel, it stands to reason that during recessions, the amount of business travel diminishes. Conversely, during an expansion of the economy, business travel increases. During recessions when corporate profits are down and costs are rising, one of the means of reducing corporate costs is to curtail business travel. It can be seen from this that a relationship exists between the fluctuations in the economy and the travel trend. However, this relationship is very general, since fluctuations in the economy do not exactly coincide with fluctuations in traffic. The reason for this is twofold. First, there is never just one factor at play. Every year's traffic is influenced by many factors simultaneously.

Secondly, there is a time lag between the movement in the economy and the influence on traffic. To attempt to predict this time lag accurately would require very sophisticated techniques and numerous statistical data. It has been suggested that a variable time lag should be considered. The variation implied here is twofold. First, the time lag should be different for the pleasure and business markets. Secondly, it should reflect the economy at any given time as being in the state of expansion, recession or normality. Due to the sophistication involved, accuracy is usually sacrificed for simplicity and fixed lags are used.

Population: Although it stands to reason that other things being equal, the demand for air travel would increase in some proportion to the population growth, its influence is seen more clearly from the analysis of geographic concentrations of populations and its distribution by age, income and occupation. The influence of occupation and income has already been shown. Many surveys have shown that the average age of the traveler is declining. Table 7 shows that between 1960 and 1969, the percentage of the United States population in the age group 15-29 years increased from 19.5 percent to 23.4 percent.

Table 7

Population by Age: 1960 and 1969

(Total resident population, excluding Armed Forces abroad)

AGE (in years)	Percent Distribution	
	1960 (Apr. 1)	1969 (July 1)*
Total	100.0	100.0
Under 5	11.3	8.9
5-9	10.4	10.3
10-14	9.4	10.2
15-19	7.4	9.1
20-24	6.0	7.8
25-29	6.1	6.5
30-34	6.7	5.6
35-44	13.4	11.5
45-54	11.4	11.5
55-64	8.7	9.0
65-74	6.1	5.9
75-84	2.6	3.1
85 and over	0.5	0.6

* Preliminary

Source: Statistical Abstracts of the U.S. 1970

The influence of varying growth in different sectors of the population has different effects on the demand for air travel. For example, as pointed out by Wheatcroft[5] in his paper on the elasticity of demand for the North Atlantic, the influence of the population growth on the demand for air travel, should include an allowance for the growth of the European immigrant population. This section of the United States population has grown almost twice as fast as the rest of the population. He has also pointed out another demographic factor which has influenced the traffic over the North Atlantic; the tendency of the United States population to shift towards the West Coast and the influence of immigration. Data taken from the United States Abstracts shows that from 1790-1960 the centre of gravity of the United States population moved from a point 23 miles east of Baltimore, Maryland to a point 4 miles east of Salem, Marion County, Illinois, a distance of roughly 700 miles westwards. Besse and Demas[6], in their study reported that from 1940-1960 the centre of gravity of the United States population moved 160 km westwards. This might be regarded as an adverse influence for European travel, since it would imply that an increasing porportion of the United States population lives nearer other competitive areas of pleasure travel (Hawaii and the Orient).

Trips Related Factors

Fares: The Marshallian law of demand is applicable to air travel: consumers will buy more at lower prices and less at higher prices, if other things do not change.

Both personal and business air travel demand is dependent upon total trip cost and varies inversely with the trip cost as compared with other prices. Table 8 shows the historical trend of domestic and international fares and its relationship to consumer prices. The fares are represented by yield which is defined as revenue per revenue passenger mile. To compute yield, the accounting procedure is to divide the total passenger revenue for a given time in a given market by the total revenue passenger miles in that time period. Only revenue passengers are counted. The product of one passenger traveling one mile constitutes a revenue passenger mile.

Table 8 shows while consumer prices have increased sharply since 1965, the domestic and international yields have declined. It should be pointed out that a decline in yield does not always imply a change in fare levels. A change in the traffic mix and/or change in the average stage length may cause a change in the average yield. A change in the fare can also be the result of a change in the tax levied on air transportation.

Table 8

Domestic and International Yields for Scheduled Operations, Compared with Consumer Price Index

1967 = 100

Year	Domestic Fare (cents)	Foreign Fare (cents)	Domestic Fare Index	Foreign Fare Index	Consumer Price Index
1957	5.25	6.49	95.5	129.3	84.3
1958	5.58	6.46	101.5	128.7	86.6
1959	5.80	6.31	105.5	125.7	87.3
1960	6.01	6.39	109.3	127.3	88.7
1961	6.18	6.08	112.4	121.1	89.6
1962	6.35	5.87	115.5	116.9	90.6
1963	6.07	5.82	110.4	115.9	91.7
1964	6.01	5.44	109.3	108.4	92.9
1965	5.94	5.26	108.0	104.8	94.5
1966	5.69	5.13	103.5	102.2	97.2
1967	5.50	5.02	100.0	100.0	100.0
1968	5.45	4.96	99.1	98.8	104.2
1969	5.70	4.95	103.6	98.6	109.8
1970	5.80	5.02	105.5	100.0	116.3

