A METHODOLOGY FOR DETERMINING THE RELATIONSHIP BETWEEN AIR TRANSPORTATION DEMAND AND THE LEVEL OF SERVICE

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PREFACE

This report represents the results of an exploratory research study investigating the development of a methodology for determining the relationship between the supply of and the demand for air transportation services. Based upon the initial results of this exploratory research, an attempt will now be made to develop more sophisticated models to first analyze the impact of changing technology on the demand for air transportation and second to forecast the fleet requirements for the U.S. air transportation industry in the next fifteen years.

Both the exploratory research during the past year, as well as the follow on research during this year, is supported by the Ames Research Center of the National Aeronautics and Space Administration and is conducted at the Flight Transportation Laboratory at M.I.T.

During the entire research project, valuable help was received from Professor Robert W. Simpson and Dr. James T. Kneafsey at M.I.T. Appreciation is also extended to Louis J. Williams and Mark H. Waters of the Ames Research Center for their valuable comments on the draft version of this report. Although these individuals provided helpful comments, responsibility for the contents of this report rests with the authors.

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1. INTRODUCTION

Within the last ten years significant advances in the state-of-the art in air travel demand analysis stimulated researchers in the domestic air transportation field. Among these advances, researchers in academia, industry, and government have investigated the relationship between observed demand and general level of economic activity such as GNP on the one hand and general passenger-perceived characteristics such as fare on the other hand. Advanced econometric techniques have been used to develop these relationships. However, to date very little effort has been devoted to investigating the impact of a change in the supply of air transportation service on the demand for air transportation. Thus, for all practical purposes, there are no analytical economic models which show the complex interrelationship between the supply of and the demand for air transportation. This research report is an attempt to begin to understand these complex interrelationships.

During the sixties the demand for air transportation services experienced substantial growth rates due to the fact that fares (in constant dollars) were continually declining (because of increasing productivity of transport aircraft) and partly due to the fact that the level of service offered was continuously increasing, again the result of improvements in technology. However, at the beginning of the current decade the growth in the demand for air transportation services began to exhibit radical and unforseen changes. These changes were caused by a reversal of the impact of the two factors mentioned earlier, namely that the fares were now increasing (due to rapidly increasing costs, particularly with respect to the price of fuel) and the level of service was decreasing, particularly evidenced by fewer total flights and fewer direct flights.

The demand models developed in the sixties were adequate to caution airline managers on the impact of changes in the general state of the economy and changes in fare level. However, since these models did not adequately incorporate the factors relating to the supply of air transportation services, very few analysts were able to predict the impact of a change in the level of service. As a result, the industry was quite surprised to observe suppressed traffic growth rates when the level of service offered was changed as a result of a general recession in the economy and shortage of fuel. Due to the deterioration in the financial position, the carriers began to cut costs by reducing further the level of service offered. However, instead of improving the profitability of the carriers, this strategy further suppressed traffic and hence revenue, resulting in even lower profits.

On the basis of evidence from the above discussion, there is now a critical need for the development of economic models that simultaneously incorporate the factors effecting both the demand and the supply of air transportation services. In order to begin to fulfill this need, the Aeronautical Systems Office of Ames Research Center at NASA funded a research project to investigate how the supply related variables (particularly those related directly to technology) contribute to the determination of the demand for air transportation. The research was divided into two parts. The first part, mostly exploratory in nature, was designed to determine whether sophisticated economic models incorporating supply and demand factors can be developed given the state-of-the-art in econometric modeling and the limitations of the existing data. During this phase the thrust of the research effort was first to analyze the existing data, second to analyze the components of the levels of service and third to develop simple models which serve merely to generate avenues of pursuit for further research in the second phase. This report presents the results of the initial exploratory phase of the research project and contains directions for research in the second phase to be carried out in 1976.

During the first phase, research efforts were directed at investigating single equation models incorporating a level of service index in addition to the usual fare and socioeconomic terms. The models were calibrated using data from fifty-eight region pairs over a sixteen year period. The level of service index developed in this report represents an improvement over the one incorporated in past models (namely flight frequency). The new level of service index is a nondimensional generalized trip time scaled from zero to one, which takes into account not only the number of flights, but also number of intermediate stops, direct or connecting service, speed of aircraft and most important, the matching of the departure schedules to time variability of demand. Based upon the preliminary results, it appears that the level of service is a more appropriate explanatory variable in the demand model than just frequency.

The significant results of the demand models developed in this exploratory stage of the research will be discussed in the following sections of this report. Section 2 describes the reasons for calibrating the models based upon region pair data rather than city pair data. Section 3 differentiates between the supply and demand components of air travel and elaborates upon the development of the level of service index. Section 4 discusses the sampling procedures used in determining the region pairs. Section 5 contains the specification of the single equation models and presents the empirical results. The final section of this report outlines the plans for future research in Phase II of this project.

2. 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 criteria 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 2.1 by minimizing the routine commuting done across region boundaries; that is, labor supply and demand were located in the same region.[1] 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. Since other geographical delineations considered were not based upon transportation criteria, the regions in Figure 2 were adopted for this investigation.

The implications of using regions instead of cities as demand sources is shown below. First, all air carrier airports within a region are located using Figure 2.1. 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

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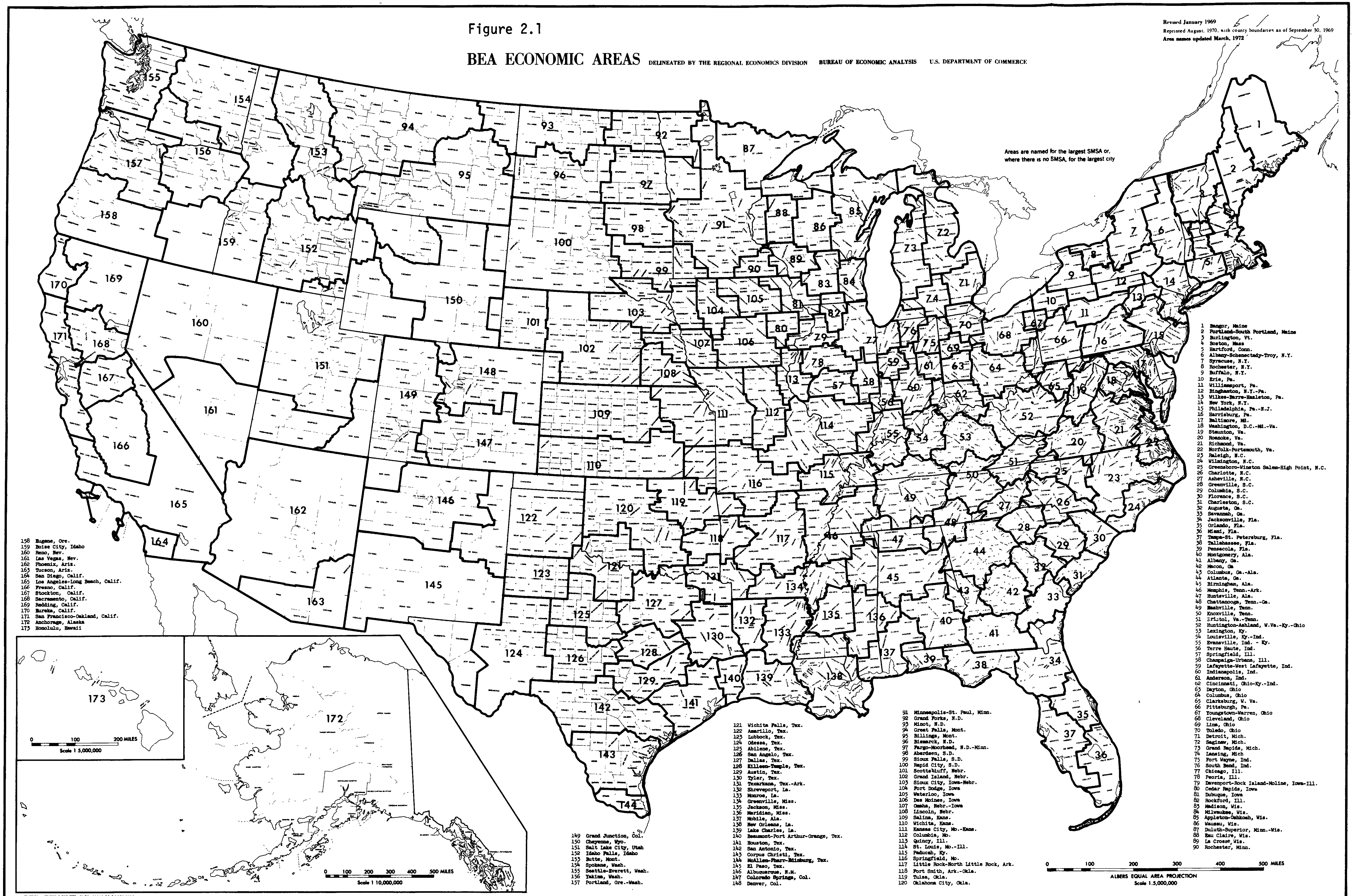
[1] U.S. Department of Commerce, Obers Projections, Vol. 1. Washington, D.C.; U.S. Water Resources Council, 1972, pp. 24-25

Figure 2.1



Boundaries of counties and county equivalents as of September 30 1969

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	Detroit Metro-Akron	Detroit City-Akron
Flint-Mansfield	Detroit Metro-Mansfield	Detroit City-Mansfield
Flint-Cleveland Hopkins	Detroit Metro-Cleveland Hopkins	Detroit city-Cleveland Hopkins
Flint-Cleveland Burke	Detroit Metro-Cleveland Burke	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. A list of all airports in all regions considered in this research is found in Appendix A.

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 subject to some modifications explained in subsequent sections of this report.

3. FACTORS EFFECTING THE SUPPLY AND DEMAND OF AIR TRANSPORTATION SERVICES

The objective of the modeling phase of this research is to relate the level of air transportation activity, measured by the number of origin to destination passengers carried in a number of specified markets, to a set of logically relevant economic, demographic, and scheduling variables. The variables used in the models have, for convenience of presentation, been separated into three classifications. The dependent variable is a measure of the number of origin to destination passengers for a given year in a given market. The supply related explanatory variables are scheduling and technology related characteristics such as number of flights offered, speed of aircraft, number of intermediate stops and connections, and the times of day when flights are offered. The demand related explanatory variables are measures of fare and of regional economics and demographics such as population, income and retail sales.

Data sources for the selected model variables are consistent as far back as 1959. Prior to that time the Civil Aeronautics Board Origin-Destination surveys were semi-annual and based upon demand in March and September rather than being aggregated over an entire quarter or year. So, for reasons of data compatibility, the time span of the modeling phase of this research has been selected to be the sixteen years between 1959 and 1974 inclusive.

A description of the data collection for this research is found in Appendix B. Documentation of the computer programs to compile this data into usable format for the modeling is contained in Appendix C.

3.1 The Dependent Variable

The Civil Aeronautics Board Origin-Destination survey is a compilation of data obtained by a ten percent systematic sampling of flight coupons issued on domestic routes. Each ticket bearing a serial number with the last digit of zero is submitted to the sample. The end product of this procedure is a set of frequency distributions, published by quarter and by year, depicting the sample number of origin to destination passengers flown between every domestic airport pair by a certified carrier. Since these figures are the most accurate available estimates of number of passengers flown between the selected regions, they were selected to be the dependent or demand variable and will serve as the measure of inter-regional air transportation activity.

3.2 Supply Related Explanatory Variables

3.2.1 Number of Daily Flights

An important performance measure to be included in the demand modeling of air transportation within a given region pair market is the availability of flights. Many existing models consider the number of flights (or number of seats) offered per day as an indication of availability. For several reasons, which are elaborated upon in Section 3.2.2, it is believed that using merely the number of daily flights as a measure of supply is insufficient, so a more comprehensive measure, LOS (Level of Service), is developed. To investigate the statistical improvement realized by the development of LOS, an analysis of two models, identical except that one uses number of flights (NFLT) and the other uses LOS as the supply variable, was undertaken.

More specifically, NFLT is defined as the product of number of flights offered in each direction of a region pair. It was felt that the product was more appropriate than the sum as the former more accurately measures the effect of a substantial imbalance in number of flights offered in the two directions. It seems intuitively logical, for instance, that a region pair with three flights daily in both directions is better served than a similar region pair with one flight daily in one direction and five in the other. The use of the sum of flights as a proxy for service would not measure this imbalance (the sum is six in both cases), whereas the product (nine in the former case and five in the latter) does differentiate between the two cases.

3.2.2 Level of Service

As mentioned in Section 3.2.1 above, many existing demand models use the number of daily flights as a measure of level of service. What these models do not consider is the time of day when these flights depart. Time of day not only relates to the needs of the passengers (the consumer value of a departure at 2:00 A.M. may be quite different from that of a departure at 5:30 P.M.), but also to the relationship between the number of flights and capacity per flight. (Are three 120-seat aircraft departures at the same time really, in practical terms, three separate consumer alternatives or the equivalent of one departure of a 360-seat aircraft?)

An additional performance measure frequently overlooked in demand modeling is type of service offered in a region pair. If one market is served by three one-stop flights per day while a similar market is served by two non-stop flights, which market is provided with the better service? This quality of service measure, if considered at all, is found to be quite difficult to quantify. A Civil Aeronautics Board staff study [2] attempted to address this problem by assigning weights to the different types of service. The study concluded that a two-stop flight is equivalent in consumer value to 0.40 non-stop flights, a one-stop flight is equivalent to 0.55 non-stop flights, etc. This approach is, however, unreasonable because the weightings are assumed to be independent of stage length. One intermediate stop may nearly double the block time of a short haul flight, whereas one stop may increase the block time of a transcontinental flight by merely fifteen to twenty percent. Thus, the proportionality of the penalty paid by intermediate stops decreases as the stage length increases.

One major objective in this research is to develop a framework from which numerical indices may be structured to address the above mentioned issues. Basically, a level of service measure, LOS, is developed which is a function of these issues. The index is a dimensionless number scaled from zero to one representing the ratio of non-stop jet flight time to the average total passenger trip time. The total trip time is the sum of the actual flight block time (including stops and connections) and the amount of waiting time for the passenger at the beginning of his trip due to schedule inconvenience.

If "perfect" service were offered in a given region pair (a non-stop jet departing at every instant of the day), there would be no such waiting period. The total trip time would be merely the non-stop jet flight time, and the ratio (level of service measure) would be unity. If poor service were offered (few flights, multistops, connections, slower aircraft, etc.), not only would block time be substantially greater than non-stop jet flight time, but many passengers would be forced to fly at inconvenient times. This inconvenience would be accounted for by the inclusion of significant "displacement" times, and the resulting level of service ratio, LOS, would be small.

The computation of LOS for this research involves the incorporation of some rather restricting assumptions. Additional research must be conducted to consider the more general and realistic situations in which these assumptions are eliminated.

The first assumption, perhaps the most limiting, is that demand for air transportation service is uniform over the day from some specified start of the day, perhaps 6:00 A.M., to some specified end of the day, perhaps 12:00 midnight. This time of day distribution of demand is, of course, rarely observed. For example, the daily demand for air transportation in short and medium haul business markets is typically bimodal. There is a peak period between 8:00 and 10:00 A.M. and another between 5:00 and 7:00 P.M. Other markets may observe quite different time of day demand variations. In transcontinental west to east coast markets there actually is a lull in what one would normally expect to be a rush hour in the late afternoon. This is caused by the fact that few people would chose to arrive at the destination (east coast) at two or three o'clock in the morning. The demand, however, picks up considerably around midnight for the night flights ("Red Eyes") which arrive on the east coast between eight and ten o'clock the next morning. Unfortunately, little data describing when passengers wish to fly in a given market is available. Therefore, the uniform distribution, which is mathematically the easiest to employ, was selected.

A second assumption is that of unlimited seat capacity on all flights. Any person who wishes to board a particular flight will not by this assumption, be prevented from doing so due to full booking. Since no convenient data describing the flight selection process of rejected passengers is available, this assumption was necessitated during this phase of the research.

An additional assumption is that "displacement" time, the inconvenience time during which a passenger must wait for a flight departing at a different time from his preferred departure time, is of equal disutility to time in flight (block time).

The determination of the average total passenger trip time is based upon the assumed behavioral pattern that over the day generic passengers randomly arrive at the origin airport and that each boards the next scheduled flight to his or her destination. This behavioral pattern is similar to what is observed in an urban subway or bus system. The passenger's total trip time is then the sum of the block time of his particular flight and the difference between the time when he arrived at the airport and the departure time.

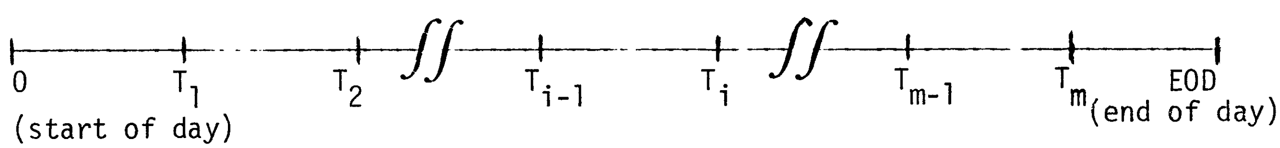
This exact pattern is, of course, rarely observed, except perhaps in some short haul high density markets with shuttle service. Virtually everyone who flies is aware of the schedule and plans his arrival at the origin airport accordingly. However, this assumption is not totally unreasonable in that if a passenger wishes to fly at some given time of day and is delayed by the schedule, this waiting time, albeit not spent at the airport, is indeed lost or displaced time resulting in personal inconvenience.

Passengers who "arrive at the airport" (wish to depart) after the final departure of the day are assumed in this analysis to fly on the first departure of the following day. No additional waiting time is attached for the delay incurred between the specified end of the day and the start of the (next) day.

The description of the computation of LOS is aided by referring to Figure 3.1, a schematic representation of time over one day.

Figure 3.1

Time Axis Representation of m Daily Departures



The following notation is defined:

m = number of daily flights
i = index of flights $\quad$ i = 1, 2, ... , m
T_i = departure time of flight i
A_i = arrival time (origin time zone) of flight i
EOD = prescribed end of day

To limit the algebraic complexity in the formulas, time has been standardized in that all T_i and A_i values and EOD are expressed in terms of number of hours after the prescribed start of the day. For instance, if the start of the day were chosen to be 6:00 A.M., the first flight departed at 9:30 A.M. and arrived at 11:45 A.M., and the end of day were set at 12:00 midnight, then T_1 would be 3.50 (hours after start of day), A_1 would be 5.75, and EOD would be 18.00.

Consider those passengers who will board flight i, where i is not equal to one. Since they will "arrive at the airport" uniformly between times T_{i-1} and T_i, their average waiting (displacement) time will be $1/2(T_i - T_{i-1})$. Their flight block time, including stops and connections, will be $A_i - T_i$. Their total trip time is then the sum of these. Since arrivals are uniform over the day, the proportion of total daily passengers boarding flight i is $(T_i - T_{i-1})/EOD$. Hence, their contribution to the average total passenger trip time, t_i, is:

$$t_i = \frac{T_i - T_{i-1}}{EOD} \left[1/2(T_i - T_{i-1}) + A_i - T_i \right] \qquad (3.1)$$

Now consider those passengers who will board the first flight of the day. These consumers are comprised of the passengers who desire to fly early in the day and those who "arrived at the airport" between Tm and EOD on the prior day. Their average waiting time is $1/2 \left[T_i + (EOD - T_m) \right]$ and their flight block time is $A_i - T_i$. Since these passengers comprise the proportion $\left[A_i + (EOD - T_m) \right] / EOD$ of the total daily demand, their contribution to the average total passenger trip time, t_i, is:

$$t_i = \frac{T_1 + (EOD - T_m)}{EOD} \left\{ 1/2 \left[T_1 + (EOD - T_m) \right] + A_1 - T_1 \right\} \qquad (3.2)$$

Summing the right hand side of equation (3.2) and the summation of the right hand side of equation (3.1) over all flights from two to n yields the average total passenger trip time, $\bar{t}$.

$$\bar{t} = \frac{T_1 + (EOD - T_m)}{EOD} \left\{ 1/2 \left[T_1 + (EOD - T_m) \right] + A_1 - T_1 \right\} + \sum_{i=2}^{m} \frac{T_i - T_{i-1}}{EOD} \left[1/2 \, (T_i - T_{i-1}) + A_i - T_i \right] \qquad (3.3)$$

This equation simplifies to:

$$\bar{t} = \frac{EOD}{2} + A_1 - T_m + \frac{1}{EOD} \left[A_1 (T_1 - T_m) + \sum_{i=2}^{m} A_i (T_i - T_{i-1}) \right] \qquad (3.4)$$

The non-stop jet flight time t_{nj} is estimated by the following formula:

$$t_{nj} = 0.5 + \frac{D}{V} \qquad (3.5)$$

where D is the intercity distance and V is jet cruising ground speed which is taken to be 800 km/hr (500 mph) if the flight is east to west, 960 km/hr (600 mph) if the flight is west to east, and 880 km/hr (550 mph) otherwise.

This equation, while it yields reasonable estimates of the true non-stop jet block flight time over most ranges, tends to be somewhat inaccurate for short ranges. Future research will provide a better overall model of nonstop jet flight time applicable over all ranges.

As previously mentioned, the (one direction) level of service measure, LOS, is the ratio of the non-stop jet flight time to the average total passenger trip time.

$$LOS = \frac{t_{nj}}{\bar{t}}$$

Numerical examples of LOS calculations using hypothetical airline schedules may be found in Appendix D.

Most specifically, the level of service measure used in the modeling segment of this research is, for a given region pair, the product of the LOS indices in each direction. The reasons for selecting the product as opposed to the sum are identical for those regarding NFLT described in Section 3.2.1.

3.3 Demand Related Explanatory Variables

3.3.1 Fare Variables

The most commonly used fare variable in air transportation demand modeling is the "standard coach" fare. Since not all passengers pay this fare, particularly in markets where special discount and night fares are available, it was felt that in this research alternative structures of the fare variable may produce more appropriate measures. In most of the regression analyses an "estimated average fare" was incorporated. While it turns out that this fare structure is not an unbiased estimator of the average per passenger fare paid in a given market in a given year, it is sensitive to complex fare structures and hence was believed more appropriate than standard coach.

For one particular year, 1968, three models using different fare variables were analyzed for comparative purposes. One model uses as the fare variable the "standard" fare which in most cases is the standard coach fare, but adjustments are made for markets in which a different fare is prevalent. A second model uses the estimated average fare, and the third model uses the "actual average fare" based upon compiled statistics on the actual number of passengers who paid the various fares offered in the individual markets in that year.

In all instances during this research, the fare variables were expressed in constant dollars. This was accomplished by multiplying the current dollar fares by the consumer price index for the corresponding year.

3.3.1.1 Standard Fare

The "standard fare" for a given market in a given year is taken to be the prevailing market fare. In most cases this meant that the jet coach or prop coach fare was used. In some markets, especially during the early portion of the study period, only first class seats were available; in these cases the first class fare was used. In cases where a combination of options was available, the more prevalent fare was chosen subject to the decision rules outlined in Figure 3.2.

After the standard fares for each airport pair in a given region pair have been determined using this set of decision rules, a weighted (by number of passengers carried between these airport pairs) average of these fares is computed. This average is then accepted as the standard fare for the region pair.

Figure 3.2
Decision Rules For Determining Standard Fares

Sample Airport Pair Schedule

Departure Times	D.R.I	D.R.2	D.R.3	D.R.4	D.R.5
8:30a	F	F	AT	FY	F
11:30	F	A	AT	FY	FY
2:30p	F	F	AT	FY	FY
5:30	F	A	AT	FY	A
8:30	F	A	AT	FY	A

Hypothetical Fare Levels:

F $30 (jet first class)

A $27 (prop first class)

Y $24 (jet tourist/coach)

T $22 (prop tourist/coach)

D.R.1 All fares in the same class. FARE = F = $30.

D.R.2 Combination of classes is available between flights. Select the one which is more prevalent. FARE = A = $27.

D.R.3 Combination of classes is available within flights. For each flight reduce to one class by selecting the lowest fare offered. This assumes that given a choice, the passenger will elect to pay the lowest available fare. Then apply D.R.1. FARE = T = $22.

D.R.4 Combination of classes is available both between and within flights. Apply D.R.3 where appropriate and then D.R.2. FARE = Y = $24.

D.R.5 Same as D.R.2, but end result is a tie. In this case select the lowest of the tieing classes. FARE = Y = $24.

3.3.1.2 Estimated Average Fare

The computation of the "estimated average fare" is based upon two assumptions regarding the behavioral pattern of passengers. The first of these is that the distribution of the daily passengers on the various flights offered in a region pair is consistent with the set of assumptions incorporated in the determination of the level of service index, LOS, described in Section 3.2.2. Under this set of assumptions it was concluded that

$$\pi_i = \frac{T_i + EOD - T_m}{EOD} \qquad (3.7)$$

and

$$\pi_i = \frac{T_i - T_{i-1}}{EOD} \qquad (3.8)$$

where π_i = proportion of daily passengers in one direction of a region pair market flying on flight i.

The second assumption is that all passengers boarding any given flight will pay the lowest available published fare for that flight. Then the estimated average fare for one direction of a given region pair in a given year is a weighted (by the π_i's) average of the lowest fare offered on each flight in that direction.

On connecting flights if the lowest priced classes of service are the same for each segment, then the fare class applied to the connection is that class. If the lowest priced classes are different, then the class requiring the higher fare is applied to the connection. This is in keeping with practices of the airlines as defined by the fare quotations from the Official Airline Guide published beginning in October 1974 when fares for all connecting flights were quoted as well as for direct flights. For example, a connection with coach fare on the first segment and night coach for the second segment would be assigned the coach fare for the route.

The assumption that passengers will pay the lowest possible fare while being true for most people is naturally not true for all. Given a choice between first class and coach there will generally be a percentage of passengers who will elect to fly first class. Therefore, this estimator of the average fare is negatively biased. However, in spite of this bias the estimated average fare was determined to be superior to the commonly used standard coach fare since it is sensitive to published discount fares which may have substantial effects on the demand for air transportation service.

While fare structures are equivalent in either direction in a region pair, schedules are not necessarily equivalent. Hence the estimated average fare in one direction of a given market may be slightly different than that in the reverse direction. The FARE variable used in the regression analyses for a given market in a given year is the average of the estimated average fare in each direction multiplied by the consumer price index for that year. This variable is computed using the specially designed program, LOSFARE, documented in Appendix C.

3.3.1.2 Actual Average Fare

Since 1968 the Civil Aeronautics Board has published an addendum to its quarterly Origin-Destination survey a table which details the number of passengers carried by fare class in all domestic airport pairs. Given this information a weighted (by proportion of passengers paying each type of fare) average of fares may be computed for all region pairs. This figure is an unbiased estimator of the true average fare paid in a given market and is referred to in this analysis as the "actual average fare."

This figure is more appealing than the estimated average fare in that it is an unbiased estimator. However, its disadvantage is that the schedule for a region pair must be included in this analysis. Thus, although the computation of the estimated average fare is quite straightforward, the computation of the actual average fare requires considerably more data analysis. As will be discussed in Section 5, it appears from our somewhat limited empirical testing that the marginal benefit realized by computing the actual average fare is not sufficiently great to warrant the additional data analysis.

3.3.2 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 Sales Management magazine. This edition generally appears in the summer, and the statistics published at that time reflect the buying power for each county for the preceding calendar year.

The BPI is defined by the following relationship[2]:

$$BPI_i = 0.5\ I_i + 0.3\ R_i + 0.2\ P_i \tag{3.9}$$

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.

[2] Kotler, Philip. Marketing Management: Analysis, Planning and Control, p. 207

4. DETERMINATION OF APPROPRIATE REGION PAIRS

In Section 2 of this report the concept of "region pair" markets as opposed to the common "city pair" formulation was discussed. The set of elements selected for this study was the 173 regions delineated in 1972 by the Bureau of Economic Analysis for a number of reasons stated in that section. These regions can be coupled to form nearly 15,000 unique region pairs, and a significant part of this research was the selection of a representative sample of these for the analysis. The first stage of this task involved a matrix selection process with three factors: market density, extent of competition, and length of haul.

The market density factor was stratified into three classifications based upon the C.A.B. Origin-Destination survey of 1970. A low density market was defined as a region pair which generated an average of fewer than 50 passengers each way each day. A medium density market averaged between 50 and 200 passengers, and a high density market was a region pair with more than 200 passengers carried each way each day.

The extent of the competition factor was dichotomized into monopolistic and competitive markets. A monopolistic market was defined as a region pair in which the second most active airline carried fewer than 10% of the number of passengers than the most active airline in the region pair carried. Again 1970 was selected as the base year. For example, suppose Eastern Airlines carried 70% of the traffic between Boston and New York in 1970. For this market to be considered competitive, at least one other airline would have to have carried more than 7% of the traffic.

Length of haul was stratified into three classifications for the purpose of market selection. Short haul routes were defined as those with interregional distance of less than 480 km (300 miles). Medium haul was defined as between 480 km (300 mi) and 1770 km (1100 mi). Interregional distance was defined as the direct distance between the largest airports in each region. This stratificaiton was defined only for the purpose of market selection; in the analytical phase of this research, length of haul was redefined into five classifications as will be discussed in Section 5.

Considering the three classifications of market density, the two classes of competition, and the three classes of length of haul, 3 X 2 X 3 = 18 cross classifications result. Two regions were selected from each of these yielding an initial sample of 36 region pairs. Careful attention was paid in the selection of these markets to maintaining a fairly even geographical distribution across the nation. These 36 markets are listed in the top section of Figure 4.1.

In addition to those markets chosen by the process described above, eighteen markets were added, which during the sixties experienced a change in either the extent of competition or in level of service due to introduction or elimination of direct flights. Two markets with chronically poor level of service characterized by only connecting service during the study period, and two markets with consistently high level of service were added to increase the statistical variance of the LOS index for the econometric analysis. Finally, two region pairs which experienced significant improvements in interregional surface transportation during the time span of this study were added, bringing the total to sixty region pairs. The twenty-four region pairs in this second stage of market selection are listed in the lower half of Figure 4.1.

Two markets were deleted during the analysis. Data collection problems arose with the Honolulu-Los Angeles and Anchorage-New York region pairs, the only two involving regions not located within the Continental United States. Thus, the final number of region pairs examined was fifty-eight.

Each region pair selected represents an effort to choose those markets which best exemplify the category characteristics. Occasionally, the subset of markets in a particular category was so small that there was little choice. In a few certain instances the mileage criterion was slightly relaxed if a region pair which better exemplified those characteristics could be found in so doing. A statement of the explicit reasons behind the selection of each region pair may be found in Appendix E.

Figure 4.2 is a diagram of the location of the region pairs on a national map. This plot verifies the effort to create a fairly even geographical distribution of the markets.

