A MULTI-EQUATION DEMAND MODEL

FOR AIR TRANSPORTATION SERVICES

by

TESHOME SEYOUM

B.S.E., Princeton University
(1976)

SUBMITTED IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE
IN AERONAUTICS AND ASTRONAUTICS
AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY
(September, 1978)

Signature of Author _____
                    Department of Aeronautics and Astronautics,
                    July, 1978

Certified by _____
             Thesis Supervisor ,

Accepted by _____
            Chairman, Department of Aeronautics and
            Astronautics

A MULTI-EQUATION DEMAND MODEL

FOR AIR TRANSPORTATION SERVICES

by

TESHOME SEYOUM

SUBMITTED TO THE DEPARTMENT OF AERONAUTICS
AND ASTRONAUTICS IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE IN
AERONAUTICS AND ASTRONAUTICS

ABSTRACT

The purpose of this thesis is to present the results of a research effort undertaken to test a model for passenger demand in an airline market. The model is written in order to attempt to describe the interaction of business and personal travellers through use of a simultaneous equation formulation. This kind of approach to demand modelling has not been attempted before, perhaps mainly due to the lack of reliable data on passenger characteristics with respect to trip purpose. Data has been collected on this from a major airline while fares and other transport variables have been obtained from the Official Airline Guide. The model is calibrated using multiple regression analysis and the results are presented for each of 24 markets (time series regression) as well as cross-sectional results they have in common.

Thesis Supervisor: Robert W. Simpson

Title: Professor of Aeronautics and Astronautics

ACKNOWLEDGEMENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Previous attempts at modelling air passenger movements at the market level have not differentiated the air passenger by the purpose of his (or her) trip. It is common knowledge that people take air trips or any kind of journey for some purpose. The purposes for which people travel are too many and varied to enumerate; however, it would serve our purpose if we could distinguish travellers into those who travel for personal reasons and those who take their trip due to some business related objective for which that trip is necessary. The reasons we would like to classify passengers in this manner are threefold. One, most passengers making use of the commercial air transportation system at present fall mainly into these two categories. Secondly, making the distinction as such enables one to assign important economic characteristics to each class thatmakes them readily available for econometric modelling. Also such a breakdown enables us to study the various classes of service provided by airlines as they relate to the two passenger groups.

A. Airline Economics: A Brief Review

The Airline Function

In order to better understand the role of demand modelling in commercial air transportation, it is important to understand at least in brief the economics of the industry.

In general, the classical theories of microeconomics are applicable to airline economics. The law of supply and demand and the concept of elasticity and so on still hold. However, the airline product or the output quantity is not so easily defined. A seat not sold today cannot be preserved for future sale. In addition, the industry is regulated. These and other problems related to the operational features of providing an air transportation service make it necessary to study Airline Economics separately with a knowledge of the technical problems that come into play.

In general, it is essential to be able to conceptualize the overall function of an air transport company. Figure 1 is a description of the production method for an airline. An airline hires labor, aircraft and together with route authority provides useful flight hours through its operations functions. Through its network sales efforts (marketing, etc.) it manages to serve people throughout its network. Both in its operations function and marketing functions, knowledge of future traffic flows is essential in its planning. The way in which it deploys its aircraft over its network, both in terms of frequency of service and type of aircraft, is highly dependent on the traffic it expects to attract. Pricing policies adopted are also heavily reliant on the results of its anticipated demand.

Crew Hours

Manager Hours

Aircraft Hours

Operations

Useful

Flight Hours

Network

Passengers Move from A to B
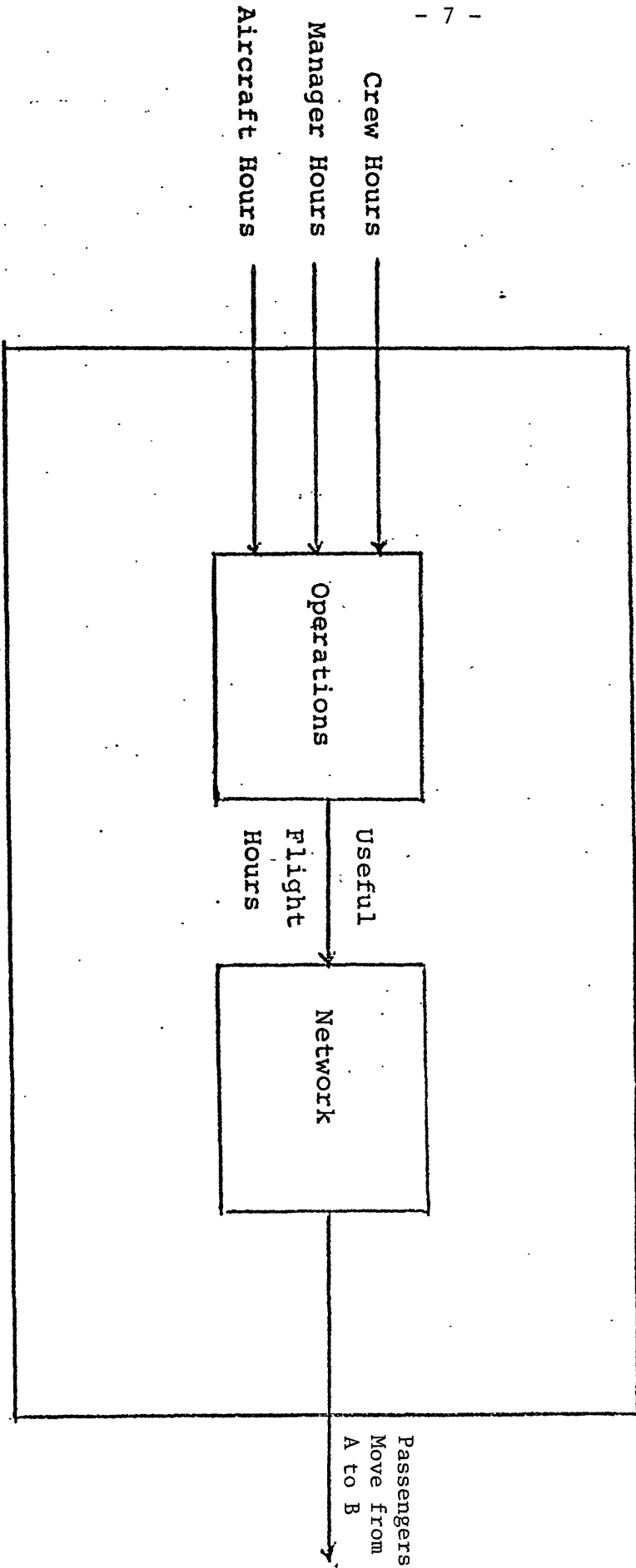
Figure 1. The Airline Function in Block Diagram

Market Structures for Air Transport

A market is defined by its demand function. The demand function contains or should contain enough information about that market so as to distinguish it from other markets. The attributes of a market are enumerated in terms of demographic factors of the origin and destination city pair. The market is defined generally for a region pair and for a particular class of service as well as for a given trip purpose. So for example, the market for pleasure travel between New York and Miami on coach class is different from the business market using first class even though the travel may be over the same region pair.

Several actors participate in an airline market. First, we have the buyers who are the users of the air transportation service. These are residents of regions i and j, in general, though not necessarily. We should note that not all passengers who happen to be flying on that segment are buyers in that market. Their market could be some other region pair but these "transit" travellers could have been routed over this market (market segment, strictly speaking). The producers in the market are the carriers who provide scheduled service. In most major U.S. markets there are about two or three carriers providing service and the question of market share becomes very significant.

In most cases, the producers are also the sellers in a market. However, we also have travel agents, tour operators and freight forwarders who represent themselves to sellers and

act as "middle-men" in a given market. Travel agents work for
tour operators who own several travel agencies. They receive
a fixed commission depending on their sales. Freight-
forwarders consolidate freight and provide it to the airline.
Some freight forwarders provide door to door service. Last
but not least, we have the major actor which is the market
regulator. In the case of the United States, this is the
Civil Aeronautics Board more popularly known as the C.A.B.
Its function is to overlook the industry and provide economic
regulation. The interaction of these groups can be repre-
sented by a diagram (Figure 2).

The concept of scheduled service implies several things.
Regular service is provided which is independent of actual
load. The prices charged are therefore based on average costs
over longer periods of time and over a region. An airline
cannot cancel an individual service because of poor load and
completely cease any service at all without public approval.
Scheduled service also implies that preplanned trips are
possible which is a tremendous benefit for both the business
and personal traveller. Prices are known and stable over
time. Changes in fares have to be filed before the Civil
Aeronautics Board 90 days prior to when it is supposed to go
into effect. Due to the existence of several flights, one can
devise an itinerary made up of connecting flights if no
direct flight is available. Fares are fully refundable if the
buyer changes his mind about wanting the service, even after
the flight has occurred. In order to operate efficiently,

```
┌──────────────────────────────────────────────────────────────┐
│              M A R K E T       R E G U L A T O R               │
└──────────────────────────────────────────────────────────────┘
      │                 │                 │                 │
 ┌─────────┐       ┌─────────┐      ┌─────────┐       ┌─────────┐
 │    B    │       │    S    │      │    B    │       │    P    │   Sched-
 │    U    │       │    E    │      │    R    │       │    R    │   uled
 │    Y    │       │    L    │      │    O    │       │    O    │   Air
 │    E    │       │    L    │      │    K    │       │    D    │   Carrier
 │    R    │       │    E    │      │    E    │       │    U    │
 │    S    │       │    R    │      │    R    │       │    C    │
 │         │       │    S    │      │    S    │       │    E    │
 │         │       │         │      │         │       │    R    │
 │         │       │         │      │         │       │    S    │
 └─────────┘       └─────────┘      └─────────┘       └─────────┘
```
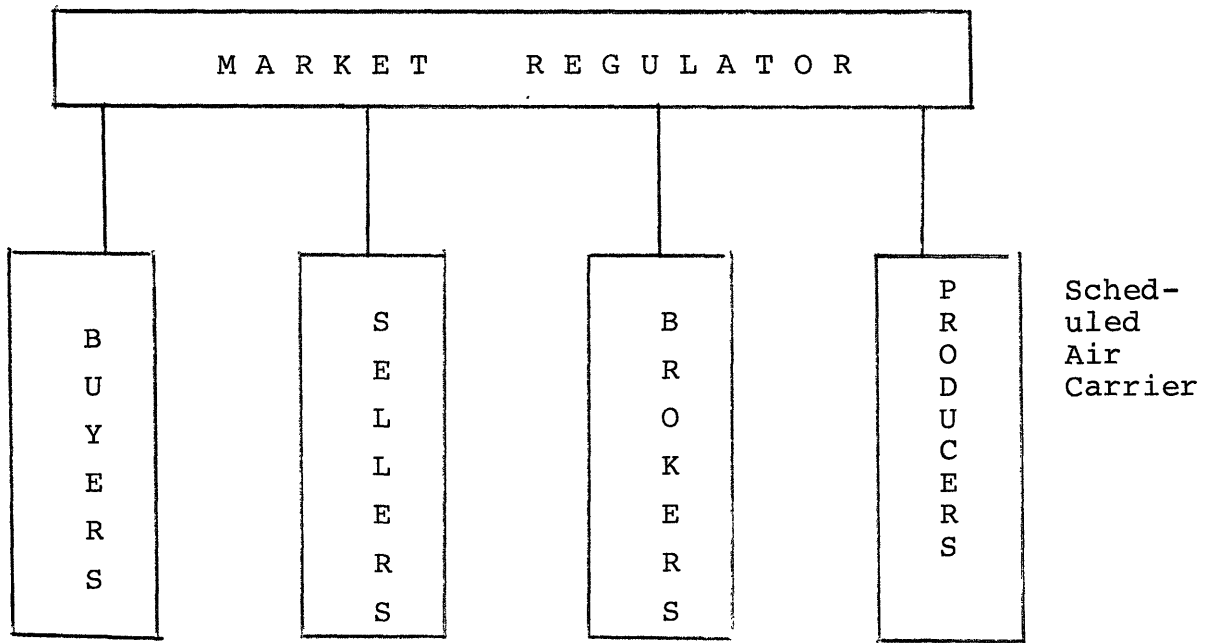
Figure 2.   Actors in a Public Air Transport System

airlines have to avoid empty movement of vehicles. They have to attract loads sufficient to have reasonable load factors. This can also be achieved through controlling vehicle routings and frequencies.

Airline Operating Costs and Profitability

Costs are generally subdivided into 2 groups, direct and indirect operating costs. In the Civil Aeronautics Board Report Form 41, the Uniform System of Accounts and Reports, this distinction is not made and any cost category is assigned an account number for identification purposes. These range from 5100 to 7000 in steps of 100 or multiples of 100. However, the Flight Transportation Lab has found it convenient to categorize operating costs into four sections. This enables one to visualize these costs in groups such that each component has something in common with another component in its group, thus emphasizing the similarities rather than the differences between them. The overall breakdown is as follows.

			Percentage of Total
I.	Flight Costs		50
	A.	Direct Operations	35
		1. Crew	12
		2. Fuel	23
	B.	Maintenance	14
		1. Airframe	4
		2. Engine	4
		3. Burden	12

		Percentage of Total
C.	Ownership Costs	12
	1. Interest on Capital	
	2. Obsolescence	
	3. Insurance	.5
II.	Ground Costs	20
A.	Reservations and Sales	8
B.	Traffic Servicing	7.2
C.	Aircraft Servicing	6.4
III.	System Costs	20
A.	Stewardesses	8.9
B.	Promotion (Ads)	1.1
C.	Administration	3.8
D.	Ground Equipment	3.0

The flight operating costs are similar to the costs found in the CAB's "Aircraft Operating Costs and Performance Reports." The ground operating costs are those costs related to operations at an airport. The system costs are those costs attributed to the operation of the firm as a whole.

B. Demand Models and Forecasting

Past attempts to accurately model air transportation demand have met with little success. At the same time, as air transportation assumes an increasingly important role in the economy, the need for better forecasting accuracy is ever present. Analysts have realized that traditional forecasting

methods such as trend extrapolation are inadequate due to the
impact upon travel demand of recent changes within the
economic and operating environment such as high inflation
rates, escalating fuel and labor costs, and uncertainties with
regard to future technology and regulatory conditions. Models
that are based upon more sophisticated theoretical methodolo-
gies, such as the one being tested in this work, have in
general been limited by either insufficient understanding of
the total air transportation system or by lack of relevant
data.

Demand forecasting plays an important role in various
segments of the commercial aviation system. Demand forecasts
are required by airlines as an input to their planning
processes. The inability of airline management to be able to
predict the sharp decline of traffic growth rates in the late
sixties and early seventies was responsible for the subsequent
over capacity caused by their introduction of wide-body air-
craft. However, airlines since seemed to have learned from
this mistake and have begun to recognize the importance of
accurate forecasting.

Airport authorities have the need for accurate forecasting
in order to be able to predict runway capacity and therefore
their ability to control delays and delay costs. Manufacturers
of aircraft and aircraft engines not only need to know overall
systemwide rates of growth in airline traffic but also in
particular markets since length of haul and market density
determine the design characteristics of a new airplane being

introduced to the carriers.