Source: CAB Report - July 1971

"Productivity and Employment Costs in System Operations of the Trunk Airlines and Pan American, from 1957 through 1970"

While the transportation cost is a significant determinent of the demand for air travel, the total trip cost appears to be a more important explanatory variable, especially in the case of international travel. Table 9 shows the historical trend of the total average cost of a transatlantic trip. The declining trend since 1960 is due to the decline in fares and the decline in average expenditures while traveling in Europe. The downward trend in expenditures abroad is explained partially by the growing number of United States citizens with limited funds who are now traveling and partially by the fact that air travelers have been staying shorter periods in Europe and spending less. The average stay declined from about 66 days in 1950 to 45 days in 1963. Data presented in a recent Boeing publication indicates that in 1969 the average stay had further declined to 28 days.

Table 10 compares the major components of the cost of a ten day trip in Europe and a large city in the United States for the years 1958 and 1970. In both cases, the air fare represents a smaller part of the total cost in 1970 compared to 1958. This was accompanied by an increase in the ground costs. This table also shows that in the case of the European trip, almost half of the total cost represents the air fare, while for the domestic trip, the hotel bill accounts for half of the total cost.

Table 9

Average Cost of a North Atlantic Trip

Year	Transportation Cost	Expenses While in Europe and Mediterranean	Total Cost
1951	$ 610	$ 759	$ 1369
1952	630	767	1397
1953	641	812	1453
1954	628	858	1467
1955	640	889	1529
1956	660	867	1527
1957	666	867	1533
1958	655	876	1531
1959	650	850	1500
1960	660	840	1500
1961	630	760	1390
1962	595	705	1300
1963	550	605	1200
1964	520	650	1170
1965	510	610	1120
1966	487	583	1071
1967	460	562	1022
1968	455	510	965

Source: Ref. 4 and the Annual Reports on Foreign Travel published in the Survey of Current Business, U.S. Department of Commerce.

Table 10

Components of Cost of Travel

Component	Distribution of Expenses for a 10-Day Trip: In Europe 1958	In Europe 1970	In a Large City in U.S. 1958	In a Large City in U.S. 1970
Air Fare	75.8%	48.7%	31.6%	18.7%
Meals	12.0	25.3	26.2	32.2
Hotels	12.2	26.0	42.2	49.1
Total	100%	100%	100%	100%

Source: Air Transport 1971. ATA, Washington, D.C.

455

The cause of declining fares when the price of almost everything else has been going up is the continuous reduction in the unit operating costs (both direct and indirect) for the scheduled airlines due to the higher productivity of the successive generations of civil aircraft. The jet aircraft has considerably higher productivity being both bigger and faster than the piston-engined aircraft. Although the new aircraft also have higher operating costs per hour than their predecessors, the gain in productivity per hour was greater than their increase in costs per hour. Therefore, the net effect of their introduction was to produce a fall in the average unit operating costs.

The reduction in the normal air fares has been important in attracting new and repeat travelers. They have made it more attractive for consumers who had never traveled before and others to take more frequent trips. There have also been many special areas, adapted to certain categories of users. The big fare reductions brought about by the introduction of a new class are probably those which strike the public most, but it would be a mistake to underestimate the influence of special fares, which have certainly generated a constant and very substantial increase in traffic. Examples of such fares are:

- Excursion fares, which presupposes a given length of stay, sometimes with departures only on certain days of the week. Often they are limited to certain times of the year which are staggered according to the point of origin of the passengers

- Out-of-season fares, which also tend to lessen the seasonal nature of traffic while permitting certain categories of passengers to go on a trip at a lower price.
- Family fares
- Group fares granted automatically to parties comprising more than a certain number of members.

In addition to the introduction of special fares, Charter has played a very important role in the development of air travel, especially in the international market. Historically, charter operations were started by scheduled airlines using spare (unproductive) equipment at off-peak periods. However, advanced equipment, with higher productivity (increased capacity and speed) and lower unit operating costs brought about by high load factors have made charter operations profitable.

In recent years, charter traffic across the North Atlantic has been growing very rapidly relative to the traffic on scheduled carriers. The supplemental airlines have increased their share of traffic very significantly from less than 2 percent of the total transatlantic passenger traffic in 1963 to over 15 percent in 1969. Charter sales have increased as the price spread between charters and scheduled services has increased. This gap in fares (estimated over $160 average in 1968) from California to Europe has been largely responsible for the growth of supplemental charters in the market.

Supplemental charter traffic refers to the carriers offering charter service only. In the early sixties, several carriers were authorized to supplement the scheduled carriers by concentrating on charters for bona fide groups. However, authorization was not for these carriers to sell individually ticketed, point-to-point, transportation to the general public. It appears that the main reason for the tremendous growth in supplemental carriers traffic is simply that these carriers have misinterpreted their authorization and have carried traffic other than bona fide groups.

Charters, although a small percentage of the total transatlantic market, are very important in several key markets. They account for one-third of the transatlantic traffic originating in California, and almost 85% of these charters are on supplemental carriers. The price spread between charters and scheduled service depends on the length of travel, the ratio of ferry mileage* to live mileage and the load factors. In 1968, for example, this spread was about $70 for New York-London roundtrip and about $160 for Los Angeles-London roundtrip.