Figure 4.1

List of Selected Region Pairs

Density	Competitive State	Length	Distance km	Distance mi**	Market	Distance km	Distance mi**	Market
Low	Monopoly	Short	120	75	Norfolk-Richmond	370	230	Cincinnati-Nashville
Low	Competitive	Short	90	55	Lincoln-Omaha	170	106	Bismarck-Minot
Low	Monopoly	Medium	640	397	Dallas-Jackson	1230	762	San Antonio-Tucson
Low	Competitive	Medium	740	462	Oklahoma City-St. Louis	550	342	Knoxville-Memphis
Low	Monopoly	Long	2300	1432	Omaha-San Francisco	2620	1626	Dallas-Portland, Or.
Low	Competitive	Long	3760	2339	Portland, Or-Washington	2410	1500	Las Vegas-New Orleans
Medium	Monopoly	Short	360	223	Fargo-Minneapolis	560	345	Las Vegas-Reno
Medium	Competitive	Short	410	256	Cincinnati-Pittsburgh	470	293	Dallas-Lubbock
Medium	Monopoly	Medium	1350	840	Denver-San Diego	600	373	Atlanta-Cincinnati
Medium	Competitive	Medium	840	522	Chicago-Rochester	680	425	Atlanta-New Orleans
Medium	Monopoly	Long	1960	1217	Cleveland-Denver	2790	1736	St. Louis-San Francisco
Medium	Competitive	Long	1940	1204	Houston-Washington	2320	1441	Chicago-Tucson
High	Monopoly	Short	220	139	Albany-New York	370	229	Kansas City-St. Louis
High	Competitive	Short	150	94	Cleveland-Detroit	490	303	Houston-New Orleans
High	Monopoly	Medium	970	602	Atlanta-Detroit	680	423	Chicago-Omaha
High	Competitive	Medium	1480	920	Miami-Washington	670	419	Las Vegas-San Francisco
High	Monopoly	Long	4090	2542	Los Angeles-Miami	1770	1098	Kansas City-New York
High	Competitive	Long			*	2610	1624	Denver-New York
	Connecting to Direct	Short	470	289	Lexington-Pittsburgh	460	285	Dayton-Milwaukee
		Medium	1690	1052	San Diego-Seattle	780	487	Portland, Me.-Washington
		Long			*	1940	1204	Houston-Salt Lake City
	Monopoly to Competitive	Short	220	138	Raleigh-Richmond	550	339	Dayton-St. Louis
		Medium	1160	721	Atlanta-Dallas	1000	623	Boston-Detroit
		Long	1760	1095	Detroit-Houston	1640	1020	Denver-Seattle
	Competitive to Monopoly	Short	120	74	Chicago-Milwaukee	350	215	Dayton-Pittsburgh
		Medium	590	367	Albany-Pittsburgh	1530	948	Cincinnati-Miami
	Connecting to Direct	Short	250	155	Detroit-Erie	190	117	Albany-Binghamton
	Connecting		760	475	Milwaukee-Nashville	580	362	Cleveland-Richmond
	High Level of Service		350	215	New York-Washington	1160	721	Chicago-New York
	Surface Mode Improvements		350	215	Norfolk-Philadelphia	180	113	Reno-Sacramento

*Markets deleted due to insufficient data. **Statute Miles

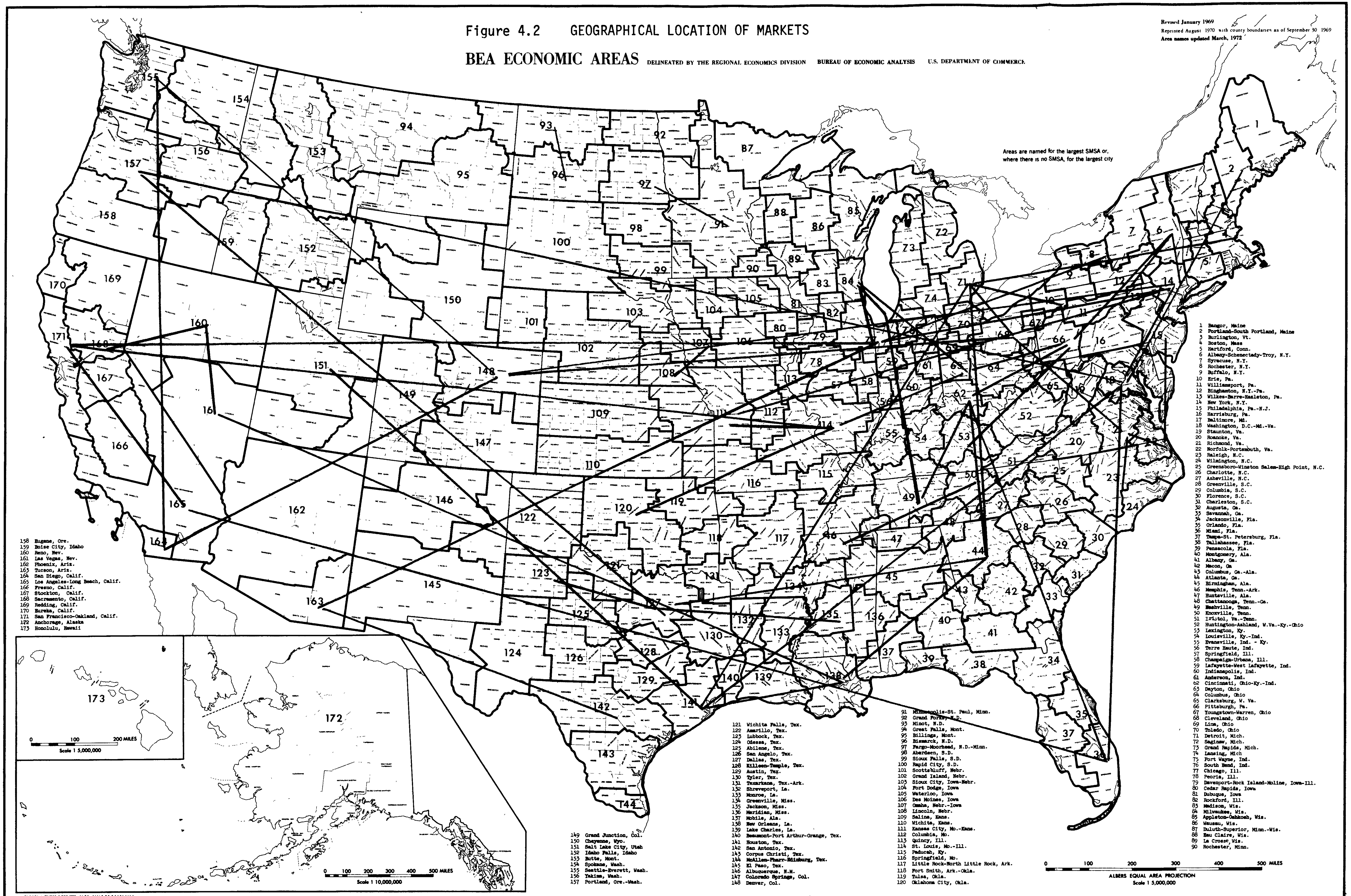


Figure 4.2 GEOGRAPHICAL LOCATION OF MARKETS

Boundaries of counties and county equivalents as of September 30, 1969

5. MODEL SPECIFICATION AND EMPIRICAL RESULTS

5.1 Model Specification

The general form of the demand models used throughout this analysis is as follows:

$$D = \beta_o FARE^{\beta_1} BPI^{\beta_2} LOS^{\beta_3} \varepsilon \qquad (5.1)$$

This is the common "log-linear" structure which can be linearized by taking logarithms to yield

$$LND = \ln\beta_o + \beta_1 LNFARE + \beta_2 LNBPI + \beta_3 LNLOS + \ln\varepsilon \qquad (5.2)$$

where the LN prefix on each variable name indicates that the variables of equation (5.2) are the natural logarithms of the corresponding variables of equation (5.1). For a comprehensive description of each variable refer to Section 3 above.

The coefficients of the variables of equation (5.2) are estimated using the ordinary least squares regression technique. Given these estimates, the expected value of the dependent variable LND can be determined by any set of independent variables by substitution into the following equation:

$$\widehat{LND} = b_0 + b_1 LNFARE + b_2 LNBPI + b_3 LNLOS \qquad (5.3)$$

where $\widehat{LND}$ is the conditional expected value of the natural logarithm of demand, and the b_i values are the estimates of the coefficients obtained by the regression analysis. For a more general and complete description of demand modeling refer to Appendix F.

Several reasons provoked the selection of the log-linear specification. Primarily this structure was chosen because it is by far the most commonly used in previous research. Since much of this current work is comparative with past results, it was felt that these comparisons would be facilitated if the specifications are similar. Secondly, the β_i coefficients in a log-linear form are estimates of the elasticities of explanatory variables which are valuable numbers for analytic purposes. In addition, the log-linear structure is simple to solve relative to many other forms, for instance an intrinsically non-linear form (see Appendix F). Since it was felt that the log-linear specification relative to other candidates (linear, intrinsically non-linear, etc.) is an appropriate functional form, and since unnecessary complexities were to be avoided in this exploratory stage of research, the log-linear form was selected.

5.2 Empirical Results

Five sets of regression analyses are conducted in this research. In each set the general form of the demand model, equation (5.1), is specially modified to analyze the effects of different forms of the variables or different attributes of the industry. The first set is a statistical evaluation of the use of the level of service measure, LOS, as a surrogate for the number of flights. The second set investigates the utilization of the three fare variables discussed in Section 3.3.1. The final three sets compare the values of the parameters in different environments related to the level of competition in markets, length of haul, and the sixteen year time span covered in this study.

5.2.1 Statistical Effect of Level of Service Measure

A set of arguments presented earlier in this report implies that the replacement of the number of daily flights by a more comprehensive level of service index makes intuitive sense for the improvement of air transportation demand modeling. A fundamental empirical investigation in this research is a test to determine whether this measure is as good an improvement statistically as it appears to be intuitively.

Data for all fifty-eight region pairs for all years in which there was service in these markets between 1959 and 1974 were used to estimate the parameters of the following two models:

$$D = \beta_{10} FARE^{\beta_{11}} BPI^{\beta_{12}} NFLT^{\beta_{13}} \varepsilon_1 \qquad (5.4)$$

$$D = \beta_{20} FARE^{\beta_{21}} BPI^{\beta_{22}} LOS^{\beta_{23}} \varepsilon_2 \qquad (5.5)$$

where D = number of origin to destination passengers

FARE = estimated average fare

BPI = Buying Power Index

NFLT = product of number of flights in each direction

LOS = level of service index

Refer to Section 3 above for a more complete description of the variables.

The models were linearized using the standard log-linear transformation (see Appendix F) yielding:

$$LND = \ln\beta_{10} + \beta_{11}LNFARE + \beta_{12}LNBPI + \beta_{13}LNNFLT + \ln\varepsilon_1 \qquad (5.6)$$

$$LND = \ln\beta_{20} + \beta_{21}LNFARE + \beta_{22}LNBPI + \beta_{23}LNLOS + \ln\varepsilon_2 \qquad (5.7)$$

The ordinary least squares technique was utilized to estimate the coefficients, and the results are as follows:

$$\widehat{LND} = 4.6978 + \underset{(6.123)}{0.2487}LNFARE + \underset{(8.524)}{0.1924}LNBPI + \underset{(28.102)}{0.6001}LNNFLT \qquad (5.8)$$

$$R^2 = 0.72$$

and

$$\widehat{LND} = 11.5389 - \underset{(9.091)}{0.3535}LNFARE + \underset{(17.187)}{0.3442}LNBPI + \underset{(26.432)}{1.1087}LNLOS \qquad (5.9)$$

$$R^2 = 0.71$$

$n = 875$ in both cases

The numbers in parentheses are the corresponding t statistics.

Although minor multicolinearity exists in both of these models, it is less of a problem in the model using LOS.

One immediately obvious problem with these results is the counter-intuitive sign of the estimate of the fare elasticity in equation (5.8). In equation (5.9), the level of service model, this estimated figure is -0.3535 which, in terms of absolute value, appears suspiciously low. In equation (5.8), the number of daily flights model, the fare elasticity figure bears a positive sign which appears to contradict economic reasoning.

The major reason for these deficiencies may be the imperfect specification of the model due to the presence of "two way causality." In a general linear model one condition for the validity of the ordinary least squares solution of the estimates of the coefficients is that each right hand side (explanatory) variable must not be dependent upon the left hand side variable. In other words, all causality must proceed from the right side of the equation to the left side. If one or more of the explanatory variables are jointly dependent upon the left hand side variable, a "two way causality" exists, and, among other undesirable effects, the estimates of the coefficients will be biased.

The FARE and BPI variables are not dependent upon air transportation demand. Airline fares are a function only of intercity distance and the Buying Power Indices are socioeconomic characteristics of the two regions in a market. The NFLT and LOS variables are, however, jointly dependent upon air transportation demand. If demand in a given market were suddenly to increase, then the carriers would increase number of flights and level of service. Hence, a two way causality exists in these models and it is to be expected that the estimates of the coefficients will be biased.

One remedy for this undesirable situation is a restructuring of the models into multi-equation forms and solving the systems using a technique known as two stage least squares. This process is discussed in Appendix F.

The introduction of the level of service index, LOS, has reduced the bias in the estimate of the fare elasticity. While, as previously mentioned, the absolute value of this estimate may be considered to be suspiciously low, it certainly is an improvement over the positive elasticity obtained by the number of flights, NFLT, model. Therefore, it can be concluded that the use of this index has salvaged a portion of the accuracy lost due to the imperfect specification of the model.

Additional improvements in the model due to the level of service index can be observed by an inspection of the t ratios for the estimated coefficients. While the t ratio for the service variable dropped slightly (less than 6%) the t ratio for the fare variable increased approximately 50%, and the t ratio for the Buying Power Index variable increased approximately 100%. The coefficient of multiple determination (R^2) remained virtually constant, which implies that for prediction purposes the two models appear to be equivalent. However, since the t ratios show significant overall improvement, the level of service model is preferred for analytical purposes, as one can place greater confidence in the individual coefficients.

5.2.2 Reevaluation of the FARE Variable

It was believed during this research effort that, in addition to the two way causality, the model may be less than perfectly specified due to an inappropriate fare variable. While the standard coach fare is a common measure of price in air transportation demand modeling, it was felt that perhaps this was improper since very few people actually pay the standard coach fare. In addition, the employment of this fare variable in a demand model does not reflect the impact of the presence of discount fare plans which may have a substantial effect upon demand.

This conception was investigated by conducting multiple regression analyses on three cross sectional models each employing a different fare variable. All fifty-eight region pairs for a single year were used in each model. The year selected was 1968 because at this time the airlines' scheduling system was in a relatively steady state. Demand had been growing at a constant rate for a number of years, no radical technological changes had been recently introduced, and there were no major strikes in the airline industry to force extensive cancellations. Furthermore, several major discount fares (e.g., youth and military standby) were in operation, and data are available (Civil Aeronautics Board Origin-Destination Survey) on the utilization of these various plans.

The first model is specified identically to that of equation (5.5) except it uses the standard fare. The second model is identical except it uses the estimated average fare. The third model uses as its fare the actual average fare paid by passengers in the given markets in that year. These variables are discussed in greater detail in Section 3.3.1.

The results are as follows:

$$\widehat{LND} = \underset{}{12.2758} - \underset{(3.382)}{0.4941LNFARE1} + \underset{(4.323)}{0.3226LNBPI} + \underset{(7.423)}{1.2672LNLOS} \qquad (5.10)$$

where FARE 1 = standard fare $\qquad R^2 = 0.75$

$$\widehat{LND} = \underset{}{12.3001} - \underset{(3.424)}{0.4978LNFARE2} + \underset{(4.365)}{0.3228LNBPI} + \underset{(7.715)}{1.2775LNLOS} \qquad (5.11)$$

where FARE 2 = estimated average fare $\qquad R^2 = 0.75$

$$\widehat{LND} = 12.1254 - \underset{(3.022)}{0.4863LNFARE3} + \underset{(4.393)}{0.3408LNBPI} + \underset{(6.435)}{1.2030LNLOS} \qquad (5.12)$$
$$R^2 = 0.73$$

where FARE 3 = actual average (per passenger) fare paid

The figures in parentheses are again the corresponding t ratios.

Comparing the results expressed in equations (5.10-12) indicates that the variable coefficents, the t ratios, and the coefficients of multiple determination (R^2) do not vary significantly between the models. The conclusion drawn from this analysis is that the respective elasticities, their precisions, and the prediction accuracy of the models are independent of the fare variable selected. Therefore, any reasonable fare variable used in such a model should produce equivalent results.

5.2.3 Effect of Competition

In an effort to measure the effect of competition the fifty-eight markets were divided into three categories based upon level of competition. Those markets denoted in Figure 4.1 as monopolistic comprised one category, those denoted as competitive comprised another, and the remaining markets were the third category. Multiple regression analyses were conducted to estimate the coefficients of the model described by equation (5.1) for each of these three classifications.

Comparison of the results of the regression analyses indicates very little dissimilarities in the estimates of the coefficients. Although the values of the variables, particularly the level of service, may be substantially different in a monopolistic market than in a competitive market, the elasticities tend to be nearly identical. The general conclusion is then that although the introduction of competition will usually improve level of service in a given market, the elasticities will remain quite stable over a reasonable range.

This conclusion is encouraging from the standpoint of specification of the level of service index, LOS. It is very reasonable to believe that once a market approaches saturation of capacity (e.g., New York-Chicago), the elasticity of demand with respect to level of service would vanish. By design of the index, LOS itself has a tendency to become very insensitive to the introduction of additional service. For example, if a market currently offers eighty flights per day, the addition of eight more flights would probably have little effect on the number of daily passengers. Using number of flights as a measure of level of service one would expect a diminishing elasticity (the variable has been increased by ten percent, while demand has increased only slightly). However, in this saturated market, the addition of eight new flights would have a negligible effect on LOS, as this index itself is nearly saturated. Thus, the introduction has produced a more hyperbolic (constant elasticity) demand function which for analytical purposes is desirable.

The results of the regression analyses for this classification of markets are tabulated in Appendix G.

5.2.4 Effect of Stage Length

The individual markets were segmented by interregional distance into five categories: ultra short haul (less than 260 km (160 mi)), short haul (260 km (160 mi) to 560 km (350 mi)), medium haul (560 km (350 mi) to 880 km (550 mi)), long haul (880 km (550 mi) to 2410 km (1500 miles)), and ultra long haul (over 2410 km (1500 miles)). The model structure used for these five analyses was again that of equation (5.1).

The impact of the existence of alternative modes, which are not accounted for in the model, rendered the estimation of the coefficients in the ultra short haul category model questionable. Most notable is the spurious positive correlation between fare and demand (although one might argue that the income effect is so strong here, that the coefficient should be positive). Within the range of zero to 160 miles, as the stage length decreases, air travel becomes less attractive due to the alternative of surface transportation. So in this category there is a situation where demand and fares both increase as a function of length of haul. The statistical result was a dubious price elasticity estimate of +0.9346.

Comparing the remaining four analyses, the short (350-550 miles) (560-890 km) and ultra long (over 1500 miles) (2415 km) markets appear to be more price elastic than the medium and long markets, and the elasticities with respect to Buying Power Index appear to increase with increased length of haul. However, it appears inappropriate to draw any concrete conclusions from these observations, since the data, which were submitted in time series by market, were found to be highly autocorrelated (Durbin-Watson statistics ranged from 0.490 to 0.681 for these four analyses). This undesirable effect must, in future research, be eliminated by improved model specification before sufficient confidence may be placed in the estimates of the coefficients.

One interesting conclusion may, however, be mentioned. It appears from these analyses that the elasticity with respect to level of service appears to decrease as stage length increases. This is intuitively reasonable in that travelers are more sensitive to time of day scheduling in short and medium haul trips (between 260 km (160 mi) and 880 km (550 mi)) than in ultra long haul trips (over 240 km (1500 mi)). For an ultra long haul journey a consumer would be less likely to choose not to take a planned trip due to inconvenient scheduling and would be much less likely to select an alternative mode.

The numerical results of these analyses are tabulated in Appendix G.

5.2.5 Cross-Sectional Analysis

The sixteen year time span, from 1959 through 1974, covered by this research, was divided into four periods of four years each for this phase of the study. This division was convenient for analytical purposes since each four year segment corresponds to a period of unique development in the airline industry. The 1959-1962 period encompassed the time when the first jets were placed in service on the most profitable trunkline routes. The 1963-1966 period corresponds to the time when most of the remaining trunkline routes were converted from props to jets. The 1967-1970 period saw much activity in route expansion and jet aircraft being introduced on local service routes. The 1971-1974 period, in contrast to the other twelve years, was one of escalating costs without further increases in productivity, cutbacks in level of service, and a generally weak financial situation for the airlines, the result of fuel shortages, price increases, and a recessionary economy.

Comparison of the results of the regression analyses indicates that the coefficients of the model appear to be quite stable over these four time periods. The only change of significance is that during the second period (1963-1966), the elasticities with respect to fare and level of service, their t ratios, and the coefficient of multiple determination are noticably lower than in the other periods. This implies that an explanatory factor not included in the specification of the model had a particular effect on the demand for air transportation during this time. One possible explanation is the major airline strike during the summer of 1966, the effect of which was felt on demand, but not measured by any of the explanatory variables.

The numerical results of these regression analyses are tabulated in Appendix G.

5.3 Summary

A major conclusion of this research effort is that the use of a more comprehensive level of service measure is not only an intuitive but also a statistical improvement for analyzing and planning in the air transportation industry. This implies an immediate need for further development of the index, LOS, used herein. It is also evident from the analysis that the parameters of the model are quite insensitive to the structure of the fare variable as long as it is constructed in a reasonable and consistent manner.

The utilization of the level of service index, LOS, as specified in the single equation model, yields a set of coefficients which are stable with respect to the level of competition in given market. Thus, the introduction of LOS has produced a demand function with a less variable elasticity with respect to level of service which is desirable for analytical purposes. Although statistical problems were present due to autocorrelation, it may nevertheless be inferred that the elasticity with respect to level of service appears to decrease as length of haul increases. Finally, the results show that the coeffecients of the model have been quite stable over the sixteen year time span during which the industry has experienced significant changes in technology, fares and level of service.

6. RESEARCH OBJECTIVES IN PHASE II

As seen from the exploratory research results in the previous section, it is possible to obtain significant improvements in economic models to forecast the demand for air transportation given the state-of-the-art and the existing socioeconomic and traffic related data. However, a substantial amount of research is required before models can be developed which are policy oriented both at the carrier management as well as government decision making levels.

From the preliminary investigation of the factors affecting the demand for air transportation, it is evident that very little is known about the impact of changes in the supply side of the production process. Thus, if existing forecasting models are to be improved upon, the specification should contain not only the demand but also the supply related factors. NASA has a particular interest in the end results since technology is a major and influential component in the supply side of the equation. Thus, if more understanding about the impact of improved technology on the demand for air transportation is sought, additional resources must be committed to systems research in technology.

The immediate plan for the second phase of this research is to improve the specification of the models explored in this first phase. The two most pressing problems with the current models are the existence of the two way causality and autocorrelation in the time series data.

As stated in Section 5 and Appendix F, an attempt will be made to eliminate or at least reduce two way causality by developing multi-equation models (possibly using non-linear specification) and through the use of more advanced econometric techniques such as Ridge regression, Bayesian regression, two and three stage least squares estimation, and indirect least squares. The problem of autocorrelation in the time series data will be solved by introducing additional variables, some of which may be lagged.

Once the overall specification of the economic model is improved, the next area of investigation will be to improve the variables themselves. First, the left hand variable, traffic, in the demand model could be improved by taking into account the total traffic between two regions instead of just the local origin-destination traffic. It is possible to obtain the relevant statistics from the Service Segment Flow Data tapes of the Civil Aeronautics Board. Second, it may also be necessary to either modify or use a different set of variables to account for the socioeconomic activity. For example, it may be useful to weight the three components of BPI differently. Third, considerable attention will be paid to the question of how different classes of passengers (e.g., business, personal) select a particular flight. For each class of traveler the disutility of time displacement from when they wish to fly and that of actual flight block time and how these disutilities are related must be investigated. It is hoped that some of the major airlines will provide the results of their on-board passenger surveys to explore this area of investigation.

On the supply side of the equation immediate plans for continuation of this research dictate improvement of the existing level of service index. First, the assumption of infinite capacity used in the analyses of this report eliminates the consideration of load factor. Since load factor is a definite component of level of service, this assumption must be eliminated and each flight considered to be of finite capacity. This is particularly important if one is to analyze the effects of change in technology upon air passenger demand.

Second, the time of day demand variation function used in the initial models assumed constant demand throughout the day. This assumption is obviously inadequate since daily demand for air transportation in short and medium haul business markets is typically bimodal. On most routes, peaks occur between 8:00 and 10:00 A.M. and between 5:00 and 7:00 P.M. Other markets may exhibit quite different time of day demand variations. Therefore, it is necessary to develop appropriate methodologies for determining this function. These methodologies may require data from passenger surveys or at least the use of the Civil Aeronautics Board's existing segment service flow data and advanced statistical techniques such as exponential smoothing.

Any model can be only as good as the available data. As these level of service models become more sophisticated, the analyst must be cautious to insure that either the required data are available or that reasonable methods are available for collecting the required data. This area is of particular relevance in the calibration of consumer decision models regarding flight selection and the determination of the time of day demand variation for individual markets.

The results of the limited empirical study described in the report imply that the introduction of level of service indices as variables is helpful in the improvement of existing demand models. Ultimately, if level of service indices can appropriately measure changes in not only the scheduling procedure but changes in technology (larger or smaller aircraft, faster aircraft, more efficient aircraft, etc.), these indicators can be used as aggregate supply variables in systems of equations. Expanding single equation demand models into multi-equation econometric systems is a very desirable step forward in the improvement of specification of air passenger econometric models for analysis, planning and forecasting.

Applied research in some of the areas described above should begin to lead to the development of economic models which would be more useful not only for forecasting the demand for air transportation but in evaluating the impact of a particualr change - for instance, restructuring of passenger fares or the introduction of more efficient aircraft. A goal of the next study phase is to identify additional specific areas of research that address the problems in air transport planning faced by both industry and government.

Appendix A. Enumeration of the Airport Pairs

AKRON (CAK)
Charlottesville
Denver
Detroit
Flint
Richmond

ALBANY (ALB)
Binghamton
Bridgeport
Elmira
Islip
Johnstown
New York
Pittsburgh
Poughkeepsie
Wheeling
White Plains

ALLENTOWN (ABE)
Elizabeth City
Newport News
Norfolk

APPLE VALLEY (APV)
Ft. Lauderdale
Key West
Miami
Vero Beach
West Plam Beach

ASTORIA (AST)
Dallas
Ft. Worth
Washington

ATHENS (AHN)
Baton Rouge
Cincinnati
Dallas
Detroit
Flint
Ft. Worth
Natchez
New Orleans

ATLANTA (ATL)
Baton Rouge
Cincinnati
Dallas
Detroit

ATLANTA(cont.)
Flint
Ft. Worth
Natchez
New Orleans

ATLANTIC CITY (ACY)
Elizabeth City
Newport News
Norfolk

AUGUSTA (AUG)
Washington

BATON ROUGE (BTR)
Athens
Atlanta
Cedar City
Galveston
Houston
Las Vegas
Rome

BEMIDJI (BJI)
Fargo
Jamestown, N.D.

BINGHAMTON (BGM)
Albany
Glens Falls
Plattsburgh

BISMARCK (BIS)
Minot
Williston

BLYTHE (BLH)
Ft. Lauderdale
Key West
Miami
Vero Beach
West Palm Beach

BOSTON (BOS)
Detroit
Flint

BOWLING GREEN (BWG)
Cincinnati
Milwaukee

BRAINERD (BRD)
Fargo
Jamestown, N.D.

BRIDGEPORT (BDR)
Albany
Chicago
Denver
Glens Falls
Kansas City
Manhattan
Plattsburgh
St. Joseph
Topeka
Washington

CAPE MAY (WWD)
Elizabeth City
Newport News
Norfolk

CEDAR CITY (CDC)
Baton Rouge
Elko
Ely
Monterey
Natchez
New Orleans
Oakland
Reno
Salinas
San Francisco
San Jose
Santa Rosa

CHARLOTTESVILLE (CHO)
Akron
Cleveland
Elizabeth City
Fayetteville
Goldsboro
Mansfield
Newport News
Norfolk
Raliegh
Rocky Mount

CHICAGO (CHI)
Bridgeport
Islip
Milwaukee
New York

CHICAGO(cont.)
Omaha
Poughkeepsie
Rochester
Tucson
White Plains

CHICO (CIC)
Ft. Lauderdale
Key West
Miami
Vero Beach
West Plam Beach

CINCINNATI (CVG)
Athens
Atlanta
Bowling Green
Clarksville
Ft. Lauderdale
Johnstown
Key West
Miami
Nashville
Pittsburgh
Rome
Shelbyville
Vero Beach
West Palm Beach
Wheeling

CLARKSVILLE (CKV)
Cincinnati
Milwaukee

CLEVELAND (CLE)
Charlottesville
Denver
Detroit
Flint
Richmond

CORVALLIS (CVO)
Dallas
Ft. Worth
Washington

CROSSVILLE (CSV)
Jackson, Tn
Memphis

DALLAS (DAL)
Astoria
Athens
Atlanta
Corvallis
Jackson, Ms
Lubbock
Portland, Or
Redmond
Rome
Salem
Vicksburg

DAYTON (DAY)
Ft. Leonard Wood
Johnstown
Marion, Il
Milwaukee
Mt. Vernon
Pittsburgh
St. Louis
Wheeling

DENVER (DEN)
Akron
Bridgeport
Cleveland
Hoquiam
Islip
Mansfield
New York
Olympia
Port Angeles
Poughkeepsie
San Diego
Seattle
White Plains

DETROIT (DTT)
Akron
Athens
Atlanta
Boston
Cleveland
Erie
Galveston
Houston
Hyannis
Laconia
Lawrence
Manchester
Mansfield
Nantucket
New Bedford

DETROIT(cont.)
Providence
Rome
Worcester

EL CENTRO (IPL)
Ft. Lauderdale
Key West
Miami
Vero Beach
West Palm Beach

ELIZABETH CITY (ECG)
Allentown
Atlantic City
Cape May
Charlottesville
Philadelphia
Reading
Richmond
Trenton
Wilmington, Del

ELKO (EKO)
Cedar City
Chico
Lake Tahoe
Las Vegas
Marysville
Sacramento

ELMIRA (ELM)
Albany
Glens Falls
Plattsburgh

ELY (ELY)
Cedar City
Chico
Lake Tahoe
Las Vegas
Marysville
Sacramento

ENID (WDG)
Ft. Leonard Wood
Marion, Il
Mt. Vernon
St. Louis

ERIE (ERI)
Detroit
Flint

FAIRMONT (FRM)
Fargo
Jamestown, N.D.