There are numerous approaches to forecasting future demand which do not necessarily involve using models. One can use pure judgement, making an informed estimate by an individual who is intimately acquainted with the factors related to the forecasted variable. These factors are weighted and evaluated according to the experience and intuition of the analyst. Secondly, using a mechanical or direct method, one can relate the variable to be forecasted to time through various types of growth curves which are developed, tested, and extended. It is based on the assumption that future experience is a direct function of past experience. A mathematical model or formula is very useful in eliminating much of the guesswork from forecasting, and, to the extent possible, this model or formula should be a mathematical representation of the relationships among those factors which tend to influence inter-city travel. The variable to be forecasted or modelled is written in equation form as a function of several independent (exogenous) variables. The exact functional form to be used varies considerably. In general the equations are written such that the dependent variable is expressed as a product of several independent variables.

$$T = KX_1^{\alpha} X_2^{\beta} X_3^{\alpha} \ldots$$

In most cases, since this formulation is non-linear, it is desired to linearize it by taking the logarithm of both sides of the equation, yielding,

$$LOGT = LOGK + \alpha LOGX_1 + \beta LOGX_2 + \gamma LOGX_3$$

The variables can be replaced by new variables with the understanding that,

$T' = LOGT$

$K' = LOGK$

$X_1' = LOGX_1$

$X_2' = LOGX_2$

$X_3' = LOGX_3$.

Now we will have a linear equation in the new variables,

$$T' = K' + \alpha X_1' + \beta X_2' + \gamma X_3'$$

The coefficients can take on any value between minus infinity and plus infinity. Hence, some of the variables could have been in the denominator of the right hand side of the original equation. It is possible to have several equations of this form in any given model thus providing a system of equations which could be linked together by having certain variables or coefficients in common.

The Gravity Model

There are several variations to this model. It is derived from Newton's gravitational law of physics. It is given as follows

$$D_{ij} = K \frac{P_i P_j}{d_{ij}^2}$$

This says that the demand for air travel between cities i and j is directly proportional to the product of their respective populations and inversely proportional to the square of the distance between them. Some minor variations, or more correctly, generalizations of this model are proposed by Richard Quandt in "Some Perspectives of Gravity Models" in volume one of Studies in Travel Demand, published by Mathematica at Princeton, New Jersey. The first variation is given by

$$D_{ij} = k \frac{P_i^{\alpha i} P_j^{\alpha j}}{d_{ij}^2}$$

This takes into account the possible differences in the inducement caused by each city. The problem with this formulation is that more often than not, it is difficult to estimate inter-city distance since the populations do not live at nodes. Moreover, it is also difficult to define a population for each city.

The second variation proposed is one where the possible effects of income (Y), city characteristics (e.g., percent of

labor employed in manufacturing and mining) M, cost and travel time variables (H and C), and S, a variable for "supply convenience of travel." The formulation is as follows.

$$D_{ij} = P_i^{\alpha_1} P_j^{\alpha_2} Y_i^{\alpha_3} Y_j^{\alpha_4} M_i^{\alpha_5} M_j^{\alpha_6} H_i^{\alpha_7} C_i^{\alpha_8} S_{ij}^{\alpha_9}$$

Gravity models do not consider the presence of alternative travel modes. Moreover, they ascribe the same explanatory variables to all markets being modelled or analyzed. However, many economists and statisticians have employed the gravity model of travel.

CHAPTER II

DISCUSSION OF THE MODEL

A. Components of Demand in an Airline Market

The simple demand functions of the previous section do
not adequately describe important elements of demand in a
domestic airline market. Demand is assumed homogeneous, that
is, no distinction is made between those passengers that are
paying for their trip and those for which their company or
organization (including government) is picking up the tabs.
We therefore create two groups of passengers, business and
personal. It is expected but not a priori assumed in the
model that these two groups have dissimilar or differing
demands from the air transportation system. Business travellers
are expected to demand fast reliable service and be relatively
insensitive to price changes. This group excludes those
business travellers who work for themselves and may not be
that sensitive to service changes but could be affected by
changes in price.

Now that the distinction between business and personal
has been made, we turn to the various classes of service now
available to users of the air transport industry. Basically,
we can break down an airline service into 3 classes. These are
first class (f), coach class (c) and discount class (d). All
the domestic trunks have these classes of service. Some
local service carriers do not have either first class or
discount class. Even though there is no one discount class
per se, this class has been created to account for the

numerous discount fares that have been introduced by the
carriers through a new "marketing" approach in the last half
of the 1960's. Passengers are usually assigned in regular
coach. In flight services are the same as for those paying
the full coach fare; however, there are various restrictions
as to trip duration and reservation policies. In order to
create components of demand we begin to assign the two
traveller groups (business and personal) to the three classes
of service (first class, coach class, and discount class).
This creates six passenger components. Six equations are
written to model each demand component.

$$D_{fb} = M_b \cdot I_f \cdot P_f^{\alpha_b} \cdot P_c^{\gamma_b} \cdot T^{\beta_b} \cdot BPI^{\theta_b}$$

$$D_{cb} = M_b \cdot I_c \cdot P_c^{\alpha_b} \cdot P_f^{\gamma_b} \cdot T^{\beta_b} \cdot BPI^{\theta_b}$$

$$D_{db} = 0$$

$$D_{cp} = M_p \cdot I_c \cdot P_c^{\alpha_p} \cdot P_d^{\gamma_p} \cdot T^{\beta_p} \cdot BPI^{\theta_p}$$

$$D_{dp} = M_p \cdot I_d \cdot P_d^{\alpha_p} \cdot P_c^{\gamma_p} \cdot T^{\beta_p} \cdot BPI^{\theta_p}$$

$$D_{fp} = 0$$

where,

D_{fb} -   demand for first class service by business travellers

D_{fp} -   demand for first class service by personal travellers

D_{cb} -   demand for coach class service by business travellers

D_{cp} -   demand for coach class service by personal travellers

D_{db} -   demand for discount class service by business travellers

D_{dp} — demand for discount class service by personal travellers

P_f — price for first class service

P_c — price for coach service

P_d — representative discount price

M_b — market size variable for business demand

M_p — market size variable for personal demand

I_f — image variable for first class service

I_c — image variable for coach class service

I_d — image variable for discount class service

BPI — buying power index

α_b — price elasticity of business demand

α_p — price elasticity of personal demand

γ_b — price cross elasticity of business demand

γ_p — price cross elasticity of personal demand

β_b — time elasticity of business demand

β_p — time elasticity of personal demand

θ_b — income elasticity of business demand

θ_p — income elasticity of personal demand

Two of these components, D_{fp} and D_{db} are very small and may
be ignored. This assumption has been verified after the data
was obtained and examined. First class use by personal
travellers, however, was discovered to be much greater than
the virtually non-existent discount class business travellers.
This assumption reduces the model from six to four coupled
equations. Here we use the mathematical form of the demand
function to represent each component of demand. It includes

two major diversions.

    1) We assume the business traveller is making a

       choice between first class and coach.

    2) We assume that the personal traveller makes a

       similar choice between coach and discount.

Figure 3 shows the interaction among the components.

We can use the image variable as a proxy for the qualify of service variables, I_f, I_c, and I_d for each class. In this work it has not been possible to quantify these variables independently so they have been lumped into the constant term of each equation. These variables would represent factors that are characteristic for a given class that have been conceived in the customers notion of that class. Various service attributes contribute to this conception. For example, with respect to the difference between first class and coach we have factors such as overall seating comfort, overall spaciousness, noise level, meal and table service, menu selection, prompt deplaning, attention given by hostess, privacy, luggage allowance, storage space at seat, drink price, meeting people socially, and making business contacts. It is also important to note that the importance given to these various attributes by the passenger is very much a function of the length of haul of that particular flight he (or she) is taking. On longer flights, the tendency is for these factors to be much more significant because of the extended duration of the flight and therefore the greater the extent one has to cope with deficiencies in these attributes.

	Trip Purpose	
Service Class	Business	Personal
First	D_{fb}	D_{fp}
Coach	D_{cb}	D_{cp}
Discount	D_{db}	D_{dp}

Figure 3. Components of Demand in an Airline Market

On shorter flights, these are not so critical and some
carriers do not even provide first class seating.

B. Travel Time

One of the variables that have been used in the modelling
is travel time. Actually, the way it is used in this research
is more complicated than just the time to fly between a
given market, that is, from departure at an origin to arrival
at the destination. The fashion in which it is used here is
to include the effects of both actual flying time and waiting
time due to disparities between schedules and times desired
for a particular flight. Thus it is more of a level of
service variable. It is an important performance measure of
air transportation services.

This variable is used here as it was formulated by
Steve Eriksen (see Reference). The average total trip time,
T, is given as follows.

$$T = \sum_{j=1}^{n} \pi_j TT_j = \sum_{j=1}^{n} \pi_j \min_{j}(|D_j - t_j| + A_i - D_i - Z + \gamma_i)$$

where,

    n = number of time points (equally separated) in the
        travelling day

    j = index of time points j = 1 (start of travelling day),
        2,...,n (end of travelling day)

    t_j = time of day at time point j

π_j = proportion of daily passengers preferring to depart at time point j

m = number of daily flights

i = index of daily flights   i = 1,2,...m

D_i = local departure time of flight i

A_i = local arrival time of flight i

Z = number of time zones crossed (positive if east to west, negative if west to east)

γ_i = connection adjustment for flight i

$\quad$ 0.0 for direct flights

= 0.5 for online flights

$\quad$ 1.0 for interline connections

TT_j = total trip time

The adjusted flight time for any flight i, AFT_i, is the difference between the arrival and departure times, $A_i - D_i$, minus the time zone change, Z, plus the connection adjustment γ_i.

$$AFT_i = A_i - D_i - Z + \gamma_i$$

The displacement time for any passenger preferring to depart at time point j and selecting flight i, DT_{ji}, is the absolute value of the difference between the departure time of flight i, D_i, and the time of day at time point j, t_j.

$$DT_{ji} = |D_i - t_j|$$

A passenger preferring to depart at time point j will select that flight which will minimize the sum of displacement time plus adjusted flight time. This minimized sum is his total trip time, TT_j. The average total trip time, T, is the weighted average (by the π_j factors) of the total trip times of the passengers who prefer to depart at each of the n time points over the travelling day.

Although it is very difficult to determine the π_j's Ericsen used data from the Boston/New York Eastern Airlines shuttle as a basis for deriving theoretical time of day distributions for all of the directed region pairs in this sample. The π_j's are given by:

$$\pi_j = \frac{\sqrt{p(j) \cdot p(j + \partial)}}{\sum\limits_{j=1}^{41} \sqrt{p(j) \cdot p(j + \partial)}}$$

where

$p(j)$ = proportion of daily passengers desiring to depart at time $t(j)$

$\partial = 2(t_o + Z) - 2$ (rounded to nearest integer)

Z = number of time zones crossed

t_o = nonstop jet time in hours

A computer program called LOS_COMP, developed by Ericsen at the Flight Transportation Lab, was used to calculate the travel times for the 24 markets used in the study. The program is written in PL/1. LOS_COMP accepts as its input a card

containing the region codes, the number of scheduled flights
(n), the nonstop jet time (t_o), and the time zone difference
(Z). The cover card is followed by one card for each of the
n scheduled flights which contains the pertinent flight data
including local departure and arrival times and the code of
the carriers (optional). The program internally determines
the time of day demand distribution π_j for j = 1,2,...,41 and
then computer the level of service (travel time) using the
previously described procedures. The output includes a
reproduction of the flight schedule and a table of intermediate
steps leading to the determination of the travel time. Table
1 and Table 2 are sample outputs for region pair Chicago to
Los Angeles for the first quarter of 1974.

TBAR is the average total trip time used in the model as
T. The flight scheduled was obtained from the Official
Airline Guide for both directions in a given market. Since
both schedules and actual flying time are not symmetric for a
given market, the computer runs were performed for each
direction and the results added to come up with a roundtrip
average total trip time, T. This variable appears in all four
equations of the model since it is not dependent on class of
service or trip purpose. The elasticities with respect to
travel time are assumed to vary by purpose of trip.

FLIGHT	DEPART	ARRIVE	ADJUSTED FLIGHT TIME	STATUS
1	24.83	26.95	4.12	DIRECT
2	8.50	10.67	4.17	DIRECT
3	8.75	11.92	5.17	DIRECT
4	9.00	12.03	5.03	DIRECT
5	9.25	11.48	4.23	DIRECT
6	9.50	11.65	4.15	DIRECT
7	9.50	11.65	4.15	DIRECT
8	10.00	12.07	4.07	DIRECT
9	10.08	12.17	4.08	DIRECT
10	10.08	12.33	4.25	DIRECT
11	10.50	15.07	6.57	DIRECT
12	11.75	13.72	3.97	DIRECT
13	12.00	14.17	4.17	DIRECT
14	13.00	15.17	4.17	DIRECT
15	13.00	15.25	4.25	DIRECT
16	13.75	18.40	6.65	DIRECT
17	13.92	17.83	5.92	DIRECT
18	14.00	16.03	4.03	DIRECT
19	14.92	19.03	6.12	DIRECT
20	15.50	19.23	5.73	DIRECT
21	15.67	18.72	5.05	DIRECT
22	15.83	18.08	4.25	DIRECT
23	16.00	18.03	4.03	DIRECT
24	16.00	18.08	4.08	DIRECT
25	16.00	19.28	5.28	DIRECT
26	17.25	19.97	4.72	DIRECT
27	17.50	19.67	4.17	DIRECT
28	17.58	20.32	4.73	DIRECT
29	17.58	21.08	5.50	DIRECT
30	18.00	20.07	4.07	DIRECT
31	18.33	20.33	4.00	DIRECT
32	18.33	20.58	4.25	DIRECT
33	19.25	21.38	4.13	DIRECT
34	21.25	24.27	5.02	DIRECT
35	22.00	24.10	4.10	DIRECT

Table 1.   Flight Schedule for the Chicago-Los Angeles
Market (February, 1974).

J	T(J)	PI(J)	FLIGHT BOARDED	DISPLACE- MENT TIME	ADJUSTED FLIGHT TIME	TRIP TIME	CONTRIBUTION TO TOTAL TRIP TIME
1	4.00	0.003	2	4.50	4.17	8.67	0.022
2	4.50	0.004	2	4.00	4.17	8.17	0.035
3	5.00	0.009	2	3.50	4.17	7.67	0.070
4	5.50	0.014	2	3.00	4.17	7.17	0.099
5	6.00	0.023	2	2.50	4.17	6.67	0.155
6	6.50	0.033	2	2.00	4.17	6.17	0.201
7	7.00	0.036	2	1.50	4.17	5.67	0.207
8	7.50	0.038	2	1.00	4.17	5.17	0.199
9	8.00	0.035	2	0.50	4.17	4.67	0.162
10	8.50	0.031	2	0.00	4.17	4.17	0.129
11	9.00	0.029	5	0.25	4.23	4.48	0.130
12	9.50	0.027	6	0.00	4.15	4.15	0.112
13	10.00	0.025	8	0.00	4.07	4.07	0.101
14	10.50	0.023	9	0.42	4.08	4.50	0.103
15	11.00	0.023	12	0.75	3.97	4.72	0.107
16	11.50	0.022	12	0.25	3.97	4.22	0.093
17	12.00	0.024	13	0.00	4.17	4.17	0.098
18	12.50	0.025	13	0.50	4.17	4.67	0.116
19	13.00	0.026	14	0.00	4.17	4.17	0.108
20	13.50	0.027	18	0.50	4.03	4.53	0.122
21	14.00	0.031	18	0.00	4.03	4.03	0.125
22	14.50	0.035	18	0.50	4.03	4.53	0.158
23	15.00	0.040	18	1.00	4.03	5.03	0.203
24	15.50	0.046	23	0.50	4.03	4.53	0.207
25	16.00	0.046	23	0.00	4.03	4.03	0.184
26	16.50	0.046	23	0.50	4.03	4.53	0.207
27	17.00	0.041	27	0.50	4.17	4.67	0.191
28	17.50	0.036	27	0.00	4.17	4.17	0.149
29	18.00	0.030	30	0.00	4.07	4.07	0.124
30	18.50	0.025	31	0.17	4.00	4.17	0.105
31	19.00	0.024	33	0.25	4.13	4.38	0.107
32	19.50	0.023	33	0.25	4.13	4.38	0.099
33	20.00	0.023	33	0.75	4.13	4.88	0.112
34	20.50	0.022	33	1.25	4.13	5.38	0.119
35	21.00	0.019	35	1.00	4.10	5.10	0.095
36	21.50	0.015	35	0.50	4.10	4.60	0.067
37	22.00	0.011	35	0.00	4.10	4.10	0.046
38	22.50	0.008	35	0.50	4.10	4.60	0.035
39	23.00	0.005	35	1.00	4.10	5.10	0.024
40	23.50	0.000	1	1.33	4.12	5.45	0.000
41	24.00	0.000	1	0.83	4.12	4.95	0.000

TBAP = 4.724

Table 2. Sample Output of the Level of Service Program for Chicago-Los Angeles (February, 1974).