The impact of lower fares depends among other things on the purpose of the trip. The pleasure traveler who uses charter services, does so to save money and is, therefore, willing to put up with a certain amount of inconvenience.

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* Ferry mileage refers to the aircraft flying without revenue load. One reason for the negligible supplemental charter activity on the North Atlantic during off-season is due to the high ferry to live mileage ratio.

Many surveys have shown (TWA on-board surveys, PONYA) that the two categories most attracted to charter travel are ethnic and religious groups and educational and youth organizations. Ethnic groups are often attracted to a particular destination with which they feel they have emotional ties, often a desire to visit the homeland. Their travel is generally for the purpose of visiting friends or relatives. Price in this case plays a very important role. The cost of the stay after arriving at their destination is small. Similarly, students are usually limited by cash, have a specific destination and the cost of their stay is small relative to the cost of transportation. Charters, therefore, are attracted to these groups because they can generate full plane-loads through established organizations.

Charters are also attracted to professional and cultural organizations. These include organizations from the upper income sections of the community, for example, the medical, legal, cultural organizations such as symphony and art societies and political organizations. Charitable organizations are also included in this group.

Trip Time: The decision to go by air is mainly a function of trip time. Speed is the primary competitive advantage of air travel over other modes, for the air journey has become both shorter and more reliable with speed improvements in newer aircraft.

Over the years the cruise speed of each generation of new aircraft have increased from about 110 miles per hour for the Ford Tri-Motor to almost 600 miles per hour for the Boeing 747 introduced in service in 1970. The increases in non-stop range of aircraft have also led to shorter point-to-point travel times through the elimination of intermediate stops. A longer-range capability was not necessarily combined with higher cruising speed in newer aircraft.

Reduction in trip time, basically due to the higher speeds of aircraft, has affected both the business traveler as well as the pleasure traveler. Higher speeds have meant that the businessman can reach his destination in less time. Higher speeds also mean that the pleasure traveler can visit more distant places in a given time.

The total demand for air travel (pleasure and business) varies inversely with the time required to complete a given trip. The value placed upon travel time for both pleasure and business purposes would presumbly be related to some measure of the traveler's earning rate. One such measure is the wage rate. There are, of course, many reasons why the value of time spent in travel might be larger or smaller than the traveler's wage rate. To the extent that the business traveler works during part of the flight or the pleasure traveler reads or watches a movie, travel does not take time away from other activities that have value.

In addition, traveling might be sufficiently relaxing, exciting, or prestigious to the extent that travelers would pay for these pleasures by placing a lower rate on their value of time. Conversely, those for whom travel is boring, fatiguing or frightening would value travel time at rates higher than otherwise. Thus, although it is reasonable to expect that the higher the traveler's earnings, the higher the value he would place upon his time, the exact value he places upon his time actually be either greater than or less than his earning rate.[3]

<u>Comfort, Safety, Convenience</u>: It is extremely difficult, if not impossible, to determine the exact effect of comfort, safety and convenience on the volume of traffic. The difficulty lies in the fact that these variables are difficult to quantify and that their relative numerical value is rather subjective. Nevertheless, they do affect travel demand even if the contribution may be small. It has been suggested that changes in these variables such as comfort and convenience tend to occur more or less evenly over time. It is assumed that while each of these variables may be quite difficult to measure empirically, the net effect of all these factors may be approximated by a time trend function.

461

Comfort: Improvements in the quality of air travel tends to be of greater importance as a competitive factor rather than in creating new travel. Comfort is related to the comfort in the aircraft as well as comfort at the aiport. With respect to comfort in the aircraft, there have been gradual product improvements related to the air trip. The newer aircraft have gradually improved the quality of the air service. Major innovations which have led to greater comfort are the pressurized cabins and the reduction in cabin noise and vibration. Other factors contributing to inflight comfort have been a significant improvement in the quality of food service, items such as special meals, vast quantities and variety of reading material, inflight stereo, multi-channel music and movies. The level of inflight comfort has also been increased due to lower values of seating density, the classical example being the B-747. The distance between seats and their individual width vary with the type of service which the passenger buys.

The comfort level at the airport has also been steadily improving. Modern facilities at the airports, easy and comfortable access to the aircraft (covered ramps, mobile lounges) have increased the level of comfort.

Access times to and egress times from the airports have generally increased around some larger cities. This is partly due to the movement of airports to locations more distant from the city centers but mostly due to the increasing traffic congestion on the roads.

Safety: It is true that a certain percentage of the traveling public will always be diverted to other modes for safety reasons. For this group, fear plays a large role in keeping them away from the airlines. This remains true even though the relative improvement in the safety of airline service, according to the measures usually presented, has been greater than for major surface transport media as shown by Table 11. Of course, the absolute number of passenger deaths due to aircraft accidents has been growing but the number of passengers has been increasing more rapidly. Table 11 also shows the comparative transport safety record of the United States carriers compared to other countries. It is interesting to note that the record of the United States scheduled domestic, international and territorial airlines is significantly better compared to all scheduled airlines of the ICAO Contracting States.