FARGO (FAR)
Bemidji
Brainerd
Fairmont
Mankato
Minneapolis

FAYETTEVILLE (FAY)
Charlottesville
Richmond

FLINT (FNT)
Akron
Athens
Atlanta
Boston
Cleveland
Erie
Galveston
Houston
Hyannis
Laconia
Lawrence
Manchester
Mansfield
Nantucket
New Bedford
Provudence
Rome
Worcester

FT. LAUDERDALE (FLL)
Apple Valley
Blythe
Cincinnati
El Centro
Long Beach
Los Angeles
Oxnard
Palmdale
Palm Springs
Paso Robles
Riverside
Santa Ana
Santa Barbara
Santa Maria
Washington

FT. LEONARD WOOD (TBN)
Dayton
Enid
Kansas City
Manhattan
Monterey
Oakland
Oklahoma City
St. Joseph
Salinas
San Francisco
San Jose
Santa Rosa
Topeka

FT. WORTH (GSW)
Astoria
Athens
Atlanta
Corvallis
Jackson, Ms
Lubbock
Portland, Or
Redmond
Rome
Salem
Wicksburg

GALVESTON (GLS)
Baton Rouge
Detroit
Flint
Natchez
New Orleans
Rock Springs
Salt Lake City
Vernal
Washington

GLENS FALLS (GFL)
Binghamton
Bridgeport
Elmira
Islip
Johnstown
New York
Pittsburgh
Poughkeepsie
Wheeling
White Plains

GOLDSBORO (GSB)
Charlottesville
Richmond

HOQUIAM (HQM)
Denver
San Diego

HOUSTON (HOU)
Baton Rouge
DEtroit
Flint
Natchez
New Orleans
Rock Springs
Salt Lake City
Vernal
Washington

HYANNIS (HYA)
Detroit
Flint

ISLIP (ISP)
Albany
Chicago
Denver
Glens Falls
Kansas City
Manhattan
Plattsburgh
St. Joseph
Topeka
Washington

JACKSON, MS (JAN)
Dallas
Ft. Worth

JACKSON, TN (MKL)
Crossville
Knoxville
London
Rockwood

JAMESTOWN, N.D. (JMS)
Bemidji
Brainerd
Fairmont
Mankato
Minneapolis

JOHNSTOWN (JST)
Albany
Cincinnati
Dayton
Glens Falls

JOHNSTOWN(cont.)
Lexington
Plattsburgh

KANSAS CITY (MKC)
Bridgeport
Ft. Leonard Wood
Islip
Marion, Il
Mt. Vernon
New York
Poughkeepsie
St. Louis
White Plains

KEY WEST (EYW)
Apple Valley
Blythe
Cincinnati
El Centro
Long Beach
Los Angeles
Oxnard
Palmdale
Palm Springs
Paso Robles
Riverside
Santa Ana
Santa Barbara
Santa Maria
Washington

KNOXVILLE (TYS)
Jackson, Tn
Memphis

LACONIA (LCI)
Detroit
Flint

LAKE TAHOE (TVL)
Elko
Ely
Reno

LAS VEGAS (LAS)
Baton Rouge
Elko
Ely
Monterey
Natchez
New Orleans
Oakland

LAS VEGAS(cont.)
Reno
Salinas
San Francisco
San Jose
Santa Rosa

LAWRENCE (LWM)
Detroit
Flint

LEWISTON (LEW)
Washington

LEXINGTON (LEX)
Johnstown
Pittsburgh
Wheeling

LINCOLN (LNK)
Omaha

LONDON (LOZ)
Jackson, Tn
Memphis

LONG BEACH (LGB)
Ft. Lauderdale
Key West
Miami
Vero Beach
West Plam Beach

LOS ANGELES (LAX)
Ft. Lauderdale
Key West
Miami
Vero Beach
West Palm Beach

LUBBOCK (LBB)
Dallas
Ft. Worth

MANCHESTER (MHT)
Detroit
Flint

MANHATTAN (MHK)
Bridgeport
Ft. Leonard Wood
Islip
Marion, Il

MANHATTAN(cont.)
Mt. Vernon
New York
Poughkeepsie
St. Louis
White Plains

MANKATO (MKT)
Fargo
Jamestown, N.D.

MANSFIELD (MFD)
Charlottesville
Denver
Detroit
Flint
Richmond

MARION, IL (MWA)
Dayton
Enid
Kansas City
Manhattan
Monterey
Oakland
Oklahoma City
St. Joseph
Salinas
San Francisco
San Jose
Santa Rosa
Topeka

MARTHA'S VINEYARD (MVY)
Detroit
Flint

MARYSVILLE (MYV)
Elko
Ely
Reno

MEMPHIS (MEM)
Crossville
Knoxville
London
Rockwood

MIAMI (MIA)
Apple Valley
Blythe
Cincinnati
El Centro

MIAMI(cont.)
Long Beach
Los Angeles
Oxnard
Palmdale
Palm Springs
Paso Robles
Riverside
Santa Ana
Santa Barbara
Santa Maria
Washington

MILWAUKEE (MKE)
Bowling Green
Chicago
Clarksville
Dayton
Nashville
Shelbyville

MINNEAPOLIS (MSP)
Fargo
Jamestown, N.D.

MINOT (MOT)
Bismarck

MONTEREY (MRY)
Cedar City
Ft. Leonard Wood
Las Vegas
Marion, Il
Mt. Vernon
Omaha
St. Louis

MT. VERNON (MVN)
Dayton
Enid
Kansas City
Manhattan
Monterey
Oakland
Oklahoma City
St. Joseph
Salinas
San Francisco
San Jose
Santa Rosa
Topeka

NANTUCKET (ACK)
Detroit
Flint

NASHVILLE (BNA)
Cincinnati
Milwaukee

NATCHEZ (HEZ)
Athens
Atlanta
Cedar City
Galveston
Houston
Las Vegas
Rome

NEW BEDFORD (EWB)
Detroit
Flint

NEW ORLEANS (MSY)
Athens
Atlanta
Cedar City
Galveston
Houston
Las Vegas
Rome

NEWPORT NEWS (PHF)
Allentown
Atlantic City
Cape Mya
Charlottesville
Philadelphia
Reading
Richmond
Trenton
Wilmington, Del

NEW YORK (NYC)
Albany
Chicago
Denver
Glens Falls
Kansas City
Manhattan
Plattsburgh
St. Joseph
Topeka
Washington

NORFOLK (ORF)
Allentown
Atlantic City
Cape May
Charlottesville
Philadelphia

NORFOLK(cont.)
Reading
Richmond
Trenton
Wilmington, Del

OKLAHOMA CITY (OKC)
Ft. Leonard Wood
Marion, Il
Mt. Vernon
St. Louis

OLYMPHIA (OLM)
Denver
San Diego

OMAHA (OMA)
Chicago
Lincoln
Monterey
Oakland
Salinas
San Francisco
San Jose
Santa Rosa

OXNARD (OXR)
Ft. Lauderdale
Key West
Miami
Vero Beach
West Palm Beach

PALMDALE (LNS)
Ft. Lauderdale
Key West
Miami
Vero Beach
West Palm Beach

PALM SPRINGS (PSP)
Ft. Lauderdale
Key West
Miami
Vero Beach
West Palm Beach

PASO ROBLES (PRB)
Ft. Lauderdale
Key West
Miami
Vero Beach
West Palm Beach

PHILADELPHIA (PHL)
Elizabeth City
Newport News
Norfolk

PITTSBURGH (PIT)
Albany
Cincinnati
Dayton
Glens Falls
Lexington
Plattsburgh

PLATTSBURGH (PLB)
Binghamton
Bridgeport
Elmira
Islip
Johnstown
New York
Pittsburgh
Poughkeepsie
Wheeling
White Plains

PORT ANGELES (CLM)
Denver
San Diego

PORTLAND, ME (PWM)
Washington

PORTLAND, OR (PDX)
Dallas
Ft. Worth
Washington

POUGHKEEPSIE (POU)
Albany
Chicago
Denver
Glens Falls
Kansas City
Manhattan
Plattsburgh
St. Joseph
Topeka
Washington

PROVIDENCE (PVD)
Detroit
Flint

RALEIGH (RDU)
Charlottesville
Richmond

READING (RDG)
Elizabeth City
Newport News
Norfolk

REDMOND (RDM)
Dallas
Ft. Worth
Washington

RENO (RNO)
Cedar City
Chico
Lake Tahoe
Las Vegas
Marysville
Sacramento

RICHMOND (RIC)
Akron
Cleveland
Elizabeth City
Fayetteville
Goldsboro
Mansfield
Newprot News
Norfolk
Raleigh
Rocky Mount

RIVERSIDE (RAL)
Ft. Lauderdale
Key West
Miami
Vero Beach
West Plam Beach

ROCHESTER (ROC)
Chicago

ROCKLAND (RKD)
Washington

ROCK SPRINGS (RKS)
Galveston
Houston

ROCKWOOD (RKW)
Jackson, Tn
Memphis

ROCKY MOUNT (RMT)
Charlottesville
Richmond

ROME (RMG)
Baton Rouge
Cincinnati
Dallas
Detroit
Flint
Ft. Worth
Natchez
New Orleans

SACRAMENTO (SAC)
Elko
Ely
Reno

ST. JOSEPH (STJ)
Bridgeport
Ft. Leonard Wood
Islip
Marion, Il
Mt. Vernon
New York
Poughkeepsie
St. Louis
White Plains

ST. LOUIS (STL)
Dayton
Enid
Kansas City
Manhattan
Monterey
Oakland
Oklahoma City
St. Joseph
Salinas
San Francisco
San Jose
Santa Rosa
Topeka

SALEM (SLE)
Dallas
Ft. Worth
Washington

SALINAS (MRY)
Cedar City
Ft. Leonard Rood
Las Vegas
Marion, Il
Mt. Vernon
Omaha
St. Louis

SALT LAKE CITY (SLC)
Galveston
Houston

SAN ANTONIO (SAT)
Tucson

SAN DIEGO (SAN)
Denver
Hoquiam
Olympia
Port Angeles
Seattle

SAN FRANCISCO (SFO)
Cedar City
Ft. Leonard Wood
Las Vegas
Marion, Il
Mt. Vernon
Omaha
St. Louis

SAN JOSE (SJC)
Cedar City
Ft. Leonard Wood
Las Vegas
Marion, Il
Mt. Vernon
Omaha
St. Louis

SANTA ANA (SNA)
Ft. Lauderdale
Key West
Miami

SANTA ANA(cont.)
Vero Beach
West Palm Beach

SANTA BARBARA (SBA)
Ft. Lauderdale
Key West
Miami
Vero Beach
West Palm Beach

SANTA MARIA (SMX)
Ft. Lauderdale
Key West
Miami
Vero Beach
West Palm Beach

SANTA ROSA (STS)
Cedar City
Ft. Leonard Wood
Las Vegas
Marion, Il
Mt. Vernon
Omaha
St. Louis

SEATTLE (SEA)
Denver
San Diego

SHELBYVILLE (SYI)
Cincinnati
Milwaukee

TOPEKA (TOP)
Bridgeport
Ft. Leonard Wood
Islip
Marion, Il
Mt. Vernon
New York
Poughkeepsie
St. Louis
White Plains

TRENTON (TTN)
Elizabeth City
Newport News
Norfolk

TUCSON (TUS)
Chicago
San Antonio
Victoria

VERNAL (VEL)
Galveston
Houston

VERO BEACH (VRB)
Apple Valley
Blythe
Cincinnati
El Centro
Long Beach
Los Angeles
Oxnard
Palmdale
Palm Springs
Paso Robles
Riverside
Santa Ana
Santa Barbara
Santa Maria
Washington

VICKSBURG (VKS)
Dallas
Ft. Worth

VICTORIA (VCT)
Tucson

WASHINGTON (WAS)
Astoria
Augusta
Bridgeport
Corvallis
Ft. Lauderdale
Galveston
Houston
Islip
Key West
Lewiston
Miami
New York
Portland, Me
Portland, Or
Poughkeepsie
Redmond
Salem
Vero Beach
West Palm Beach
White Plains

WEST PLAM BEACH (PBI)
Apple Valley
Blythe
Cincinnati
El Centro
Long Beach
Los Angeles
Oxnard
Palmdale
Palm Springs
Paso Robles
Riverside
Santa Ana
Santa Barbara
Santa Maria
Washington

WHEELING (HLG)
Albany
Cincinnati
Dayton
Glens Falls
Lexington
Plattsburgh

WHITE PLAINS (HPN)
Albany
Chicago
Denver
Glens Falls
Kansas City
Manhattan
Plattsburgh
St. Joseph
Topeka
Washington

WILLISTON (ISN)
Bismarck

WILMINGTON, DEL (ILG)
Elizabeth City
Newport News
Norfolk

WORCESTER (ORH)
Detroit
Flint

Appendix B: Data Collection

Because of the non-uniformity of the airlines's flight schedules as published in the Official Airline Guide, several assumptions were required and a methodology developed for transferring the data from the appropriate copies of the O.A.G. to computer cards for use in this research. The five step process used to insure consistency across all region pairs is described below.

Step 1. The following set of assumptions and procedures was applied to all data published in the Official Airline Guide before it was punched on to cards. As an illustration, the excerpt shown in Figure B.1 was transformed into the card listing shown in Figure B.2 by the four rules described below.

1) The O.A.G. separates connections from direct flights in its tabulations. It was more appropriate for the purposes of this work that all flights, conections and direct trips, be logged in one table chronologically. This is especially appropriate in the case of markets served by only a few flights where the only service over a long period of time may be connecting; this has been done is transforming the data in Figure B.1 to Figure B.2.

2) The O.A.G. prints future schedules changes which results in some flights being effective for only part of the month. The schedule flown at the end of September was arbitrarily chosen for use in this research. Consequently, flights commencing before October 1 or being discontinued after September 30 were included while flights commencing after September 30 or being discontinued before October 1 were not included. In Figure B.1, this means that American 581 was included since it commenced on September 15 and that United 425 using a 737 was included since it also commenced on September 15 while United 425 using a 727 was not included since it was discontinued before the end of the month.

FIGURE B.1 SAMPLE PUBLICATION EXCERPT FROM THE OFFICIAL AIRLINE GUIDE

```
To DETROIT

From PROVIDENCE

   F 75.93  6.07 82.00 164.00
UA Y 60.17  4.83 65.00 130.00
   Y 58.33  4.67 63.00 126.00
AA YM 41.00    AA M 33.00
AA Y[illegible] 52.00    AA [illegible] 49.00

146        8:35a 11:27a AA 285  F/Y  BAC B 1
25         8:35a 11:27a AA 287  F/Y  727 B 1
3[illegible]         8:35a 11:27a AA 289  F/Y  72S B 1
           3:55p  8:16p AA 581  F/Y  72S   2
                         AA 581 EFFECTIVE SEP15
           4:55p  7:47p UA 425  F/Y  727   1
                    UA 425 DISCONTINUED AFTER SEP14
           4:55p  7:47p UA 425  F/Y  737 D 1
                         UA 425 EFFECTIVE SEP15
x567       6:35p  9:27p AA 497  F/Y  727 D 1
567        6:35p  9:27p AA 497  F/Y  72S D 1

                CONNECTIONS
           7:00a 10:12a AL 671   S   D95   0
                        AA 497  F/Y  727   0
                         8:06a LGA  9:15a
           7:40a 10:12a AA 981  F/Y  BAC   0
                        AA 497  F/Y  727   0
                         8:40a LGA  9:15a
           7:40a 10:47a AA 981  F/Y  BAC   0
                        UA  75  F/Y  72S   0
                         8:40a LGA  9:45a
           2:59p  7:18p NA 491  F/Y  727   0
                        AA 493  F/Y  727   0
                         4:07p LGA  6:00p
           2:59p  7:36p NA 491  F/Y  727   0
                        UA  41  F/Y  D10   0
                         4:07p LGA  6:15p
           3:00p  7:18p AA 985  F/Y  72S   0
                        AA 493  F/Y  727   0
                         4:05p LGA  6:00p
           3:00p  7:36p AA 985  F/Y  72S   0
                        UA  41  F/Y  D10   0
                         4:05p LGA  6:15p
           7:55p 10:46p EA 673  F/Y  D9S   0
                        AA 495  F/Y  707   0
                         8:28p BOS  9:00p
```

FIGURE B.2: SAMPLE CARD LISTING GENERATED FROM THE DATA IN FIGURE B.1.

```
FARE  82.00F  63.00Y
0700A 1012A AL/AA D9S/727 0/0 LGA S/FY
0740A 1012A AA/AA BAC/727 0/0 LGA FY/FY
0740A 1047A AA/UA BAC/72S 0/0 LGA FY/FY
0835A 1127A AA BAC 1 FY
0259P 0718P NA/AA 727/727 0/0 LGA FY/FY
0259P 0736P NA/UA 727/D10 0/0 LGA FY/FY
0300P 0718P AA/AA 72S/727 0/0 LGA FY/FY
0300P 0736P AA/UA 72S/D10 0/0 LGA FY/FY
0355P 0816P AA 72S 2 FY
0455P 0747P UA 737 1 FY
0635P 0927P AA 727 1 FY
```

3) Connections using airports within the same region (either the originating region or destination region) should not be included. An example of this is shown by the 7:55p connection in Figure B.1. The connecting airport is Boston which is in the same region as Providence. When schedules in the Providence-Detroit airport pair are aggregated over the entire region pair (which will, of course, include schedules in the Boston-Detroit airport pair), the 10:46p Detroit arrival (American flight 495) will appear twice, one as a Boston-Detroit nonstop and once as Providence-Detroit connection. In dealing with a level of service over an entire region, this should not be allowed since the second flight does not increase the level of service from the Boston region to the Detroit region; the overall level of service to the region pair is not improved by counting the same flight twice. The convention adopted for this research is to drop such connections while including the direct flight; in this case, the Providence-Detroit connection would be dropped in favor of the direct flight from Boston so the 7:55p departure in FigureB.1 should not be included in Figure B.2.

4) Only flights which operate a minimum of four days per week were included. This is due to the fact that the input data in Figure B.2 is assumed to be a daily schedule without provision for special cases as shown in the 6:35p departure which operates four days with a 727 and three days with a 72S. The cut off of four flights per week as minimum was arbitrary but chosen because it represents operation on more than half the days of the week. This means that only the 6:35p American departure using the 727 should be included.

5) In some cases, there is a departure at the same time every day but the flight number or the equipment depends on the day of the week. Note the 9:35a departure in Figure B.1 uses three different types of equipment throughout the week and the airline has chosen to change the flight number with each type of aircraft. Using rule 4, none of these flights would be chosen since none operates a minimum of four days per week. However, since taken together they do constitute one departure every day at the same time, the most prevalent departure, flight 285 using the BAC aircraft, is accepted for Figure B.2 while the others are not.

The fare information is punched on a separate card with the identifier "FARE" punched in the first four columns. The importance of this code is brought out in the program documentation. Only fares without restriction should be included; this includes first class, coach, economy, night coach, etc., but excludes military, excursion, advance purchase, youth fares, etc. In cases where all carriers did not charge the same dollar amount for the same fare class, the amount charged by the majority of the carriers be included. In Figure B.1, United charges $65 for the Providence-Detroit trip while the remaining carriers (in this case, only American) all charge $63. The $63 figure would be used for the jet coach fare in this market as shown on the FARE card punched and listed in Figure B.2.

Step 2. The connections only are examined for each airport pair. Many times, the data from the Official Airline Guide includes duplication of services, especially from the standpoint of level of service which is being examined here. For example, the two 2:59p connections shown in figure 10 both use the same flight to New York as do the two 3:00p connections. The actual choice to a passenger for either of these two departures is not two flights each but one flight each. The situation early in the morning illustrated by the first three departures in figure 11 is somewhat more complicated. The logic of this step attempts to clear up these problems.

In general, the fastest connections will be chosen except that on-line connections are preferred to off-line connections up to a maximum of 30 additional minutes of en route trip time. In the case of the four entries at about 3:00p in figure 11, this means that the 3:00p American on-line connection is chosen and the 2:59p National/United connection is chosen. Had the 3:00p connection not been an on-line connection, then the earlier arrival time would have been assigned to the 2:59p departure with the later arrival time assigned to the 3:00p departure.

The early morning situation is somewhat more complicated. Note that while there are three listed connections, the middle one is merely the originating flight from the third and the connecting flight from the first. However, the middle flight is preferable since it involves both on-line change as well as the least amount of time. Given this choice, both the third flight and first flight are subsequently eliminated since they represent duplicated flights already selected in the second flight.

Suppose the situation is slightly different and the following triad of flights is listed:

Leave	Arrive	Airlines
0700A	1012A	AA/AA
0740A	1012A	AL/AA
0740A	1047A	AL/UA

Since on-line connections are preferred up to a maximum of 30 minutes, then in this case the 7:40a departure with the 10:12a arrival is still the preferred of the three. Once this has been chosen, then neither the first nor third departure may be chosen since duplication of flight segments will occur. Thus, once again the second flight is chosen and the first and third are dropped.

Finally, suppose the flights were listed as follows:

Leave	Arrive	Airlines
0715A	1012A	AA/AA
0740A	1012A	AL/AA
0740A	1047A	AL/UA

Now, the convention regarding on-line connections holds and the first flight is preferred to the second one. Once the first flight has been chosen, it is also possible to choose the third flight since no duplication of services will result. For this case, then, the second flight is eliminated but the first and third are kept.

For the example given in FigureB.2, application of the rules and assumption of this step results in reduction to the card listing shown in Figure B.3.

FIGURE B.3: REDUCTION OF LISTING IN FIGURE B.2 USING RULES OF STEP 2.

```
FARE  82.00F  63.00Y
0740A 1012A AA/AA BAC/727 0/0 LGA FY/FY
0835A 1127A AA BAC 1 FY
0259P 0736P NA/UA 727/D10 0/0 LGA FY/FY
0300P 0718P AA/AA 72S/727 0/0 LGA FY/FY
0355P 0816P AA 72S 2 FY
0455P 0747P UA 737 1 FY
0635P 0927P AA 727 1 FY
```

<u>Step 3.</u> Up to a maximum overlap of 30 minutes, a flight which departs before another one but which arrives after it will not be eliminated from consideration. However, if the difference, at either end of the trip, is 31 minutes or more, those flights will be eliminated as being of a level of service so inferior to the shorter flights that they are not even considered by potential consumers. This convention does not apply to flights whose departure, or arrival, times are exactly the same; that is, a 7:00a nonstop and a 7:00a onestop which arrives almost an hour later will both be retained. However, if the onestop were to leave at 6:59a while the nonstop departure at 7:00a remained unchanged, then the 6:59a departure would be eliminated because it is a lapped flight whose arrival times differ by more than 30 minutes. There is no distinction between direct flights and connections. If a connection laps a direct flight by more than 30 minutes on either end, then the direct flight should be eliminated. In Figure B.3, the 3:55p departure is lapped by the 4:55p flight. Although the difference in arrival times is only 29 minutes, the difference in departure times is one hour; therefore, the 3:55p flight would be dismissed on the grounds that its level of service is so inferior to that offered at 4:55 that it would not be an alternative to consumers. In some markets, it is necessary to examine more than just pairs of flights when many departures with varying numbers of stops are bunched up at the same time. However, in these cases, the same rules apply to ALL pairs of flights in the group; that is, in a group of three flights, the rules apply to the first two, the last two and the first and third as well. Application of the rules of step 3 to the data listed in Figure B.3 results in the elimination of 3:55p only.

Step 4. Steps 1 through 3 effect the reduction of data for each airport pair. In this step, for each region pair, data so reduced for each component airport pair is aggregated to form one chronological flight listing. No distinction is made between direct flights and connections. Recall that for cities with several airports (i.e., New York, Detroit, Chicago, Los Angeles, San Francisco, Dallas, Washington, etc), steps 1 through 3 apply to airport pairs and each airport must be examined separately even though the Official Airline Guide aggregates data for these cities in most cases. For purposes of this research, this aggregation occurs now in step 4.

Step 5. The final step in this process is the elimination of duplicate flights. While connections through airports in the same region were eliminated in step 1, this step refers to direct flights. Although no examples occur in Figure B.1, a flight routing of Providence-Boston-Detroit would fall into this category of a flight that would be eliminated by this step. As was the case in note 3 of step 1, inclusion of both listings of this flight, a onestop from Providence to Detroit and a nonstop from Boston to Detroit, would imply a greater level of service than that which actually exists. Duplication unchecked until this point can also occur in connecting flights. For example, a Boston-Detroit connection and a Providence-Detroit connection may connect with the same flight in New York; the flight leaving the east coast the latest (resulting in the shortest en route trip time) would be included while the other would be eliminated. In Figure B.3, suppose a Boston-Detroit flight connecting through LaGuardia to American 497 leaves Boston at 7:30a. When aggreagtion occurs in step 4, this results in two flights in the Boston-Detroit region pair using American 497. The later flight is kept, this being the Providence departure, and the earlier departure is eliminated, this being the Boston flight.

The same conventions regarding on-line connections being favored up to a maximum of 30 extra minutes of additional en route trip time are still in effect. Similarly, there is no distinction made between direct flights and connections. If, in the case just mentioned, American 497 originates in Boston at 7:30a and goes onestop to Detroit through LaGuardia, it would still be eliminated in favor of the 7:40a Providence departure which connects to American 497 in New York because of the later departure time from the Boston region.

Appendix C. Documentation of Computer Programs for Data Analysis

The data analysis process in this research involved the transferral of information from the raw data cards (Appendix B) to the output of the regression analyses (Section 5 and Appendix G). This process was comprised of two sequential stages. The demand, flight data, Consumer Price Indices, Buying Power Indices, and fare data cards were combined into an input deck and read into a comprehensive data compilation program, LOSFARE. This is a special purpose program written as part of this research effort in PL/I and listed in Figure C.2. The output of LOSFARE is a punched data deck with a format compatible with that of the input requirements for the multiple regression analysis routine of P-STAT. P-STAT is a general purpose statistical package developed at Princeton University in 1971.

The basic internal functions of LOSFARE are the calculations of the level of service index, LOS, and the estimated average fare, FARE, for each region pair for each year using the methodologies outlined in Section 3. The demand and Buying Power Indices are merely read in and then punched out as appropriate. The number of flights is easily determined by counting the number of flight data cards within each region pair.

Once this data deck was produced, it was a simple matter to construct decks for the two runs which involved a different fare index calculation method. The computer was not required for the standard fare; in this case, the output deck with the estimated average fare was duplicated, leaving the fare index field blank and the standard fare figures were subsequently punched in. Another computer program was written for the computation of the actual average fare which used the data deck with the estimated average fare as input, calculated the actual average fare from auxilliary data sources, and punched new cards altering the fare index field only. The source list of this program is presented in Figure C.3. The control cards for the regression analyses using P-STAT are listed in Figure C.4, along with the data deck for the regression analysis of all region pairs and all years.

C.1 Calculation of the Level of Service Index, LOS, and the Estimated Average Fare, FARE

The computer program LOSFARE is listed in Figure C.2. It is written in PL/I and was executed using an IBM Model 370 computer. For simpler documentation purposes, the program was divided into sections which have been numbered sequentially and titled. (Comments in PL/I are introduced into the mainstream of the program by being surrounded by /* (text) */ .) PL/I allows any combination of letters to comprise a variable name and assumes that those names beginning with the letters I through N, inclusive, are integers and those names beginning with the other letters of the alphabet are decimals. The differentiation is important, expecially in the case of variables which are subscripts for other variables. This convention may be changed through use of a DECLARE statement; similarly, the dimensions of all array variables must be included in a DECLARE statement. The DECLARE statements used for this program may appear anywhere in the text but usually appear at the beginning of the program as shown in Figure C.2.

C.1.1 Input Data

Data is read and stored in PL/I through use of a GET EDIT statement. Four sets of data are read and stored in this fashion in Section 1 of the program. The data are stored in locations addressed by the variable names which appear in the parentheses following the words GET EDIT. In Section 1, the first statement reads and stores the values of the Consumer Price Index in the array variable CPI. Next, the hierarchy of the domestic airline fare structure is read and stored in the array variable TABLE. This structure proceeds from highest fare level to lowest and includes only those fares which are available to all persons at all times. The order used in this program was as follows:

Symbol	Rank	Description
F	1	Jet First Class, Prop First Class also prior to 1965
A	2	Prop First Class beginning in 1965
L	3	Jet Intermediate Class, used by United Airlines during the middle 1960s for a passenger compartment with 5 abreast seating (F had 4 abreast and Y had 6 abreast.)
S	4	Standard Class used mainly by the local service carriers in aircraft with one class seating
R	5	Standard Class used by Mohawk Airlines; in general, class S and R fares are the same as Y fares for long hauls but are higher in short markets. Prior to 1965, class R referred to jet coach class
Y	6	Jet Coach class beginning in 1965; Jet Economy Class prior to 1965.
T	7	Prop Coach Class
K	8	Jet Economy Class beginning in 1965
FN	9	Deluxe Night Coach Class
SN	10	Night Standard Class
YN	11	Night Jet Coach Class
N	12	Night Class

Finally, a loop is set up in which the Buying Power Indices are read and stored in two steps into the array variable BPI. The first step (values of index J from 1 to 8) correspond to the Buying Power Indices between 1959 and 1966; the second step (values of index J from 9 to 16) corresponds to the Buying Power Indices between 1967 and 1974. The PL/I command DO I=1 TO 51 and its corresponding END statement enclose the group of statements which are executed 51 times (as I varies in value). The value of I corresponds to each of the 51 unique regions utilized in this study.

The next four sections (2 through 5) are concerned with reading and storing data which is unique to the various region pairs. This is by far the largest portion of the input data deck and is schematically outlined in Figure C.1. With the exception of the flight schedule cards, each card in this portion of the data deck is characterized by a four letter code name in the first four columns. For each region pair, the first card has code CITY. This is followed by several PASS cards, one for each airport pair within the region pair for which data was available in the C.A.B. Origin-Destination Survey of Airline Passenger Traffic. These are followed by one TOTAL card which reports total region pair traffic. Each PASS or TOTAL card has room for only eight years of data so for each market there are two groups of PASS cards followed by one TOTAL card; the first group constitutes data for the period between 1959 and 1966 while the second group constitutes data for the period between 1967 and 1974. The order in which the PASS cards are read is important and is dependent upon the number of FARE cards as described below.