C. Market Area Around an Airport and Buying Power Index

The Market Area Around an Airport

Several well documented characteristics of passenger behavior in flight selection indicate that an airport generally attracts demand from a larger area than its respective city or SMSA. These characteristics include the following:

1. Airline passengers may be drawn from cities with air carrier service to more distant airports depending upon the relative levels of service available. For example, consider a traveler desiring to travel from Providence to Cleveland sometime after the only direct flight which leaves at 8:50 A.M. While several connections are available during the rest of the day, a number of nonstops depart from Boston, 96 km (60 miles) away, and be as convenient in terms of total trip time. Thus, some of the Providence-Cleveland demand can be expected to spill over into the Boston-Cleveland statistics solely because of the schedule offered.

2. Commuter airlines, while becoming a more integral part of the air transportation system since their beginning in the late 1960's, do not report traffic statistics to the C.A.B. in the same detail as do the trunk and local service carriers. While recent C.A.B. actions have attempted to bring the commuters closer to the mainstream of air transportation activity by the introduction of joint fares and interline ticketing, the unregulated commuters began operations in an environment virtually disjoint from the rest of the airline

system. Under these conditions, a ticket written from New
York to Los Angeles with a connection to Palm Springs on
Golden West Airlines would statistically have represented an
origin to destination trip in the New York-Los Angeles city
pair, while in fact it would be more accurate to consider
this the New York-Los Angeles region pair with Palm Springs
included within the Los Angeles region.

3. Due to economic pressures brought before the Board
by the airlines, the C.A.B. approved suspensions and deletions
of service to a large number of small communities forcing
those passengers formerly served by the suspended flights to
use airports farther away. If the replacement airport is
within the same region as the abandoned one, working with
region pairs will show a decline to almost nothing at the
abandoned airport and an increase at the replacement airport.

These points appear to support use of regions rather
than cities to insure more accurate modeling and analysis of
the level of passenger movements. However, this reasoning is
highly dependent upon the quality and accuracy of the
delineation of the region themselves. In 1972, the Bureau of
Economic Analysis of the Department of Commerce investigated
the use of geographical regions delineated by critera based
upon transportation data. By using the journey-to-work data
from the 1960 Census of Population, the Bureau divided the
country into the 173 self-sufficient regions shown in Figure
by minimizing the routine commuting done across region
boundaries; that is, labor supply and demand were located in

the same region. Region boundaries were restricted to county boundaries and, for the purposes of this work, there is at least one air carrier airport serving each region.

The implications of using regions instead of cities as demand sources is shown below.

For example, listings for Detroit and Cleveland are shown below.

Region	Airports Within the Region
Detroit	Flint
	Detroit City
	Detroit Metropolitan
Cleveland	Akron
	Mansfield
	Cleveland Hopkins International
	Cleveland Burke Lakefront

Each region pair is comprised of a set of airport pairs found by enumerating the airports in one region with those in the other. The Detroit-Cleveland region pair contains the following twelve airport pairs.

Flint Akron   Flint-Cleveland Burke

Flint-Mansfield   Detroit Metro-Akron

Flint-Cleveland Hopkins   Detroit Metro-Mansfield

Detroit Metro-Cleveland Hopkins   Detroit City-Mansfield

Detroit Metro-Cleveland Burke   Detroit City-Cleveland Hopkins

Detroit City-Akron   Detroit City-Cleveland Burke

Note that even if there is more than one airport within a
metropolitan area, all airports must be counted and matched
with all airports in the other region. This occurs above
with Detroit (Metropolitan and City) and Cleveland (Hopkins
and Burke). Most often, the Official Airline Guide aggregates
airports within the same city, but for purposes of this
research, each airport must be considered separately.

The demand in a region pair will be the sum of the
demands of the component airport pairs; the supply of service
in a region pair will be the aggregate of the flights offered
in each of the component airport pairs.

Buying Power Index

The Buying Power Index (BPI) is an aggregation of three
important socioeconomic characteristics of a given area and
has been selected in this analysis to be the proxy for the
level of economic activity in the specified regions. The
major advantage in the selection of BPI is the accessibility
of the data. BPI is published annually by county in the
"Survey of Buying Power" edition of <u>Sales Management</u> magazine.
This edition generally appears in the summer, and the statis-
tics published at that time reflect the buying power for each
county for the preceding calendar year. The BPI is defined
by the following relationship:

$$BPI_i = 0.5\ I_i + 0.3\ R_i + 0.2\ P_i$$

where

BPI_i = percentage of national buying power in area i

I_i = percentage of national income in area i

R_i = percentage of national retail sales in area i

P_i = percentage of national population in area i

An additional advantage in the selection of BPI is the fact that since this index is published by counties, it lends itself extremely well to the concept of regional markets where the region boundaries are county lines. The BPI of an entire region is simply the sum of the published BPI indices for each county within the region. Furthermore, BPI has been tabulated in a consistent format over a period that contains the time interval under consideration in this research.

D. Price Elasticities, Cross Elasticities and Diversion Curves

This simple model of demand in an airline market has now created two distinctly separate price elasticities, and two price cross elasticities. First class business and coach business are related to first class fare and coach fare respectively through the fare elasticity of business demand, while coach personal traffic and discount personal traffic are related to coach and discount fare respectively through the price elasticity of personal demand. The price cross elasticity for a given trip purpose is used to relate the

demand in a given class of service to the fare of the comple-
mentary class of service.

The major distinction used between the two price
elasticities is that of trip purpose. Possible differences
due to class of service are ignored. For example, the price
elasticity of demand for business is assumed to be the same
regardless of the class of service used, the same being true
for personal demand.

It is worth noting that price elasticity is equivalent
to the percentage change in demand observed for a unit percen-
tage change in price. Cross elasticity refers to the
percentage change in demand of one category for a unit percen-
tage change in the price of a related service. The concept
of price and cross elasticities lead us into the idea of
diversion. The values of these coefficients determine the
split between business and personal traffic in the three
classes of service.

We see that there are two price elasticities in the
market, not a single value. We would expect the price
elasticity for business travellers to be inelastic while α_p
for personal travellers might be highly elastic. Conversely,
we would expect the time elasticity of business travellers,
β_b to be highly elastic while β_p for personal travellers is
inelastic.

There are two "cross-elasticities" of demand in the
model shown here: γ_b, the cross elasticity for business
demand as it splits between first and coach service as a

function of relative prices: γ_p, a similar cross elasticity
for personal demand is a function of coach and discount prices.

The important point is that there are at least two
distinct price elasticities in the airline market which must
be found, not the single value often sought. Knowledge of the
values of these constants enables one to see the effect on
the various demand components of changes in a variable, most
notably price of a given class of service. The curves thus
constructed are known as diversion curves.

We can derive the relationship for the business split,
BS, or personal split, PS, from the paired equations of our
model.

$$BS_c = \frac{D_{cb}}{D_b}$$

$$= \frac{D_{cb}}{D_{cb} + D_{fb}}$$

$$= \frac{1}{1 + \frac{D_{fb}}{D_{cb}}}$$

From our model,

$$\frac{D_{fb}}{D_{cb}} = \frac{I_{fb}}{I_{cb}}(\frac{P_f}{P_c})^{\alpha_b} \cdot (\frac{P_c}{P_f})^{\gamma_b}$$

$$= \frac{I_f}{I_c}(\frac{P_f}{P_c})^{\alpha_b - \gamma_b}$$

Therefore,

$$BS_c = \cfrac{1}{1 + \dfrac{I_f}{I_c}\left(\dfrac{P_f}{P_c}\right)^{\alpha_b} {}^{-\gamma_b}}$$

This describes the percentage of coach service used by business demand as a function of the relative quality of service, $\dfrac{I_f}{I_c}$, and the relative price, $\dfrac{P_f}{P_c}$. It results in a diversion curve of the form shown in Figure 4. The shape of the curve depends strongly upon the values of price elastici-ties for the business traveller, α_b, and the value of the cross elasticity, γ_b. A similar diversion curve exists for the personal travel split which should be much more sensitive to $\dfrac{P_c}{P_d}$ because of the elastic values of its price elasticities. When the two prices are equal, that is, at $\dfrac{P_f}{P_c} = 1$ the business split is only determined by the relative classes of service as is observed from the graph. As first class fare becomes much higher in relation to coach fare, it is to be expected that the percentage of business demand in coach approaches one hundred percent.
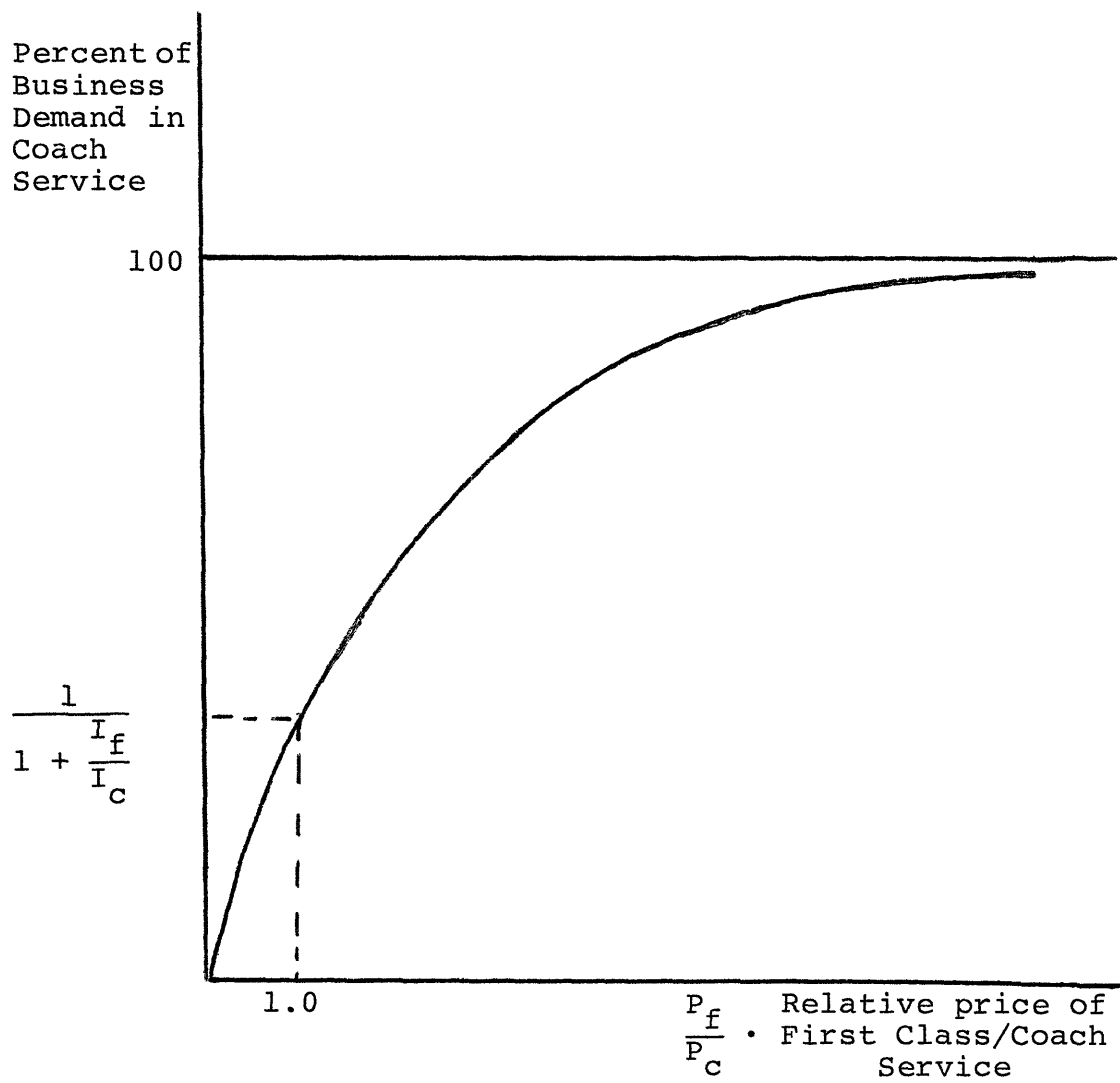
Figure 4. Diversion of Business Demand to Coach

CHAPTER III

DATA COLLECTION

A. Demand Data

Demand data was obtained from United Airlines in August of 1976 in the form of a computer printout. The information was made possible through on board surveys that United regularly performs on approximately 276 of its flights. The sample represents an "average day" in the life of United Airlines. The data does not show actual traffic on a given market. It presents of the number of people who responsed to the questionnaires how many in each class of service considered their trip either business or personal. Also a breakdown of the discount traffic is given by type of discount fare. This made the calculation of the representative discount fare possible. Table 3 presents an example of the printout from United. It is given for two markets Chicago-Los Angeles and Atlanta-Cleveland for August 1975 (third quarter). The statistics are shown for the middle month of each quarter. They are daily data and not necessarily origin-destination.

Since the data was not origin destination, which is the one commonly used for demand modelling, it was necessary to make certain assumptions in order to proceed with the regressions. The assumption was made that the same percentage of the sample (non O-D) that belonged to a certain demand group, say first class business would be applicable toward the actual origin-destination traffic that existed for a given

	Atlanta-Cleveland		Chicago-Los Angeles	
	Bus.	Pleas.	Bus.	Pleas.
First Class	16	8	29	24
Full Coach	60	33	118	68
Military Discount	-	-	-	-
Visit USA	-	-	1	7
Bargain Fare	1	3	8	38
Economy Fare	-	-	10	7
Layaway Fare	-	-	-	-
'Package' Tour --Independent	-	2	7	7
'Package' Tour --Group	-	-	-	-
Group Fare	-	-	-	-
Airline Employee Travel Agent, Relative	-	-	-	-
No Answer	1	1	1	4
Analyzed Respondents	77	48	179	151

Table 3. Demand Data, Atlanta-Cleveland and Chicago-Los Angeles
(November 1974)

market. There was no reason to believe that this would not
be the case. The calculated percentages were then applied to
the total Origin Destination traffic available for the Civil
Aeronautics Board Survey Table 10. So the extension was made
from just limited data toward the whole market having made
the added assumption that the same percentages again apply to
the total demand in the market. For example,

$$D_f^b = \frac{SD_f^b}{SD} \times D$$

where

D_f^b = first class business demand

SD_f^b = sample first class business demand

SD = total sample demand in a given market

(i.e., analyzed respondents less no answers)

D = total origin destination demand in a given market.