The attitude of the traveler towards safety is somewhat related to his experience as an air traveler. This was substantiated by the results by a Michigan University survey on the feelings about air safety. The question asked was, "Do you feel that air travel is safer now (1962) than it was 10 years ago?" The results show that 74 percent of the experienced air travelers felt that air travel was safer now, compared to 58 percent of the inexperienced travelers. Fourteen percent of the inexperienced travelers indicated that air safety had in fact deteriorated.

Table 11

Comparative Transport Safety Record

Passenger Fatality Rate per 100 Million Passenger Miles

	United States			Scheduled Airlines	
	Motor Buses	Rail Roads	Autos	U.S.	All ICAO Members
1960	0.11	0.16	2.2	0.76	1.29
1961	0.15	0.10	2.2	0.30	1.11
1962	0.11	0.14	2.2	0.26	0.97
1963	0.26	0.07	2.3	0.23	0.78
1964	0.15	0.05	2.4	0.26	0.58
1965	0.16	0.07	2.4	0.31	0.56
1966	0.23	0.16	2.5	0.07	0.70
1967	0.18	0.09	2.4	0.22	0.40
1968	0.24	0.10	2.4	0.27	0.47
1969	0.22	0.07	2.3[E]	0.11	0.43
1970	N.A.	0.09[P]	2.2[E]	0.001	0.27*

E = Estimated P = Preliminary * = Includes USSR

Source: ATA's U.S. Air Transport 1971 and ICAO's Monthly Bulletin, May 1972.

Convenience: Factors contributing to greater conveniences have been excess capacity, an increased number of flights in any given market, increasing number of origins and destinations, more direct flights, city-centre baggage check-in locations etc. Excess capacity implies that the passengers are not forced to plan their trips well in advance. This is especially important to the business traveler whose plans cannot be confirmed too far ahead of his departure.

Increased frequency reduces the waiting time at the terminals and provides greater flexibility in making connections. A greater number of origins and destinations also implies a reduction in connecting time and, hence, a reduction in the total trip time. Direct flights also have the same effect. For example, the success of non-stop flights from the United States West Coast to Europe have shown the convenience of direct flights. Where a traffic market does not justify direct flights, the carriers have offered through- plane service. For example, Cleveland-New York-London, Los Angeles-London-Paris and Detroit-Boston-London are specific instances of through-plane service. In these cases, stop-over times are lower than connecting times and passengers are assured of being on the plane and not missing a connection.

City-centre check-in locations save the passenger carrying his baggage to the airport and thus avoid lengthy check-in queues at the airport. It also reduces his pre-flight check-in time at the origin. The net effect of all these factors is to increase passenger convenience and to reduce the total trip time.

466

Theoretical Foundation of the Demand Function

Although it is not esstential, it is useful for the analyst to have some idea of the theoretical background to the formulation of the demand function. In this section an attempt is made to outline in descriptive form some of the basic concepts relating to the theory of demand. Demand is treated as consisting of two parts: the demand for business air travel and that for pleasure air travel. The foundations of the two components are different. The demand for pleasure travel is derived from microeconomic theory, the utility theory to be more precise. The demand for business air travel has not been formalized as yet. However, its foundations lie in the macroeconomic as well as microeconomic theory.

The Demand Function For Pleasure Travel

The theoretical demand function for pleasure travel can be derived from an analysis of the traditional cardinal or ordinal consumer utility theory. An individual's utility can be thought of as satisfaction received from consuming different goods and services. The term cardinal utility refers to the explicit measurement of utility on an absolute scale. In contrast, the ordinal utility theory assumes that an individual is only capable of stating which of the two groups of goods and services he prefers, if either.

The important concept in arbitrarily assigning an absoluate scale to the utility measurement is not the absolute size of the utility derived from each commodity, but rather its size relative to all other commodities.

The cardinal utility function relates an individual's total utility to his consumption of a set of goods and services. If we know the prices of each of these commodities as well as the available income of the consumer, then the utility is maximum when the marginal utility per dollar is the same for all commodities in the set. This results in maximum utility because if the marginal utility per dollar was less from consuming service A than from service B, then the individual could increase his total satisfaction, just by rearranging his purchases without spending additional money. This can be shown mathematically. Assume that x_1 denotes the quantity of the i^{th} commodity consumed in a given time period, then the utility function can be written as

$$U = F(X_1, X_2, --- X_i, ---X_n) \quad (1)$$

where U relates the total utility of the individual to his consumption of a set of n different goods and services such as food, housing, transportation, etc.