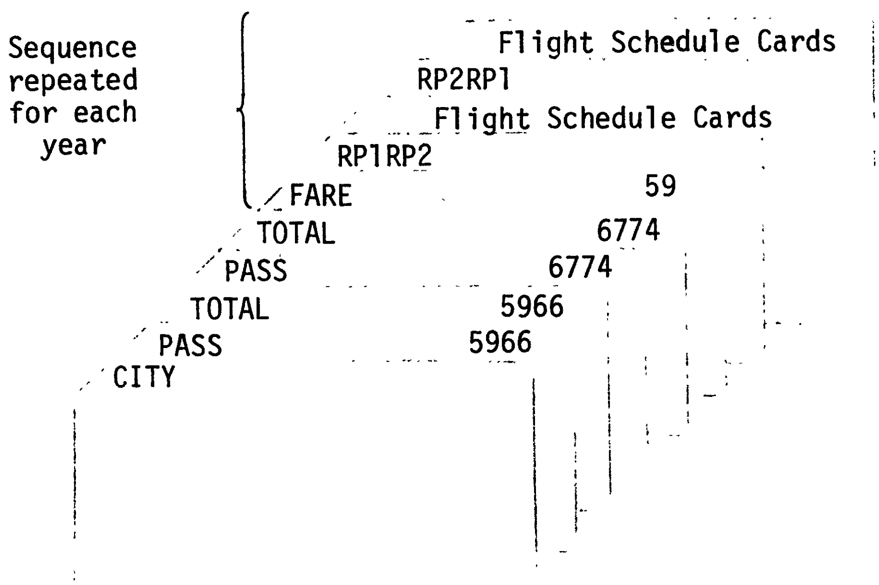
In all cases, there were fewer FARE cards than PASS cards reflecting the fact that demands were registered in the C.A.B's ticket count in markets where direct service had not been provided. Recall that the FARE cards were punched from data collected from the Official Airline Guide and, throughout the study period, only fares for direct flights were published. For airport pairs where both a FARE card and a set of PASS cards were punched, it was important that these be paired. For airport pairs where a set of PASS cards was punched but for which there was no FARE data, the data on the PASS cards had to be ignored, although not totally, since this was incorporated into the region pair demand data which appear on the TOTAL card. At this stage, the PASS cards with corresponding FARE cards were separated from those without. The order in which the matched set of cards was input was kept constant; that is, the PASS cards were input in an explicit order: those with matching FARE cards first in a well-defined progression, although any order could be selected, followed by those without matching FARE cards in a random order. Note that Figure C.1 shows that there were FARE cards punched for each year while the PASS cards occur only at the front of the region pair's data deck. Each time FARE cards were read in, they had to be read in the same order by airport pair to insure proper processing and avoid a series of lengthy and costly sort routine executions.

In Section 2, the PASS and TOTAL cards were read and stored. First, however, the CITY card is encountered and one parameter on this card tells the computer how many of the following PASS cards have matching

FARE cards later on. This value is stored in variable G and the region pair distance is stored in variable DS. The first two statements in this section direct the computer to the stopping procedure if a card without code CITY is found at the head of the region pair's data deck. Once the value of G is determined, as is done in the third statement in this section, the remainder of the commands execute a routine in which the data from the matched PASS cards are read and stored in array variable PASS (I,J). The unmatched PASS cards are read and ignored, and the data from the TOTAL card is read and stored, also in array variable PASS(I,J) with I=37, one more than the 36 airport pairs in the largest region pair (Miami-Los Angeles).

Section 3 begins at the point to which program execution returns for each year within each region pair. The first two statements check to be sure the code name on the first card for each year is FARE; if it is not, then the region pair has been fully examined and execution is transfered to another section for printing and punching of results. After this checking and some initializing, the data from the fare cards are read and stored in array variables FR and CL, the former used for the dollar amount of the fare and the latter for the fare class symbol. Between 1962 and 1964, jet fare classes were usually followed by a "J"; that is, jet first class was denoted "FJ", jet coach class was denoted "RJ", jet standard class was denoted "SJ" and so on. The next statement checks for the presence of a trailing "J" in all cases except for "FJ" and eliminates the "J" if it is found. In the case of jet first class, since the symbol "F" was used during the period 1962 through 1964 to denote prop first class, elimination of this trailing "J" would result in the

Figure C.1: General Format For the Data Deck of LOSFARE



inability to treat jet first class separately from prop first class. Recall that this method requires an average fare for each fare class which is calculated over the entire region pair. The remainder of this section executes a routine wherein the appropriate data from the matched PASS and FARE cards are multiplied together, the products added and the resulting sums divided by the demand to arrive at the average fare paid over the region pair for each fare class.

Section 4 begins at the point at which execution for a flight schedule begins; this is done twice for each year within a region pair as is signified by the first statement within the section. If L is incremented to 3, then both directions have already been analyzed and control is transferred around the next several sections of commands. In addition to some initialization, all that is done in this section is that the header card to each flight schedule is read. Data included on this card include F(L), the number of flights in this region pair in this direction, Z, the time zone difference in this region pair in this direction and SOD, the specified start of the day.

Section 5 begins at the point to which program execution returns for each flight card. In this set of statements, each flight card is read and relevant data stored in appropriate fields. These data include the departure time, the arrival time, a code symbol, the fare field if the flight is a direct trip, and the fare field if the flight is a connection. The two times are subdivided into three parts: the hour, the minute and the final letter which denotes morning or afternoon. The code symbol, denoted by CODE, reads column 15 of the flight card; if this column is blank, the flight is a direct trip while if there is a "/" in this column, the flight is a connection. The CODE variable then directs the program to read columns 22-26 (the fare field for direct flights) or columns 35-44 (the fare field for connecting flights) as appropriate. The remaining four statements of Secion 5 internally transform the times of day into a 24 hour clock.

C.1.2. Fare Selection for Direct and Connecting Flights

Section 6 is executed only for direct flights as can be seen from its initial statement. The routine for determining which fare is applicable for a direct flight is rather simple. The direct fare field (columns 22-26 and denoted by THFR) is read in reverse order until a character other than a blank is encountered. If this character is an "N" and the year is later than 1964 then this is recognized as trailing character and one more character is read before the proper fare may be determined. Similarly, if the year is prior to 1965 and the first character encountered is a "C", this is also recognized as a trailing character but only if the next character is a "T"; otherwise, the "C" stands alone. In the former case, the symbol "N" has never been used alone for fare purposes since 1965 and encountering an "N" in most cases indicates the existence of "YN". This method finds the lowest fare available on that flight since fares are listed in the Official Airline Guide in order of decreasing amount.

Section 7 is executed if Section 6 is not; that is, this routine caters to connecting flights. The end of this routine completes the loop of commands executed for each flight card. The first loop in this section uses M as an index for the flight in the connection is being examined; thus, once M exceeds two, the work of these statements is completed. In a manner similar to that of Section 6, this loop determines for each flight in the connection the lowest fare available on demand and stores the result in CNCLASS(M). Examination of the commands in this loop shows a distinct similarity with Section 6 as would be expected. Following this loop, several small loops determine which of the two CNCLASS(M) values should be used as the fare to be assigned the connecting flight as a whole. If the two values are the same, there is no problem and CLASS(I) is arbitrarily set equal to CNCLASS(1) as shown in the statement immediately after the loop. Otherwise, execution turns to the fare structure input into the array variable TABLE and outlined in detail above. Each of the CNCLASS(M) values is located in the table by execution of the two small loops on K and J, respectively. If either fare cannot be located in the table, then CLASS(I) is automatically assigned a value of "Y". However, in debugging the program, all instances of this occuring were corrected so that this statement is in reality only a vestige of the correction process. Finally, whichever fare corresponds to the greater dollar amount is assigned to the location CLASS(I).

C.1.3. Determination of Level of Service and Fare Values

Section 8 is a single statement in which the end of the airline day is determined. This is set to 8:00 P.M. or the time of the last flight out, whichever is later. (Also, 8:00 P.M. = 2000 on a 24 hour clock.) As mentioned above, beginning with Section 8, the loop for each flight card has been completed and logic has regurned to dealing with each complete (directional) flight schedule.

Section 9 is the routine in which the basics of the level of service index and the fare index are calculated. Both rely heavily on the assumption of constant arrivals throughout a well-defined time period. The entire section is executed once for each flight given that the entire set of flights has been read and stored, as shown by the first DO statement. This is followed by the one basic LOS index calculation while the remainder of the section deals with calculation of the fare index. The next DO group merely locates the fare for each flight among the list of those fares input from the FARE cards which were subsequently modified into an average fare for each fare class for this particular region pair in Section 3 (these values were stored in CLS(K)). If K=9 after this loop has been executed, then no match was found while if K is less than 9 a match was found. In the latter case, flow is transferred to the last four statements of the section; in the former case, sequential execution continues in an effort to assign a fare to this flight for which a dollar value exists in the CLS array.

The next IF statement deals with the specific case of a connection in which both segments offer K class fares but for which no published K class through fare exists; for this case, the fare class for the connection is changed to Y. Rationale for this change was gained from editions of the Official Airline Guide published beginning in October, 1974 in which fares for connections are published in addition to fares for direct flights. If this case does not apply, the next DO statement locates the value of CLASS (I)in the fare structure hierachy as stored in the array variable TABLE.

The next two nested DO groups on H and K then move backward in the fare structure (i.e. proceed through higher fare classes) in an attempt to find the next highest fare class for which a published dollar amount, as given in the array variable CLS, exists. If this is successful, then the variable H will emerge from this nested DO group with a positive value; otherwise, its value will be 0. If its value is positive, then execution may proceed to the final four statements of this section, otherwise sequential flow continues as shown in the next IF statement.

In the sequential case, the program returns to the origianl point of entry into the fare structure and then proceeds in a forward direction (i.e. through lower and lower fares) in an attempt to match the fare on this particular flight with one in the array CLS. If this again is unsuccessful, then no match is found and the departure time of this flight is printed out so the flight can be examined in detail after execution to attempt to correct the problem. During the final execution of this program, there were no such print-outs so a match was found for each flight examined for all region pairs throughout all years.

Finally, since by this time a match between CLS and CLASS has been found for each flight, the dollar amount of the average fare for that class in this region pair is weighted by the fraction of the total demand assigned to departure at this particular flight time given this schedule and a running total of the weighted fares found in this manner is stored in the location TOTAL(L). Recall that this section is executed once for each flight in each direction and that the subscript L varies from 1 to 2, depending upon direction of travel. Thus, one value of TOTAL is found for ecah direction of travel.

The actual LOS index is calculated in the first statement in Section 10. The following END statement signifies the end of the loop of instructions executed for each direction of travel for each year within the region pair. The remaining instructions in this section are executed once all flights have been examined in both directions. The first instruction calculates an average fare index from the two indices calculated in Section 9 for each direction of travel and then weights the calculated average by the appropriate value of the Consumer Price Index, depending upon the year. The remaining two DO loops locate the two regions which comprise this particular pair from among the 51 unique regions so a match can be found and used in Section 11 for purposes of printing and punching the appropriate values of the Buying Power Index.

C.1.4 Output

The first statement in Section 11 prints all the necessary information calculated in the sections above in the same format of a punched card. The second statement punches a card for each case in which flights and fares were matched in Section 9. As mentioned earlier, during the last execution of this program, there were no such eliminations. The last four statements of the program are END statements to the various DO groups which allow for accurate flow of the program logic.

C.2 Calculation of the Actual Average Fare

The program to compute the actual average fare is listed in Figure C.3. It also was written in PL/I and executed on an IBM Model 370 computer. It accepts data cards punched by the LOSFARE program in addition to data cards punched from Table 12 of the C.A.B. Origin-Destination Survery of Airline Passenger traffic, computes the actual average fare and punches new data cards which are identical to those punched by LOSFARE, except for the new fare index. Similar to LOSFARE, this program was also broken down into sections for easier documentation. In addition, a table of definitions of some of the variables was included in the declaration section prior to the start of Section 1 of the program.

C.2.1 Determination of Fares for the Various Classes and Airport Pairs

In general, all domestic airline fares are multiples of one fare which is regulated by the C.A.B. Currently, the Board regulates the domestic day coach fare and then defines all other fares in terms of this. Even in the few markets where there is airline service without a Y class fare being offered, a Y class fare is defined since the formula for its calculation is based upon distance. Examples of this type of market might be those served exclusively by local service carriers nearly all of which offer S class fares exclusively. This program utilizes what is called a key fare and then, in a similar manner, defines all other fares in terms of this key fare. However, instead of working with the region pair distance to define the Y fare, it begins with those fares published in the Official Airline Guide and read and stored from the FARE card. Consequently, several key cards are necessary so that there is at least one instance where a match exists between the set of key cards and the set of fares on the FARE card for each region pair in 1968 (recall that this program is being executed for 1968 only). Several RATE cards were prepared for use with this program on which one key fare was punched and the multiples by which this fare would have to be multiplied in order to arrive at all the other basic fares. The loop in Section 1 of this program reads a maximum of 10 of these cards, stores the respective fare classes in the array variable CLS and the ratios in the array variable RATIO and indexes each of these variables by the array KEY. The program senses the end of the RATE card deck when it fails to find "RATE" in the first five card columns. At this point, it executes the final statement of the section by reading the first region pair data card (one of those punched by the program in Fig. C.3) and control is then transferred into Section 2. Section 2 is nothing more than a definition of the point to which flow returns for each region pair execution. The final card in the data deck is blank for which a year of 0 would be registered. When this is picked up and flow returns to the beginning of Section 2, the logic directs the flow to the final END statement and execution terminates.

Section 3 is similar to Section 2 in that it merely defines the point to which flow returns for each airport pair within each region pair. The few statements of Section 2 re-initialize those quantities which must be reset for each region pair execution. Similarly, Section 3 resets several values which must be zero before each airport pair execution. The demand data punched from Table 12 of the C.A.B. Origin-Destination Survey of Airline Passenger Traffic follows each of the region pair header cards punched by the LOSFARE program. The demand data is placed behind the header cards and, for each airport pair within the region pair, is followed by a FARE card giving the fare levels of the various fare classes for each airport pair. Thus, the data deck for this program consists of one group of cards for each region pair. Each card group consists of one header card punched by LOSFARE followed by as many groups of cards as there are airport pairs in which traffic was reported. For each of these sub-groups, there are one or more data cards followed by one FARE card.

The demand data for each airport pair is read and stored in the array variables PASS (traffic figures) and CLASS (corresponding fare classes) by the first loop in Section 4. If there is more than one demand card in this airport pair, an "L" appears in column 70. This loop is capable of reading as many as six cards for a single airport pair, the maximum found to exist in the data used for this program. In general, the last card of the airport pair demand deck will not be full and the second loop in this section computes the exact number of demand entries found in the input deck for this airport pair. The final loop examines all the data read and stored by the first loop for two possible occurrences. First, any single character fare classes were punched with a blank in the first column of the fare class field. For example, jet coach class was punched as ' Y'. For internal purposes, this should be'Y ' and this loop corrects this problem. The loop also changed 'UK' demand to 'R' class demand. This is due to a problem with the C.A.B. data itself. While the Board did define 77 fare classes for use in Table 12, it neglected to define the R class under which Mohawk Airlines wrote tickets between 1965 and 1972 over its entire system. While this is not a problem in most of the markets in this study since Mohawk was a small carrier, it proved to be a significant problem in the Albany-New York/Binghamton markets in which Mohawk was the dominant carrier. In these two markets, the C.A.B. published the majority of demand as being in the UK (unknown) fare class owing to its mistaken elimination of R class fares. By redefining all UK fares to be R fares, the problem was eliminated without precipitating another one since UK fares in markets in which Mohawk did not offer service accounted for less than one percent of total demand.

Behind each set of airport pair demand cards is one FARE card containing the fare levels for all the published fares for that airport pair. The three commands which comprise Section 5 read and store this data in the array variables FARE (fare classes) and CL (dollar amounts), and then M is set to be the number of entries that appear on the FARE card.

C.2.2 Construction of Fare Table

The basic table of fares for each airport pair is constructed using the routine in Section 6. It essentially expands the FARE and CL arrays in that it builds on the table of published fares read and stored in Section 5. The routine begins by matching a key fare to one of the fares on the FARE card; if no such match exists, then the variable G emerges from the outside loop with a value of 0. However, after debugging, this did not occur and each execution did find one match as a minimum. The key fare which is found to match is then used to construct the fare table. The first part of the routine in Section 6 checks to see that no fare which has been published, and therefore explicitly input using the FARE card, is duplicated through a multiplication of a ratio by the key fare. For all such fares not explicitly input and present on the key fare card, the second part of the routine carries out this multiplication and adds the calculated fare to the fare table. The final statement in the section was used primarily in debugging the program and prints a statement in the event that no match between the list of key fares and the list of fares from the FARE card can be found. In that event, no further calculations using this airport pair are done and control is transferred to consider the next airport pair.

Excursion, military and youth fares were available as derivatives from all basic classes in 1968 and were easily calculated by taking a certain percentage of the basic fare. In this case, excursion fares allowed a discount of 25% while military and youth fares allowed a discount of 50%. Section 7 is a short routine which expands the fare table in a manner similar to that in Section 6 to include these fares. The ratios for these calculations were read and stored in the array variables STCL (fare classes) and STFR (ratios) in the second-to-last statement in the declaration section of the program just prior to the start of Section 1.

C.2.3 Computation of Actual Average Fare

Section 8 is a short routine which comprises the essence of the program. For each demand by fare type read and stored from the demand (DOAD) cards into the CLASS array, the fare table stored in the array CL is checked until a match is found. Then the number of passengers who paid that fare (stored in PASS) is multiplied by the dollar amount of the fare (stored in FARE) and the total is added to a running total variable defined by TTL. The number of passengers considered thus far is stored in the running total variable PAX.

Section 9 completes the loop which is executed for each airport pair. One line is printed giving the total demand (PAX) in this airport pair as well as the average fare paid (TTL/PAX). Then, new running total variables are defined (GTL and TLPX) so that similar results for the region pair as a whole may be calculated at a later point in the process.

C.2.4. Output

Section 10 is the final section to be executed for each region pair. Its title reflects the fact that it begins at the point where the airport pair loop ends. In this section, a line is printed with its format identical to that of a punched card, and then a statement which directs the physical punching of the card follows. The section ends with the program reading the header card of the next region pair and returning to the beginning of Section 2.

Section 11 merely includes the card which terminates execution of the program. Its title reflects the fact that it begins at the point where the region pair loop ends.

C.3 Calculation of the Regression Results

The control cards of the P-STAT program which was used for the regression analyses are shown in Figure C.4. Included in this figure is the data deck produced by the LOSFARE program for the run which includes all region pairs and all years with the estimated average fare. Nearly the entire listing in Figure C.4 is data as the P-STAT control deck itself is relatively short.

The data is input following an SDATA card on which the format for the input data is explained. P-STAT requires that the dependent variable be the final one on the card. Definition of the data fields on the cards punched by the PL/I program for use in this P-STAT run is rather straightforward as shown below.

The few cards which actually execute the regression program appear following the 877 data cards on the final page of the listing in Figure C.4. The GENVAR card instructs the program to internally generate the set of variables by a series of numerical transformations which are listed on the cards following it. The TRCARD instructions tell the program which transformations are performed. These transformations serve to linearize the input data by taking logarithms as discussed in Section 5 of the text of this report. Products of the individual BPI's, LOS indices and frequencies are also accomplished by these statements. The *END card signals the end of this step and the cards following it instruct the program to generate the regression equations and associated correlation matrices along with other pertinent information in the final analysis of the equations themselves.

63BGMALB	13.18	0.3843	0.6881	0.1804	0.2339	4.	6.	639.
Year / Region R / Region S	Fare Index	BPI in region R	BPI in region S	LOS from R to S	LOS from S to R	FREQ from R to S	FREQ from S to R	Two-way demand between R and S

FIGURE C.2: Source List of Program LOSFARE

```
COMPILER          LOSFARE: PROCEDURE OPTIONS(MAIN);

    SOURCE LISTING

LOSFARE: PROCEDURE OPTIONS(MAIN);
/*
     THIS PROGRAM COMPUTES A LEVEL OF SERVICE INDEX FOR AIR TRANSPORTATION
OF PASSENGERS BASED ON A GIVEN SCHEDULE OF FLIGHTS.  IT ALSO CALCULATES THE
AVERAGE FARE PAID PER TICKET BASED ON THE LOWEST FARES AVAILABLE ON DEMAND
FOR EACH FLIGHT OPERATED.
*/
DECLARE (YEAR,Z,F(2),DHR,DMIN,AHR,AMIN,CPI(16),D(120),A(120),LOS(2),
 BOD,BPI(51,16),TOTAL(3),FR(8,8),AVFARE(8),PAX(8),SOD,DS,AD,
  PASS(37,16)) FLOAT;
DECLARE (G,H,P) FIXED BINARY;
DECLARE (CITY(2), REF(51)) CHARACTER(3), (DMER,AMER,CODE(120))
 CHARACTER(1), CNFF CHARACTER(10), (THER,ID) CHARACTER(5), (CLASS(120),
  CL(8),CNCLASS(2),TABLE(12),CLS(8)) CHARACTER(2);
DECLARE PUNCH FILE OUTPUT;
/*
  1. READ CPI DATA, CLASS DATA AND BPI DATA
*/
GET EDIT ((CPI(I) DO I=1 TO 16)) (COL(1),16(F(5,3)));
 GET EDIT ((TABLE(I) DO I=1 TO 12)) (COL(1),12(A(2),X(1)));
  DO I=1 TO 51;
   GET EDIT (REF(I), (BPI(I,J) DO J=1 TO 8))
    (COL(1),X(14),A(3),X(6),8(F(6,4)));
     GET EDIT((BPI(I,J) DO J=9 TO 16))
      (COL(1),X(17),8(F(6,4)));
       END;
/*
  2. READ DEMAND DATA
*/
GET EDIT(ID) (COL(1),A(5));
 DO WHILE (ID='CITY ');
  GET EDIT(G,DS) (COL(6),F(3),F(5));
   PASS=0;
    DO N=1 TO 2;
     K=((N-1)*8)+1;
      L=K+7;
      DO I=1 TO G;
       GET EDIT(ID,(PASS(I,J) DO J=K TO L))
        (COL(1),A(5),X(6),8(F(6),X(1)));
         END;
          DO WHILE (ID¬='TOTAL');
           GET EDIT(ID) (COL(1),A(5));
            END;
             GET EDIT((PASS(37,J) DO J=K TO L)) (X(6),8(F(6),X(1)));
              END;
/*
```

```
COMPILER          LOSFARE: PROCEDURE OPTIONS(MAIN);

   3.  CALCULATE AVERAGE REGION FARE FOR EACH FARE CLASS
 */
 GET EDIT(ID)  (COL(1),A(5));
  DO WHILE (ID='FARE ');
   FAX=0;
    FR=0;
     AVFARE=0;
      CLS='  ';
       DO J=1 TO 6 WHILE (ID='FARE ');
        GET EDIT ((FR(I,J), CL(I) DO I=1 TO 8), YEAR)
         (COL(6),8(F(6,2),A(2)),X(3),F(2));
          DO I=1 TO 8 WHILE (CL(I)¬='  ');
          IF SUBSTR(CL(I),2,1)='J' & SUBSTR(CL(I),1,1)¬='F'
          THEN CL(I)=SUBSTR(CL(I),1,1)||' ';
           DO K=1 TO 8 WHILE (CLS(K)¬='  ' & CLS(K)¬=CL(I));
           END;
            IF CLS(K)='  ' THEN CLS(K)=CL(I);
             AVFARE(K)=AVFARE(K)+FR(I,J)*PASS(J,YEAR-58);
              IF FR(I,J)¬=0 THEN FAX(K)=FAX(K)+PASS(J,YEAR-58);
               END;
                GET EDIT(ID)  (COL(1),A(5));
                 END;
                  DO K=1 TO 8 WHILE (CLS(K)¬='  ');
                   AVFARE(K)=AVFARE(K)/FAX(K);
                    END;
                     TOTAL=0;
                      P=0;
 /*
   4.  READ CITY PAIR DATA
 */
 DO L=1 TO 2;
  GET EDIT (CITY(L),F(L),Z,SCD) (COL(6),A(3),2(F(3)),X(3),F(4));
   N=F(L);
    AD=0.0;
     CODE=' ';
 /*
   5.  READ AND TRANSFORM FLIGHT DATA
 */
 DO I=1 TO N;
  GET EDIT(DHR,DMIN,DMER,AHR,AMIN,AMER,CODE(I),THFR,CNFR)
   (COL(1), 2(2(F(2)),A(1),X(1)),X(2),A(1),X(6),A(5),X(8),A(10));
    IF DMER='P' & DHR¬=12  THEN DHR=DHR+12;
     IF AMER='P' & AHR¬=12 THEN AHR=AHR+12;
      D(I)=.01*((100*DHR+5*DMIN/3)-SCD);
       A(I)=.01*((100*AHR+5*AMIN/3)-SCD)-Z;
 /*
   6.  DETERMINE LOWEST AVAILABLE FARE FOR DIRECT FLIGHTS
 */
 IF CODE(I)=' '
```

```
  THEN DO;
   DO K=4 TO 1 BY -1 WHILE (SUBSTR(THFR,K,2)='  ');
    END;
     CLASS(I)=SUBSTR(THFR,K,2);
      IF YEAR>64 & CLASS(I)='N '
       THEN CLASS(I)=SUBSTR(THFR,K-1,2);
        IF YEAR<65 & CLASS(I)='C ' & K>1 THEN
         IF SUBSTR(THFR,K-1,2)¬='TC' THEN CLASS(I)='C ';
          ELSE CLASS(I)='TC';
           END;
/*
  7. DETERMINE LOWEST AVAILABLE FARE FOR CONNECTING FLIGHTS
*/
ELSE DO;
 J=0;
  DO M=1 TO 2;
   IF M=1 THEN DO K=2 TO 5 WHILE (CODE(I)¬=SUBSTR(CNFR,K,1));
     END;
      ELSE DO J=4 TO 1 BY -1 WHILE (SUBSTR(CNFR,K+J,2)='  ');
       END;
        CNCLASS(M)=(SUBSTR(CNFR,K+J+M-2,M));
         IF YEAR>64 & CNCLASS(M)='N '
          THEN CNCLASS(M)=SUBSTR(CNFR,K+J+M-3,2);
           IF YEAR<65 & CNCLASS(M)='C ' & K+J+M-2>1 THEN
           IF SUBSTR(CNFR,K+J+M-3,2)¬='TC' THEN CNCLASS(M)='C ';
            ELSE CNCLASS(M)='TC';
             END;
                 IF CNCLASS(1)=CNCLASS(2)  THEN CLASS(I)=CNCLASS(1);
              ELSE DO;
              DO K=1 TO 12 WHILE (CNCLASS(1)¬=TABLE(K));
               END;
                DO J=1 TO 10 WHILE (CNCLASS(2)¬=TABLE(J));
                 END;
               IF K=11 | J=11 THEN CLASS(I)='Y ';
                ELSE IF K<J THEN CLASS(I)=CNCLASS(1);
                       ELSE CLASS(I)=CNCLASS(2);
                        END;
                         END;
                          END;
/*
  8. DETERMINE END OF DAY FOR DEMAND PURPOSES
*/
IF D(N)>.01*(2000-SCD) THEN EOD=D(N);
  ELSE EOD=.01*(2000-SCD);
/*
  9. COMPUTE AVERAGE FARE. USE NEXT HIGHEST FARE FOR CLASSES WHICH HAVE NO
*/
DO I=1 TO N;
 IF I¬=1 THEN AD=AD+A(I)*(D(I)-D(I-1));
```

```
COMPILER        LOSFARE: PROCEDURE OPTIONS(MAIN);


 DO K=1 TO 8 WHILE (CLASS(I)¬=CLS(K));
  END;
   IF K=9 & CODE(I)='/' & CLASS(I)='K ' THEN CLASS(I)='Y ';
   DO J=1 TO 12 WHILE (CLASS(I)¬=TABLE(J) & K=9);
    END;
     DO H=J TO 1 BY -1 WHILE (K=9);
      DO K=1 TO 8 WHILE (TABLE(H)¬=CLS(K));
       END;
        END;
         IF H=0 THEN DO H=J+1 TO 10 WHILE (K=9);
          DO K=1 TO 8 WHILE (TABLE(H)¬=CLS(K));
           END;
            END;
             IF J=11 THEN P=1;
             IF J=8 | J=11 | J=13 THEN DO;
              P=1;
               PUT SKIP EDIT (D(I)) (F(9,4));
                END;
              ELSE IF I=1
               THEN TOTAL(L)=TOTAL(L)+(D(1)+EOD-D(N))*AVFARE(K)/EOD;
                ELSE TOTAL(L)=TOTAL(L)+(D(I)-D(I-1))*AVFARE(K)/EOD;
                 END;
/*
  10. COMPUTE LEVEL OF SERVICE INDEX, DISCOUNTED FARES AND FIND BPI
*/
LOS(L)=(0.5+DS/(550+2*20))/((A(1)*(D(1)-D(N))+AD)/EOD+EOD/2-D(N)+A(1));
 END;
  TOTAL(3)=(TOTAL(1)+TOTAL(2))/(2*CPI(YEAR-58));
   DO J=1 TO 51 WHILE (REF(J)¬=CITY(1));
    END;
     DO K=1 TO 51 WHILE (REF(K)¬=CITY(2));
      END;
/*
  11. PRINT TABLE
*/
PUT SKIP EDIT(YEAR,CITY(1),CITY(2),TOTAL(3),BPI(J,YEAR-58),
 BPI(K,YEAR-58),LOS(1),LOS(2),F(1),'.',F(2),'.',PASS(37,YEAR-58),'.')
   (F(2),2(A(3)),F(8,2),4(F(8,4)),2(X(4),F(3),A(1)),F(7),A(1));
IF P=0 THEN PUT FILE (PUNCH) EDIT (YEAR,CITY(1),CITY(2),TOTAL(3),
 BPI(J,YEAR-58),BPI(K,YEAR-58),LOS(1),LOS(2),F(1),'.',F(2),'.',
  PASS(37,YEAR-58),'.')
   (COL(1),F(2),2(A(3)),F(8,2),4(F(8,4)),2(X(4),F(3),A(1)),F(7),A(1));
          GET EDIT(ID) (COL(1),A(5));
           END;
            END;
             END LOSFARE;
```