In the cases of discount traffic, it was necessary to add up
all the various discount traffic corresponding to the
different fares. For the others then,

$$D_f^P = \frac{SD_f^P}{SD} \times D \qquad \text{this was assumed zero}$$

$$D_c^b = \frac{SD_c^b}{SD} \times D$$

$$D_c^P = \frac{SD_c^P}{SD} \times D$$

$$D_d^B = \frac{SD_d^B}{SD} \times D \qquad\qquad \text{this was assumed zero}$$

$$SD_d^B = \sum_{n=o}^{k} SD_{dn}^b$$

$$D_d^P = \frac{SD_d^P}{SD} \times D$$

$$SD_d^P = \sum_{n=o}^{k} SD_{dn}^P$$

where,

    n = index number for a given discount fare

    k = the number of discount fares used in a market

    D_f^P = first class personal demand = 0

    SD_f^P = sample first class personal demand

    D_f^b = first class business demand

    SD_f^b = sample first class business demand

    D_c^c = coach business demand

    SD_c^b = sample coach business demand

    D_c^P = coach personal demand

    SD_c^P = sample coach personal demand

D_d^b = discount business demand = 0

SD_d^b = sample discount business demand

D_d^P = discount personal demand

SD_d^P = sample discount personal demand

So D_f^b, D_c^b, D_c^P, and D_d^P were the four dependent variables used in the regression analysis. They were computed as above and then transformed by taking their natural logarithm to implement the log-linear form that was used. The demands showed considerable irregularity over time (10 quarters) for a given market. This was due to seasonality, but more so the unavailability of sufficient traffic at some time periods for some markets. This can be seen in Figures 5, 6, and 7. The markets represented here are New York-San Francisco, Los Angeles-Des Moines and Chicago-San Francisco. Note that the vertical scale is in the natural logarithm so that a 1 unit variation is a multiple of e difference where e = 2.718.

Several measures were tried in order to deal with this problem. First a straight line was drawn through the variations to smooth out the demands. In some instances the lines were horizontal which caused problems in the time series regressions. Secondly, three dummy variables S_1, S_2, and S_3 were created and included in the models to account for seasonal variations. They are defined as follows,
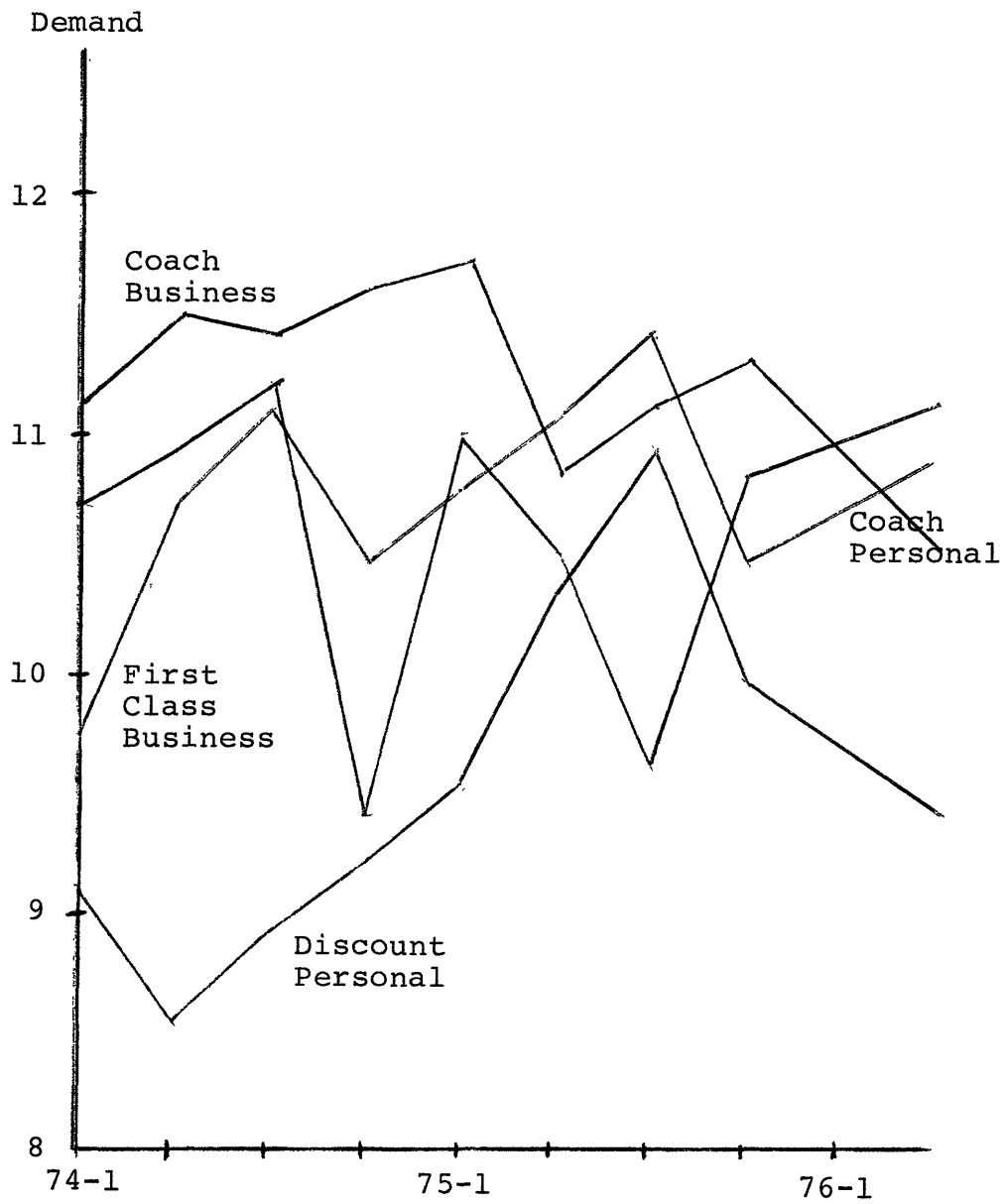
Figure 5. Demand Split for New York-San Francisco
(natural log scale)
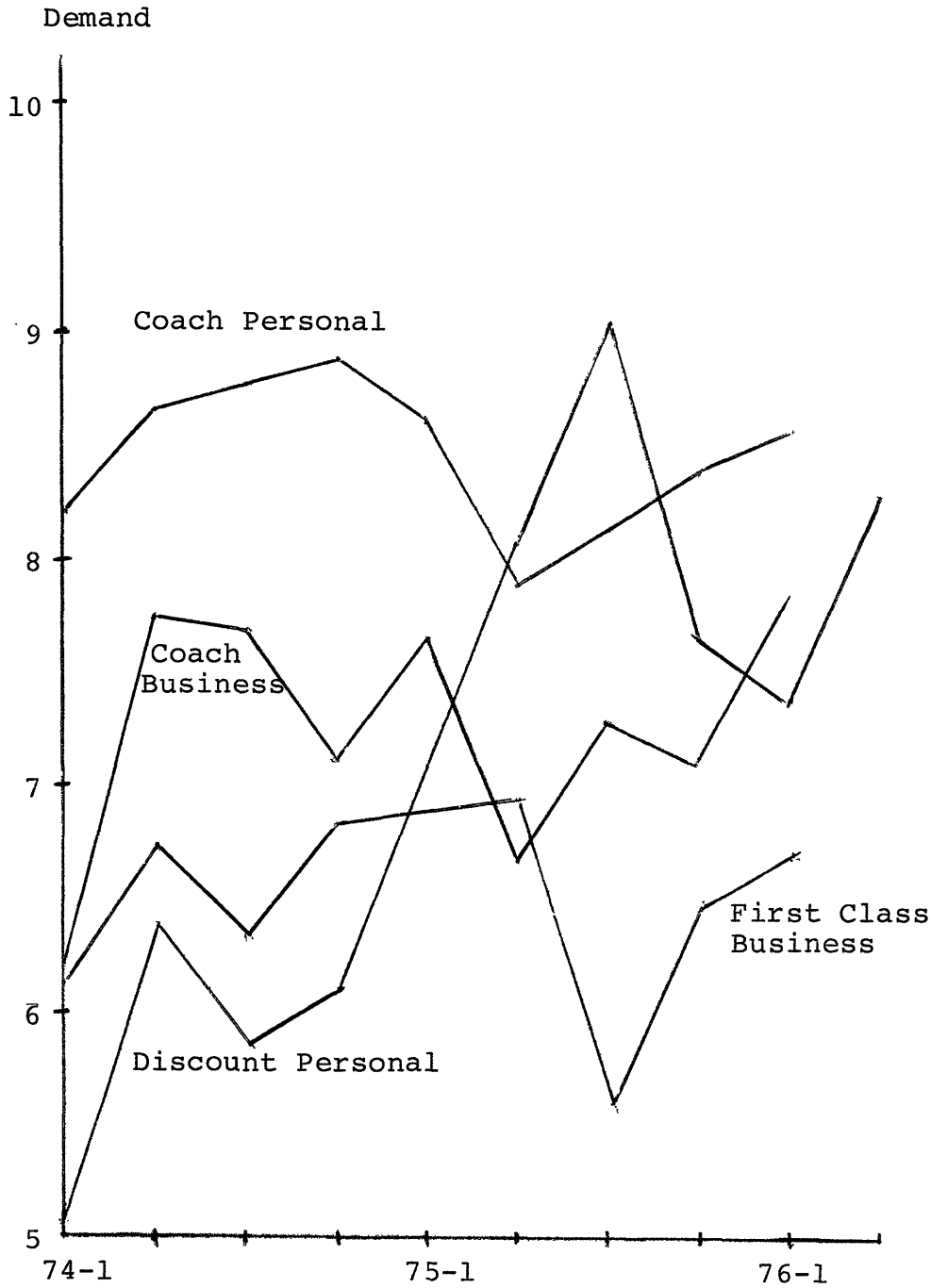
Figure 6. Demand Split for Los Angeles-Des Moines
           (natural log scale)
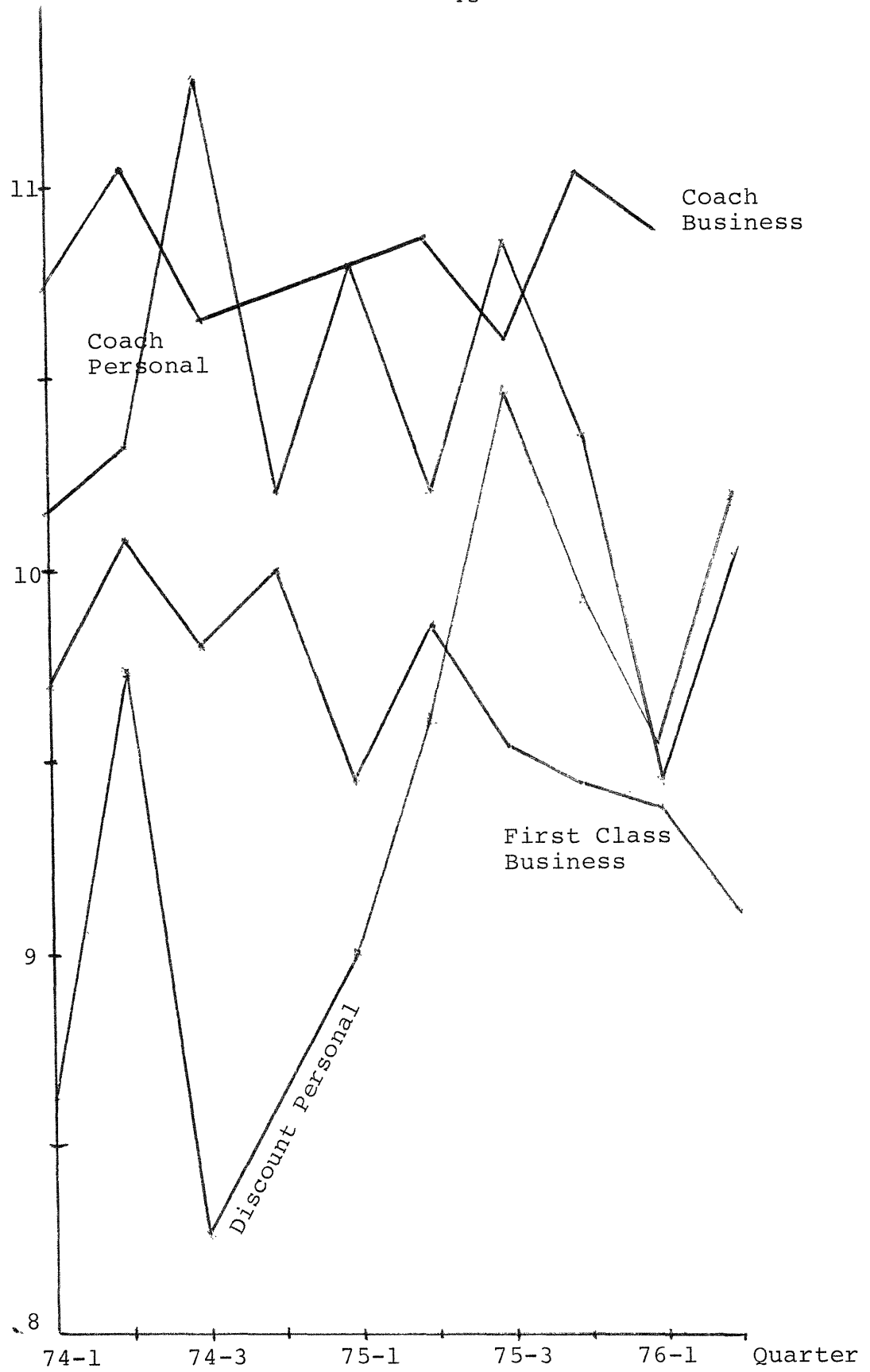
Figure 7. Demand Split for Chicago-San Francisco
          (natural log scale)

$$S_1 = \begin{cases} 1 \text{ if winter} \\ 0 \text{ if not} \end{cases}$$

$$S_2 = \begin{cases} 1 \text{ if spring} \\ 0 \text{ if not} \end{cases}$$

$$S_3 = \begin{cases} 1 \text{ if summer} \\ 0 \text{ if not} \end{cases}$$

The coefficients associated with these variables will then provide an estimate of the amount of seasonality of any given season, present in a market. A negative coefficient would indicate a more than normal traffic (seasonality exists) and a positive coefficient would indicate the opposite situation where a slackening of demand occurs.

As mentioned before, the study was performed for 24 domestic U.S. markets flown by United Airlines during the period spanning from the first quarter of 1974 to the second quarter of 1976. The markets that were studied are presented in Table 4. Very few instances existed when no demand data was presented for a given market at a certain time period. In a couple of cases no first class demand was available for the market Los Angeles-Memphis, for example. This and minimal, in most cases, zero usage of discount fares caused the regression observations to decrease from the expected 240 to around 200. This was because the regression was performed after logarithmic transformations of the data took place, which gave the impossible situation of infinity for the zero

Table 4:   Market List Used in the Study

 1.   New York-San Francisco

 2.   Los Angeles-Memphis

 3.   Atlanta-Cleveland

 4.   Chicago-Cleveland

 5.   Chicago-Denver

 6.   Chicago-Detroit

 7.   Chicago-Los Angeles

 8.   Chicago-Philadelphia

 9.   Cleveland-Denver

10.   Denver-Detroit

11.   Denver-Milwaukee

12.   Denver-San Francisco

13.   Detroit-Washington, D.C.

14.   Los Angeles-Portland

15.   Los Angeles-Washington, D.C.

16.   Chicago-Honolulu

17.   Chicago-San Francisco

18.   Chicago-Boston

19.   Las Vegas-Chicago

20.   Los Angeles-Honolulu

21.   Denver-Boston

22.   Cleveland-Miami

23.   Minneapolis-Chicago

24.   Los Angeles-Des Moines

demands. This problem did not, however, severely handicap the study since there was still a sufficient degree of freedom left after the reduction in data.