If we assume that P_i represents the price of the i^{th} commodity and Y denotes the consumer's income, then the total utility of the consumer is limited by his budget constraint

$$Y = X_1P_1 + X_2P_2 + --- + X_1P_1 + --- + X_nP_n \tag{2}$$

The utility can be maximized through the use of the Lagrangian multiplier method.

$$L = F(x_1, x_2, \cdots x_i -- x_n) + \lambda\left(Y - \sum_{i=1}^{n} X_i P_i\right) \tag{3}$$

The satisfaction of first order conditions will maximize the consumer's utility. The second order conditions or the sign of the bordered Hessian determinant will determine whether the utility is maximum or minimum.

$$\frac{\partial L}{\partial X_i} = \frac{\partial U_i}{\partial X_i} - \lambda P_i = 0 \tag{4}$$

and

$$\frac{\partial L}{\partial \lambda} = Y - \sum_{i=1}^{n} X_i P_i \tag{5}$$

$$\therefore \frac{(\partial U_1/\partial X_1)}{P_1} = \frac{(\partial U_2/\partial X_2)}{P_2} = \cdots \frac{(\partial U_n/\partial X_n)}{P_n} \tag{6}$$

Equation 6 expresses that the marginal utility per dollar of each of the n goods and services is equal. This equation states that for a given marginal utility, the lower the price the higher is the marginal utility per dollar. Thus, as the price of a good increases, the marginal utility per dollar decreases and it pays the consumer to decrease the quantity he buys. The reverse of this argument also holds and this confirms the concept of the downward sloping demand curve.

The solution to Equations 4 and 5 will also provide the consumer's demand function for each of the n available commodities. For example, the consumer's demand function for the i^{th} commodity, say air travel, can be obtained by solving for X_i. In general, the demand function for the i^{th} commodity will be of the following form:

$$X_i = X_i (P_1, P_2, ---, P_i, ---P_n, Y) \qquad (7)$$

If we hold the consumer's income constant and the prices of all other commodities remain unchanged, then the quantity of the i^{th} commodity consumed by an individual will depend on the price of the i^{th} commodity.

Although the exact shape of the demand function for the i^{th} commodity depends on the parameters and functional nature of the consumer's utility function, we will assume that the Marshallian law of demand is applicable to air travel: consumers will buy more at lower prices and less at higher prices, all other things being equal.

The Demand Function for Business Travel

There is no formal derivation for the demand function for business travel. However, we can point out the areas of economic theory which can contribute to the formulation of the theory. It is logical to assume that the air travel demand for business trips is related to the economy in general and specifically to the level of investment by the business concerns, the interest rates available, some measure of stock prices, etc. At the same time, it is logical to assume that the air travel demand for business trips is related to the firm's output of products and services. We are, therefore, assuming that an individual firm will treat the business travel by its employees as another input factor to the production activity. In this case, we are hypothesizing that the demand for business air trips can be derived from the demand for the output of all major industries producing goods and services.

Air Travel Demand Models

A market demand model explains the demand of all consumers for a particular good or service. This model can be used to explain the behavior of consumers in a particular market, all markets, a particular class of travel, all classes of travel, the market share of a particular mode, the market share of a particular carrier, or some combination of these. The models used to estimate the demand for air travel can be broadly classified into four categories: aggregate, gravity, modal split and inter and intra modal market share. This section contains a brief description of the models and the basic theoretical assumptions. The problems involved with the statistical specification and the empirical significance of the models is dealt with in the next section.

The Aggregate Models

The most simplistic models used for explaining the demand for air travel are single-equation aggregate market demand models. The aggregate model assumes that the service, air travel, is a homogeneous unit such as revenue passenger miles or revenue ton miles, etc. The index revenue passenger miles is determined by summing over all routes the product of number of passengers and the distance flown by each.

These models usually relate the total demand for air travel, to a selected number of demographic characteristic of the traveler and the market and the trip related factors, that is, factors describing the level of service offered.

There are normally four sets of "independent" variable in the model: some measure of average price of air travel, a measure of price of other commodities such as an alternative travel mode, a measure of the traveler's family income and some form of a time trend to account for factors which have not been included explicity in the model.

The aggregate model assumes that the volume of passenger traffic is related to the same parameters in all markets. This implies that the travel demand in the New York-Bermuda market can be characterized by the same parameters as in the New York-Chicago market. This assumption is weak, since the first is a pleasure market and the latter is mostly a business market. This being the case, although price paid by the traveler may be important in both cases, the impact of price is different in the two cases.

Normally, the single equation aggregate demand models do not contain a supply parameter. This is justified on the grounds that the airlines usually operate with considerably less than full capacity and it is unnecessary to include a supply variable.

Secondly, monopolistic routes are almost nonexistent and insufficient capacity is unlikely due to the market forces. The standard criticisms of excluding the supply factor are, first, that there may be some routes with very high load factors and secondly, that an increase in supply may increase demand.

The price variable is usually taken to be the average yield, that is, average revenue per revenue passenger mile for a given period. In theory, only one price should exist for a homogeneous commodity at any given time in a competitive market. However, in the case of air travel we have different prices. The average yield is a weighted average revenue and as such is subject to change even if the level of fare does not change. A change in the composition of the passenger mix or average length of haul can change the numerical value of yield. Similar arguements can be put forward for the use of an average per capita income.