Figure C.3: Source List of Modified Program to Compute the Actual Average Fares

```
COMPILER              LOSFARE: PROCEDURE OPTIONS(MAIN);

   SOURCE LISTING

LOSFARE: PROCEDURE CPTICNS(MAIN);
DECLARE (YEAR, FARE(5C), TTL, PAX, PASS(50), RATIO(10,50), GTL, TLPX,
 BPI(2), LOS(2), NF(2), DEMAND, KE(10), STFR(3)) FLOAT(8);
DECLARE (AP(2), CITY(2)) CHARACTER(3), (CODE, KEY(10), STCL(3))
 CHARACTER(1), (CLASS(50), CL(50), CLS(10,50)) CHARACTER(2), ID
  CHARACTER(5);
DECLARE (C, E, F, G) FIXED BINARY;
/*
      DEFINE VARIABLES
       CL    = FARE CLASS ON FARE CARD
       CLASS = FARE CLASS ON DOAD CARD
       CLS   = FARE CLASS CN RATE CARD
       C = NUMBER OF EXCURSION FARES COMPUTED
       E = INDEX OF KEY FARE
       F = NUMBER OF KEY FARE CARDS INPUT
       G = NUMBER OF EXTRA FARE CLASSES COMPUTED
       K = INDEX OF KEY FARE ON FARE CARD
       L = NUMBER OF CLASSES/FARES TO BE COMPUTED FROM A PARTICULAR KEY CARI
       M = NUMBER OF CLASSES/FARES EXPLICITLY INPUT ON FARE CARD
       N = NUMBER OF DEMANDS/CLASSES INPUT ON DOAD CARD
*/
F=0;
GET EDIT (ID, ((STCL(I), STFR(I)) DO I=1 TO 3))
 (COL(1), A(5), 3(A(1), X(2), F(4,2), X(1)));
GET EDIT (ID) (COL(1), A(5));
/*
  1. READ KEY CARDS
*/
DO I=1 TO 10 WHILE (ID='RATE ');
    F=F+1;
    GET EDIT (KEY(I), ((CLS(I,J), RATIO(I,J)) DO J=1 TO 9))
     (COL(6), A(1), X(1), 9(A(2), X(1), F(4,2), X(1)));
    DO J=1 TO 9 WHILE (CLS(I,J)¬='  ');
        END;
    KE(F) = J-1;
    GET EDIT (ID) (COL(1), A(5));
    END;
GET EDIT (YEAR, CITY(1), CITY(2), BPI(1), BPI(2), LOS(1), LOS(2),
 NF(1), NF(2), DEMAND)
 (COL(1), F(2), 2(A(3)), X(8), 4(F(8,4)), 3(F(8,0)));
/*
  2. ITERATE FOR EACH REGION PAIR FROM THIS POINT
*/
DO WHILE (YEAR¬=0);
GTL=0;
TLPX=0;
```

```
COMPILER          LOSFARE: PROCEDURE OPTIONS(MAIN);


GET EDIT (ID) (COL(1), A(5));
/*
  3. ITERATE FOR EACH AIRPORT PAIR FROM THIS POINT
*/
DO WHILE (ID='DOAD ');
     PAX=0;
     TTL=0;
     D=C;
     G=0;
     CODE='L';
/*
   4. READ DEMAND DATA
*/
DO J=1 TO 6 WHILE (CODE='L');
     GET EDIT (((PASS(I), CLASS(I)) DO I=(8*J-7) TO (8*J)), CODE,
      AP(1), AP(2))
       (COL(6), 8(F(6), A(2)), A(1), X(4), 2(A(3)));
     END;
DO I=(8*J-15) TO (8*J-8) WHILE (CLASS(I)¬='  ');
     END;
N=I-1;
DO I=1 TO N;
     IF SUBSTR(CLASS(I),1,1)=' ' THEN CLASS(I)=SUBSTR(CLASS(I),2,1);
     IF CLASS(I) = 'LK' THEN CLASS(I) = 'R ';
     END;
/*
   5. READ FARE DATA
*/
GET EDIT (((FARE(I), CL(I)) DO I=1 TO 8)) (COL(6), 8(F(6), A(2)));
DO I=1 TO 8 WHILE (CL(I)¬='  ');
     END;
M=I-1;
/*
   6. CONSTRUCT FARE TABLE
*/
DO E=1 TO F WHILE (G=0);
     DO K=1 TO M WHILE (CL(K)¬=KEY(E));
          END;
     L=KE(F);
     IF K<=M THEN DO J=1 TO L;
          DO I=1 TO M WHILE (CL(I)¬=CLS(E,J));
               END;
          IF I>M THEN DO;
               G=G+1;
               FARE(G+M) = RATIO(E,J)*FARE(K);
               CL(G+M) = CLS(E,J);
               END;
          END;
     END;
```

```
COMPILER        LOSFARE: PROCECURE OPTIONS(MAIN);

 IF G=0 THEN PUT SKIP EDIT ('KEY FARE NOT FOUND', AP(1), AP(2))
  (A(18), X(1), 2(A(3)));
  ELSE DO;
/*
  7. CALCULATE EXCURSION, MILITARY AND YOUTH FARES
*/
DO I=1 TO (G+M);
    IF SUBSTR(CL(I),2,1)=' ' THEN DO;
        D=D+1;
        DO J=(D*3-2) TO (D*3);
            CL(G+M+J) = SUBSTR(CL(I),1,1)||STCL(J-((D-1)*3));
            FARE(G+M+J) = STFR(J-((D-1)*3))*FARE(I);
            END;
        END;
    END;
/*
  8.  CALCULATE RESULTS
*/
DO I=1 TO N;
    DO J=1 TO (G+M+(D*3)) WHILE (CLASS(I)¬=CL(J));
        END;
    IF J<=(G+M+(D*3)) THEN DO;
        TTL = TTL + FARE(J)*PASS(I);
        PAX = PAX + PASS(I);
        END;
    END;
/*
   9.  PRINT RESULTS
*/
PUT SKIP EDIT (YEAR, AP(1), AP(2), PAX, TTL/PAX)
(F(2), 2(A(3)), F(6), X(1), F(6,2));
GTL = GTL + TTL;
TLPX = TLPX + PAX;
END;
GET EDIT (ID) (COL(1), A(5));
END;
/*
  10. END OF AIRPORT PAIR ROUTINE
*/
IF G¬=C THEN DO;
    PUT SKIP EDIT (YEAR, CITY(1), CITY(2), GTL/TLPX/1.042, BPI(1),
     BPI(2), LOS(1), LOS(2), NF(1), '.', NF(2), '.', DEMAND, '.')
      (F(2), 2(A(3)), F(8,2), 4(F(8,4)), 3(F(7), A(1)));
    PUT FILE (PUNCH) EDIT (YEAR, CITY(1), CITY(2), GTL/TLPX/1.042,
     BPI(1), BPI(2), LOS(1), LOS(2), NF(1), '.', NF(2), '.', DEMAND,
      '.')
       (COL(1),F(2), 2(A(3)), F(8,2), 4(F(8,4)), 3(F(7), A(1)));
    END;
GET EDIT (YEAR, CITY(1), CITY(2), BPI(1), BPI(2), LOS(1), LOS(2),
```

```
COMPILER        LOSFARE: PROCEDURE OPTICNS(MAIN);

 NF(1), NF(2), DEMAND)
 (CCL(1), F(2), 2(A(3)), X(8), 4(F(8,4)), 3(F(8,0)));
END;
/*
  11. END OF REGION PAIR RCUTINE
*/
ENC LOSFARE;
```

Figure C.4: P-STAT Control Cards and Sample Input Data Deck

```
P-STAT, VERSION 3.06, REVISION 3,  APRIL 20,1975
 150 VARIABLE SIZE.  COPYRIGHT(C) 1971, 1975, ROALD BUHLER
SEE PAGE 7 OF THE P-STAT 3.06 REVISION 3 MANUAL (DATED APRIL 20,1975)
FOR SOME NEW FEATURES ADDED IN THIS REVISION.

         .......... P-STAT INPUT ..........

         HEAD=(M.I.T. FLIGHT TRANSPORTATION LABORATORY)$
         SDATA=X,NV=8,FORMAT=(8X,8F8.0)$
         63BGMALB   13.18  0.3843  0.6881  0.1804  0.2339      4.      6.     639.
         63BNACVG   21.43  0.5691  0.9573  0.2300  0.2221      4.      4.    1047.
         63CVGATL   30.07  0.9573  0.9448  0.2906  0.3028      5.      8.    2004.
         63DALATL   50.75  1.2409  0.9448  0.4393  0.3366      6.      6.    3716.
         63DENCLE   85.87  0.7445  2.2838  0.5167  0.3313      8.      6.    1462.
         63DTTATL   42.02  2.7434  0.9448  0.3322  0.3256      5.      5.    3158.
         63DTTBOS   44.91  2.7434  3.3283  0.3776  0.4100     19.     16.    8178.
         63DTTCLE   10.95  2.7434  2.2838  0.5427  0.4597     25.     24.    8371.
         63ERIDTT   18.43  0.2242  2.7434  0.3457  0.3686      7.      7.     743.
         63HOUDTT   81.91  1.0150  2.7434  0.2964  0.3337      4.      6.    1177.
         63JANDAL   30.74  0.2037  1.2409  0.2598  0.2906      5.      6.    1344.
         63LASLAS   28.90  0.1301  0.1301  0.2786  0.2844      3.      5.    3171.
         63LBBDAL   22.47  0.1838  1.2409  0.3540  0.2979      8.      7.    4769.
         63LNKOMA    7.69  0.1747  0.4159  0.3093  0.3036      8.      8.     331.
         63MEMTYS   27.74  0.6784  0.3398  0.3715  0.2992      8.      7.    1589.
         63MIACVG   58.80  1.0456  0.9573  0.3958  0.3062      6.      5.    4813.
         63MIALAX  152.78  1.0456  5.7790  0.5435  0.6332      4.      7.    4800.
         63MKECHI   10.42  1.1082  4.8304  0.6903  0.5974     31.     30.    4194.
         63MOTBIS   14.51  0.0965  0.0718  0.2382  0.1597      5.      6.     193.
         63MSPFAR   18.57  1.3764  0.1698  0.2987  0.3139      5.      5.    2597.
         63MSYATL   33.56  0.8763  0.9448  0.5420  0.4595     11.     14.    4603.
         63MSYHOU   24.50  0.8763  1.0150  0.5750  0.5470     22.     24.   12862.
         63MSYLAS  106.43  0.8763  0.1301  0.2154  0.4012      1.      2.     282.
         63NYCALB   15.02 10.6621  0.6881  0.4344  0.4521     16.     18.   11585.
         63NYCCHI   48.45 10.6621  4.8304  0.7169  0.6796     49.     54.  100701.
         63NYCDEN  104.74 10.6621  0.7445  0.5579  0.5917     13.     17.    9001.
         63NYCMKC   74.09 10.6621  1.1830  0.4668  0.5141     15.     12.    8945.
         63OMACHI   32.33  0.4159  4.8304  0.4034  0.4147     10.      9.    7023.
         63ORFPHL   20.62  0.4957  3.7896  0.2876  0.2580      9.     10.    3321.
         63PDXDAL  136.53  0.7674  1.2409  0.2078  0.2123      1.      1.     333.
         63PITALB   30.29  1.8690  0.6881  0.2273  0.2778      5.      5.    1456.
         63PITCVG   24.23  1.8690  0.9573  0.2660  0.3066      4.      4.    2648.
         63PITDAY   20.34  1.8690  0.5605  0.3061  0.2858      8.      5.    2010.
         63RICORF   10.25  0.4411  0.4957  0.2672  0.2055      4.      3.     348.
         63RICRDU   13.94  0.4411  0.6121  0.4458  0.3310     11.      9.     596.
         63ROCCHI   36.15  0.5400  4.8304  0.3190  0.3567      9.      8.    3511.
         63SACRNO   11.74  0.5757  0.1155  0.3944  0.3390     10.     10.    3249.
         63SANDEN   61.82  0.6577  0.7445  0.4119  0.4331      6.      7.    1858.
         63SEADEN   72.45  1.1411  0.7445  0.2767  0.3407      4.      5.    2460.
         63SEASAN   73.72  1.1411  0.6577  0.3693  0.4232      5.      7.    2374.
         63SFOLAS   34.07  2.8126  0.1301  0.3610  0.3213      7.      6.   11472.
         63SFOOMA  102.80  2.8126  0.4159  0.4140  0.3626      5.      3.    1732.
         63SFOSTL  109.87  2.8126  1.6391  0.4760  0.4063      9.      6.    3212.
         63STLDAY   28.73  1.6391  0.5605  0.2812  0.2570      6.      5.    1230.
         63STLMKC   19.27  1.6391  1.1830  0.4693  0.4677     13.     13.   10372.
         63STLOKC   35.21  1.6391  0.5254  0.3051  0.3173      5.      6.    1492.
         63TUSCHI  105.77  0.2115  4.8304  0.5094  0.3185      3.      4.    2310.
         63WASHOU   83.24  1.6064  1.0150  0.4020  0.4076      9.      8.    1974.
```

51	63WASMIA	63.33	1.6064	1.0456	0.3974	0.4280	12.	9.	12168.
52	63WASNYC	16.69	1.6064	10.6621	0.5664	0.5459	75.	82.	122443.
53	63WASPDX	153.58	1.6064	0.7674	0.3159	0.5063	5.	5.	505.
54	64BGMALB	14.27	0.3763	0.6800	0.1900	0.1817	6.	4.	671.
55	64BNACVG	21.15	0.5738	0.9480	0.2199	0.2470	4.	5.	1183.
56	64CVGATL	29.08	0.9480	0.9582	0.4217	0.3053	8.	8.	2233.
57	64CVGMIA	64.52	0.9480	1.1021	0.5377	0.3618	11.	6.	5477.
58	64DALATL	52.52	1.2221	0.9582	0.5240	0.4516	7.	7.	4346.
59	64DENCLE	85.34	0.7565	2.2182	0.5605	0.3954	10.	9.	1467.
60	64MIALAX	150.81	1.1021	5.9128	0.5453	0.6564	4.	9.	5837.
61	64DTTATL	41.04	2.7811	0.9582	0.3356	0.3127	4.	6.	3820.
62	64DTTBOS	44.80	2.7811	3.3187	0.3594	0.3915	12.	17.	8753.
63	64DTTCLE	10.87	2.7811	2.2182	0.5764	0.4871	29.	26.	8774.
64	64ERIDTT	18.19	0.2229	2.7811	0.2463	0.2638	6.	6.	736.
65	64NYCCHI	48.20	10.4525	4.7793	0.7673	0.6922	55.	58.	114904.
66	64HOUDTT	83.28	1.0237	2.7811	0.3377	0.3801	5.	8.	1384.
67	64JANDAL	31.13	0.2038	1.2221	0.2782	0.2765	5.	5.	1311.
68	64LBBDAL	22.32	0.1911	1.2221	0.3773	0.3616	8.	9.	5497.
69	64MEMTYS	27.73	0.6902	0.3528	0.3246	0.2972	7.	8.	1796.
70	64MKECHI	10.05	1.0858	4.7793	0.5797	0.5903	34.	27.	4790.
71	64MKEDAY	25.24	1.0858	0.5613	0.2396	0.2119	9.	6.	456.
72	64MOTBIS	14.28	0.0935	0.0666	0.2462	0.2151	5.	5.	268.
73	64MSPFAR	17.80	1.3610	0.1614	0.3133	0.3511	6.	6.	2790.
74	64MSYATL	33.84	0.8874	0.9582	0.5369	0.4695	11.	15.	5057.
75	64MSYHOU	23.44	0.8874	1.0237	0.6125	0.5851	23.	22.	13910.
76	64MSYLAS	105.06	0.8874	0.1589	0.3391	0.4504	3.	3.	328.
77	64NYCALB	14.75	10.4525	0.6800	0.3988	0.4576	21.	19.	12255.
78	64NYCDEN	105.24	10.4525	0.7565	0.5873	0.6296	17.	17.	10277.
79	64NYCMKC	74.36	10.4525	1.1685	0.4727	0.5207	16.	14.	10802.
80	64OMACHI	32.50	0.4128	4.7793	0.4286	0.4771	9.	9.	7971.
81	64OMALNK	7.59	0.4128	0.1711	0.3418	0.3198	8.	8.	341.
82	64ORFPHL	21.48	0.5093	3.7759	0.2770	0.2744	13.	11.	3301.
83	64ORFRIC	10.12	0.5093	0.4489	0.2354	0.2132	5.	4.	385.
84	64PDXDAL	134.77	0.7853	1.2221	0.2030	0.2089	1.	1.	534.
85	64PITALB	30.36	1.8472	0.6800	0.2227	0.2715	6.	6.	1341.
86	64PITCVG	23.65	1.8472	0.9480	0.2645	0.3097	4.	5.	3008.
87	62PITDAY	20.81	1.9172	0.5634	0.2731	0.2724	5.	5.	1894.
88	64PITDAY	19.63	1.8472	0.5613	0.3009	0.2739	6.	6.	2245.
89	64RICCLE	33.85	0.4489	2.2182	0.2200	0.2134	5.	6.	668.
90	64RICRDU	12.64	0.4489	0.6213	0.2561	0.4536	7.	11.	659.
91	64RNOLAS	28.53	0.1220	0.1589	0.3188	0.3208	4.	4.	3402.
92	64ROCCHI	36.89	0.5310	4.7793	0.4061	0.3902	11.	10.	4043.
93	64SACRNO	12.11	0.5752	0.1220	0.3524	0.3276	10.	12.	3586.
94	64SANDEN	61.92	0.6515	0.7565	0.4418	0.4390	9.	11.	2298.
95	64SEADEN	82.03	1.1071	0.7565	0.3829	0.3227	4.	4.	2573.
96	64SEASAN	78.94	1.1071	0.6515	0.4136	0.3641	9.	8.	3076.
97	64SFOLAS	34.48	2.8156	0.1589	0.4297	0.4176	8.	8.	10541.
98	64SFOSTL	108.45	2.8156	1.6257	0.5718	0.4504	7.	5.	4360
99	64SFOOMA	101.57	2.8156	0.4128	0.4135	0.3805	4.	4.	1994
100	64STLDAY	28.19	1.6257	0.5613	0.2987	0.2320	9.	4.	1343

101	64STLMKC	19.01	1.6257	1.1685	0.4711	0.4117	15.	14.	11632.
102	64STLOKC	34.62	1.6257	0.5355	0.2861	0.3016	4.	4.	1717.
103	64TUSCHI	97.91	0.2043	4.7793	0.5841	0.3712	4.	5.	2506.
104	64TUSSAT	45.91	0.2043	0.4858	0.2720	0.2826	2.	2.	214.
105	64WASHOU	93.51	1.6027	1.0237	0.4337	0.4852	10.	8.	2153.
106	64WASMIA	56.63	1.6027	1.1021	0.4272	0.4545	9.	6.	13021.
107	64WASNYC	16.74	1.6027	10.4525	0.5521	0.6525	69.	66.	134621.
108	64WASPDX	151.92	1.6027	0.7853	0.1986	0.5366	3.	6.	667.
109	64WASPWM	40.85	1.6027	0.3476	0.2330	0.2127	4.	4.	710.
110	65BNACVG	20.79	0.5714	0.9411	0.2159	0.2379	5.	5.	1231.
111	65BNAMKE	43.49	0.5714	1.0710	0.1504	0.1194	1.	1.	238.
112	65CVGATL	27.68	0.9411	0.9779	0.4193	0.3852	9.	9.	2862.
113	65DALATL	50.07	1.2312	0.9779	0.5269	0.4369	8.	7.	5203.
114	65DENCLE	81.29	0.7483	2.2327	0.5175	0.4967	11.	10.	1697.
115	65DIALAX	148.25	1.1120	5.9205	0.5484	0.7064	11.	12.	8143.
116	65DTTATL	41.47	2.8307	0.9779	0.4028	0.3753	8.	5.	4316.
117	65DTTBOS	42.58	2.8307	3.3076	0.4422	0.4448	17.	17.	10541.
118	65DTTCLE	10.94	2.8307	2.2327	0.6149	0.5445	25.	25.	9108.
119	65ERIDTT	17.88	0.2229	2.8307	0.3002	0.3163	6.	6.	921.
120	65HOUDTT	81.70	1.0491	2.8307	0.3383	0.3878	7.	8.	1593.
121	65JANDAL	29.16	0.2084	1.2312	0.2783	0.3054	5.	6.	1431.
122	65LBBDAL	22.13	0.1909	1.2312	0.4423	0.4054	9.	12.	6208.
123	65MEMTYS	27.34	0.7136	0.3500	0.3683	0.3221	8.	8.	2150.
124	65MIACVG	60.56	1.1120	0.9411	0.4165	0.4741	8.	8.	6375.
125	65MKECHI	9.97	1.0710	4.7964	0.6051	0.7027	35.	35.	5831.
126	65MKEDAY	24.55	1.0710	0.5746	0.2274	0.2335	8.	7.	574.
127	65HOTBIS	15.36	0.0919	0.0657	0.2564	0.2291	5.	5.	261.
128	65MSPFAR	17.28	1.3384	0.1612	0.2798	0.3162	6.	5.	3704.
129	65MSYATL	33.14	0.9037	0.9779	0.6665	0.5311	13.	14.	5959.
130	65MSYHOU	24.08	0.9037	1.0491	0.5371	0.4649	17.	16.	16467.
131	65MSYLAS	92.12	0.9037	0.1583	0.3391	0.4397	3.	3.	540.
132	65NYCALB	14.42	10.5371	0.6733	0.4900	0.4089	23.	19.	15604.
133	65NYCCHI	47.30	10.5371	4.7964	0.7931	0.7399	64.	73.	129982.
134	65NYCDEN	101.89	10.5371	0.7483	0.5811	0.5539	10.	14.	13153.
135	65NYCMKC	71.43	10.5371	1.1754	0.5147	0.5723	23.	23.	13076.
136	65OMACHI	33.54	0.4071	4.7964	0.4292	0.4772	11.	10.	8695.
137	65OMALNK	8.28	0.4071	0.1681	0.3201	0.2908	8.	8.	373.
138	65ORFPHL	20.36	0.5131	3.7988	0.3018	0.2865	15.	8.	3637.
139	65PDXDAL	114.76	0.7827	1.2312	0.2881	0.3141	1.	1.	590.
140	65PDXWAS	143.73	0.7827	1.6364	0.6045	0.4649	7.	5.	936.
141	65PITALB	29.84	1.8345	0.6733	0.2361	0.2862	5.	6.	1751.
142	65PITCVG	22.76	1.8345	0.9411	0.2974	0.3274	7.	10.	3351.
143	65PITDAY	19.18	1.8345	0.5746	0.3072	0.3175	7.	8.	2451.
144	65RICCLE	30.07	0.4574	2.2327	0.2390	0.2036	4.	6.	731.
145	65RICORF	9.95	0.4574	0.5131	0.2327	0.2555	4.	5.	474.
146	65RICRDU	14.34	0.4574	0.6247	0.1715	0.3836	4.	10.	608.
147	65RNOLAS	28.57	0.1291	0.1583	0.3228	0.3222	6.	8.	3839.
148	65ROCCHI	36.40	0.5407	4.7964	0.4780	0.4211	10.	10.	4730.
149	65SACRNO	12.11	0.5737	0.1291	0.3597	0.4094	11.	12.	2923.
150	65SANDEN	58.93	0.6383	0.7483	0.4407	0.4852	8.	11.	2556.

151	65SEADEN	76.16	1.0909	0.7483	C.3559	0.3896	3.	5.	3241.
152	65SEASAN	74.92	1.0909	0.6383	C.4401	0.3757	10.	11.	3982.
153	65SFOLAS	26.33	2.8199	0.1583	0.4782	0.4032	8.	9.	13655.
154	65SFOSTL	107.95	2.8199	1.6125	C.5595	0.4293	9.	5.	5749.
155	65SFOOMA	103.76	2.8199	0.4071	0.4573	0.7374	7.	6.	2544.
156	65STLDAY	27.76	1.6125	0.5746	C.2965	0.2147	8.	4.	1513.
157	65STLMKC	18.77	1.6125	1.1754	C.5446	0.5035	20.	19.	13393.
158	65STLOKC	31.98	1.6125	0.5305	C.2967	0.3459	5.	7.	2020.
159	65TUSCHI	97.48	0.2027	4.7964	C.6369	0.3865	8.	8.	2873.
160	65TUSSAT	45.13	0.2027	0.4930	0.2357	0.2670	2.	2.	300.
161	65WASHOU	80.63	1.6364	1.0491	C.4552	0.4343	9.	10.	3131.
162	65WASMIA	58.06	1.6364	1.1120	0.4161	C.4275	16.	10.	16225.
163	65WASNYC	17.43	1.6364	10.5371	C.5733	0.6765	70.	73.	147873.
164	65WASPWM	40.16	1.6364	0.3494	0.3009	0.2817	5.	5.	916.
165	65BGMALB	14.00	0.3736	0.6733	0.1853	0.2461	5.	6.	993.
166	66BGMALB	13.85	0.3647	0.6697	0.1935	0.1747	4.	4.	973.
167	66BNACVG	17.40	0.5934	0.9219	0.2689	0.2809	5.	4.	1480.
168	66CVGATL	27.29	0.9219	1.0178	0.4575	0.4235	9.	10.	3330.
169	66DALATL	48.77	1.2705	1.0178	0.5833	0.4400	8.	10.	6823.
170	66DAYPIT	18.96	0.5801	1.7924	0.4002	0.3253	9.	8.	2899.
171	66DENCLE	75.04	0.7449	2.2374	0.4986	0.6310	11.	9.	2089.
172	66DTTATL	39.72	2.9035	1.0178	0.4556	0.4343	12.	8.	5360.
173	66DTTBOS	41.99	2.9035	3.2512	0.4317	0.4632	20.	23.	13142.
174	66DTTCLE	10.80	2.9035	2.2374	0.6026	0.5855	30.	27.	10423.
175	66ERIDTT	17.39	0.2233	2.9035	C.2806	0.2641	5.	5.	1057.
176	66PITCVG	21.96	1.7924	0.9219	C.3807	0.3750	8.	10.	3585.
177	66HOUDTT	72.40	1.0388	2.9035	0.4568	0.4272	11.	11.	2122.
178	66RICORF	9.67	0.4531	0.5098	0.2367	0.2524	4.	5.	383.
179	66RICRDU	14.22	0.4531	0.6240	0.0920	0.5489	2.	7.	434.
180	66JANDAL	27.18	0.2058	1.2705	C.2962	0.2974	7.	6.	1606.
181	66LBBDAL	21.14	0.1869	1.2705	C.4556	0.4056	9.	9.	7344.
182	66MEMTYS	26.52	0.7006	0.3535	C.3716	0.3098	10.	7.	2843.
183	66MIACVG	59.02	1.1122	0.9219	C.4584	0.5054	8.	9.	7343.
184	66MIALAX	142.21	1.1122	5.8494	0.5670	0.6697	7.	13.	8902.
185	66MKECHI	9.77	1.0795	4.8260	C.6368	0.6869	32.	33.	6874.
186	66MKEDAY	23.96	1.0795	0.5801	0.2507	0.2655	11.	6.	629.
187	66MOTBIS	14.97	0.0918	0.0649	0.2149	0.2205	4.	4.	243.
188	66MSPFAR	16.58	1.4017	0.1599	0.3445	0.3771	6.	7.	3543.
189	66MSYATL	31.96	0.9329	1.0178	0.5698	0.5138	12.	17.	7521.
190	66MSYHOU	23.31	0.9329	1.0388	C.6303	0.5520	20.	19.	17641.
191	66MSYLAS	100.41	0.9329	0.1559	0.3370	0.4375	2.	2.	678.
192	66NYCALB	13.83	10.3440	0.6697	0.5055	0.4810	20.	22.	18102.
193	66NYCCHI	45.20	10.3440	4.8260	0.7345	0.7477	68.	74.	140521.
194	66NYCDEN	97.84	10.3440	0.7449	C.5602	0.5340	12.	12.	15557.
195	66NYCMKC	69.24	10.3440	1.1923	0.5500	0.5707	23.	33.	14160.
196	66OMACHI	31.88	0.4023	4.8260	C.4421	0.4783	9.	11.	10111.
197	66OMALNK	7.87	0.4023	0.1721	0.2986	0.2805	7.	6.	333.
198	66ORFPHL	20.80	0.5098	3.7335	0.3046	0.3311	16.	14.	4270.
199	66PDXDAL	111.57	0.7979	1.2705	0.2893	0.3131	1.	1.	810.
200	66PDXWAS	141.20	0.7979	1.6435	0.6348	0.4527	9.	5.	1055.

201	66PITALB	29.01	1.7924	0.6697	0.2203	0.2772	5.	6.	1950.
202	66RICCLE	28.41	0.4531	2.2374	0.2337	0.2536	4.	5.	800.
203	66RNOLAS	27.78	0.1191	0.1559	C.3475	0.3242	5.	6.	4428.
204	66ROCCHI	34.97	0.5190	4.8260	0.4378	0.4873	11.	11.	6396.
205	66SACRNO	11.21	0.5848	0.1191	0.3635	0.4329	10.	10.	2928.
206	66SANDEN	58.50	0.6208	0.7449	0.4455	0.4425	9.	9.	3315.
207	66SEADEN	72.12	1.1319	0.7449	0.4700	0.4544	5.	5.	3861.
208	66SEASAN	69.55	1.1319	0.6208	0.4411	0.3215	10.	8.	4879.
209	66SFOLAS	25.88	2.7927	0.1559	C.4337	0.3864	9.	8.	16548.
210	66SFOOMA	92.75	2.7927	0.4023	0.4473	0.4760	4.	5.	3087.
211	66SFOSTL	105.15	2.7927	1.6210	0.5905	0.5041	13.	9.	7296.
212	66STLDAY	26.14	1.6210	0.5801	C.3194	0.2794	8.	5.	1521.
213	66STLMKC	17.98	1.6210	1.1923	0.5564	0.5328	20.	19.	13875.
214	66STLOKC	31.58	1.6210	0.5301	0.3254	0.3851	7.	7.	2316.
215	66TUSCHI	92.99	0.1919	4.8260	0.6769	0.4074	8.	8.	3396.
216	66TUSSAT	51.72	0.1919	0.4994	0.1951	0.2819	1.	2.	399.
217	66WASHOU	76.50	1.6435	1.0388	C.4905	0.4929	14.	14.	3331.
218	66WASMIA	61.03	1.6435	1.1122	C.4192	0.5084	9.	10.	16301.
219	66WASNYC	16.88	1.6435	10.3440	0.6267	0.7571	71.	74.	154084.
220	59BGMALB	12.57	0.4022	0.7293	0.1664	0.2285	4.	5.	882.
221	59BNACVG	20.16	0.5596	0.9565	0.2770	0.2403	5.	5.	983.
222	59CVGATL	30.98	0.9565	0.8724	0.2959	0.3348	7.	8.	1378.
223	59DALATL	57.80	1.1747	0.8724	0.3525	0.3070	7.	10.	2146.
224	59DENCLE	76.55	0.6928	2.3252	0.3810	0.2387	4.	3.	1006.
225	59DTTATL	45.70	2.8898	0.8724	0.2863	0.2746	6.	9.	2057.
226	59DTTBOS	48.30	2.8898	3.3804	C.3441	0.3516	20.	19.	5319.
227	59DTTCLE	9.73	2.8898	2.3252	0.5715	0.5193	32.	32.	10695.
228	59ERIDTT	16.04	0.2326	2.8898	0.3381	0.3037	8.	8.	896.
229	59NYCCHI	48.52	10.6708	4.8316	0.5409	0.5097	58.	61.	82645.
230	59HOUDTT	77.28	0.9433	2.8898	0.2528	0.2613	5.	6.	773.
231	59JANDAL	29.62	0.1915	1.1747	C.2655	0.2214	5.	4.	1059.
232	59LBBDAL	23.60	0.1962	1.1747	0.3136	0.3598	7.	8.	3262.
233	59MEMTYS	28.29	0.6836	0.3617	C.1841	0.2841	3.	5.	843.
234	59MIACVG	64.51	1.0000	0.9565	0.2994	0.2916	5.	5.	3682.
235	59MIALAX	171.33	1.0000	5.1367	0.3682	0.4243	7.	7.	3354.
236	59MKECHI	9.22	1.0772	4.8316	C.6200	0.5954	33.	32.	3567.
237	59MOTBIS	14.36	0.0976	0.0716	C.1883	0.1932	4.	4.	158.
238	59MSPFAR	18.21	1.3723	0.1764	0.4008	0.1733	4.	4.	2106.
239	59MSYATL	35.79	0.8685	0.8724	0.3898	0.3504	11.	15.	3105.
240	59MSYHOU	24.34	0.8685	0.9433	C.4174	0.3895	17.	18.	9020.
241	59NYCALB	13.75	10.6708	0.7293	0.4210	0.4287	17.	17.	10117.
242	59NYCDEN	102.82	10.6708	0.6928	0.3557	0.4696	9.	12.	6853.
243	59NYCMKC	67.91	10.6708	1.1997	0.3165	0.3197	9.	9.	7837.
244	59OMACHI	31.33	0.3991	4.8316	0.3857	0.3895	13.	13.	5320.
245	59OMALNK	6.47	0.3991	0.1779	C.2919	0.3669	10.	10.	357.
246	59ORFPHL	21.65	0.5128	3.8758	C.2397	0.2394	4.	6.	2641.
247	59PDXDAL	134.71	0.7789	1.1747	C.2305	0.2140	1.	1.	288.
248	59PITALB	29.44	2.0108	0.7293	0.1449	C.2095	2.	3.	1014.
249	59PITCVG	23.42	2.0108	0.9565	0.3008	0.2982	6.	6.	2467.
250	59PITDAY	19.24	2.0108	0.5928	0.2632	0.2679	8.	6.	1645.