B. Fares Data

Fares for the 24 markets were obtained from the Official Airline Guide for the relevant time periods. The issues used were the ones published for the 15th of the middle month of each quarter. There are two O.A.G. issues for each month, one for schedules beginning on the 1st and one for those beginning on the 15th. The latter was used, although the first one would have been just as valid, since it was not clear exactly when the United demand surveys were performed during the month. Aside from schedules, the O.A.G. prints fares by class of service. There were instances when certain discount fares were not available from this source. This was especially true of "Bicentennial Fares" which were in effect during the whole year of 1975. Fortunately, we were able to communicate directly with United Airlines in order to obtain the necessary information. The following is a list of the fares that fell into this category together with a description of each according to the discussion.

Midweek Excursion Fares

These fares expired on February 28, 1974. They were applicable only on markets over 2000 miles. The fares are constant from a city and vary by market distance from that city.

Discover America Fares

These fares were in effect during the first two quarters
of the study (first and second quarter of 1974). They were
at 12 1/2% reduction from the coach fare.

Bicentennial Fares

These were at 25% off of coach fare with certain
exceptions. From June 15 to September 15, 1975 they were
at 15% off. They expired on January 31, 1976.

Freedom Fares

These fares were a replacement for the Bicentennial
fares when they expired. They were in effect January 1, 1976
to September 15, 1976. The price was at 15% reduction from
coach. From September 15, 1976 on, they were changed to
20% off coach. The dates for Florida markets are different.

This information was extremely useful in determining the
dollar amount of fares in some of the markets. It was a
supplement to the information from the Official Airline Guide.

Representative Discount Price

The regressions were performed for 24 markets over ten
quarters beginning in the first quarter of 1974 and ending
in the second quarter of 1976. During this period and for
most of these markets, various discount prices were in effect.
Table 5 shows these discount fare plans over the ten quarters
which were in effect for most of the 24 markets. Of these

Fare Plan	May 76	Feb 76	Nov 75	Aug 75	May 75	Feb 75	Nov 74	Aug 74	May 74	Feb 74
Military Discount	x	x	x	x	x	x	x	x	x	x
Economy		x	x	x	x	x	x			
Package Tour	x	x	x	x	x	x	x	x	x	x
Package Tour Gr.	x	x	x	x	x	x	x	x	x	x
Group Fare	x	x	x	x	x	x	x	x		
Visit USA			x	x	x	x	x	x	x	
Layaway			x	x	x	x	x	x	x	
Bicentennial			x	x	x	x				
Bargain Days						x	x			
Family Plan									x	x
Youth Fare									x	x
Discover Am.									x	x
Midweek Exc.										x
Military Study										x
Other	x	x	x	x	x	x	x	x	x	x
Employee, etc.	x	x	x	x	x	x	x	x	x	x
Freedom	x	x								

Table 5. Usage of Discount Fares

several fares, a few could not be used because the traffic
using these fares was too low and in most cases non-existent.

In order to arrive at a single discount fare that would
be representative of all these fares, the different fares were
weighted by the demand each generated. So for example,

$$P_D = \sum_{n=0}^{k} D_n P_n^d / \sum_{n=0}^{k} D_n \quad \text{for each market in a given period}$$

where

P_D = representative discount price for a market for a
given quarter

k = number of discount fares available for a given
market

n = index of a particular discount fare

D_n = demand using a given fare n

P_n^d = amount of a given discount price

note $\sum_{n=0}^{k} D_n$ = total discount traffic in a given market.

The three individual fares (P_f, P_c, and P_d) have been adjusted
for inflationary effects by dividing by the Consumer Price
Index. The data on CPI was obtained for the time periods of
the regression from the N.B.E.R. Time Series Data Bank of the
TROLL system. The Consumer Price Indices are shown in Table
6.

CHAPTER IV

REGRESSION METHODS

Regression is a method by which the parameters of a given equation or system of equations could be estimated. There are various estimation procedures that can be used in regression. However, these are basically the same and are derived from the basic techniques of the Ordinary Least Squares.

A. Ordinary Least Squares Technique

The Ordinary Least Squares Method (OLS) is a way of estimating the parameters of a given model. For example, let us assume a simple one independent variable model of the form

$$y_i = \beta_0 + \beta_1 x_i + \varepsilon_i$$

where,

y_i = the observed dependent variable

x_i = the observed independent variable

ε_i = the error term for that observation.

We are trying to estimate the values of β_0 and β_1. In particular, the method of least squares requires that we consider the sum of the n squared deviations, denoted by Q:

$$Q = \sum_{i=1}^{n} (y_i - \beta_0 - \beta_1 x_i)^2$$

The estimates of β_0 and β_1 are those values of b_0 and b_1 respectively which minimize Q. They could be found by trial and error procedure. However, this is not necessary since it can be shown that the values of b_0 and b_1 which minimize Q for any particular set of sample data are given by the following simultaneous equations:

$$\Sigma y_i = nb_0 + b_1 \Sigma x_i$$

$$\Sigma x_i y_i = b_0 \Sigma x_i + b_1 \Sigma x_i^2$$

These equations are called normal equations; b_0 and b_1 are the point estimators of β_0 and β_1 respectively. The quantities Σy_i, Σx_i, and so on are calculated from the sample observations (x_i, y_i). The equations then can be solved simultaneously for b_0 and b_1. Alternatively, b_0 and b_1 can be obtained directly as follows:

$$b_0 = \frac{\Sigma x_i y_i - \dfrac{(\Sigma x_i)(\Sigma y_i)}{n}}{\Sigma x_i^2 - \dfrac{(\Sigma x_i)^2}{n}} = \frac{\Sigma (x_i - \bar{x})(y_i - \bar{y})}{\Sigma (x_i - \bar{x})^2}$$

$$b_1 = \frac{1}{n}(\Sigma y_i - b_1 \Sigma x_i) = \bar{y} - b_1 \bar{x}$$

where $\bar{x}$ and $\bar{y}$ are the means of the two sets of data.

B. Linearization

The demand model as presented in Chapter II is in a non-linear form. In order to apply the Ordinary Least Squares technique, it was necessary to linearize it by taking the log (natural) of both sides of the four equations. We then have

$$logD_{fb} = logK_{fb} + \alpha_b logP_f + \beta_b logT + \theta_b logBPI$$

$$LOlogD_{cb} = logK_{cb} + \alpha_b logP_c + \gamma_b logP_f + \beta_b logT + \theta_b logBPI$$

$$logD_{cp} = logK_{cp} + \alpha_p logP_c + \gamma_p logP_d + \beta_p logT + \theta_p logBPI$$

$$logD_{dp} = logK_{dp} + \alpha_p logP_d + \gamma_p logP_c + \beta_p logT + \theta_p logBPI$$

The data (both dependent and independent variables) were transformed logarithmically before performing the regressions. This presented a problem in those data points where, for example, there was no demand for a market at some period. The computer gave a very high and negative value for the logarithm. However, these data points were skipped during the regressions and consequently the number of observations were reduced, in some cases considerably. There was not the problem, however, of insufficient degrees of freedom since, we started out with 240 observations.

C. The TROLL System

The statistical work for this project was undertaken on the M.I.T. IBM-370 computer system using TROLL. TROLL is an interactive computer system for research in economics and other social sciences. The author has found the TROLL system extremely useful and very flexible and recommends it use by future researchers intending to use statistical data processing. TROLL consists of a set of tasks and a file system. Each task is a specific information processing capability. For example, the regression task estimates coefficient values in equations, whereas the data editing task creates or updates data vectors.

The following is a brief description of the tasks whose understanding the author feels is essential for those who will need to perform regression analyses on the TROLL system. There are three such tasks.

1. DEDIT Task

This task enables the user to create and/or update a data vector for future use or for whatever purpose. The command format for this task is:

DEDIT filename, periodicity, start data;

Always use a semi-colon after every TROLL command unless you are specifically instructed by TROLL to type something. 'Filename' refers to the name you have chosen for your data file (up to 8 characters, etc.). 'Periodicity' should always

be 1 unless the particular dataset is quarterly (use 4) or monthly (use 12). If your data is not a time series and just a set of numbers use 1.

'Start date' should also be 1,

e.g., DEDIT x, 1, 1;

This command should be typed to create a dataset called x which is a set of numbers or an annual series beginning with year 1. To update an already existing file the periodicity and start date are not specified.

To enter the data vector, the following command is given:

ADD TOP, value 1, value 2,...;

where value 1 and value 2 are the first 2 numbers of the data vector and so on. After creating a new file, one has to give thecommand 'file' to store the dataset permanently.

2. MODEDIT Task

This task creates or updates a model, just like DEDIT does the same thing for data files.

The commands are:

USEMOD V;

This tells the computer to create model V.

ADDSYM ENDOGENOUS V1 V2 V3, EXOGENOUS X1 X2 X3,

COEFFICIENT C1 C2 C3;

This command creates and declares the variable(s) and

constant(s) of your equation(s).

Then,

ADDED TOP, V1 = C1X1 + C2X2 + C3X3,

              V2 = C2X1 + C3X2 + C1X3.

              V3 = C3X1 + C1X2 + C2X3;

This command creates the equations of the model. All the
terms in the equations must have been declared in the ADDSYM
command previously. You can create any number of equations.
The choice in this example is completely arbitrary. Then,
to store the model one has to type:

FILEMOD;

3. REG Task

This task performs regression using any of the models
one has created. The variables in the model you are using
have to have been created and stored in the DEDIT task.
Every variable in the model has to have the same periodicity,
usually all 1.

USEMOD y;

Period n;

These two commands inform the computer to use a model y and
that the periodicity of the variables is n, which is previously
set anyway.

REG date1 to date2;

This command is to regress from date 1 to date 2 using the above model. (Date could refer to observation number.)

DOEQ 1;

This command tells the computer to perform the regression on the first equation of the above model. (It could be that there is only 1 equation in the model.) The command still has to be typed because it actually initiates the regression besides specifying the equation. After this command, the computer prints out the standard regression statistics. This output can be controlled.

There are various other tasks, notably the DO task which is extremely useful to the TROLL user. However, the above basic tasks are the basic necessity to perform regression on TROLL. The TROLL PRIMER (available at IPS) should be consulted for these other tasks and general familiarity with the system.

In addition to data processing capabilities TROLL has a large system library which contains economic data and information on the United States starting from the 1940's to the present. Relevant data such as GNP, population and employment statistics are available together with a large number of other statistics. The author has made use of the data on Consumer Price Index in delfating the prices over time. This data is available in the N.B.E.R. Time Series Data Bank.

CHAPTER V

VARIATIONS OF THE MODEL

A. Multicollinearity

Three variations of the previously presented model have been regressed. The first two were used in order to attempt to solve the problem of multicollinearity without seriously hampering the usefulness of the model. Multicollinearity is a common problem in regression analysis and refers to the situation when two or more independent (exogenous) variables are related to each other outside of the obvious relationship in the model. In our particular model the problem of multicollinearity was especially severe. This was due to the very high degree of correlation existing between first class and coach fare and to a much lesser degree between coach and the representative discount price. There is also a relationship between distance (in the form of travel time in our model) and fares. It was assumed that the severity of multicollinearity here was of such a small extent that inclusion of fare variables together with travel time is permissible. Incidentally, the relationship arises from the fact that operating costs are directly related to length of haul and therefore the CAB determines fares—using a distance based formula. The first variation studied was a model where one of the two collinear variables in each of the four equations was dropped. In this case, we are left with the following rather simple model.

$$D_{fb} = K_{fb} \cdot I_f \cdot P_f^{\alpha_b} \cdot T^{\beta_b} \cdot BPI^{\theta_b}$$

$$D_{cb} = K_{cb} \cdot I_c \cdot P_c^{\alpha_b} \cdot T^{\beta_b} \cdot BPI^{\theta_b}$$

$$D_{cp} = K_{cp} \cdot I_c \cdot P_c^{\alpha_p} \cdot T^{\beta_p} \cdot BPI^{\theta_p}$$

$$D_{dp} = K_{dp} \cdot I_d \cdot P_d^{\alpha_p} \cdot T^{\theta_p} \cdot BPI^{\theta_p}$$

In this model, the cross elasticities have disappeared. We cannot study diversion phenomena any more. We can only determine the direct elasticities of each passenger category, business and personal. The effects of travel time and the income variable, buying power index remain the same. The results of this regression are presented in Chapter VI.

The second variation used to alleviate multicollinearity imposes less restrictions on the original model than the first variations. Here we capitalize on the fact that coach price is much less correlated to our calculated representative discount price. Therefore in this case we remove coach price from the first class (business) equation and first class price from the coach business equation. So the last two equations remain the same. The model now looks as follows:

$$D_{fb} = K_{fb} \cdot P_f^{\alpha_b} \cdot T^{\beta_b} \cdot BPI^{\theta_b}$$

$$D_{cb} = K_{cb} \cdot P_c^{\alpha_b} \cdot T^{\beta_b} \cdot BPI^{\theta_b}$$

$$D_{cp} = K_{cp} \cdot P_c^{\alpha_p} \cdot P_d^{\gamma_p} \cdot T^{\beta_b} \cdot BPI^{\theta_p}$$

$$D_{dp} = K_{dp} \cdot P_c^{\gamma_p} \cdot P_d^{\alpha_p} \cdot T^{\beta_p} \cdot BPI^{\theta_p}$$

In this scenario, diversion is allowed between coach class and discount class by personal travellers but that is all. Hence, we can estimate the cross elasticity of price for personal travellers. The results of this regression are also presented in Chapter VI.

B. Seasonality

It has already been mentioned in Chapter III, section A that the demand was adjusted for seasonality by linearizing the observed traffic for the ten quarters. The alternative measure taken was to incorporate dummy variables in the model. The model in the logarithmic form appears as follows:

$$\log D_{fb} = \log K'_{fb} + \alpha_b \log P_f + \gamma_b \log P_c + \beta_b \log T + \theta_b \log BPI$$
$$+ K_1 S_1 + K_2 S_2 + K_3 S_3$$

$$\log D_{cb} = \log K'_{cb} + \alpha_b \log P_c + \gamma_b \log P_f + \beta_b \log T + \theta_b \log BPI$$
$$+ K_1 S_1 + K_2 S_2 + K_3 S_3$$

$$\log D_{cp} = \log K'_{cp} + \alpha_p \log P_c + \gamma_p \log P_d + \beta_p \log T + \theta_p \log BPI$$
$$+ K_1 S_1 + K_2 S_2 + K_3 S_3$$

$$\log D_{dp} = \log K'_{dp} + \alpha_p \log P_d + \gamma_p \log P_c + \beta_p \log T + \theta_p \log BPI$$
$$+ K_1 S_1 + K_2 S_2 + K_3 S_3$$

The primes on the constant terms indicate that the image variables have been included in the terms for lack of any

method to quantify the quality of service for each class.
The definitions for the dummy variables are repeated here.

$$S_1 = \begin{cases} 1 \text{ if winter} \\ 0 \text{ if not} \end{cases}$$

$$S_2 = \begin{cases} 1 \text{ if spring} \\ 0 \text{ if not} \end{cases}$$

$$S_3 = \begin{cases} 1 \text{ if summer} \\ 0 \text{ if not} \end{cases}$$

The results of using this variation are similarly explained
in the following chapter.

CHAPTER VI

RESULTS AND CONCLUSIONS

The research work out of which this thesis emerged
was largely exploratory in nature. The model suggested
in basically theoretical and is an attempt to try and ex-
plain what occurs in the airline marketplace in a mathe-
matical fashion. Like most econometric models of this kind,
it suffers from statistical problems inherent in the data and
the particular formulation of the model. The most severe
problem encountered was that of multicollinearity. This
causes the coefficient estimates to be inconsistent and
vary considerably depending on the segment of data used.
The extent of the variation is a function of the severity
of the multicollinearily which was, in this case, extremely
high.