The demand for air travel cannot be explained by price and income alone. It is generally recognized that some measure of value of time should be included in the model. The increases in aircraft speed relative to other competitive modes of transportation have been a very significant factor in the growth of the air travel. On the other hand, advanced technology has required greater amounts of investments which in turn, have affected the cost and in turn, the price of air travel.

Although there are many reasons for choosing aggregate market-demand models, the most important one is the lack of adequate published data. It is true that a first class revenue passenger mile cannot be added to the one generated by the economy class passenger or that average yield is inadequate, since no one pays the average fare. However, since data does not exist by class of service (other than first class vs. economy), purpose of trip, true origin-destination, by type of fare, etc., the analyst is forced to investigate the demand for air travel on an aggregate basis. The second major problem related to the data is the inability to quantify subjective data such as changes in personal taste. In general, the mathematical formulation of the aggregate demand model can be expressed as:

$$T_{ij}(t) = K \cdot F_{air}^{\alpha}(t \pm \epsilon_1) \cdot F_{competition}^{\beta}(t \pm \epsilon_2) \cdot Y^{\gamma}(t \pm \epsilon_3) \cdot S^{\delta}(t) \cdot g(t)$$

where:

T_{ij} (t) = traffic between origin i and destination j during time period (t)

K = constant

F_{air} = some average price for air travel

$F_{competition}$ = some average price for a competitive mode of transportation.

Y = some measure of the traveler's family income.

S = representative aircraft speeds.

g(t) = time function

ϵ = lag or lead for the variable

This is a multiplicative type of extrinsic model. An extrinsic model is one where, although time can enter the relationship as a predictor variable, it cannot be the sole predictor variable. The left hand side of the demand function contains a small number of variables which are presumably more important, and the net effect of the excluded variables is represented by a stochastic variable, a time trend. This variable accounts for all forces which should be included explicity in the behavioral demand function but are unquantifiable or subjective. Variation of these forces is, therefore, allowed through the use of a time trend function. The basic assumption is that the effect of the stochastic variable is similar to that observed in the past and, furthermore, on the long-term basis, time function will satisfactorily account for many of the secondary variables. The selection of the predictor variables is limited due to the availbility of data and the difficulty of quantification.

The exponents in the model represent partial elasticities, one elasticity coefficient for each factor which may be regarded as an average elasticity over the range of the data. The implicit assumption here is that the partial elasticities are constant. This aggregate form of the demand model contains one term to represent inter-mode cross-elasticity. It does not, however, contain intra-mode cross-elasticities. This is to say that first class traffic is not separated from the economy or excursion traffic and business travel demand is not separated from the pleasure travel demand. These limitations of the aggregate model exist due to the substantial limitations of the data available to reflect the price upon which the traveler makes his decision and the lack of techniques to secure homogeneity so that the price and income effects may be isolated.

The model also includes the flexibility to incorporate the delays with which the socio-economic factors exert their influence on the volume of traffic. For example, the family income in year t may effect the demand for air travel in year t, (t-1), or (t+1).

The Gravity Models

The gravity model for the demand for air travel is based on the gravitational law of physics. The model expresses the relationship between the demand for air travel between two cities as a function of the population of the two cities and the distance between them. The general form of the model can be expressed as:

$$T_{ij}(t) = K \cdot \frac{P_i^{\alpha}(t)\, P_j^{\beta}(t)}{d_{ij}^{\gamma}}$$

where:

$T_{ij}(t)$ = traffic between city i and city j during some time period t.

K = constant

P_i = population of city i.

P_j = population of city j.

d_{ij} = the distance between city i and city j.

The general form of the model does not assume that the population of each city should have equal travel inducing effects, or that the exponent of the distance factor has a numerical value of 2. The basic limitations of this model are:

1. it is difficult to define precisely the population of a city;
2. the model assumes that the population of a city lives at a "node" of a city;
3. city characteristics, such as average income, type of city, etc., are excluded from the model;
4. it is assumed that the same factors characterize the demand for all city-pairs.

It is possible to generalize the gravity model further by including factors such as average income, community of interest, availability of alternate modes of transportation, etc. By definition, then, gravity models are cross-sectional in nature, that is, they are generally used to analyze the demand for air travel between different city-pairs.

The variable "community interest" is an interesting one to analyze. Brown and Watkins[7] represent "community of interest" by the number of international air passengers travelling on the same route. Although it is difficult to prove the significance of these two factors in explaining the community of interest, they appear to provide a reasonable "fit" to the empirical data.

Modal Split Models

A modal split model determines the functional relationship between the share of traffic attracted to a particular mode over a route. The most common form of the modal split model assumes that total trip time and total cost are the two most significant factors which the travelling public will use in determining their choice of a mode of travel.

The mathematical formulation of one form of a modal split model is given in Figure 6. The total trip time includes the times for access, egress, passenger processing and waiting for the next line haul service.