251	59RICORF	9.05	0.4435	0.5128	0.2720	0.2388	4.	4.	718.
252	59RICRDU	12.60	0.4435	0.6126	0.2815	0.2628	6.	6.	424.
253	59RNOLAS	28.46	0.1001	0.1051	0.1804	0.1916	2.	2.	1564.
254	59ROCCHI	40.95	0.5140	4.8316	0.3345	0.3428	6.	9.	2482.
255	59SACRNO	11.08	0.5082	0.1001	0.2942	0.2630	6.	7.	2466.
256	59SANDEN	63.98	0.6042	0.6928	0.2751	0.2932	3.	3.	1198.
257	59SEADEN	73.42	1.1024	0.6928	0.3792	0.2339	4.	4.	1839.
258	59SEASAN	82.26	1.1024	0.6042	0.4335	0.6557	6.	6.	2195.
259	59SFOLAS	28.17	2.5963	0.1051	0.2280	0.2205	4.	5.	8248.
260	59SFOOMA	88.70	2.5963	0.3991	0.2440	0.6051	2.	3.	1298.
261	59SFOSTL	109.17	2.5963	1.6718	0.4290	0.3800	6.	6.	2434.
262	59STLDAY	26.66	1.6718	0.5928	0.2830	0.2845	6.	5.	1275.
263	59STLMKC	18.39	1.6718	1.1997	0.5021	0.4332	19.	17.	8955.
264	59STLOKC	35.61	1.6718	0.5329	0.3174	0.2965	6.	7.	1193.
265	59TUSCHI	86.32	0.1945	4.8316	0.3181	0.2531	3.	3.	1904.
266	59WASHOU	86.20	1.4399	0.9433	0.3423	0.3486	6.	4.	1841.
267	59WASMIA	62.65	1.4399	1.0000	0.3663	0.3536	13.	11.	11034.
268	59WASNYC	17.40	1.4399	10.6708	0.5194	0.6063	111.	106.	71010.
269	59WASPDX	150.42	1.4399	0.7789	0.2513	0.4232	3.	4.	891.
270	59WASPWM	39.98	1.4399	0.3570	0.1289	0.1330	1.	1.	632.
271	60BGMALB	13.87	0.4047	0.7297	0.2073	0.2347	6.	5.	729.
272	60BNACVG	21.48	0.5555	0.9659	0.2887	0.2558	5.	6.	953.
273	60BNAMKE	36.98	0.5555	1.0985	0.1435	0.1159	1.	1.	136.
274	60CVGATL	31.13	0.9659	0.9042	0.2948	0.3314	8.	8.	1368.
275	60DALATL	54.38	1.1750	0.9042	0.3916	0.3464	8.	6.	2308.
276	60DENCLE	70.19	0.7098	2.3389	0.3782	0.2609	4.	4.	1052.
277	60DTTATL	43.32	2.8272	0.9042	0.2800	0.3068	8.	7.	2123.
278	60DTTBOS	49.95	2.8272	3.3610	0.2300	0.2607	5.	4.	5719.
279	60DTTCLE	11.05	2.8272	2.3389	0.4756	0.5306	28.	26.	9928.
280	60ERIDTT	18.49	0.2337	2.8272	0.3073	0.2817	7.	7.	787.
281	60PITDAY	20.57	1.9868	0.5852	0.3084	0.2843	8.	5.	1568.
282	60HOUDTT	87.39	0.9689	2.8272	0.2332	0.1862	2.	2.	913.
283	60HOUMSY	25.18	0.9689	0.3868	0.4096	1.0336	17.	20.	9674.
284	60HOUWAS	78.79	0.9689	1.5302	0.3437	0.3190	4.	3.	1887.
285	60RICORF	8.91	0.4221	0.4998	0.2216	0.2151	3.	3.	403.
286	60JANDAL	31.26	0.2010	1.1750	0.2601	0.2495	5.	5.	1058.
287	60LASRNO	29.88	0.1063	0.1023	0.1877	0.1843	2.	2.	1805.
288	60LBBDAL	23.78	0.1892	1.1750	0.3486	0.3908	8.	8.	3603.
289	60MEMTYS	29.71	0.6942	0.3450	0.2154	0.2835	5.	7.	923.
290	60MIACVG	58.53	1.0163	0.9659	0.3103	0.3738	3.	6.	4020.
291	60MIALAX	141.88	1.0163	5.3274	0.2616	0.4417	3.	3.	4048.
292	60MKCSTL	18.95	1.1850	1.6596	0.4547	0.3380	18.	18.	8440.
293	60MKECHI	10.27	1.0985	4.8343	0.5515	0.5267	35.	32.	3203.
294	60MOTBIS	15.53	0.0899	0.0668	0.1580	0.1880	4.	4.	100.
295	60MSPFAR	19.68	1.3683	0.1641	0.2752	0.2297	4.	4.	2200.
296	60MSYATL	35.10	0.8868	0.9042	0.3773	0.3527	14.	14.	3394.
297	60NYCALB	14.53	10.7549	0.7297	0.4145	0.4364	17.	17.	10660.
298	60NYCCHI	49.34	10.7549	4.8343	0.4952	0.5217	62.	57.	83796.
299	60NYCDEN	102.57	10.7549	0.7098	0.3294	0.4714	9.	9.	7497.
300	60NYCMKC	70.84	10.7549	1.1850	0.3118	0.3345	11.	9.	7800.

301	60OMACHI	34.38	0.3988	4.8343	0.3906	0.4313	13.	12.	5375.
302	60OMALNK	7.67	0.3988	0.1749	0.2495	0.2716	7.	7.	336.
303	60PDXDAL	137.03	0.7615	1.1750	0.2317	0.2117	1.	1.	268.
304	60PHLORF	20.89	3.8908	0.4998	0.0865	0.1307	2.	4.	2084.
305	60PITALB	30.83	1.9868	0.7297	0.1459	0.2049	2.	3.	1050.
306	60PITCVG	24.80	1.9868	0.9659	0.2835	0.3129	5.	6.	2293.
307	60RICRDU	13.87	0.4221	0.6166	0.3710	0.1848	7.	5.	427.
308	60ROCCHI	42.45	0.5251	4.8343	0.3180	0.3685	7.	9.	2599.
309	60SACRNO	11.26	0.5509	0.1023	0.2821	0.2967	9.	9.	2470.
310	60SANDEN	62.89	0.6359	0.7098	0.2421	0.2637	3.	3.	1261.
311	60SEADEN	81.10	1.1177	0.7098	0.3373	0.2670	5.	5.	1760.
312	60SFOLAS	28.30	2.6805	0.1063	0.2984	0.2725	7.	5.	7424.
313	60SFOOMA	91.52	2.6805	0.3988	0.2516	0.2929	3.	3.	1298.
314	60SFOSTL	102.24	2.6805	1.6596	0.3323	0.3629	4.	5.	2434.
315	60STLDAY	26.55	1.6596	0.5852	0.2361	0.2786	5.	4.	1138.
316	60STLOKC	37.06	1.6596	0.5296	0.2982	0.3185	5.	7.	1094.
317	60TUSCHI	87.90	0.2022	4.8343	0.3546	0.2311	3.	3.	1918.
318	60WASMIA	55.38	1.5302	1.0163	0.3791	0.3540	7.	7.	10921.
319	60WASNYC	18.54	1.5302	10.7549	0.4696	0.6088	95.	99.	73492.
320	61BGMALB	13.79	0.3877	0.7059	0.2293	0.2385	6.	5.	657.
321	61BNACVG	21.26	0.5580	0.9729	0.2601	0.2404	4.	5.	1000.
322	61BNAMKE	37.72	0.5580	1.0981	0.1446	0.1173	1.	1.	167.
323	61CVGATL	30.41	0.9729	0.9038	0.2812	0.3045	7.	7.	1540.
324	61DALATL	54.97	1.2142	0.9038	0.3844	0.3458	5.	9.	2543.
325	61DENCLE	83.60	0.7504	2.3030	0.5110	0.3527	8.	6.	1151.
326	61DTTATL	41.01	2.6690	0.9038	0.2856	0.2836	6.	8.	2257.
327	61DTTBOS	46.75	2.6690	3.4046	0.3423	0.2890	16.	18.	5949.
328	61DTTCLE	10.83	2.6690	2.3030	0.5483	0.5090	30.	30.	9003.
329	61ERIDTT	18.30	0.2314	2.6690	0.3458	0.2959	7.	7.	642.
330	61PITCVG	24.55	1.9623	0.9729	0.2813	0.2941	6.	6.	2226.
331	61HOUDTT	75.14	0.9931	2.6690	0.3081	0.2400	6.	5.	940.
332	61JANDAL	30.77	0.2015	1.2142	0.2651	0.3104	5.	5.	1114.
333	61LBBDAL	22.27	0.1848	1.2142	0.3364	0.3413	8.	7.	3678.
334	61MEMTYS	27.38	0.6660	0.3428	0.2506	0.2091	6.	5.	1220.
335	61MIACVG	58.83	1.0279	0.9729	0.3757	0.3629	7.	6.	4389.
336	61MIALAX	148.30	1.0279	5.5827	0.4325	0.6404	5.	6.	4269.
337	61MKECHI	10.24	1.0981	4.7973	0.8341	0.6111	36.	31.	2845.
338	61MOTBIS	14.66	0.0899	0.0688	0.1965	0.2687	4.	4.	123.
339	61MSPFAR	20.32	1.3852	0.1685	0.2826	0.2432	4.	3.	1587.
340	61MSYATL	31.43	0.8663	0.9038	0.3589	0.4071	9.	12.	3553.
341	61MSYHOU	24.77	0.8663	0.9931	0.4742	0.4890	21.	16.	10111.
342	61MSYLAS	96.09	0.8663	0.1090	0.2556	0.3069	1.	2.	117.
343	61NYCALB	14.94	10.8681	0.7059	0.4266	0.3922	14.	15.	10254.
344	61NYCCHI	46.09	10.8681	4.7973	0.5132	0.5876	65.	69.	84973.
345	61NYCDEN	101.16	10.8681	0.7504	0.4274	0.5580	11.	15.	8081.
346	61NYCMKC	69.11	10.8681	1.1951	0.3392	0.4582	7.	8.	8095.
347	61OMACHI	33.07	0.4117	4.7973	0.4076	0.3826	13.	11.	5751.
348	61OMALNK	7.59	0.4117	0.1740	0.3167	0.2364	7.	7.	264.
349	61ORFPHL	19.08	0.5061	3.8779	0.2668	0.1639	5.	4.	2350.
350	61PDXDAL	135.66	0.7635	1.2142	0.2078	0.2140	1.	1.	298.

351	61PDXWAS	154.17	0.7635	1.5622	0.4440	0.3758	4.	3.	533.
352	61PITALB	30.52	1.9623	0.7059	0.1594	0.2256	4.	5.	1004.
353	61PITDAY	19.62	1.9623	0.5636	0.2268	0.3206	6.	7.	1607.
354	61RICORF	10.16	0.4563	0.5061	C.2432	0.2127	4.	4.	403.
355	61RICRDU	13.73	0.4563	0.6175	0.2333	0.3804	6.	4.	400.
356	61RNOLAS	29.58	0.1070	0.1090	0.2060	0.2060	2.	2.	2045.
357	61ROCCHI	38.20	0.5326	4.7973	0.2986	0.3682	7.	10.	2698.
358	61SACRNO	11.24	0.5524	0.1070	C.2660	0.2369	7.	7.	2297.
359	61SANDEN	57.38	0.6520	0.7504	C.2741	0.2739	4.	3.	1459.
360	61SEADEN	79.13	1.1370	0.7504	0.3218	0.3007	4.	3.	2130.
361	61SEASAN	77.71	1.1370	0.6520	0.3897	0.4185	11.	5.	2080.
362	61SFOLAS	28.66	2.7247	0.1090	0.2910	0.2623	5.	4.	6947.
363	61SFOOMA	89.00	2.7247	0.4117	C.2416	0.3581	2.	3.	1459.
364	61SFOSTL	115.23	2.7247	1.6476	C.5361	0.3370	6.	6.	2655.
365	61STLDAY	26.90	1.6476	0.5636	0.2601	0.2619	5.	4.	1228.
366	61STLMKC	18.74	1.6476	1.1951	0.4615	0.4014	14.	11.	9045.
367	61STLOKC	34.96	1.6476	0.5324	C.3399	0.3373	6.	6.	1188.
368	61TUSCHI	87.81	0.2016	4.7973	C.3840	0.2541	2.	2.	2025.
369	61TUSSAT	50.84	0.2016	0.4953	0.0991	0.1749	2.	1.	120.
370	61WASHOU	82.63	1.5622	0.9931	0.3497	0.3998	8.	11.	1591.
371	61WASMIA	56.65	1.5622	1.0279	0.3872	0.3295	9.	7.	10618.
372	61WASNYC	17.64	1.5622	10.8681	C.5540	0.6133	89.	94.	83729.
373	61WASPWM	41.07	1.5622	0.3428	0.1761	0.1799	2.	2.	643.
374	62BGMALB	12.92	0.3839	0.6955	0.1789	0.2057	3.	3.	519.
375	62BNACVG	21.69	0.5625	0.9730	C.2624	0.2399	5.	5.	963.
376	62CLEDTT	11.42	2.3052	2.7162	0.4713	0.4389	18.	19.	8944.
377	62CVGATL	30.54	0.9730	0.9219	0.2934	0.3151	6.	8.	1642.
378	62DALATL	53.81	1.2316	0.9219	0.4390	0.3488	6.	11.	2896.
379	62DENCLE	84.72	0.7473	2.3052	0.5887	0.3767	7.	6.	1128.
380	62DTTATL	41.84	2.7162	0.9219	0.3406	0.3173	3.	4.	2725.
381	62DTTBOS	44.84	2.7162	3.3764	C.3873	0.4047	12.	15.	6604.
382	62ERIDTT	18.65	0.2270	2.7162	0.3193	0.3207	7.	7.	803.
383	62HOUDTT	94.46	1.0086	2.7162	0.3144	0.3316	2.	4.	1017.
384	62JANDAL	31.24	0.2040	1.2316	0.2650	0.2988	5.	6.	1124.
385	62LBBDAL	23.23	0.1820	1.2316	0.3583	0.3288	8.	8.	4116.
386	62MRMTYS	28.47	0.6612	0.3392	C.2798	0.2868	6.	5.	1256.
387	62MIACVG	60.59	1.0320	0.9730	C.3720	0.3266	5.	6.	4542.
388	62MIALAX	154.64	1.0320	5.6463	0.5534	0.6372	3.	5.	4335.
389	62MKECHI	10.46	1.1084	4.8367	C.6208	0.5699	27.	23.	3186.
390	62MOTBIS	14.73	0.0871	0.0657	0.2788	0.2165	6.	5.	170.
391	62MSPFAR	17.79	1.3910	0.1642	C.3262	0.3440	5.	5.	2353.
392	62MSYATL	32.79	0.8725	0.9219	C.4253	0.4441	11.	11.	3923.
393	62MSYHOU	23.88	0.8725	1.0086	0.5538	0.5030	16.	17.	10397.
394	62MSYLAS	107.73	0.8725	0.1214	C.2160	0.3894	1.	2.	296.
395	62NYCALB	15.22	10.7751	0.6955	C.4750	0.4184	19.	18.	10544.
396	62NYCCHI	47.96	10.7751	4.8367	C.7091	0.6743	52.	53.	88822.
397	62NYCDEN	104.32	10.7751	0.7473	C.5274	0.6562	10.	12.	8211.
398	62NYCMKC	76.20	10.7751	1.1887	0.4219	0.5231	6.	7.	8118.
399	62OMACHI	34.12	0.4176	4.8367	0.4375	0.4402	10.	10.	6006.
400	62OMALNK	7.78	0.4176	0.1748	0.2970	0.2842	7.	7.	232.

401	62ORFPHL	19.48	0.4998	3.8583	C.2231	0.1239	4.	3.	2949.
402	62PDXDAL	138.19	0.7634	1.2316	C.2088	0.2133	1.	1.	288.
403	62PITALB	30.44	1.9172	0.6955	0.2108	0.2668	4.	4.	1323.
404	62PITCVG	24.53	1.9172	0.9730	0.2617	0.3109	4.	5.	2628.
405	62RICORF	10.38	0.4433	0.4998	0.1984	0.2175	3.	4.	347.
406	62RICRDU	14.11	0.4433	0.6135	0.2638	0.2732	6.	4.	427.
407	62RNOLAS	29.25	0.1108	0.1214	0.2820	0.2856	3.	3.	2560.
408	62ROCCHI	87.03	0.5343	4.8367	C.3025	0.3834	7.	10.	2989.
409	62SACRNO	11.51	0.5636	0.1108	C.3722	0.3538	10.	10.	2536.
410	62SANDEN	55.68	0.6622	0.7473	0.2496	0.2489	2.	2.	1472.
411	62SEADEN	81.18	1.1502	0.7473	0.3215	0.3366	3.	3.	2790.
412	62SEASAN	73.76	1.1502	0.6622	0.3735	0.4003	4.	4.	2421.
413	62SFOLAS	30.81	2.7403	0.1214	0.3939	0.3693	9.	8.	8123.
414	62SFOOMA	97.79	2.7403	0.4176	C.3103	0.2510	2.	1.	1440.
415	62SFOSTL	112.10	2.7403	1.6381	C.4994	0.3681	5.	6.	2888.
416	62STLDAY	29.08	1.6381	0.5634	0.2244	0.1864	3.	2.	1256.
417	62STLMKC	19.18	1.6381	1.1887	0.4753	0.4759	11.	11.	10163.
418	62STLOKC	34.40	1.6381	0.5264	0.3531	0.3692	5.	5.	1545.
419	62TUSCHI	90.74	0.2084	4.8367	0.3744	0.2908	2.	2.	2061.
420	62WASHOU	102.25	1.5746	1.0086	0.3368	0.3583	6.	7.	1022.
421	62WASMIA	60.42	1.5746	1.0320	0.3891	0.3463	7.	4.	10468.
422	62WASNYC	17.38	1.5746	10.7751	0.5479	0.6255	59.	58.	102148.
423	62WASPDX	183.39	1.5746	0.7634	0.3226	0.4703	2.	5.	350.
424	62WASPWM	41.89	1.5746	0.3528	C.1352	0.1385	1.	1.	614.
425	67BGMALB	11.89	0.3624	0.6833	0.1603	0.0968	3.	2.	700.
426	67BNACVG	17.04	0.6102	0.9162	0.2557	0.3004	5.	4.	1669.
427	67BNAMKE	41.10	0.6102	1.0821	0.1346	0.1461	1.	1.	565.
428	67CVGATL	25.83	0.9162	1.0406	C.4213	0.4071	8.	10.	3955.
429	67DALATL	45.98	1.2801	1.0406	0.5822	0.5361	12.	9,	8135.
430	67DENCLE	73.78	0.7450	2.2241	0.5440	0.5338	15.	12.	2569.
431	67DTTATL	39.54	2.8480	1.0406	C.4551	0.4293	13.	9.	6206.
432	67DTTBOS	41.78	2.8480	3.2423	C.5242	0.4710	32.	31.	14331.
433	67DTTCLE	10.66	2.8480	2.2241	0.5849	0.5986	26.	25.	11973.
434	67ERIDTT	18.65	0.2210	2.8480	0.2978	0.2621	6.	6.	1082.
435	67HOUDTT	68.80	1.0578	2.8480	0.4385	0.4040	12.	8.	2691.
436	67HOUWAS	75.80	1.0578	1.7174	C.4992	0.4828	16.	17.	4185.
437	67JANDAL	27.24	0.2079	1.2801	0.3007	0.3011	7.	7.	2160.
438	67LBBDAL	20.09	0.1845	1.2801	C.4876	0.4647	11.	12.	8618.
439	67MEMTYS	25.59	0.7040	0.3485	0.3633	0.3630	8.	7.	2890.
440	67MIACVG	59.47	1.1395	0.9162	0.4698	0.4348	5.	10.	8045.
441	67MIALAX	139.75	1.1395	5.8329	0.5843	0.7430	10.	16.	11775.
442	67MKECHI	9.65	1.0821	4.7716	0.6558	0.7196	34.	32.	7408.
443	67MKEDAY	23.21	1.0821	0.5834	0.2407	0.2680	9.	7.	655.
444	67MOTBIS	15.10	0.0852	0.0631	0.2035	0.2284	4.	4.	287.
445	67MSPFAR	16.14	1.4238	C.1568	0.3468	0.3857	6.	7.	5154.
446	67MSYATL	31.60	0.9475	1.0406	C.6307	0.5136	16.	17.	9026.
447	67MSYHOU	22.07	0.9475	1.0578	C.6532	0.6229	25.	27.	20789.
448	67MSYLAS	97.60	0.9475	0.1558	0.3619	0.4943	4.	4.	870.
449	67NYCALB	13.22	10.3541	0.6833	0.5128	0.5067	22.	24.	20138.
450	67NYCCHI	43.94	10.3541	4.7716	C.7772	0.7386	70.	76.	150215.

451	67NYCDEN	95.10	10.3541	0.7450	0.5891	0.5941	13.	13.	18187.
452	67NYCMKC	67.30	10.3541	1.1897	0.5729	0.4934	30.	29.	15581.
453	67OMACHI	29.14	0.4035	4.7716	0.4920	0.5373	9.	10.	11066.
454	67OMALNK	7.79	0.4035	0.1672	0.3191	0.2916	7.	6.	420.
455	67ORFPHL	20.33	0.5018	3.6914	0.3804	0.4029	14.	15.	6605.
456	67PDXDAL	105.45	0.7878	1.2801	0.6028	0.5436	10.	7.	1119.
457	67PITALB	28.78	1.7476	0.6833	0.2752	0.3101	7.	5.	1977.
458	67PITCVG	21.04	1.7476	0.9162	0.4661	0.4204	9.	10.	4211.
459	67PITDAY	18.31	1.7476	0.5834	0.4331	0.4306	10.	10.	3581.
460	67RICCLE	30.12	0.4491	2.2241	0.2539	0.2619	7.	6.	928.
461	67RICORF	9.40	0.4491	0.5018	0.2590	0.3044	5.	6.	473.
462	67RICRDU	13.92	0.4491	0.6351	0.1724	0.1362	2.	3.	431.
463	67RNOLAS	27.00	0.1166	0.1558	0.3180	0.3462	4.	6.	5498.
464	67ROCCHI	33.68	0.5270	4.7716	0.5066	0.4968	11.	13.	6385.
465	67SACRNO	10.94	0.5658	0.1166	0.3058	0.2783	8.	8.	3430.
466	67SANDEN	56.77	0.6267	0.7450	0.5098	0.2875	13.	15.	3551.
467	67SANSEA	68.22	0.6267	1.1648	0.3906	0.4996	9.	10.	6172.
468	67SATTUS	48.09	0.5071	0.1929	0.2108	0.1928	2.	1.	458.
469	67SEADEN	70.10	1.1648	0.7450	0.5451	0.3788	7.	9.	5405.
470	67SFOLAS	25.28	2.8224	0.1558	0.4009	0.4099	10.	11.	19074.
471	67SFOOMA	88.60	2.8224	0.4035	0.5597	0.5017	5.	5.	3677.
472	67SFOSTL	101.15	2.8224	1.5858	0.6184	0.5776	14.	10.	9316.
473	67STLDAY	26.18	1.5858	0.5834	0.3188	0.3362	6.	6.	2184.
474	67STLMKC	17.65	1.5858	1.1897	0.6483	0.5748	24.	24.	16145.
475	67STLOKC	31.45	1.5858	0.5265	0.3243	0.3643	7.	8.	2553.
476	67TUSCHI	89.96	0.1929	4.7716	0.5654	0.4656	7.	8.	3628.
477	67WASMIA	59.96	1.7174	1.1395	0.6061	0.7723	16.	13.	21860.
478	67WASNYC	16.54	1.7174	10.3541	0.6372	0.7092	81.	81.	187840.
479	67WASPDX	137.25	1.7174	0.7878	0.4492	0.6429	7.	11.	1363.
480	67WASPWM	37.95	1.7174	0.3446	0.3023	0.3071	6.	5.	1228.
481	68BGMALB	14.79	0.3613	0.6306	0.2523	0.1838	5.	3.	767.
482	68BNACVG	17.19	0.6080	0.9024	0.3030	0.3121	7.	5.	1661.
483	68BNAMKE	35.51	0.6080	1.0981	0.1341	0.1472	1.	1.	780.
484	68CVGATL	25.22	0.9024	1.0452	0.4391	0.4116	9.	10.	4642.
485	68CVGMIA	55.71	0.9024	1.1664	0.5015	0.4493	10.	7.	9507.
486	68DALATL	45.40	1.3342	1.0452	0.5963	0.5376	11.	12.	9223.
487	68DENCLE	71.70	0.7503	2.2241	0.5500	0.5349	16.	13.	3354.
488	68MIALAX	131.39	1.1664	5.8676	0.6069	0.6964	16.	19.	12668.
489	68DTTATL	38.13	2.8653	1.0452	0.4384	0.4330	12.	15.	7983.
490	68DTTBOS	40.01	2.8653	3.2473	0.4411	0.4943	32.	35.	17799.
491	68DTTCLE	10.90	2.8653	2.2241	0.5198	0.5305	23.	21.	11865.
492	68ERIDTT	17.75	0.2170	2.8653	0.4101	0.2751	6.	5.	1228.
493	68HOUDTT	66.57	1.0747	2.8653	0.4644	0.4263	12.	13.	3004.
494	68JANDAL	27.42	0.2008	1.3342	0.4205	0.3997	9.	10.	2290.
495	68LBBDAL	21.12	0.1813	1.3342	0.5097	0.5075	11.	12.	10119.
496	68MEMTYS	25.14	0.7018	0.3426	0.3856	0.3599	11.	11.	3196.
497	68MKECHI	9.54	1.0981	4.8292	0.6888	0.6706	30.	26.	6646.
498	68MKEDAY	22.92	1.0981	0.5824	0.2599	0.2564	9.	7.	768.
499	68MKEDAY	27.33	1.0981	0.5824	0.2708	0.2439	9.	6.	768.
500	68MOTBIS	12.93	0.0841	0.0624	0.2157	0.1761	4.	4.	262.

501	68MSPFAR	16.18	1.4038	0.1526	0.3480	0.4194	7.	8.	5853.
502	68MSYATL	30.47	0.9503	1.0452	0.6431	0.5117	19.	19.	10447.
503	68MSYHOU	21.58	0.9503	1.0747	0.6521	0.6148	27.	28.	22289.
504	68MSYLAS	93.09	0.9503	0.1602	0.4107	0.5344	5.	5.	974.
505	68NYCALB	13.96	10.3931	0.6306	0.4845	0.5765	26.	28.	20641.
506	68NYCCHI	42.57	10.3931	4.8292	0.7757	0.7408	98.	101.	172085.
507	68NYCDEN	91.17	10.3931	0.7503	0.6122	0.6189	17.	19.	21040.
508	68NYCMKC	63.40	10.3931	1.1898	0.5876	0.5013	33.	36.	17950.
509	68OMACHI	28.19	0.3840	4.8292	0.4657	0.5288	10.	10.	12808.
510	68OMALNK	9.47	0.3840	0.1619	0.3074	0.2347	8.	8.	376.
511	68ORFPHL	20.89	0.5002	3.6989	0.3949	0.3462	15.	21.	7515.
512	68PDXDAL	100.77	0.7971	1.3342	0.6207	0.5637	9.	9.	1571.
513	68PITALB	29.75	1.7207	0.6306	0.3014	0.3310	10.	10.	2317.
514	68PITCVG	20.31	1.7207	0.9024	0.4434	0.3789	8.	9.	4369.
515	68PITDAY	18.37	1.7207	0.5824	0.4201	0.4392	10.	10.	3869.
516	68PITLEX	23.99	1.7207	0.3011	0.2729	0.2341	3.	3.	680.
517	68RICCLE	30.58	0.4479	2.2241	0.2615	0.2493	8.	7.	1104.
518	68RICORF	9.60	0.4479	0.5002	0.3138	0.2849	5.	7.	451.
519	68RICRDU	14.40	0.4479	0.6380	0.1994	0.1401	3.	3.	386.
520	68RNOLAS	25.91	0.1143	0.1602	0.4064	0.3875	4.	7.	5626.
521	68ROCCHI	32.58	0.5337	4.8292	0.4949	0.4855	12.	12.	6924.
522	68SACRNO	11.52	0.5604	0.1143	0.2932	0.2945	7.	8.	3274.
523	68SANDEN	54.70	0.6455	0.7503	0.5164	0.4726	11.	13.	4762.
524	68SEADEN	67.18	1.1925	0.7503	0.5695	0.5283	8.	11.	6686.
525	68SEASAN	64.30	1.1925	0.6455	0.5314	0.4379	16.	10.	6926.
526	68SFOLAS	23.43	2.8501	0.1602	0.4907	0.6330	18.	18.	22069.
527	68SFOOMA	85.50	2.8501	0.3840	0.6003	0.5506	9.	7.	4573.
528	68SFOSTL	96.72	2.8501	1.5812	0.6872	0.7391	15.	10.	11210.
529	68SLCHOU	85.41	0.4705	1.0747	0.2906	0.3069	2.	4.	634.
530	68STLDAY	24.95	1.5812	0.5824	0.3410	0.3321	7.	7.	2671.
531	68STLMKC	17.04	1.5812	1.1898	0.6536	0.6178	20.	21.	19016.
532	68STLOKC	30.08	1.5812	0.5235	0.3082	0.4165	6.	9.	2880.
533	68TUSCHI	85.32	0.1901	4.8292	0.6377	0.5181	7.	11.	4671.
534	68TUSSAT	45.88	0.1901	0.5177	0.3954	0.3305	3.	4.	599.
535	68WASHOU	73.77	1.7533	1.0747	0.7259	0.4771	17.	15.	5012.
536	68WASMIA	58.40	1.7533	1.1664	0.5663	0.5140	15.	14.	21222.
537	68WASNYC	16.43	1.7533	10.3931	0.6113	0.6781	82.	82.	191030.
538	68WASPDX	131.48	1.7533	0.7971	0.4619	0.6292	7.	9.	1602.
539	68WASPWM	36.47	1.7533	0.3427	0.3497	0.3200	5.	5.	1508.
540	69BGMALB	17.47	0.3682	0.6897	0.0930	0.0774	1.	1.	489.
541	69BNACVG	19.71	0.6108	0.9283	0.2998	0.2828	5.	4.	1832.
542	69CLEDTT	13.47	2.2089	2.8102	0.4720	0.4565	18.	20.	11679.
543	69CVGATL	24.60	0.9283	1.0790	0.4699	0.4757	10.	14.	4658.
544	69DALATL	44.34	1.3693	1.0790	0.6198	0.6190	12.	16.	10726.
545	69DAYSTL	24.54	0.5926	1.5836	0.3925	0.3205	8.	6.	3247.
546	69DENCLE	66.48	0.7554	2.2089	0.5364	0.5475	13.	14.	4150.
547	69DTTATL	35.83	2.8102	1.0790	0.5466	0.4284	16.	17.	9122.
548	69DTTBOS	38.59	2.8102	3.2530	0.4661	0.5342	35.	36.	19756.
549	69ERIDTT	19.33	0.2199	2.8102	0.2225	0.2889	4.	5.	1279.
550	69NYCALB	15.96	10.2178	0.6897	0.4664	0.5314	23.	27.	20033.