Table 7 is an outline of the results in terms of
elasticity estimates and R^2 for the basic model (model 1).
When the data was pooled, the estimates were of the correct
order of magnitude and correct sign. The estimates for
the price elasticity for business travellers were somewhat
high, especially for those using first class service.
The estimate for coach business travellers was much more
realistic although still a bit high. For business tra-
vellers who are relatively price inelastic, an estimate of
zero to -0.5 is not unusual.

For pleasure (personal) traffic, while the coach equation gave a reasonable value of -.89 (typically -1.5), the discount equation yielded an unrealistic estimate of +1.90 which is also of counter-intuitive sign. A priori, cross-elasticities were expected to be close to zero, although not necessarily, since no previous studies have provided any estimates. Thus comparisons could not be made. The coach class equations are the only ones conforming to this expectation. Price cross-elasticities were estimated to be 0.55 and 0.71 for the business and personal coach travellers respectively. The final estimate says that a unit percentage change in first class price will cause a 0.55 per cent change in coach business traffic. For the second, the same amount of discount fare change will cause a 0.71 per cent change in coach pleasure traffic. The positive sign for these values is reasonable, since it is expected that, for example, an increase in the traffic of a given class will be caused by an increase in the cost of a related (substitutable) class of service. On the whole, the correlation coefficients using pooled data were very low as can be observed from the table. Perhaps one would question the legitimacy of pooling cross sectional with time series data. The markets vary considerably in terms of market density, length of haul, competition. A more comprehensive study would involve performing regressions of markets separated by grouping them into such market characteristics. The variability in this characteristics in responsible for the poor fit obtained using pooled data.

Cross-sectional estimates produced a significantly better fit. The only drawback here was that for most of the time periods, coefficient values turned out to be abnormally high and often of counter-intuitive sign. Cross sectional data still retains the market variability characteristics (size, length of haul, etc); however, the variation with time is lost. It is, hence, somewhat surprising that the fit turned out to be better, especially since the data had been smoothed out over the 10 periods to eliminate seasonality.

The results for the individual markets (time series data) showed significantly improved goodness of fit over both the pooled and the cross-sectional data. This was primarily due to lack of significant variability in the demand figures for an individual market over time. The correlation coefficients were on the average 0.90. Such high correlations are usually expected when dealing with time series data. Coefficients estimated for these data were very satisfactory both in magnitude and sign (most cases). However, here again, it was not possible to obtain a trend as to the relative size of price elasticities of business and personal demand. The estimates for certain markets notably Los Angeles-Memphis, Chicago-Cleveland and Denver-San Francisco, showed coefficient values quite out of the range of normal expectations.

Model 2 represents the formulation suggested to overcome multicollinearity. In this instance, no two-price terms appear in the same equations. The results are given below. The results

for the second variation suggested to combat this problem could
not be presented, since it would only make sense if the estima-
tions were simultaneous. Due to software problem with the
T.R.O.L.L. peculiar goodness of fit statistics were observed
which led to abandonment of this task. The simultaneous re-
gression facilities of the T.R.O.L.L. system are in the
experimental phase at present.

The results for the model variation to overcome seasonality
problems without smoothing the demand over time is also shown
below.

Model 2

$LNDFB = 15.23 - 0.17 \ LNBPI - 1.36 \ LNPF + 0.0 \ LNT$ $\quad R^2 = 0.02$

$LNDCB = 11.73 + 0.387 \ LNBPI - 0.52 \ LNPC + 0.0 \ LBT$ $\quad R^2 = 0.26$

$LNDCP = 10.03 + 0.81 \ LNBPI - 0.12 \ LNPC + 0.0 \ LNT$ $\quad R^2 = 0.07$

$LNDDP = 9.86 + 0.348 \ LNBPI - 0.38 \ LNPD - 0.01 \ LNT$ $\quad R^2 = 0.008$

Model 3

$LNDFB = 9.2 \ LNPF + 1.12 \ LNPC + 0.0 \ LNT + .32 \ LNBPI + .06S_1 + .05S_2 - .26S_3$ $\quad R^2 = 0.14$

$LNDCB = 0.5 + 0.47 \ LNPC - 0.78 \ LNPF + 0.1 \ LNBPI - .005S_1 - .008S_2 - .6S_3$ $\quad R^2 = .035$

$LNDCP = 10.63 - .90 \ LNPC + 0.68 \ LNPD + 0.0 \ LNT + 0.17 \ LNBPI - .06S_1 - .03S_2 + 0.5S_3$ $\quad R^2 = 0.14$

$LNDDP = -3.7 - 0.7 \ LNPD + 0.4 \ LNPC + 0.0 \ LNT - 0.09 \ LNBPI - 0.1S_1 + .035S_2 + .34S_3$ $\quad R^2 = 0.12$

As mentioned earlier, the effort in this work was mainly
to investigate the feasibility of a demand model whose nature

was of a form that had to the author's knowledge never been tried before. Severe multicollinearity problems handicap the model in the way it is presented. The remedy offhand available, that of eliminating certain of the variables, seems to have taken away the essence of what the model was intended to show. The step of taking logarithms to some extent alleviates this problem.

For future work, perhaps it would be worthwhile to investigate further into how the model could be altered in a fashion such as to combat multicollinearity and still retain the important characteristics. This would be especially feasible if more good data were available with increased sample size.

MODEL 1

	CONST	α_b	δ_b	β_b	θ_b	α_p	δ_p	β_p	θ_p	R^2
POOLED										
EQUATION 1	15.5	-3.0	1.73	0.0	-.12	—	—	—	—	.02
2	11.6	-1.1	0.55	0.0	0.39	—	—	—	—	.26
3	10.56					-.89	.71	0.0	0.18	.10
4	13.89					1.90	-3.1	0.0	0.36	.02
X-SECTIONAL 1974-1										
EQUATION 1										
2										
3	7.60				0.33	0.32	0.93	-1.7	0.36	0.33
4	2.58				0.36	1.32	1.23	-2.8	0.47	0.42
1974-2										
EQUATION 1	-3.87	17.2	-12.6	-5.8						0.68
2	0.18	-12.9	16.54	-5.1						0.73
3	7.62					-0.35	1.93	-1.9	0.0	0.32
4	19.05					6.92	4.05	-.26	0.55	0.22
1974-3										
EQUATION 1	-0.43	-0.17	4.76	-5.18	0.36					0.58
2	2.29	2.98	1.18	-5.02	0.30					0.63
3	9.44					-0.72	1.41	-1.15	0.37	0.49
4	3.90					1.04	1.37	-2.68	0.31	0.38
1974-4										
EQUATION 1	-3.76	11.27	-6.01	-6.24	0.14					0.61
2	-0.27	-6.46	16.95	-5.74	0.34					0.70

MODEL 1 (CONT'D)

	CONST	α_b	σ_b	β_1	θ_b	α_p	σ_p	β_p	θ_p	R^2
EQUATION 3	9.64	-0.26	0.48	-0.45	0.31					0.31
4	6.23	-0.04	-0.54	1.50	0.81					0.27
1975-1										
EQUATION 1	-3.99	35.57	-10.77	-42.9	-6.62					0.40
2	-4.10	-9.43	15.20	-7.13	0.24					0.69
3	7.26					1.39	0.10	-1.77	-0.02	0.10
4	1.61					0.47	2.93	-3.60	-.04	0.33
1975-2										
EQUATION 1	6.33	6.03	-6.11	0.0	0.43					0.33
2	9.47	-5.54	5.13	0.0	0.47					0.42
3	11.01	-6.97	6.99	0.0	0.27					0.33
4	10.05					12.44	-12.2	0.0	0.31	0.49
1975-3										
EQUATION 1	-9.66	23.85	-17.1	-6.6	0.06					0.61
2	-7.20	-17.50	23.21	-6.95	0.06					0.69
3	6.06					-5.01	8.12	-3.45	-.07	0.35
4	0.31					12.85	-7.37	-5.50	-.04	0.70
1975-4										
EQUATION 1	-8.68	23.9	-17.7	-5.99	0.27					0.69
2	-8.05	-20.2	25.9	-7.08	0.25					0.79
3	7.22					-8.3	11.26	-3.3	0.10	0.52
4	2.08					13.41	-8.4	-6.1	0.13	0.57

MODEL 1 (CONT'D)

	CONST	α_b	γ_b	β_b	θ_b	α_p	γ_p	β_p	θ_p	R^2
1976-1										
EQUATION 1	-10.66	30.14	-25.2	-5.78	0.38					0.64
2	-10.39	-26.3	32.1	-7.21	0.30	-6.9	9.5	-3.1	0.10	0.79
3	8.17									0.50
4	-0.53					11.3	-5.0	-6.3	-.03	0.66
1976-2										
EQUATION 1	0.39	-3.9	8.4	-4.3	0.09					0.39
2	1.28	8.9	-3.7	-5.7	0.03					0.55
3	5.44					1.79	0.47	-2.3	-0.10	0.17
4	-1.55					0.36	4.62	-4.7	-0.25	0.38
TIME SERIES										
ATL-CLE										
EQUATION 1	4.79	-5.8	7.56	-0.65	-.07					0.96
2	7.71	6.12	-3.8	-0.83	-.04					0.95
3	11.75					-1.25	-.01	-1.54	-.05	0.78
4	9.87					-.02	-1.57	1.97	-.05	0.78
ORD-CLE										
EQUATION 1	7.38	-6.69	9.18	-3.05	-.04					0.92
2	10.61	3.16	-2.27	-1.40	-.01					0.91
3	6.19					1.34	0	-0.31	-.01	0.62
4	18.43					0.52	-.73	10.4	0.27	0.72

MODEL 1 (CONT'D)

	CONST	α_b	σ_b	β_b	θ_b	α_ρ	σ_ρ	β_ρ	θ_ρ	R^2
ORD-DEN										
EQUATION 1	7.53	-1.5	2.6	-1.2	-.02					0.93
2	12.9	-2.5	1.45	0.97	.01					0.93
3	5.7					-1.2	3.02	-1.1	-.01	0.89
4	12.8					-1.8	0.70	0.66	0	0.89
ORD-DTN										
EQUATION 1	10.8	-8.9	10.9	-4.4	0.13					0.94
2	11.6	0.0	0.0	0.0	0.0					1.00
3										
4										
ORD-LAX										
EQUATION 1	-4.31	-1.1	5.2	-1.93	0.19					0.97
2	9.18	0.8	-.17	-.03	0.03					0.97
3	10.85					0.0	0.0	0.0	0.0	1.00
4	2.80					-3.2	-1.96	14.2	0.21	0.98
ORD-PHL										
EQUATION 1	9.65	0.0	0.0	0.0	0.0					1.0
2	11.0	6.0	0.0	0.0	0.0					
3	10.0	c				0.0	0.0	0.0	0.0	
4	8.75					0.0	0.0	0.0	0.0	
CLE-DEN										
EQUATION 1	9.07	13	-2.2	0.64	.01					0.92
2	5.95	3.1	-1.9	-0.89	-.01					0.92
3	2.92					1.11	1.12	-1.6	.03	0.84
4	11.68					-.68	-.63	0.92	-.01	0.84

MODEL 1 (CONT'D)

	CONST	α_b	σ_b	β_b	θ_b	α_p	σ_p	β_p	θ_p	e^2
DEN-DTW										
EQUATION 1	12.7	0.99	-2.5	0.30	0.07					0.96
2	-3.3	1.81	1.21	-.19	0.09					0.61
3	-5.5					1.77	-1.8	8.2	-1.4	0.99
4	31.3					3.21	-2.75	-14.	2.4	0.96
DEN-MKE										
EQUATION 1	6.7	0.0	0.0	0.0	0.0					1.00
2	8.8	0.0	0.0	0.0	0.0					1.00
3	-9.16					2.07	-1.0	7.5	-1.0	0.99
4	-4.3					-0.66	1.38	5.0	-0.67	0.99
DEN-SFO										
EQUATION 1	9.0	0.01	0.0	0.0	0.0					0.0
2	9.85	-0.4	0.5	0.1	0.0					0.75
3	9.60					0.0	0.0	0.0	0.0	1.00
DTW-WAS										
EQUATION 1	5.7	-2.9	5.4	-3.4	-0.2		0.0	0.0	0.0	0.94
2	10.5	0.0	0.0	0.0	0.0					
3	10.1					0.0	0.0	0.0	0.0	1.00
4	9.48					0.1	-0.4	0.05	-0.02	0.38
LAX-PDX										
EQUATION 1	4.3	-3.3	5.0	-0.75	0.05		0.0	0.0	0.0	0.92
2	11.5	-1.4	0.43	0.22	-0.01					0.72
3	9.4					0.0	0.0	0.0	0.0	
4	-153					.33	.64	6.6	2.1	0.42

MODEL 1 (CONT'D)

	CONST	α_b	σ_b %	β_b	β_a	α_P	σ_P	β_P	β_P	R^2
LAX-WAS										
EQUATION 1	4.83	-1.3	2.6	-0.57	0.03					0.93
2	11.7	-0.43	0.22	0.09	0.0					0.93
3	11.3					-0.68	0.0	0.24	-.01	0.89
4	10.83	0.01	-0.68	0.24	-0.001					0.89
ORD-HNL										
EQUATION 1	-3.2	5.6	-3.5	-0.47	0.06	-0.63	-.07	0.17	-.01	0.93
2	3.9	-2.1	3.1	-0.24	0.03	-0.14	0.06	-1.1	-.12	0.89
3	13.1									0.87
4	8.7									0.32
ORD-SFO										
EQUATION 1	5.1	-2.4	4.3	-1.4	-.02	0.16	0.55	-0.38	0.01	0.92
2	10.9	0.0	0.0	0.0	0.0	-0.67	-0.29	0.49	-.01	1.00
3	8.2									0.42
4	12.5									0.92
ORD-BOS										
EQUATION 1	8.8	-1.9	2.2	-.05	0.03	-1.3	1.28	.01	.09	0.86
2	10.98	0.56	-0.5	-.01	0.01	-1.7	1.73	-.01	-.12	0.86
3	10.73									0.69
4	8.22									0.65
LAS-ORD										
EQUATION 1	0.69	-.30	2.3	0.0	-.06		-.076		.03	0.87
2	6.84	0.90	-.12	0.0	-.02	-0.28				0.87
3	1.57	1.52	0.52	0.0	-.05			0.0		0.92
4	13.1									0.92

MODEL 1 (CONT'D)

	CONST	α_b	γ_b	β_b	θ_b	α_p	γ_p	β_p	θ_p	R^2
LAX–HNL										
EQUATION 1	6.83	-.01	0.71	-0.35	-.01					0.96
2	11.79	-.35	0.00	0.13	.01					0.96
3	13.66					-0.6	-0.1	0.32	.01	0.97
4	13.01					-0.1	-.58	0.32	.01	0.97
DEN–BOS										
EQUATION 1	7.9	0.0	0.0	0.0	0.0					
2	10.03	-.69	0.3	0.41	-.02					0.94
3	6.70					0.0	0.0	0.0	0.0	1.00
4	9.94					-.68	0.01	0.33	0.0	0.86
CLE–MIA										
EQUATION 1	5.26	-.44	1.66	-0.94	0.03					0.98
2	6.10	-.19	0.57	0.44	0.05					0.17
3										
4										
MSP–ORD										
EQUATION 1	-60	140	-180	228	-.37					0.93
2	12.1	-.43	.14	-.49	0.0					0.70
3	10.1					-.08	0.61	-.89	-.01	0.59
4	-518					135	8.7	57	-.47	0.06
LAX–DSM										
EQUATION 1	3.66	-.13	103	-.46	0.0					0.93
2	5.59	0.69	-.04	-.31	0.0					0.93
3	6.50					0.0	0.0	0.0	0.0	
4	47.0					-11.1	1.74	0.44	-.04	0.45

	CONST	α_b	σ_b	β_b	θ_b	α_p	σ_p	β_p	θ_p	R^2
JFK-SFO										
EQUATION 1	12.3	0.11	-.64	0.26	-.01					0.91
2	9.52	0.64	-.11	-0.26	.01					0.91
3	10.15	0.00				0.0	0.0	0.0	0.0	1.00
4	11.79					-.23	-.51	.54	-.01	0.95
LAX-MEM										
EQUATION 1	4.62	-1.6	2.95	-.98	-.01					0.93
2	10.86	-1.7	0.91	0.56	0.00					0.92
3	-1×10^5					1.22	0.05	6×10^4	9×10^{-4}	0.67
4	-4×10^5					-.012	-1.64	1.8×10^5	.01	-.74

REFERENCES

1. Quandt, R. E., _Some Perspectives of Gravity Models: Studies in Travel Demand_ (Vol. 1), Mathematica, Princeton, N. J.