Figure 6

Modal Split Model

$$MS_{ijm} = \frac{C_{ijm}^{\alpha} \cdot T_{ijm}^{\beta}}{\sum_{m=1,m} C_{ijm}^{\alpha} \cdot T_{ijm}^{\beta}}$$

WHERE MS_{ijm} = SHARE OF TRAFFIC BETWEEN i AND j TRAVELLING ON MODE m

C_{ijm} = TOTAL TRIP COST = ACCESS + EGRESS + TRIP FARE

T_{ijm} = TOTAL TRIP TIME

= $T_a + T_p + T_w + T_b + T_e$

T_a, T_e = TIME FOR ACCESS, EGRESS

T_p = TIME TO PROCESS PASSENGER AT STATION

T_w = TIME TO WAIT FOR NEXT SERVICE = $\frac{TD/2}{f_{ijm}}$

T_b = BLOCK TIME ON MODE m

TD = DAILY HOURS OF OPERATION FOR MODE m

f_{ijm} = DAILY FREQUENCY OF SERVICE FOR MODE m

α = TRIP COST ELASTICITY

β = TRIP TIME ELASTICITY

Source: Concept Studies For Future Intercity Air Transportation Systems. MIT - FTL, 1970

These factors are taken to account for the "convenience" aspect of the system. The model does not contain factors on comfort safety and reliability. In this figure, the time to wait for next service, T_w depends on daily frequency. The total trip cost, again, consists of trip fare and the cost of access and egress.

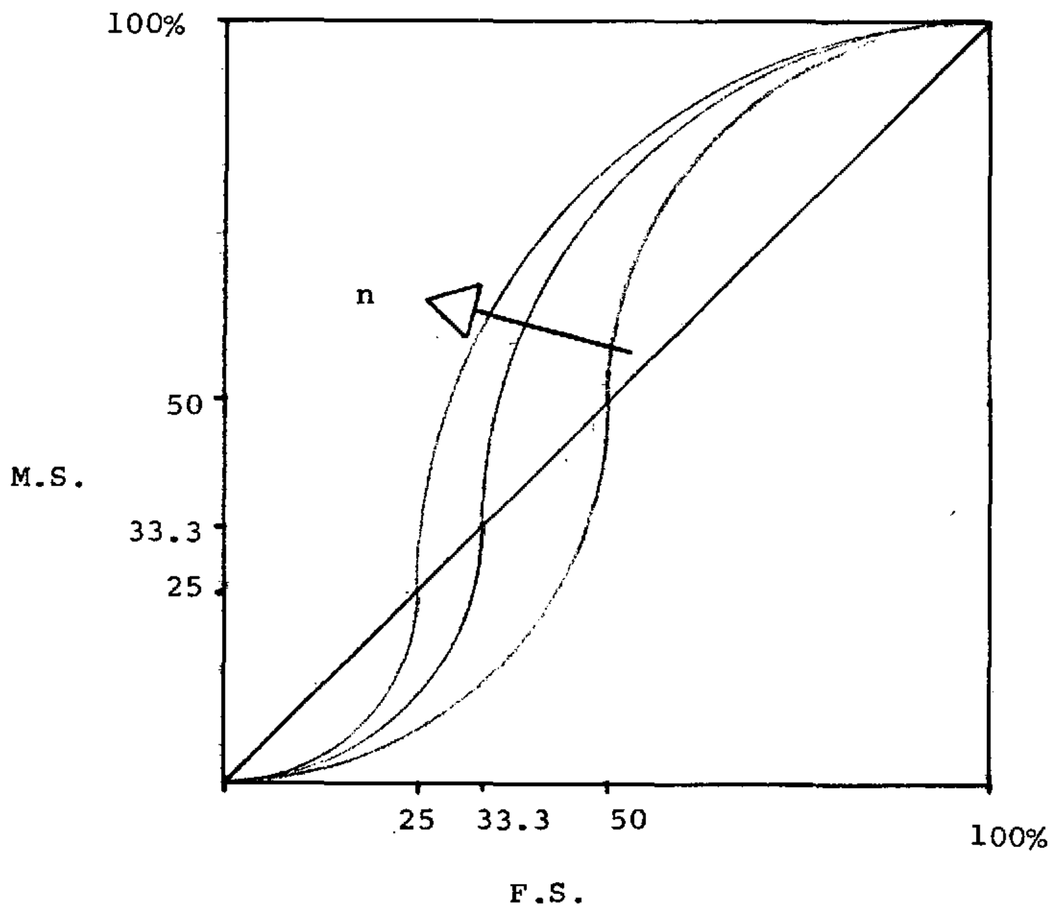
Market Share Models

A market share model shows the realtionship between the share of the passenger traffic for an airline in a given competitive market and the factors which describe the quality of service offered in the market by the carrier. Since, for a typical United States airline market, service factors such as fares and the type of aircraft are similar for all competitors in the market, the market share becomes a function of factors such as frequency of service, departure and arrival times, the image of the carrier, etc.

Research in the area of market share estimation in the airline industry has indicated that the most significant explanatory variable of market share is frequency share. More precisely, the empirical evidence shows that market share is an S-shaped curve and its location is a function of the number of carriers in the market. This concept is illustrated in Figure 7.