551	69HOUDTT	63.14	1.1259	2.8102	0.5310	0.5129	17.	11.	4043.
552	69JANDAL	27.98	0.2020	1.3693	0.4267	0.4341	10.	9.	2465.
553	69LBBDAL	21.86	0.1712	1.3693	0.5116	0.5064	12.	10.	10386.
554	69MEMTYS	24.45	0.7074	0.3470	0.4382	0.3389	12.	14.	3301.
555	69MIACVG	54.16	1.2183	0.9283	0.4809	0.5127	11.	9.	10483.
556	69MIALAX	123.45	1.2183	5.8625	0.6069	0.7692	11.	19.	15217.
557	69MKECHI	11.93	1.0385	4.7027	0.6662	0.5742	26.	23.	5517.
558	69MOTBIS	12.75	0.0813	0.0628	0.1875	0.1586	4.	4.	220.
559	69MSPFAR	18.52	1.3960	0.1499	0.4193	0.4603	6.	9.	6153.
560	69MSYATL	30.71	0.9500	1.0790	0.5879	0.5747	19.	19.	11095.
561	69MSYHOU	23.35	0.9500	1.1259	0.6460	0.6460	33.	28.	23006.
562	69MSYLAS	87.12	0.9500	0.1716	0.4611	0.5929	5.	5.	1340.
563	69NYCCHI	41.16	10.2178	4.7027	0.7704	0.6416	91.	94.	185453.
564	69NYCDEN	87.43	10.2178	0.7554	0.5855	0.5812	13.	16.	24994.
565	69NYCMKC	61.45	10.2178	1.1290	0.5416	0.5014	30.	31.	19819.
566	69OMACHI	28.23	0.3953	4.7027	0.5020	0.5398	8.	8.	13043.
567	69OMALNK	12.39	0.3953	0.1572	0.2401	0.2817	6.	6.	201.
568	69ORFPHL	21.73	0.4920	3.7182	0.3494	0.3401	16.	18.	8279.
569	69PDXDAL	96.54	0.8083	1.3693	0.6074	0.5411	14.	12.	1690.
570	69PITALB	30.97	1.7237	0.6897	0.3201	0.3624	9.	9.	2388.
571	69PITCVG	21.21	1.7237	0.9283	0.3786	0.3453	7.	8.	4428.
572	69PITDAY	19.39	1.7237	0.5926	0.4431	0.4357	11.	12.	4039.
573	69PITLEX	25.50	1.7237	0.3016	0.2687	0.2469	3.	3.	762.
574	69RICCLE	31.89	0.4729	2.2089	0.2535	0.2617	5.	7.	988.
575	69RICORF	11.84	0.4729	0.4920	0.3292	0.3206	9.	8.	446.
576	69RICRDU	15.62	0.4729	0.6635	0.2764	0.3042	5.	6.	482.
577	69RNOLAS	26.41	0.1147	0.1716	0.3384	0.3967	5.	7.	6693.
578	69ROCCHI	32.93	0.5490	4.7027	0.4680	0.5104	12.	13.	7479.
579	69SACRNO	12.84	0.5570	0.1147	0.3685	0.3704	8.	8.	3094.
580	69SANDEN	52.82	0.6717	0.7554	0.4737	0.4378	12.	13.	4856.
581	69SEADEN	58.50	1.2391	0.7554	0.6314	0.5167	13.	13.	7505.
582	69SEASAN	61.93	1.2391	0.6717	0.5268	0.4559	11.	12.	7518.
583	69SFOLAS	25.00	2.8296	0.1716	0.5334	0.5044	13.	15.	23231.
584	69SFOOMA	85.35	2.8296	0.3953	0.6117	0.3790	8.	7.	4804.
585	69SFOSTL	91.99	2.8296	1.5836	0.7221	0.5914	16.	12.	12105.
586	69SLCHOU	81.97	0.4566	1.1259	0.4115	0.4263	5.	7.	684.
587	69STLMKC	18.29	1.5836	1.1290	0.6820	0.5878	23.	21.	19229.
588	69STLOKC	30.35	1.5836	0.5427	0.3314	0.4108	9.	9.	3222.
589	69TUSCHI	81.61	0.2063	4.7027	0.6551	0.4820	8.	11.	5294.
590	69TUSSAT	45.01	0.2063	0.5153	0.4050	0.2582	3.	3.	645.
591	69WASHOU	74.92	1.7045	1.1259	0.4899	0.4862	17.	15.	4906.
592	69WASMIA	56.12	1.7045	1.2183	0.6083	0.4847	18.	23.	24983.
593	69WASNYC	17.50	1.7045	10.2178	0.6655	0.6798	79.	80.	193958.
594	69WASPDX	124.77	1.7045	0.8083	0.5070	0.6439	7.	12.	2077.
595	69WASPWM	37.12	1.7045	0.3344	0.3363	0.3252	7.	6.	1642.
596	70BNACVG	22.00	0.6070	0.9294	0.3373	0.2802	6.	5.	1733.
597	70BNAMKE	42.99	0.6070	1.0253	0.2935	0.2333	5.	5.	718.
598	70CVGATL	27.96	0.9294	1.0995	0.5093	0.5250	11.	13.	4701.
599	70DALATL	45.19	1.3986	1.0995	0.6600	0.6648	13.	16.	11714.
600	70DENCLE	73.09	0.7715	2.1265	0.5421	0.5488	17.	15.	3878.

601	70DTTATL	69.35	2.7250	1.0995	0.5394	0.4267	15.	20.	9051.
602	70DTTBOS	49.57	2.7250	3.2904	0.5210	0.3805	19.	22.	19379.
603	70DTTCLE	14.78	2.7250	2.1265	0.5422	0.5678	25.	21.	12338.
604	70ERIDTT	21.44	0.2115	2.7250	0.1279	0.1731	3.	3.	967.
605	70PITLEX	29.23	1.7294	0.3007	0.3429	0.2988	4.	4.	674.
606	70HOUDTT	64.21	1.1717	2.7250	0.4775	0.5101	18.	16.	4532.
607	70JANDAL	29.94	0.1979	1.3986	0.4367	0.4192	10.	10.	2907.
608	70LBBDAL	25.80	0.1604	1.3986	0.5156	0.5650	10.	11.	9313.
609	70MEMTYS	28.00	0.7051	0.3507	0.4153	0.3465	14.	9.	3086.
610	70MIACVG	57.40	1.3106	0.9294	0.5298	0.5563	12.	11.	10448.
611	70MIALAX	122.48	1.3106	5.7945	0.7121	0.7811	18.	24.	17067.
612	70MKECHI	12.90	1.0253	4.6123	0.5658	0.5747	22.	22.	5381.
613	70MKEDAY	24.94	1.0253	0.5773	0.3080	0.3288	9.	8.	1316.
614	70MOTBIS	14.62	0.0815	0.0636	0.1924	0.1653	4.	4.	161.
615	70MSPFAR	20.84	1.4182	0.1522	0.4018	0.4375	8.	7.	4932.
616	70MSYATL	31.60	0.9430	1.0995	0.5472	0.5123	20.	15.	11263.
617	70MSYHOU	23.21	0.9430	1.1717	0.6870	0.6873	29.	31.	22971.
618	70MSYLAS	82.71	0.9430	0.1757	0.3660	0.5969	6.	5.	1561.
619	70NYCALB	18.59	10.2621	0.7010	0.5467	0.4905	20.	24.	17262.
620	70NYCCHI	48.15	10.2621	4.6123	0.7319	0.7522	81.	79.	173010.
621	70NYCDEN	92.21	10.2621	0.7715	0.6097	0.6710	15.	16.	23329.
622	70NYCMKC	67.07	10.2621	1.1388	0.5358	0.4798	17.	13.	17690.
623	70OMACHI	31.81	0.4071	4.6123	0.5488	0.5755	11.	12.	11709.
624	70OMALNK	11.18	0.4071	0.1593	0.2462	0.1383	5.	3.	128.
625	70ORFPHL	22.23	0.4796	3.6771	0.4385	0.3325	17.	15.	7984.
626	70PDXDAL	97.16	0.8174	1.3986	0.6405	0.6064	11.	11.	1595.
627	70PITALB	33.53	1.7294	0.7010	0.3091	0.3276	7.	9.	2498.
628	70PITCVG	24.22	1.7294	0.9294	0.3490	0.3792	7.	7.	4138.
629	70PITDAY	20.64	1.7294	0.5773	0.4626	0.3678	11.	11.	3355.
630	70RICCLE	33.84	0.4594	2.1265	0.2507	0.2430	5.	4.	851.
631	70RICORF	13.76	0.4594	0.4796	0.3662	0.2781	8.	8.	350.
632	70RICRDU	16.36	0.4594	0.6650	0.3438	0.2743	6.	5.	615.
633	70RNOLAS	24.94	0.1178	0.1757	0.3658	0.3732	5.	6.	7405.
634	70ROCCHI	37.86	0.5498	4.6123	0.4274	0.4935	7.	8.	7092.
635	70SACRNO	15.48	0.5574	0.1178	0.2725	0.2778	4.	4.	1494.
636	70SANDEN	53.62	0.6925	0.7715	0.5427	0.5102	14.	15.	4688.
637	70SEADEN	53.31	1.2146	0.7715	0.6062	0.5099	10.	10.	7939.
638	70SEASAN	65.35	1.2146	0.6925	0.5000	0.5030	9.	8.	6570.
639	70SFOLAS	28.19	2.8386	0.1757	0.5269	0.5702	15.	13.	20090.
640	70SFOOMA	85.87	2.8386	0.4071	0.6149	0.4537	5.	7.	4409.
641	70SFOSTL	96.97	2.8386	1.5658	0.6538	0.3891	16.	7.	11014.
642	70SLCHOU	83.40	0.4625	1.1717	0.4334	0.4123	4.	7.	747.
643	70STLDAY	27.68	1.5658	0.5773	0.3966	0.3717	13.	8.	3339.
644	70STLMKC	21.50	1.5658	1.1388	0.5438	0.6549	21.	20.	16444.
645	70STLOKC	35.42	1.5658	0.5487	0.3418	0.3922	9.	10.	3399.
646	70TUSCHI	84.26	0.2184	4.6123	0.6374	0.4640	7.	8.	5794.
647	70TUSSAT	48.47	0.2184	0.5072	0.3332	0.2535	4.	4.	626.
648	70WASHOU	72.04	1.7786	1.1717	0.5024	0.5126	18.	13.	5633.
649	70WASMIA	58.94	1.7786	1.3106	0.5684	0.6092	20.	17.	25368.
650	70WASNYC	20.91	1.7786	10.2621	0.6697	0.6875	82.	83.	173228.

651	70WASPBX	125.54	1.7786	0.8174	0.4893	0.6079	7.	13.	2094.
652	70WASPWM	37.83	1.7786	0.3437	0.3801	0.3717	7.	6.	2106.
653	71BNACVG	23.51	0.6073	0.9174	0.2203	0.2439	5.	3.	1773.
654	71BNAMKE	43.06	0.6073	1.0157	0.2769	0.2715	6.	5.	663.
655	71CVGATL	29.03	0.9174	1.1284	C.5009	0.4936	13.	14.	4811.
656	71DALATL	46.49	1.3843	1.1284	0.6448	0.6663	13.	17.	12390.
657	71DENCLE	75.39	0.7875	2.1028	0.5790	0.5867	17.	17.	4081.
658	71MIALAX	119.30	1.3122	5.6907	C.7419	0.7586	12.	17.	17427.
659	71DTTATL	40.11	2.7539	1.1284	C.4968	0.4321	13.	13.	10011.
660	71DTTBOS	46.05	2.7539	3.2841	C.5266	0.5373	23.	22.	19501.
661	71DTTCLE	15.07	2.7539	2.1028	0.4241	0.4887	19.	16.	11449.
662	71ERIDTT	20.61	0.2090	2.7539	0.0934	0.0930	1.	1.	460.
663	71PITCVG	25.50	1.7083	0.9174	0.4182	0.4370	9.	8.	3902.
664	71HOUDTT	63.79	1.1725	2.7539	C.4526	0.4830	12.	9.	4753.
665	71JANDAL	29.91	0.1980	1.3843	0.4196	0.4025	9.	9.	2788.
666	71LBBDAL	26.38	0.1556	1.3843	0.4925	0.5593	11.	11.	8813.
667	71MEMTYS	28.10	0.7135	0.3558	C.3564	0.3310	9.	11.	3046.
668	71MIACVG	58.14	1.3122	0.9174	0.5249	0.5128	13.	11.	10386.
669	71MKECHI	13.19	1.0157	4.5661	0.5780	0.5473	21.	20.	4652.
670	71MKEDAY	25.56	1.0157	0.5763	0.2943	0.2937	3.	3.	1524.
671	71MOTBIS	14.84	0.0824	0.0626	C.1954	0.1604	4.	4.	139.
672	71MSPFAR	20.91	1.4218	0.1553	C.3051	0.4008	7.	7.	3961.
673	71MSYATL	32.39	0.9223	1.1284	C.5711	0.5815	21.	16.	11141.
674	71MSYHOU	23.18	0.9223	1.1725	0.6243	0.6620	27.	27.	23872.
675	71MSYLAS	79.09	0.9223	0.1814	0.4276	0.5991	5.	6.	1647.
676	71NYCALB	18.28	10.2938	0.7155	0.5367	0.5001	19.	21.	13026.
677	71NYCCHI	48.64	10.2938	4.5661	0.8226	0.7559	67.	68.	173837.
678	71NYCDEN	93.29	10.2938	0.7875	C.5924	0.6434	28.	28.	24735.
679	71NYCMKC	68.62	10.2938	1.1434	0.4472	0.4576	24.	30.	17394.
680	71OMACHI	32.15	0.4014	4.5661	0.5686	0.6007	12.	13.	11892.
681	71OMALNK	11.54	0.4014	0.1570	0.2360	0.2302	5.	5.	117.
682	71ORFPHL	22.64	0.4787	3.6437	0.4482	0.3931	15.	12.	8371.
683	71PDXDAL	93.73	0.8219	1.3843	0.6270	0.5406	8.	8.	1861.
684	71PITALB	33.80	1.7083	0.7155	0.3389	0.3543	6.	9.	2309.
685	71PITDAY	20.61	1.7083	0.5763	0.4214	0.2913	7.	6.	2977.
686	71PITLEX	29.68	1.7083	0.3052	0.3572	0.2942	4.	4.	744.
687	71RICCLE	38.12	0.4636	2.1028	0.2246	0.2369	5.	6.	919.
688	71RICORF	14.01	0.4636	0.4787	C.3109	0.2567	5.	5.	355.
689	71RICRDU	16.64	0.4636	0.6698	C.2826	0.1661	6.	5.	538.
690	71RNOLAS	25.56	0.1213	0.1814	C.3819	0.3746	6.	6.	7429.
691	71ROCCHI	40.19	0.5473	4.5661	0.4826	0.4857	11.	11.	7126.
692	71SACRNO	15.66	0.5641	0.1213	0.0920	0.1189	2.	2.	648.
693	71SANDEN	56.09	0.6972	0.7875	0.4861	0.4445	12.	12.	5469.
694	71SEADEN	57.71	1.1944	0.7875	C.5983	0.4582	8.	8.	7911.
695	71SEASAN	66.78	1.1944	0.6972	C.4807	0.4082	10.	10.	6762.
696	71SFOLAS	31.93	2.8762	0.1814	0.6864	0.5424	20.	20.	19827.
697	71SFOOMA	85.74	2.8762	0.4014	C.5769	0.3978	8.	6.	3945.
698	71SFOSTL	100.78	2.8762	1.5533	0.5789	0.5022	17.	13.	9754.
699	71SLCHOU	84.91	0.4619	1.1725	0.4562	0.4247	5.	8.	814.
700	71STLDAY	28.03	1.5533	0.5763	C.3590	0.4158	5.	6.	3388.

701	71STLMKC	22.27	1.5533	1.1434	0.5046	0.6106	16.	16.	15221.
702	71TUSCHI	98.77	0.2214	4.5661	0.6298	0.4492	9.	10.	6168.
703	71TUSSAT	49.00	0.2214	0.5122	0.3827	0.3009	3.	4.	638.
704	71WASHOU	69.94	1.8009	1.1725	0.4984	0.5183	11.	16.	5726.
705	71WASMIA	58.11	1.8009	1.3122	0.5192	0.5834	22.	19.	27973.
706	71WASNYC	21.54	1.8009	10.2938	0.7219	0.7525	83.	80.	143563.
707	71WASPDX	127.78	1.8009	0.8219	0.4334	0.6281	7.	10.	2136.
708	71WASPWM	38.75	1.8009	0.3416	0.2637	0.2114	3.	2.	2439.
709	72BNACVG	21.55	0.6214	0.9041	0.2700	0.2751	3.	3.	2147.
710	72BNAMKE	41.24	0.6214	0.9982	0.3178	0.2993	8.	9.	461.
711	72CVGATL	28.20	0.9041	1.1684	0.4745	0.5243	11.	12.	5724.
712	72DALATL	44.76	1.4413	1.1684	0.6378	0.6502	14.	18.	13893.
713	72DENCLE	73.31	0.8529	2.0810	0.5922	0.4236	14.	13.	4873.
714	72MKEDAY	24.74	0.9982	0.5777	0.3488	0.3200	7.	6.	1952.
715	72DTTATL	38.90	2.7553	1.1684	0.5363	0.4407	17.	13.	11964.
716	72DTTBOS	42.55	2.7553	3.2028	0.5322	0.5236	26.	28.	19919.
717	72DTTCLE	14.59	2.7553	2.0810	0.5890	0.6303	29.	26.	15713.
718	72ERIDTT	19.95	0.2049	2.7553	0.0934	0.0930	1.	1.	579.
719	72PITLEX	28.73	1.7109	0.3012	0.2948	0.2719	3.	3.	909.
720	72HOUDTT	63.44	1.2308	2.7553	0.4981	0.5307	15.	15.	5358.
721	72JANDAL	28.94	0.2130	1.4413	0.4205	0.4023	8.	9.	3213.
722	72LBBDAL	25.54	0.1460	1.4413	0.4726	0.5683	11.	11.	9400.
723	72MEMTYS	26.96	0.7107	0.3651	0.3679	0.3049	10.	10.	3275.
724	72MIACVG	56.85	1.3865	0.9041	0.5072	0.5239	14.	11.	11544.
725	72MIALAX	114.35	1.3865	5.5419	0.5803	0.7118	11.	17.	19262.
726	72MKECHI	12.66	0.9982	4.5090	0.5729	0.5885	21.	20.	5173.
727	72MOTBIS	14.37	0.0816	0.0608	0.2059	0.1671	4.	4.	97.
728	72MSPFAR	20.28	1.4109	0.1545	0.4092	0.3857	8.	7.	3208.
729	72MSYATL	30.82	0.9283	1.1684	0.6259	0.5830	21.	18.	12866.
730	72MSYHOU	22.77	0.9283	1.2308	0.6277	0.6798	25.	24.	26382.
731	72MSYLAS	74.20	0.9283	0.1906	0.4549	0.6094	5.	5.	1897.
732	72NYCALB	17.45	9.9093	0.6620	0.3863	0.4129	12.	13.	16135.
733	72NYCCHI	47.09	9.9093	4.5090	0.8206	0.7846	79.	75.	180525.
734	72NYCDEN	93.98	9.9093	0.8529	0.4686	0.5875	30.	30.	27825.
735	72NYCMKC	66.17	9.9093	1.1622	0.4530	0.4683	27.	31.	17427.
736	72OMACHI	31.13	0.3994	4.5090	0.5606	0.6314	11.	11.	12895.
737	72OMALNK	11.17	0.3994	0.1590	0.2302	0.2786	5.	5.	112.
738	72ORFPHL	21.23	0.5032	3.6637	0.4313	0.4488	15.	12.	10735.
739	72PDXDAL	92.57	0.8237	1.4413	0.6460	0.5504	10.	9.	1958.
740	72PITALB	32.72	1.7109	0.6620	0.4006	0.4304	10.	10.	2659.
741	72PITCVG	23.30	1.7109	0.9041	0.4240	0.4281	8.	8.	4186.
742	72PITDAY	19.95	1.7109	0.5777	0.4295	0.4201	8.	8.	3330.
743	72RICCLE	37.26	0.4808	2.0810	0.2300	0.2498	5.	7.	873.
744	72RICORF	13.57	0.4808	0.5032	0.3076	0.3032	5.	6.	360.
745	72RICRDU	15.72	0.4808	0.6752	0.3567	0.2193	8.	6.	702.
746	72RNOLAS	24.74	0.1272	0.1906	0.3057	0.3390	5.	8.	7123.
747	72ROCCHI	37.51	0.5178	4.5090	0.5460	0.4876	10.	9.	7474.
748	72SANDEN	53.92	0.7178	0.8529	0.4957	0.5068	9.	12.	7612.
749	72SEADEN	55.87	1.1712	0.8529	0.6206	0.4948	8.	11.	8333.
750	72SEASAN	64.64	1.1712	0.7178	0.5433	0.4350	12.	9.	7570.

751	72SFCLAS	30.93	2.8648	0.1906	0.4691	0.5679	21.	20.	21027.
752	72SFOOMA	87.76	2.8648	0.3994	0.6135	0.5126	7.	6.	4117.
753	72SFOSTL	97.78	2.8648	1.5377	C.6069	0.5488	15.	8.	10127.
754	72SLCHOU	82.20	0.4966	1.2308	0.4346	0.4371	4.	7.	1102.
755	72STLDAY	27.13	1.5377	0.5777	C.3885	0.4005	5.	6.	3414.
756	72STLMKC	21.34	1.5377	1.1622	0.6685	0.5980	16.	17.	15652.
757	72STLOKC	33.52	1.5377	0.5496	C.3220	0.4363	5.	7.	3331.
758	72STLOKC	33.52	1.5377	0.5496	0.3564	0.3204	6.	5.	3331.
759	72TUSCHI	85.74	0.0243	4.5090	0.6207	0.4759	10.	8.	6460.
760	72TUSSAT	43.89	0.0243	0.5203	0.2486	0.1671	2.	1.	642.
761	72WASHOU	72.16	1.8805	1.2308	0.5404	0.5674	13.	17.	7502.
762	72WASMIA	57.27	1.8805	1.3865	C.5804	0.5716	22.	26.	34233.
763	72WASNYC	20.83	1.8805	9.9093	0.7085	0.6941	77.	77.	133447.
764	72WASPDX	123.70	1.8805	0.8237	C.4923	0.6567	9.	13.	2583.
765	72WASPWM	37.51	1.8805	0.3480	0.2648	0.2154	3.	2.	2380.
766	73BNACVG	20.29	0.6382	0.9112	0.3137	0.2700	4.	3.	2633.
767	73BNAMKC	39.12	0.6382	1.0140	0.2917	0.2494	7.	10.	519.
768	73CVGATL	26.94	0.9112	1.1955	0.4193	0.5322	9.	12.	6037.
769	73DALATL	42.65	1.4459	1.1955	C.6538	0.6354	16.	18.	15545.
770	73DENCLE	71.16	0.8745	2.0527	0.5581	0.4025	19.	14.	4809.
771	73DTTATL	38.23	2.7961	1.1955	0.5418	0.5124	15.	9.	13603.
772	73DTTBOS	41.20	2.7961	3.1999	0.4865	0.5384	33.	32.	20932.
773	73DTTCLE	14.58	2.7961	2.0527	0.7136	0.5723	31.	27.	18792.
774	73ERIDTT	19.53	0.2010	2.7961	0.0936	0.0852	1.	1.	500.
775	73PITLEX	27.80	1.6747	0.3077	0.2864	0.2780	3.	3.	1114.
776	73HOUDTT	61.03	1.2729	2.7961	C.6223	0.4369	17.	22.	5433.
777	73JANDAL	28.01	0.2114	1.4459	0.4165	0.4012	9.	9.	3526.
778	73LBBDAL	24.55	0.1542	1.4459	0.5742	0.5828	12.	13.	10194.
779	73MEMTYS	26.33	0.7271	0.3791	C.3447	0.4064	13.	12.	3241.
780	73MIACVG	54.87	1.4983	0.9112	0.5319	0.5102	12.	11.	11607.
781	73MIALAX	113.37	1.4983	5.5122	C.5680	0.7533	22.	30.	19466.
782	73MKECHI	11.89	1.0140	4.4136	0.5618	0.6063	24.	22.	5113.
783	73MKEDAY	24.04	1.0140	0.5747	C.3600	0.3304	10.	7.	1974.
784	73MOTBIS	14.27	0.0821	0.0618	0.1892	0.1699	4.	4.	108.
785	73MSPFAR	19.83	1.4089	0.1572	0.3778	0.3619	5.	6.	4428.
786	73MSYATL	29.55	0.9374	1.1955	0.6220	0.5577	23.	18.	13554.
787	73MSYHOU	22.10	0.9374	1.2729	0.6598	0.6294	20.	22.	26873.
788	73MSYLAS	74.53	0.9374	0.1930	C.4426	0.5712	6.	5.	2167.
789	73NYCALB	17.13	9.6011	0.6573	0.4648	0.4422	15.	13.	16621.
790	73NYCCHI	46.35	9.6011	4.4136	0.7839	0.7248	77.	83.	174540.
791	73NYCDEN	88.62	9.6011	0.8745	0.5320	0.6310	32.	30.	28386.
792	73NYCMKC	64.00	9.6011	1.1640	0.5917	0.4209	27.	33.	16553.
793	73OMACHI	30.05	0.3916	4.4136	0.5800	0.6277	10.	10.	13191.
794	73OMALNK	10.52	0.3916	0.1528	0.2214	0.2153	6.	5.	122.
795	73ORFPHL	20.13	0.4960	3.6636	C.4113	0.4563	16.	13.	10348.
796	73ORFRIC	12.77	0.4960	0.4834	C.3043	0.3240	6.	6.	346.
797	73PDXDAL	92.20	0.8202	1.4459	0.6530	0.5802	8.	9.	2360.
798	73PDXWAS	119.46	0.8202	1.8385	C.6666	0.4777	12.	11.	2987.
799	73PITALB	30.11	1.6747	0.6573	0.3650	0.3233	7.	9.	2717.
800	73PITCVG	20.74	1.6747	0.9112	0.4107	0.4102	11.	10.	4266.