2. Taneja, N. K., _The Commercial Airline Industry_, Heath-Lexington Books, Lexington, Ma., 1976.

3. National Bureau of Economic Research. "Troll User's Guide". Cambridge: NBER Computer Research Center, 1976.

4. Eriksen, S. E., Scalea, J. C., and Taneja, N. K. "A Methodology for Determing the Relationship Between Air Transportation Demand and the Level of Service." Cambridge: MIT. Flight Transportation Laboratory Report R76-3, 1976.

DATA SOURCES

5. Civil Aeronautics Board. _Origin Destination Survey of Airline Passenger Traffic._ Table 8.

6. _Official Airline Guide:_ Oak Brook, Ill., The Dueben H. Donnelly Corporation.

APPENDIX

The data is presented for the 24 markets in the same order as the list in Table 4. The index increases from left to right. It is arranged in sets of 24 for the ten quarters, in natural logarithm form.

1	8.6	9.84	9.65	10.58
5	10.78	9.65	6.9	7.21
9	6.7	9.	8.67	9.24
13	9.15	8.28	10.1	9.38
17	9.27	9.4	7.9	8.36
21	9.78	6.63	10.35	8.23
25	8.52	9.7	9.57	10.45
29	10.65	9.65	6.95	7.26
33	6.7	9.	8.57	9.17
37	9.09	8.22	10.	9.34
41	9.22	9.38	7.9	8.31
45	9.77	6.6	10.37	8.16
49	8.44	9.57	9.52	10.32
53	10.52	9.65	7.	7.31
57	6.7	9.	8.47	9.1
61	9.03	8.16	9.9	9.3
65	9.17	9.36	7.9	8.26
69	9.76	6.57	10.39	8.09
73	8.35	9.45	9.45	10.29
77	10.39	9.65	7.05	7.36
81	6.7	9.	8.37	9.03
85	8.97	8.1	9.8	9.26
89	9.12	9.34	7.9	8.21
93	9.75	6.54	10.41	8.02
97	8.25	9.38	9.4	10.16
101	10.26	9.65	7.1	7.41
105	6.7	9.	8.27	8.96
109	8.91	8.04	9.7	9.22
113	9.07	9.32	7.9	8.16
117	90.	6.51	10.43	7.95
121	8.15	9.2	9.35	10.03
125	10.13	9.65	7.15	7.46
129	6.7	9.	8.17	8.89
133	8.85	7.98	9.6	9.18
137	9.02	9.3	7.9	8.11
141	9.73	6.48	10.45	7.88
145	8.05	9.08	9.3	9.9
149	10.	9.65	7.2	7.51
153	6.7	9.	8.17	8.82
157	8.79	7.92	9.5	9.14
161	8.97	9.28	7.9	8.06
165	9.72	6.45	10.47	7.81
169	7.96	8.95	9.25	9.77
173	9.87	9.65	7.25	7.56
177	6.7	9.	7.97	8.75
181	8.73	7.86	9.4	9.1
185	8.92	9.26	7.9	8.01
189	9.71	6.42	10.49	7.74
193	7.86	8.84	9.2	9.64
197	9.74	9.65	7.3	7.61
201	6.7	9.	7.87	8.68
205	8.67	7.8	9.3	9.06
209	8.87	9.24	7.9	7.96
213	9.7	6.39	10.51	7.67
217	7.77	8.7	9.15	9.51
221	9.61	9.65	7.35	7.66
225	6.7	9.	7.77	8.61
229	8.61	7.74	9.2	9.02
233	8.82	9.22	7.9	7.91
237	9.69	6.36	10.53	7.6

First Class Business Demand

1.	10.2	11.4	10.8	11.6
5	11.5	11.	9.	9.2
9	8.8	10.48	10.5	10.1
13	10.98	9.43	10.9	11.12
17	10.27	10.51	9.17	8.75
21	11.66	7.57	11.45	8.8
25	10.1	11.32	10.85	11.6
29	11.48	11.	8.93	9.15
33	8.8	10.49	10.5	10.12
37	10.99	9.4	10.9	11.11
41	10.25	10.52	9.19	8.76
45	11.67	7.55	11.43	8.84
49	10.05	11.27	10.9	11.6
53	11.46	11.	8.86	9.1
57	8.8	10.5	10.5	10.14
61	11.	9.37	10.9	11.1
65	10.23	10.53	9.21	8.77
69	11.68	7.53	11.41	8.88
73	9.98	11.23	10.95	11.6
77	11.44	11.	8.79	9.05
81	8.8	10.51	10.5	10.16
85	11.01	9.34	10.9	11.09
89	10.21	10.54	9.23	8.78
93	11.69	7.51	11.39	8.92
97	9.9	11.2	11.	11.6
101	11.42	11.	8.72	9.
105	8.8	10.52	10.5	10.18
109	11.02	9.31	10.9	11.08
113	10.19	10.55	9.25	8.79
117	11.7	7.49	11.37	8.96
121	9.85	11.15	11.05	11.6
125	11.4	11.	8.65	9.25
129	8.8	10.53	10.5	10.2
133	11.03	9.28	10.9	11.07
137	10.17	10.56	9.27	8.8
141	11.71	7.47	11.35	9.
145	9.78	11.1	11.1	11.6
149	11.38	11.	8.58	9.2
153	8.8	10.54	10.5	10.22
157	11.04	9.25	10.9	11.06
161	10.15	10.57	9.29	9.35
165	11.72	7.45	11.33	9.04
169	9.7	11.05	11.15	11.6
173	11.36	11.	8.51	8.85
177	8.8	10.55	10.5	10.24
181	11.05	9.25	10.9	11.05
185	10.13	10.58	9.31	8.82
189	11.73	7.43	11.31	9.08
193	9.65	11.02	11.2	11.6
197	11.34	11.	8.44	8.8
201	8.8	10.5	10.5	10.26
205	11.06	9.19	10.9	11.04
209	10.11	10.59	9.33	8.83
213	11.74	7.41	11.29	9.12
217	9.57	10.98	11.25	11.6
221	11.32	11.	8.37	8.75
225	8.8	10.57	10.5	10.28
229	11.07	9.16	10.9	11.03
233	10.09	10.6	9.35	8.84
237	11.75	7.39	11.27	9.16

Coach Business Demand

1	9.48	10.2	11.08	10.65
5	10.85	10.	9.	9.5
9	8.52	9.6	10.1	9.4
13	8.6	10.04	10.56	10.6
17	10.75	11.38	8.7	9.53
21	10.98	8.5	10.85	8.94
25	9.52	10.2	10.98	10.55
29	10.85	10.	8.93	9.45
33	8.46	9.6	10.1	9.4
37	8.62	10.06	10.53	10.57
41	10.69	11.4	8.7	9.5
45	10.96	8.5	10.85	8.9
49	9.56	10.2	10.88	10.45
53	10.85	10.	8.86	9.4
57	8.4	9.6	10.1	9.4
61	8.64	10.08	10.5	10.54
65	10.63	11.42	8.7	9.47
69	10.94	8.5	10.85	8.86
73	9.6	10.2	10.78	10.35
77	10.85	10.	8.79	9.35
81	8.34	9.6	10.1	9.4
85	8.66	10.1	10.47	10.51
89	10.57	11.44	8.7	9.44
93	10.92	8.5	10.85	8.82
97	9.65	10.2	10.68	10.25
101	10.85	10.	8.72	9.3
105	8.28	9.6	10.1	9.4
109	8.68	10.12	10.44	10.48
113	10.51	11.46	8.7	9.41
117	10.9	8.5	10.85	8.78
121	9.7	10.2	10.58	10.15
125	10.85	10.	8.65	9.25
129	8.22	9.6	10.1	9.4
133	8.7	10.14	10.41	10.45
137	10.45	11.48	8.7	9.38
141	10.88	8.5	10.85	8.74
145	9.75	10.2	10.48	10.05
149	10.85	10.	8.58	9.2
153	8.16	9.6	10.1	9.4
157	8.72	10.16	10.38	10.42
161	10.39	11.5	8.7	9.35
165	10.86	8.5	10.85	8.7
169	9.78	10.02	10.38	9.95
173	10.85	10.	8.51	9.15
177	8.1	9.6	10.1	9.4
181	8.74	10.18	10.35	10.39
185	10.33	11.52	8.7	9.32
189	10.84	8.5	10.85	8.66
193	9.8	10.2	10.28	9.85
197	10.85	10.	8.44	9.1
201	8.04	9.6	10.1	9.4
205	8.76	10.2	10.32	10.36
209	10.27	11.54	8.7	9.29
213	10.82	8.5	10.85	8.62
217	9.85	10.2	10.18	9.75
221	10.85	10.	8.37	9.05
225	7.98	9.6	10.1	9.4
229	8.78	10.22	10.29	10.33
233	10.21	11.56	8.7	9.26
237	10.8	8.5	10.85	8.58

Coach Personal Demand

1	7.05	7.55	9.6	8.65
5	9.5	8.75	7.22	6.65
9	7.76	8.18	8.6	8.65
13	8.1	8.	9.25	8.4
17	8.52	10.73	7.6	8.
21	9.2	5.85	9.54	7.33
25	7.11	7.71	9.66	8.68
29	9.7	8.75	7.26	6.72
33	7.72	8.2	8.6	8.67
37	8.12	7.16	9.29	8.44
41	8.55	10.75	7.62	8.01
45	90.18	6.12	9.57	7.4
49	7.16	7.9	9.72	8.71
53	9.9	8.75	7.3	6.79
57	7.68	8.22	8.6	8.69
61	8.14	7.92	9.32	8.48
65	8.58	10.77	7.64	8.02
69	9.16	6.39	9.6	7.47
73	7.22	8.05	9.78	8.74
77	10.1	8.75	7.34	6.79
81	7.64	8.24	8.68	0.71
85	8.16	7.88	9.36	8.52
89	8.61	10.79	7.66	8.03
93	9.14	6.66	9.63	7.54
97	7.28	8.24	9.84	8.77
101	10.3	8.75	7.38	6.93
105	7.6	8.26	8.6	8.73
109	8.18	7.84	9.4	8.56
113	8.64	10.81	7.68	8.04
117	9.12	6.93	9.66	7.61
121	7.34	8.4	9.9	8.8
125	10.5	8.75	7.42	7.
129	7.56	8.28	8.6	8.75
133	8.2	7.84	9.44	8.6
137	8.67	10.83	7.7	8.05
141	9.1	7.2	9.69	7.68
145	7.38	8.57	9.96	8.83
149	10.7	8.75	7.46	7.07
153	7.52	8.3	8.6	8.77
157	8.22	7.76	9.48	8.64
161	8.7	10.85	7.72	8.06
165	9.08	7.47	9.72	7.75
169	7.42	8.75	10.02	8.86
173	10.9	8.75	7.5	7.14
177	7.48	8.32	8.6	8.79
181	8.24	7.72	9.52	8.68
185	8.73	10.87	7.74	8.07
189	9.06	7.74	9.75	7.82
193	7.48	8.9	10.08	8.89
197	11.1	8.75	7.54	7.21
201	7.44	8.34	8.6	8.81
205	8.26	7.68	9.56	8.72
209	8.76	10.89	7.76	8.08
213	9.04	8.01	9.78	7.89
217	7.52	9.1	10.14	8.92
221	11.3	8.75	7.58	7.28
225	7.4	8.36	8.6	8.83
229	8.28	7.64	9.6	8.76
233	8.79	10.91	7.78	8.09
237	9.02	8.28	9.81	7.96

Discount Personal Demand

1	3.8902	3.49934	4.27587	3.28161
5	4.81819	4.0274	4.51488	4.44982
9	4.27587	4.32466	3.60252	4.21399
13	5.05059	5.47884	4.81819	4.23504
17	4.68798	4.93339	4.80649	4.40689
21	3.56252	4.6543	5.10442	4.72055
25	3.93308	3.54823	4.31985	3.31997
29	4.86042	4.07525	4.56168	4.49269
33	4.31985	4.36594	3.64539	4.26158
37	5.09449	5.46455	4.86042	4.28138
41	4.73158	4.9191	4.84937	4.4522
45	3.60765	4.69983	5.14947	4.76236
49	3.91899	3.53415	4.30576	3.30589
53	4.84633	4.06117	4.5476	4.47861
57	4.30576	4.35186	3.63131	4.2475
61	5.0804	5.50596	4.84633	4.2673
65	4.46261	4.54016	4.5768	4.17492
69	3.3312	4.42145	4.87343	4.49436
73	3.9051	3.52026	4.29188	3.292
77	4.83244	4.04728	4.53371	4.46472
81	4.29188	4.33797	3.61742	4.23361
85	5.06652	5.48351	4.83244	4.25341
89	4.70361	4.93174	4.82139	4.42423
93	3.57968	4.67186	5.1215	4.73438
97	3.93223	3.54656	4.31522	3.32831
101	4.85648	4.06908	4.55638	4.48993
105	4.31522	4.35967	3.64009	4.25913
109	5.0912	5.46981	4.85648	4.27818
113	4.72672	4.91804	4.84585	4.45102
117	3.60372	4.69614	5.14813	4.76223
121	4.01338	3.61989	4.34812	3.44468
125	4.86753	4.13783	4.56435	4.51452
129	4.34812	4.38203	3.78419	4.27667
133	5.0917	5.44961	4.86753	4.31303
137	4.7362	4.89784	4.86753	4.47734
141	3.68888	4.6944	5.14361	4.77632
145	3.98706	3.59357	4.32181	3.41836
149	4.84122	4.11151	4.53803	4.4882
153	4.32181	4.35571	3.75787	4.25035
157	5.06539	5.42329	4.84122	4.28672
161	4.70988	4.87152	4.84122	4.45102
165	3.66256	4.66808	5.11729	4.75
169	3.89411	3.50062	4.22886	3.32542
173	4.74827	4.01857	4.44508	4.39525
177	4.22886	4.26276	3.66493	4.1574
181	4.97244	5.33034	4.74827	4.19377
185	4.61693	4.77858	4.74827	4.35807
189	3.56962	4.57514	5.02435	4.65705
193	3.9.962	3.55281	4.2544	3.36709
197	4.77359	4.04998	4.47248	4.42403
201	4.2544	4.28746	3.70938	4.19377
205	5.0047	5.35859	4.77359	4.22886
209	4.64576	4.77858	4.77359	4.38793
213	3.60241	4.59924	5.055	4.68476
217	4.02202	3.60081	4.35552	3.42797
221	4.86485	4.1305	4.56362	4.50753
225	4.35552	4.37766	3.78841	4.2617
229	5.09247	5.31275	4.86485	4.31749
233	4.75594	4.76594	4.86485	4.46831
237	3.66237	4.68342	5.14465	4.77088