Figure 7

Market Share - Frequency Share Relationship



Source: N. K. Taneja, Airline Competition Analysis
MIT, Flight Transportation Laboratory, 1968

482

Various studies have indicated that the effects of multi-stop service and preference for various types of aircraft can best be accounted for by assigning weighted values to the daily frequency. Although these numbers have been highly criticized for their numerical and relative value, it should be pointed out that the values of these weighting factors are not extremely critical since services on competitive markets are normally very similar.

Another significant variable in the estimation of market share is the image factor which is usually built on such factors as inflight service, on-time performance, advertising, attitude of personnel, etc.

Model Selection and Evaluation

The selection of a particular model depends on the purpose of investigation, the validity, the simplicity, the accuracy, the cost of operation and maintenance and perhaps personal preference of the forecaster. The criteria for model selection and evaluation becomes significantly complex when there are a number of conflicting factors to consider. Nevertheless, it is necessary for the analyst to sort through the many factors and select a model. The following are a number of factors which can be used as guidelines for model selection and evaluation. It is not claimed that this list is complete or even that the criteria listed are more important than the ones left out.

To begin with, it is necessary for the analyst to be clear of the purpose of the investigation. For example, if the main object of the investigation is to estimate the true numerical value of demand elasticities upon which to base pricing and marketing strategies, then the unbiased estimation of the particular demand elasticity should be the criteria for model selection and evaluation. On the other hand, if the main object of the study is to forecast the demand for air travel, then the criterion for the selection of the model should be based on the forecasting ability of the model or the accuracy of the forecast.

The model selected should produce the smallest standard error of estimate and standard error of the demand coefficients. Similarly, if the purpose of the model is to produce a long-term forcast, then the choice of a cross-sectional model may not be the best one since the parameters in a cross-sectional model are estimated from a sample of observations at a given point in time.

Having narrowed the choice to a particular category of models, the next criterion should pivot on the validity of the model. The validity factor should be investigated in four parts: the theoretical foundations of the model, the underlying assumptions, the statistical validation, and the empirical calibration data in the case of econometric models. Again, these factors are only guidelines to investigate the validity of the model. The analyst can, however, perform very sophicticated and in-depth analysis of each factor. Once again, the effort put in evaluation should not be out of proportion to the development and use of the model per se.

All models should be based on some fundamental theory, may it be economics, engineering or otherwise. For instance, the demand for air travel can be based on economic theory. The analyst can go one step further and relate for example, the demand for pleasure travel to consumer's utility theory, or business travel to the theory of the firm. In other cases, the analyst can, for example, relate the gravity model to the gravitational law of physics. Unless some background theory can be put forward, it would be difficult to justify a model which, for example, predicts the air travel in the United States based on the amount of tea consumed in England.

Equally important in selecting a model, are the basic assumptions incorporated in the model. One can not justify using an aggregate demand model with constant price elasticity for forcasting the demand on a highly price elastic route. In another case, for example, the analyst can not use a model calculated using subsonic aircraft data, to forecast the potential on the supersonic aircraft. In each case, it is crucial to investigate the fundamental assumptions on which the model is based. The analyst who favors trend analysis is assuming that in the future the impact of factors influencing the market demand to air transportation will be similar to that observed in the past. Even an analyst who does not believe in forecasting, has a model and a set of assumptions For not forecasting, he is implicitly assuming a state of status quo.

The next area of investigation refers to the statistical validation of models which are known as analytic, regression or econometric.

These models may be subject to statistical problems* such as multicollinearity, autocorrelation, heteroscedasticity identification, etc. In each case, if a statistical problem exists, the chances are that the estimated parameters would be biased and the predictive ability of the model is subject to errors. The existence of more than one type of statistical problems complicates the matter further and evaluation of the model becomes even more difficult. The analyst, however, does have a set of statistics to help him determine the existence and in some cases, the extent of the problem. In the case of an econometric model, the analyst is usually provided with statistics* such as standard error of coefficient, multiple correlation coefficient, the F-statistic, the Durbin Watson or Von Neuman ratio, the Chow test, etc. A combination of one or more of these statistics and tests can be used to determine the statistical validity of an econometric model.

Closely related to the above is the general validity of the calibration data. In selecting and evaluating a particular model, one must investigate the calibration data which is used to estimate the demand parameters. Again, the data can be analyzed for adequacy, consistency and reliability. Putting it in another way, one must

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* For a description of these statistical problems, the reader is referred to standard texts such as Johnston and Wonnacott. References 8 and 9.

examine the data to see if the sample size was adequate, each data point was measured by the same rules and that the data is relatively free of significant errors.

The next set of selection criteria are somewhat interrelated. Simplicity is tied to the ease and cost of operation and maintenance on the one hand, and cost, accuracy and personal preference on the other hand. An historical trend analysis may be simple, cheap and easy to perform, but how accurate is it to forecast the demand for travel in a time period which may have supersonic aircraft, subsonic mass transportation or hypersonic aircraft or none of these? On the other hand, and equally important one has to weigh the marginal predictive accuracy against marginal cost of formulating a sophisticated model. Furthermore, a sophisticated model may not be necessarily more accurate than a simple one and yet for the sophisticated model, the collection and manipulation of the input data may be very expensive.

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489