First Class Price

1	3.64099	3.25421	4.0145	3.0029
5	4.5535	3.76504	4.25566	4.18156
9	4.0145	4.06514	3.35958	3.94736
13	4.78869	5.07787	4.5535	3.96115
17	4.43287	4.51488	4.54589	4.14803
21	3.30828	4.38919	4.84118	4.46649
25	3.68176	3.294	4.06313	3.05761
29	4.59805	3.81529	4.3008	4.22076
33	4.06313	4.11076	3.39408	3.98714
37	4.83256	5.06358	4.59805	4.00022
41	4.47669	4.5006	4.59088	4.18901
45	3.34529	4.43553	4.88752	4.50844
49	3.66768	3.27991	4.04904	3.04352
53	4.58397	3.80121	4.28672	4.20667
57	4.09667	4.09667	3.37999	3.97306
61	4.81847	5.10616	4.58397	3.98613
65	4.46261	4.54016	4.5768	4.17492
69	3.3312	4.42145	4.87343	4.49436
73	3.65379	3.26602	4.03516	3.02963
77	4.57008	3.78732	4.27283	4.19278
81	4.03516	4.08278	3.36611	3.95917
85	4.80459	5.07517	4.57008	3.97224
89	4.44872	4.51124	4.56291	4.16104
93	3.31732	4.40756	4.85954	4.48047
97	3.67518	3.30362	4.05739	3.04872
101	4.59834	3.81943	4.29687	4.21991
105	4.05739	4.10337	3.39893	3.98419
109	4.82967	5.06147	4.59834	3.99676
113	4.47455	4.49754	4.59147	4.18945
117	3.35241	4.43502	4.8826	4.50509
121	3.68888	3.30811	4.01338	3.12089
125	4.52179	3.81404	4.22926	4.1795
129	4.01338	4.04888	3.46574	3.95124
133	4.74783	5.04127	4.52179	3.97656
137	4.39856	4.46973	4.52179	4.13783
141	3.37872	4.35671	4.79854	4.43872
145	3.66256	3.28179	3.98706	3.09458
149	4.49547	3.78773	4.20295	4.15318
153	3.98706	4.02256	3.43942	3.92493
157	4.72151	5.02354	4.49547	3.95024
161	4.37224	4.44341	4.49547	4.11151
165	3.35241	4.33039	4.77222	4.4124
169	3.56962	3.18884	3.89411	3.00163
173	4.40252	3.69478	4.11	4.06024
177	3.89411	3.92962	3.34647	3.83198
181	4.62856	4.92201	4.40252	3.8573
185	4.27929	4.35047	4.40252	4.01857
189	3.25946	4.23745	4.67928	4.31946
193	3.60241	3.23647	3.91792	3.05879
197	4.7311	3.72377	4.13871	4.09039
201	3.91792	3.95261	3.38729	3.86972
205	4.66266	4.9806	4.4311	3.89411
209	4.31155	4.35047	4.4311	4.04998
213	3.28193	4.26276	4.71171	4.35047
217	3.63206	3.24187	3.94631	3.06859
221	4.44811	3.74813	4.15816	4.10207
225	3.94631	3.96854	3.40892	3.87652
229	4.67261	4.90871	4.44811	3.91202
233	4.32521	4.34048	4.44811	4.06285
237	3.30782	4.27796	4.72553	4.36295

Coach Price

1	3.35958	2.88957	3.89658	2.56107
5	3.60379	3.3554	3.89753	4.08954
9	3.60252	3.62386	2.97391	3.79244
13	4.58335	4.86447	4.32796	3.64569
17	4.30348	4.41193	4.33767	3.65968
21	3.04372	3.69605	4.35488	-7.237005E+75
25	3.39408	3.02371	3.89332	-7.237005E+75
29	4.45587	3.54312	4.00022	4.03844
33	-7.237005E+75	3.8308	3.16796	3.87959
37	4.62969	4.90314	4.4434	3.71685
41	4.45632	4.45915	3.60765	-7.237005E+75
45	3.16796	4.18001	4.6966	4.39261
49	-7.237005E+75	-7.237005E+75	3.88993	2.04022
53	4.42982	3.51353	3.98613	-7.237005E+75
57	-7.237005E+75	3.81671	2.88492	3.85021
61	3.60884	4.96254	4.29629	3.70277
65	-7.237005E+75	4.47976	4.28672	-7.237005E+75
69	3.07631	4.13096	4.58397	-7.237005E+75
73	-7.237005E+75	1.69645	3.8764	-7.237005E+75
77	4.40991	3.49964	-7.237005E+75	3.9051
81	-7.237005E+75	3.80282	3.09417	3.84794
85	4.51124	4.85087	4.2824	3.68838
89	4.16104	4.42835	4.27283	-7.237005E+75
93	3.06242	4.11707	4.57008	4.19278
97	1.60717	2.0351	3.87742	-7.237005E+75
101	4.3712	3.52676	3.99676	3.93223
105	3.75787	3.83424	3.11125	3.82538
109	4.54921	5.00836	4.30608	3.70908
113	-7.237005E+75	4.40922	4.29687	-7.237005E+75
117	3.08047	-7.237005E+75	4.59834	4.21991
121	3.4012	-7.237005E+75	3.77839	-7.237005E+75
125	4.28997	3.52636	3.97656	3.92527
129	3.74295	3.77849	-7.237005E+75	3.75926
133	4.4881	4.75932	4.26121	3.68888
137	4.14841	4.39985	4.26736	3.85721
141	3.09104	4.09938	4.54329	4.16408
145	3.37488	3.0022	3.79533	-7.237005E+75
149	4.26291	3.50493	3.94756	3.92919
153	3.72554	3.77291	3.15174	3.75027
157	4.45887	4.78315	4.23561	3.68996
161	4.12209	4.38134	4.23542	-7.237005E+75
165	3.06472	4.07908	4.51235	4.14676
169	3.28193	2.90926	3.64966	2.69415
173	4.15976	3.43035	3.81908	-7.237005E+75
177	3.60241	3.67996	3.05879	3.62368
181	4.34281	4.7223	4.11966	3.56962
185	3.99607	4.28775	4.11966	-7.237005E+75
189	2.97178	3.95261	4.39525	4.02915
193	3.28193	2.88971	3.63131	-7.237005E+75
197	4.11461	3.39299	-7.237005E+75	3.73795
201	-7.237005E+75	3.62984	3.07258	3.60563
205	4.31155	4.7563	4.09237	3.58942
209	3.96391	4.27645	4.11726	3.83198
213	2.94101	3.92816	-7.237005E+75	4.02183
217	3.29316	2.89626	3.67718	2.71577
221	4.1652	3.40993	3.81904	3.79278
225	3.60081	2.09673	3.08998	3.65458
229	4.32905	4.75733	4.10906	3.56385
233	3.99027	4.26721	3.73181	2.95418
237	3.65036	4.29912	4.06285	2.75104

Representative Discount Price

1	1.53	1.056	1.52	0.92
5	1.96	1.45	2.08	1.98
9	1.77	1.81	1.21	1.54
13	2.28	2.8	2.04	1.54
17	1.97	2.25	2.17	1.95
21	0.96	2.11	2.31	2.07
25	1.70056	1.17372	1.69046	1.02173
29	2.17895	1.61263	2.31184	2.19567
33	1.96473	2.01036	1.34391	1.71488
37	2.53766	3.10995	2.2712	1.70838
41	2.19377	2.50275	2.41502	2.16344
45	1.06747	2.35128	2.56403	2.30258
49	1.70056	1.17372	1.69046	1.02173
53	2.17895	1.61263	2.31184	2.19567
57	1.96473	2.01036	1.34391	1.71488
61	2.53766	3.10995	2.2712	1.70838
65	2.19377	2.50275	2.41502	2.16344
69	1.06747	2.35128	2.56403	2.30258
73	1.70056	1.17372	1.69046	1.02173
77	2.17895	1.61263	2.31184	2.19567
81	1.96473	2.01036	1.34391	1.71488
85	2.53766	3.10995	2.2712	1.70838
89	2.19377	2.50275	2.41502	2.16344
93	1.06747	2.35128	2.56403	2.30258
97	1.70056	1.17372	1.69046	1.02173
101	2.17895	1.61263	2.31184	2.19567
105	1.96473	2.01036	1.34391	1.70838
109	2.53766	3.10995	2.2712	1.708
113	2.19377	2.50275	2.41502	2.16344
117	1.06747	2.35128	2.56403	2.30258
121	1.70056	1.17372	1.69046	1.02173
125	2.17895	1.61263	2.31184	2.19567
129	1.96473	2.01036	1.34391	1.71488
133	2.53766	3.10995	2.2712	1.
137	708.	2.50275	2.41502	2.16344
141	1.06747	2.35128	2.56403	2.30258
145	1.70056	1.17372	1.69046	1.02173
149	2.17895	1.61263	2.31184	2.19567
153	1.96473	2.01036	1.34391	1.71488
157	2.53766	3.10995	2.2712	1.708
161	2.19377	2.50275	2.41502	2.16344
165	1.06747	2.35128	2.56403	2.30258
169	1.70056	1.17372	1.69046	1.02173
173	2.17895	1.61263	2.31184	2.19567
177	1.96473	2.01036	1.34391	1.71488
181	2.53766	3.10995	2.2712	1.708
185	2.19377	2.50275	2.41502	2.16344
189	1.06747	2.35128	2.56403	2.30258
193	1.70056	1.17372	1.69046	1.02173
197	2.17895	1.61263	2.31184	2.19567
201	1.96473	2.01036	1.34391	1.71488
205	2.53766	3.10995	2.2712	1.708
209	2.19377	2.50275	2.41502	2.16344
213	1.06747	2.35128	2.56403	2.30258
217	1.70056	1.17372	1.69046	1.02173
221	2.17895	1.61263	2.31184	2.19567
225	1.96473	2.01036	1.34391	1.71488
229	2.53766	3.10995	2.2712	1.708
233	2.19377	2.50275	2.41502	2.16344
237	1.06747	2.35128	2.56403	2.30258

Travel Time

1	0.893404	2.19004	1.35459	2.49211
5	3.19475	2.78084	0.577063	0.879125
9	-0.129898	0.918612	1.61357	1.53351
13	2.31621	1.06827	2.53159	2.62724
17	-0.143309	1.29545	1.06749	1.16508
21	1.8229	0.050234	3.29094	1.39447
25	2.41722	0.893404	1.35459	2.49211
29	3.19475	2.78084	1.35459	1.71458
33	-0.129898	0.918612	0.476047	0.830869
37	2.31621	1.29545	2.53159	2.62724
41	2.96757	-2.04261	2.92766	0.329618
45	2.19004	-1.32162	2.75877	1.92664
49	2.41722	2.41722	0.057945	2.49211
53	3.19475	2.78084	1.35459	2.49211
57	0.705561	0.918612	0.476047	-0.306651
61	1.61357	1.29545	2.75877	2.62724
65	2.96757	1.06827	-0.410401	2.16978
69	1.35459	-0.95447	1.38692	1.39447
73	2.94939	2.41722	1.58177	1.19547
77	3.19475	2.78084	1.35459	2.49211
81	1.48308	1.75407	0.476047	-0.306651
85	0.476047	0.592807	2.75877	2.85442
89	2.96757	1.06827	2.70047	-1.16828
93	3.19475	-1.78993	1.75407	0.022618
97	2.41722	2.94939	1.58177	2.71929
101	1.89811	2.78084	1.35459	2.49211
105	1.48308	2.53159	1.31151	-0.306651
109	0.476047	-0.544713	2.05613	2.85442
113	3.19475	1.06827	2.70047	1.9426
117	-0.143309	0.050234	0.918612	0.389768
121	1.04537	2.41722	2.11393	2.71929
125	3.42193	1.48419	1.35459	2.49211
129	1.48308	2.53159	2.08903	0.528807
133	0.476047	-0.544713	0.918612	2.15178
137	3.19475	1.29545	2.70047	1.9426
141	2.96757	-3.29782	2.75877	-0.445691
145	1.41252	1.04537	1.58177	3.25145
149	3.42193	3.00802	0.057945	2.49211
153	1.48308	2.53159	2.08903	1.30633
157	1.31151	-0.544713	0.918612	1.01426
161	2.49211	1.29545	2.92766	1.9426
165	2.96757	-0.176947	-0.579283	1.39447
169	0.577063	1.41252	0.209913	2.71929
173	3.9541	3.00802	1.58177	1.19547
177	1.48308	2.53159	2.08903	1.30633
181	2.08903	0.290745	0.918612	1.01426
185	1.35459	0.592807	2.92766	2.16978
189	2.96757	-0.176947	2.53159	-1.94359
193	2.41722	0.577063	0.577063	1.34743
197	3.42193	3.54018	1.58177	2.71929
201	0.186443	2.53159	2.08903	1.30633
205	2.08903	1.06827	1.75407	1.01426
209	1.35459	-0.544713	2.22501	2.16978
213	3.19475	-0.176947	2.53159	1.16729
217	-0.920832	2.41722	-0.258396	1.71458
221	2.05008	3.00802	2.11393	2.71929
225	1.71026	1.23495	2.08903	1.30633
229	2.08903	1.06827	2.53159	1.84972
233	1.35459	-0.544713	1.08749	1.46714
237	3.19475	0.050234	2.53159	1.16729

Buying Power Index

1	1.39	1.39	1.39	1.39
5	1.39	1.39	1.39	1.39
9	1.39	1.39	1.39	1.39
13	1.39	1.39	1.39	1.39
17	1.39	1.39	1.39	1.39
21	1.39	1.39	1.39	1.39
25	1.41	1.41	1.41	1.41
29	1.41	1.41	1.41	1.41
33	1.41	1.41	1.41	1.41
37	1.41	1.41	1.41	1.41
41	1.41	1.41	1.41	1.41
45	1.41	1.41	1.41	1.41
49	1.43	1.43	1.43	1.43
53	1.43	1.43	1.43	1.43
57	1.43	1.43	1.43	1.43
61	1.43	1.43	1.43	1.43
65	1.43	1.43	1.43	1.43
69	1.43	1.43	1.43	1.43
73	1.45	1.45	1.45	1.45
77	1.45	1.45	1.45	1.45
81	1.45	1.45	1.45	1.45
85	1.45	1.45	1.45	1.45
89	1.45	1.45	1.45	1.45
93	1.45	1.45	1.45	1.45
97	1.47	1.47	1.47	1.47
101	1.47	1.47	1.47	1.47
105	1.47	1.47	1.47	1.47
109	1.47	1.47	1.47	1.47
113	1.47	1.47	1.47	1.47
117	1.47	1.47	1.47	1.47
121	1.5	1.5	1.5	1.5
125	1.5	1.5	1.5	1.5
129	1.5	1.5	1.5	1.5
133	1.5	1.5	1.5	1.5
137	1.5	1.5	1.5	1.5
141	1.5	1.5	1.5	1.5
145	1.54	1.54	1.54	1.54
149	1.54	1.54	1.54	1.54
153	1.54	1.54	1.54	1.54
157	1.54	1.54	1.54	1.54
161	1.54	1.54	1.54	1.54
165	1.54	1.54	1.54	1.54
169	1.69	1.69	1.69	1.69
173	1.69	1.69	1.69	1.69
177	1.69	1.69	1.69	1.69
181	1.69	1.69	1.69	1.69
185	1.69	1.69	1.69	1.69
189	1.69	1.69	1.69	1.69
193	1.69	1.69	1.69	1.69
197	1.69	1.69	1.69	1.69
201	1.69	1.69	1.69	1.69
205	1.69	1.69	1.69	1.69
209	1.69	1.69	1.69	1.69
213	1.69	1.69	1.69	1.69
217	1.72	1.72	1.72	1.72
221	1.72	1.72	1.72	1.72
225	1.72	1.72	1.72	1.72
229	1.72	1.72	1.72	1.72
233	1.72	1.72	1.72	1.72
237	1.72	1.72	1.72	1.72

Consumer Price Index