801	73PITDAY	19.53	1.6747	0.5747	C.4131	0.3792	6.	9.	3490.
802	73RICCLE	36.02	0.4834	2.0527	C.2371	0.2445	6.	7.	1008.
803	73RICRDU	16.13	0.4834	0.6854	0.3567	0.1574	7.	3.	633.
804	73RNOLAS	24.04	0.1336	0.1930	0.3781	0.3767	7.	7.	8937.
805	73ROCCHI	37.19	0.4948	4.4136	0.5068	0.5184	11.	11.	8382.
806	73SACRNO	15.03	0.5654	0.1336	0.1556	0.0936	2.	1.	535.
807	73SANDEN	52.26	0.7383	0.8745	C.4986	0.5087	8.	11.	7789.
808	73SEADEN	54.09	1.1551	0.8745	C.6245	0.4287	6.	9.	8751.
809	73SEASAN	62.36	1.1551	0.7383	C.5114	0.4327	8.	12.	8028.
810	73SFOLAS	29.72	2.8359	0.1930	0.6112	0.4807	21.	21.	23414.
811	73SFOOMA	81.80	2.8359	0.3916	C.5598	0.4266	6.	9.	4252.
812	73SFOSTL	95.08	2.8359	1.5129	C.5674	0.5354	19.	17.	9778.
813	73SLCHOU	78.89	0.4935	1.2729	0.5051	0.4099	8.	7.	1279.
814	73STLDAY	26.30	1.5129	0.5747	0.4487	0.4493	7.	8.	3351.
815	73STLMKC	20.16	1.5129	1.1640	0.6443	0.5693	17.	16.	13623.
816	73STLOKC	37.26	1.5129	0.5634	C.3160	0.2938	9.	8.	3123.
817	73TUSCHI	79.88	0.2443	4.4136	0.6544	0.5021	12.	14.	7109.
818	73TUSSAT	46.32	0.2443	0.5373	0.4967	0.3088	8.	9.	646.
819	73WASHOU	69.40	1.8385	1.2729	C.4670	0.5216	19.	18.	8290.
820	73WASMIA	55.64	1.8385	1.4983	0.5770	0.5543	21.	22.	34318.
821	73WASNYC	19.65	1.8385	9.6011	0.6458	0.6409	71.	72.	184030.
822	73WASPWM	36.06	1.8385	0.3449	C.3188	0.3171	5.	4.	2656.
823	74ALBPIT	31.82	0.6421	1.6747	0.3185	0.2703	7.	6.	3150.
824	74ATLCVG	26.76	1.2058	0.8759	0.4907	0.4502	11.	10.	5927.
825	74ATLDAL	44.23	1.2058	1.4759	0.6519	0.6446	22.	16.	15528.
826	74ATLDTT	37.87	1.2058	2.7410	0.4799	0.4610	11.	14.	12960.
827	74ATLMSY	30.98	1.2058	0.9524	0.5786	0.6186	18.	20.	14136.
828	74BISMOT	14.22	0.0650	0.0808	0.1507	0.1555	3.	3.	139.
829	74BOSDTT	40.74	3.1376	2.7410	0.5237	0.5093	27.	22.	22046.
830	74CHIMKE	12.06	4.4096	0.9993	0.6038	0.5545	22.	23.	5119.
831	74CHINYC	46.08	4.4096	9.4228	0.6577	0.7996	63.	56.	173062.
832	74CHIOMA	30.47	4.4096	0.3967	0.5095	0.5148	8.	8.	13254.
833	74CHIROC	36.89	4.4096	0.4947	C.5125	0.5036	10.	10.	9157.
834	74CHITUS	77.85	4.4096	0.2614	0.4920	0.6917	16.	11.	7454.
835	74CLEDEN	70.41	2.0264	0.8788	0.5354	0.6099	10.	12.	4918.
836	74CLEDTT	14.87	2.0264	2.7410	0.5722	0.5487	22.	24.	19363.
837	74CLERIC	35.77	2.0264	0.4952	C.2441	0.2108	6.	4.	973.
838	74CVGBNA	20.31	0.8759	0.6526	0.1700	0.2783	3.	4.	2557.
839	74CVGMIA	55.56	0.8759	1.5882	0.4486	0.4639	10.	11.	11858.
840	74CVGPIT	22.63	0.8759	1.6747	C.3949	0.3805	7.	7.	4966.
841	74DALJAN	28.78	1.4759	0.2180	0.4170	0.4301	7.	8.	3867.
842	74DALLBB	24.27	1.4759	0.1535	0.5449	0.4689	8.	9.	10924.
843	74DALPDX	89.43	1.4759	0.8374	0.5640	0.4843	7.	9.	2343.
844	74DAYMKE	24.37	0.5568	0.9993	0.3517	0.3472	9.	6.	1869.
845	74DAYPIT	19.63	0.5568	1.6747	C.3240	0.4357	8.	8.	3863.
846	74DAYSTL	26.40	0.5568	1.4760	0.3854	0.4230	7.	6.	3512.
847	74DENNYC	89.92	0.8788	9.4228	0.5910	0.5162	32.	31.	27689.
848	74DENSAN	51.46	0.8788	0.7562	0.4728	0.5498	9.	9.	9182.
849	74DENSEA	54.84	0.8788	1.2027	0.4327	0.6059	7.	7.	8703.
850	74DTTHOU	63.43	2.7410	1.3156	C.4670	0.5000	16.	19.	5667.

```
74NYCALB    17.32   9.4228   0.6421   C.4513   0.3428    13.    10.    19073.
74FARMSP    19.90   0.1563   1.4037   C.4279   0.4217     7.     6.     6127.
74OKCSTL    34.91   0.5697   1.4760   0.3327   0.3121     7.     8.     3303.
74HOUMSY    22.38   1.3156   0.9524   0.6518   0.6696    21.    20.    28464.
74HOUSLC    79.21   1.3156   0.5072   C.3958   0.4810     8.     7.     1489.
74HOUWAS    70.37   1.3156   1.8317   0.5584   0.5579    13.    16.     9643.
74LASMSY    78.34   0.1965   0.9524   C.5695   0.4462     6.     5.     2478.
74LASRNO    24.37   0.1965   0.1367   0.3388   0.3407     8.     6.    10080.
74LASSFO    30.13   0.1965   2.8514   C.5209   0.5349    16.    17.    21991.
74LAXMIA   109.88   5.5343   1.5882   0.7503   0.5822    28.    19.    21832.
74LEXPIT    27.76   0.3206   1.6747   0.2272   0.2357     2.     3.     1243.
74LNKOMA    10.83   0.1537   0.3967   0.1163   0.2788     4.     7.      112.
74MEMTYS    26.15   0.7287   0.3917   C.3585   0.4023    10.    10.     4018.
74MIAWAS    55.56   1.5882   1.8317   0.5614   0.6249    26.    22.    33350.
74MKCNYC    64.20   1.1391   9.4228   0.5823   0.5128    17.    21.    16639.
74MKCSTL    20.17   1.1391   1.4760   C.5937   0.5960    16.    17.    16584.
74NYCWAS    19.65   9.4228   1.8317   0.7017   0.6837    63.    58.   177474.
74OMASFO    80.63   C.3967   2.8514   0.3487   0.5828     7.     6.     3783.
74ORFPHL    20.28   0.4938   3.6585   0.4334   C.3600    12.    12.    11366.
74ORFRIC    12.86   0.4938   0.4952   C.2824   0.2834     6.     7.      460.
74PDXWAS   119.84   0.8374   1.8317   0.6353   0.3873     9.     7.     3306.
74PWMWAS    36.08   0.3482   1.8317   C.3294   0.3158     5.     5.     2778.
74RDURIC    16.74   0.6880   0.4952   0.1184   0.3689     2.     8.      661.
74SACRNO    14.90   0.5645   0.1367   0.1527   0.0936     2.     1.      694.
74SANSEA    62.29   0.7562   1.2027   C.3521   0.4780     6.    11.     8792.
74SATTUS    44.25   0.5452   0.2614   0.2580   0.3893     6.     6.      704.
74STLSFO    90.68   1.4760   2.8514   C.5375   C.6438    12.    20.    10123.
*END
GENVAR,IN=X,OUT=B,NC=16$
LOGFARE
PRODBPI
PRODLOS
PRODNFLT
LOGPRODBPI
LOGPRODLOS
LOGPRODNFLT
LOGDEMAND
TRCARD   17    1          9
TRCARD   13    2     3   10
TRCARD   13    4     5   11
TRCARD   13    6     7   12
TRCARD   17   10         13
TRCARD   17   11         14
TRCARD   17   12         15
TRCARD   17    8         16
*END
CORRELATE,IN=B(C 9,13-16),COR=C,DES=D,COMPLETE,DOUBLE$
PRINT=3/C$
PAGE $
REGRESSION,COR=C(C 1,2,4,5),IN=B(C 9,13,15,16),DES=D,RES=R1$
```

```
901    DURWAT,IN=R1,OUT=DW1$
902    PRINT=3/DW1$
903    END $.
```

Appendix D: Examples of Level of Service Index Calculations

The formula for computing the level of service index from the flight schedule of one direction of a particular region pair is equation (3.6) from Section 3.2.2 of the text of this report.

$$LOS = \frac{t_{nj}}{\bar{t}} \qquad (3.6)$$

where t_{nj} is the nonstop jet flight time estimated by the equation (3.5), and $\bar{t}$ is the average passenger total trip time computed using equation (3.4).

$$t_{nj} = 0.5 + \frac{D}{V} \qquad (3.5)$$

$$\bar{t} = \frac{EOD}{2} + A_1 - T_m + \frac{1}{EOD}\left[A_1(T_1 - T_m) + \sum_{i=2}^{m} A_i(T_i - T_{i-1})\right] \qquad (3.4)$$

where D = interregional distance

$$V = \begin{cases} 600 \text{ mph if flight is west to east} & (960 \text{ kph}) \\ 500 \text{ mph if flight is east to west} & (800 \text{ kph}) \\ 550 \text{ mph otherwise} & (880 \text{ kph}) \end{cases}$$

EOD = specified end of day

m = number of flights

i = index of flights $\quad i = 1, 2, \ldots, m$

T_i = departure time of flight i

A_i = arrival time (origin time zone) of flight i

In order to minimize the complexity of equation (3.4), the EOD, T_i, and A_i terms are expressed in terms of hours after the prescribed start of the day.

For a numerical example consider the following schedule of flights from one airport to another airport located 300 miles (480 km) to the east. The prescribed start of day is 6:00 A.M., and the prescribed end of day is 12:00 midnight (EOD = 18.0).

Leave	Arrive	Number of Intermediate Stops	i	T_i	A_i
8:00 a	9:00 a	0	1	2.0	3.0
12:00 n	2:00 p	1	2	6.0	8.0
5:00 p	6:00	0	3	11.0	12.0
8:30	10:30	1	4	14.5	16.5

Substitution into equation (3.4) yields

$$t = \frac{18.0}{2} + 3.0 - 14.5 + \frac{1}{18.0}\Big[3.0(2.0 - 14.5) + 8.0(6.0 - 2.0) + 12.0\,(11.0 - 6.0) + 16.5\,(14.5 - 11.0)\Big] = 3.74 \text{ hours}$$

The interpretation of this figure is that the average passenger total trip time, including both block flight time and inconvenience waiting time, is 3.74 hours.

The nonstop jet flight time can be estimated by equation (3.5). Note that since the flight is west to east V = 600 mph (960 kph).

$$t_{nj} = 0.5 + \frac{300}{600} = 1.00 \text{ hours}$$

The level of service index, LOS, is the ratio of t_{nj} to $\bar{t}$ as defined in equation (3.6).

$$\text{LOS} = \frac{1.00}{3.74} = 0.268$$

The interpretation of this figure is that if "perfect" service were available, a nonstop jet departing at every instant of the day, the average passenger total trip time would be 26.8% of its current value.

Suppose that in an effort to upgrade service in this market, an additional nonstop flight is added to the schedule departing at 3:00 P.M. and arriving at 4:00 P.M. The schedule is now as follows:

Leave	Arrive	Number of Intermediate Stops	i	T_i	A_i
8:00 a	9:00 a	0	1	2.0	3.0
12:00 n	2:00 p	1	2	6.0	8.0
3:00 p	4:00	0	3	9.0	10.0
5:00	6:00	0	4	11.0	12.0
8:30	10:30	1	5	14.5	16.5

Substitution into equation (3.4) yields

$$\bar{t} = \frac{18.0}{2} + 3.0 - 14.5 + \frac{1}{18.0}\Big[3.0(2.0 - 14.5) + 8.0(6.0 - 2.0) + 10.0(9.0 - 6.0) + 12.0(11.0 - 9.0) + 16.5(14.5 - 11.0)\Big] = 3.40 \text{ hours}$$

Substitution of this figure into equation (3.6) yields

$$\text{LOS} = \frac{1.00}{3.40} = 0.294$$

The addition of the new flight has increased the level of service measure from 0.268 to 0.294.

Appendix E. Reasons For Selection of the Particular Region Pairs

By using the three criteria of region pair distance, extent of competition and region pair density, eighteen categories for market classification were formed. Several more were formulated by considering changes over time in the extent of competition. Even so, of the thousands of region pairs possible by pairing the 173 regions, each category generally consisted of many more region pairs than could be studied. The reasons for selection of the various region pairs that were chosen are outlined briefly in this appendix.

Short Haul: 0 - 300 miles (480 km)

Monopoly Sparse: Richmond-Norfolk (75 miles) (120 km)
Cincinnati-Nashville (230 miles) (370 km)

Each of these markets was chosen because of their relative monopolistic stability over time. No other carriers have ever challenged either Piedmont (Richmond-Norfolk) or American (Cincinnati-Nashville) in providing service in these region pairs. Recent interstate highway construction has improved surface transportation in both markets while introduction of jet service has enhanced trips by air. As in the case of all short haul region pairs, market response to the significant price increases since 1969, which have doubled the cost of flying in these markets, was of primary interest.

Monopoly Medium: Fargo-Minneapolis (223 miles) (360 km)
Las Vegas-Reno (345 miles) (560 km)

Las Vegas-Reno was chosen for this category even though it is somewhat longer than the 300 mile (480 km) maximum because no other domestic short haul market of medium density, other than Fargo-Minneapolis, had been served as consistently by a single carrier. Northwest flies between Fargo and Minneapolis and Air West (formerly Bonanza) flies between Reno and Las Vegas. Traffic has begun a slight decline in the former market as Interstate 94 nears completion; such is not the case in the latter market where no high speed roadways exist.

Monopoly Dense: Albany-New York (139 miles) (220 km)
Kansas City-St. Louis (229 miles) (370 km)

There are no domestic markets which support loads of more than 200 passengers per day each way but the two selected for this category come the closest of the high density short haul routes. Albany-New York comes closest to being monopoly; since 1963, American Airlines has operated one flight daily while Mohawk, and more recently Allegheny, has operated as many as a dozen or more. Trans World dominates the Kansas City-St. Louis market though token competition from Braniff, Ozark and Frontier has always existed.

Competitive Sparse: Omaha-Lincoln (55 miles) (90 km)
Bismarck-Minot (106 miles) (170 km)

When two or more airlines offer flights in the same sparse market, the usual case is that the flights are through to a larger metropolitan area.

Actual scheduling is concerned with the arrival time at or departure time from the larger city rather than between en route points. Omaha-Lincoln flights, flown by United and Frontier, link these two cities with Denver, Chicago, Kansas City, Washington, Dallas and Los Angeles among other points. Bismarck-Minot flights, flown by Frontier and North Central, connect these two cities with Omaha, Kansas City and Denver. These markets were chosen partially because they illustrate this phenomenon.

Competitive Medium: Cincinnati-Pittsburgh (256 miles) (410 km)
Lubbock-Dallas (293 miles) (470 km)

These two markets were chosen as representative of the competitive medium density short haul group because they both exhibit stable competitive situations between 1959 and 1974. American and Trans World continue to compete in the Cincinnati-Pittsburgh market and Braniff and Continental continue to compete in the Lubbock-Dallas market.

Competitive Dense: Cleveland-Detroit (94 miles) (150 km)
Houston-New Orleans (303 miles) (490 km)

Many competitive dense short haul routes are now served by commuters as well as trunks and locals. Because of problems associated with obtaining data from commuters, the representative markets chosen for this study must be ones where commuters are not integral suppliers of flights. While commuters did fly between the downtown airports in Cleveland and Detroit for a few years during the 1960s, this has since been replaced by Convair 440 flights operated by newly certificated Wright Airlines for which data is available. These two markets represent this category because of their relatively low level of commuter operations.

Connecting to Direct: Lexington-Pittsburgh (289 miles) (470 km)
Dayton-Milwaukee (285 miles) (460 km)

Allegheny began serving the Lexington-Pittsburgh market in 1969; prior to then, only off-line connections were offered and no service was published in the O.A.G. North Central began serving the Dayton-Milwaukee market in 1970; as in the Lexington-Pittsburgh market, only off-line connections had been available until that time, although these had been published in the O.A.G. for several years. These region pairs were chosen for examination of some of the effects of commencement of through service because the introduction of this service came near the middle of the study period.

Monopoly Direct to Competitive Direct: Richmond-Raleigh (138 miles) (220 km)
Dayton-St. Louis (339 miles) (550 km)

Though both United and Eastern have been certificated in the Richmond-Raleigh market since 1959, only Eastern has actively provided service throughout these sixteen years. Piedmont entered the market in 1969 transforming it from a virtual monopoly into a competitive market. In the case of Dayton-St. Louis, Trans World was providing flights but service was deteriorating in 1968 when Allegheny entered this market. While in both cases introduction of competition merely resulted in changing the allocation of about the same number of flights, it provided the stimulus by which the convenience of the departure times was maintained, something that had begun to wane before commencement of competitive services.

Competitive Direct to Monopoly Direct: Milwaukee-Chicago (74 miles) (120 km)
Dayton-Pittsburgh (215 miles) (350 km)

North Central has always dominated the Milwaukee-Chicago market even though all of its competitors have been trunks. Since 1959, the various competing trunks have suspended service one by one so that currently only Northwest offers token competition to North Central's large number of frequencies. Trans World was providing high frequency monopoly services in the Dayton-Pittsburgh market until Allegheny was certified in the 1960s. Since then, Trans World has suspended service leaving Allegheny as the sole carrier in the market.

Direct to Connecting: Detroit-Erie (155 miles) (250 km)
Binghamton-Albany (117 miles) (190 km)

Detroit and Erie are on opposit sides of Lake Erie and a surface trip between the two cities involves covering about 275 miles (440 km) while a flight involves only 155 miles (250 km). Nonetheless, airline participation has degenerated from a time when there were two competitors providing a total of seven daily flights to the point where there is currently no scheduled service at all. Markets where natural barriers make the surface trip considerably lengthy usually fare quite well as supporters of air transportation and this market was chosen in an attempt to find some insights into why just the opposite has occurred here. A similar, though not as striking case is true in the Binghamton-Albany market. The Catskill Mountains separate these two cities and there are no high speed roads to help cut down driving time. Nonetheless, this market has also degenerated from one which supported competitive services at one time to one which has no certificated scheduled service now.

Medium Haul: 300-1100 miles (480-1770 km)

Monopoly Sparse: Jackson-Dallas (397 miles) (640 km)
Tucson-San Antonio (762 miles) (1230 km)

The Jackson-Dallas market, perhaps more representative of this category of markets than is Tucson-San Antonio, has been served exclusively over the years by Delta Airlines. Since Dallas is one of the largest domestic connecting points, the Jackson-Dallas market is served by considerably more flights than would be necessary to serve the origin-destination demand alone; its selection allowed examination of the effects of changes in the level of service in this "saturated" market relative to similar changes in other markets not tied to major connecting points. The Tucson-San Antonio market, on the other hand, is one which has gone through a major growth period during the 1959-1974 study period. Continental first began serving this market with direct flights in 1964; prior to that, American had offered sporadic service. Since Continental's commencement of multi-stop service, the number of stops had gradually decreased to the point where one-stop flights are now flown between these two cities. The level of service seems to have peaked in the early 1970s and had declined somewhat since then. The wide range of changes in the supply of service in this market prompted its selection.

Monopoly Medium: San Diego-Denver (840 miles) (1350 km)
Cincinnati-Atlanta (373 miles) (600 km)

Both these markets were chosen because of the long term adherence to the classification title rather than for their peculiarities. Western has served the San Diego-Denver traffic with nearly all of the direct flights throughout the study period though United has occasionally offered through service and has always offered connections through Los Angeles. The Cincinnati-Atlanta market has always exclusively been served by Delta Airlines; a recent C.A.B. decision prevented commencement of competitive flights in this market.

Monopoly Dense: Detroit-Atlanta (602 miles) (970 km)
Omaha-Chicago (423 miles) (680 km)

No carrier save Delta has ever had non-stop authority in the Detroit-Atlanta market but the early years of the study period were characterized by multistop competition between Eastern, United and Delta. As traffic grew and jets were introduced, Delta exploited their singular non-stop authority to the point where no other carrier now offers through flights. United continues to offer connections through Cleveland. The Omaha-Chicago market, on the other hand, has been primarily served by

United throughout the 16 year study period though Ozark has occasionally offered five and six stop flights. Both these markets were chosen to represent this category because there are very few other medium haul, high density non-competitive domestic markets under the definitions in use here. (Competition in the Omaha-Chicago market will begin in March, 1976 when American inaugurates flights.)

Competitive Sparse: Oklahoma City-St. Louis (462 miles) (740 km)
Memphis-Knoxville (342 miles) (550 km)

The Oklahoma City-St. Louis market has been characterized by steady competition by American and Trans World throughout the study period and was chosen for this reason. The Knoxville-Memphis market is a case of American not making use of its singular non-stop authority, while United (Capital prior to 1961) and Southern actively compete with multistop flights. American Airlines has rarely offered more than one nonstop round trip in this market. Nonetheless, no other carrier appears to be seeking non-stop authority. This market was chosen to show how demand is affected when, for all intents and purposes, the highest level of service available is a one-stop flight rather than a non-stop.

Competitive Medium: Chicago-Rochester (522 miles) (840 km)
New Orleans-Atlanta (425 miles) (680 km)

The Chicago-Rochester market was being served by American and United (Capital prior to 1961) throughout the study period. Dominance in the market has shifted from United having a slight edge during the early years to the present when American enjoys a slight edge. The New Orleans-Atlanta market has been characterized by competition between Eastern and Delta (and United during the 1960s) and was one of the first domestic markets to receive jet service due to this high level of competition. This category contains a large number of markets, many similar to the two chosen as representatives.

Competitive Dense: Washington-Miami (920 miles) (1480 km)
Las Vegas-San Francisco (419 miles) (670 km)

The Washington-Miami region pair was selected from this category to provide an opportunity to examine one of the very high density Northeast-Florida markets. Carriers in this market include Northeast (Delta since 1972), Eastern and National. In addition and prior to 1972, Delta offered a high level of connecting service through Atlanta. The Las Vegas-San Francisco region pair also exemplifies the effects of a high degree of competition with five carriers offering flights throughout the study period: Trans World, Western, Pacitic (Air West after 1968), National and Delta. This market was chosen due to its high level of competition.

Connecting to Direct: San Diego-Seattle (1053 miles) (1690 km)
Portland, Me.-Washington (487 miles) (780 km)

By selecting the San Diego-Seattle market, it will be possible to examine two distinct changes in the level of service with a reasonably large data sample for each. Between 1959 and 1964, inclusive, no direct services were offered in this market at all. Then, between 1965 and 1967, Western, and sometimes United, offered multistop flights. Since 1968, direct service has continued to increase but United has been the only carrier to offer nonstops. Selection of the Portland, Me.-Washington market may allow some examination of service to sparse northern New England. When its fleet was all propeller, Northeast Airlines offered through services in this region pair. Then, as jets were introduced, it continued to operate the older propeller aircraft on its route structure north of Boston and direct services in the Portland-Washington market were discontinued. More recently, as the propeller equipment was phased out, direct services were restored and, since 1972, have been operated by Delta.

Monopoly Direct to Competitive Direct: Dallas-Atlanta (721 miles) (1160 km)
Boston-Detroit (623 miles) (1000 km)

Eastern joined Delta in serving the Dallas-Atlanta region pair in 1970 and this market was chosen as being somewhat typical in the analysis of commencement of competitive services in a market. The Boston-Detroit region pair, on the other hand, is one of the most peculiar and was chosen for this reason. Until the middle 1960s, the only flights offered in this region pair were between the airports in Boston and Detroit. The Boston-Detroit airport pair remains a monopolistic route with American providing the flights. Occasionally, Allegheny (Mohawk prior to 1972) has offered onestop flights. Since then, however, other carriers have developed services in this region pair through other airport pairs while American has stayed exclusively with the Boston-Detroit airport pair. Mohawk (Allegheny since 1972) has developed the Detroit-Providence market, United has developed the Flint-Boston market and Northeast (Delta since 1972) has developed the Manchester-Detroit airport pair.

Long Haul: More than 1100 miles (1770 km)

Monopoly Sparse: Omaha-San Francisco (1432 miles) (2300 km)
Portland-Dallas (1626 miles) (2620 km)

Because the economics of jet aircraft operation when combined by the current domestic fare structure are such that the airlines can earn profits even with very low load factors on long routes, there are very few region pairs in this category. Most of the ones which do exist contend with competitive connecting services; the Portland-Dallas region pair is an example of this with Braniff providing through services and Continental providing connecting service. The Omaha-San Francisco market is an example of a totally monopolistic region pair with United providing the flights.

Monopoly Medium: Denver-Cleveland (1217 miles) (1960 km)
St. Louis-San Francisco (1736 miles) (2790 km)

These markets are generally similar to those in the monopoly sparse category with the exception that more passengers travel in them. The Denver-Cleveland region pair is an example of a virtually totally monopolistic market; United flies in this monopoly market. The St. Louis-San Francisco is an example of a market with monopoly through services, flown by Trans World, contending with connecting competition, offered by American through Dallas.

Competitive Sparse: Portland-Washington (2339 miles) (3760 km)
Las Vegas-New Orleans (1500 miles) (2410 km)

Competition in this group of region pairs is generally the result of a carrier linking two or more nonstops together and being more concerned with the traffic on the individual segments rather than on the multistop segments. Northwest offers Portland-Washington flights through Minneapolis and United offers a similar service through Chicago. Delta offers Las Vegas-New Orleans flights through Dallas and National offers a simialr service through Houston. In both cases, there have been short periods of time where one carrier has only offered connections but since more often than not, the prevailing situation has been a competitive one, both these region pairs were good examples of long sparse competitive markets.

Competitive Medium: Houston-Washington (1204 miles) (1940 km)
Chicago-Tucson (1441 miles) (2320 km)

Only Eastern has nonstop authority in the Houston-Washington market. However, Braniff offers connecting flights through Dallas and Eastern and Delta offer connecting flights through Atlanta. The Chicago-Tucson market is a competitive nonstop market between American and Trans World which grew out of competitive multistops. Because numerous examples of both types of region pairs exist in this category, one of each was chosen for examination in our work.

Competitive Dense: Los Angeles-Honolulu (2556 miles) (4110 km)
New York-Denver (1627 miles) (2610 km)

The Los Angeles-Honolulu market had to be dropped because the Alaska and Hawaii statistics have been compiled in the domestic origin-destination survey only since 1968. The New York-Denver market supports a high degree of competition between United and Trans World and is typical of the markets in this category. Both carriers offer high frequencies and were among the first to receive jet service. It is interesting from the standpoint that while United dominated the market during most of the early years of the study period, both Trans World and United share the demand equally now. This could be related to the fact that Trans World was rather late in instituting nonstops.

Connecting to Direct: New York-Anchorage (3374 miles) (5430 km)
Salt Lake City-Houston (1204 miles) (1940 km)

The same trouble exists with the New York-Anchorage market as it does with the Los Angeles-Honolulu. Both markets were originally chosen to try to bring Alaska and Hawaii into the study in some way but this was not possible because of the need of a consistent data source. The Salt Lake City-Houston authority given to Texas International in 1970 was one of a large number of route awards given to the local service carriers to help reduce their subsidy and make their route structures more compatible with jet aircraft.

Monopoly Direct to Competitive Direct: Detroit-Houston (1095 miles) (1760 km)
Seattle-Denver (1020 miles) (1640 km)

Though slightly under the 1100 mile (1770 km) minimum, both these markets show a gradual transition from monopoly propeller to monopoly jet to competitive jet service through the study period and were chosen to examine some of the effects of these gradual changes. Both because competitive in 1969, Continental joining United in the Seattle-Denver market and American and Braniff joining Delta in the Detroit-Houston market.

Washington-New York (215 miles) (350 km)

The Washington-New York market is served by the Eastern Air Shuttle, some of the most sophisticated competition in the airline industry. By keeping back-up planes standing by, Eastern offers a guaranteed seat without a reservation and has been able to capture about 65% of the demand by offering about 40% of the supply. The Air Shuttle also operates in the Boston-New York market but this was not chosen because of heavy commuter operations.

Chicago-New York (721 miles) (1160 km)

The Chicago-New York market has been the stage for some of the fiercest competition in the industry, though not on as high a level as that of the Air Shuttle. For several years, commencing during the late 1960s, American, Trans World and United all offered hourly departures between LaGuardia and O'Hare. At one point, American was offering hourly departures to O'Hare from both LaGuardia and Newark. Because all of the carriers did not begin the onslaught of competition at the same time (American was first), it may be possible to examine some of the short term effects which result from one carrier offering a "regular" scheduled service in competition with others which offer high frequency "irregular" service.

Philadelphia-Norfolk (215 miles) (350 km)
Sacramento-Reno (113 miles) (180 km)

These markets were chosen to study some of the effects of a market improvement in another mode; in both cases chosen, the improvement has come in the auto and bus modes. In the early 1960s, the only way to drive from Philadelphia to Norfolk was the 354 mile (570 km) route through Baltimore, Washington and Richmond. With the completion of the Chesapeake Bay Bridge-Tunnel, the trip was shortened to 238 miles (380 km). Similarly during the early 1960s, the only way to drive from Sacramento to Reno was over narrow mountainous roads. The completion of Interstate 80 virtually halved the trip time to about two hours.

Appendix F: Overview of the Formulation of an Econometric Model

F.1. Single Equation Models

F.1.1. Classification of Models

Any single equation model which specifies some dependent variable, Y, as a function of n independent variables, $x_1, x_2, \ldots, x_n$, can be categorized as being a member of one of three general classes:

a. linear

b. intrinsically linear

c. intrinsically non-linear

A linear model is additive and of the form:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n + \varepsilon \qquad \text{(F.1)}$$

where β_0, $\beta_1, \ldots, \beta_n$ are coefficients to be determined and ε is an error term.

An intrinsically linear model is a function that although non-linear may be linearized using a set of simple transformations. Intrinsically non-linear models may be additive such as:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_1^2 + \ldots + \beta_n X_1^n + \varepsilon \qquad \text{(F.2)}$$

or $$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2^2 + \ldots + \beta_n X_n^2 + \varepsilon \qquad \text{(F.3)}$$

An intrinsically linear model may also be multiplicative such as:

$$Y = \beta_0 X_1^{\beta_1} X_2^{\beta_2} \ldots\ldots X_n^{\beta_n} \varepsilon \qquad (F.4)$$

An intrinsically non-linear model is an equation which cannot be linearized using a set of simple transformations. Examples of these are:

$$Y = \beta_0 + \beta_1 (X_1 X_2 + \beta_2 X_3^2) + \varepsilon \qquad (F.5)$$

and $$Y = \beta_0 + \beta_1 X_1 + e^{\beta_2 (X_2 + \beta_3 X_1 X_3)} + \varepsilon \qquad (F.6)$$

Equation (F.4) is particularly useful when the desired results are elasticities of Y with respect to the X values. For X_1, beginning by taking the first partial derivative with respect to X_1 yields:

$$\frac{\partial Y}{\partial X_1} = \beta_0 \beta_1 X_1^{\beta_1 - 1} X_2^{\beta_2} \ldots\ldots X_n^{\beta_n} \varepsilon$$

Multiplying by X_1 results in:

$$\left(\frac{\partial Y}{\partial Y}\right)(X_1) = \beta_0 \beta_1 X_1^{\beta_1} X_2^{\beta_2} \ldots\ldots X_n^{\beta_n} \varepsilon$$

Dividing by Y gives

$$\left(\frac{\partial Y}{\partial X_1}\right)\left(\frac{X_1}{Y}\right) = \frac{\beta_0 \beta_1 X_1^{\beta_1} X_2^{\beta_2} \ldots\ldots X_n^{\beta_n} \varepsilon}{\beta_0 X_1^{\beta_1} X_2^{\beta_2} \ldots\ldots X_n^{\beta_n} \varepsilon} = \beta_1 \qquad (F.7)$$

Elasticity of Y, a good or service, with respect to one of its inputs, X_1, is defined as the percentage change in Y due to a percentage change in X_1, $E_{X_1}^{Y} = \frac{\partial Y}{Y} \Big/ \frac{\partial X_1}{X_1} = (\frac{\partial Y}{\partial X_1})(\frac{X_1}{Y})$ as in (F.7). Thus, by specifying this type of model the resulting β values from the analysis are estimates of the various elasticities, which in econometric analysis are desired numerical results.

Richard E. Quandt [4] points out that demand for travel is commonly viewed as the result of an individual's rational decision making which is subject to economic, social, and demographic constraints, and that various modes or destinations of travel are regarded as commodities, each with its own price and among which the consumer choses so as to maximize some index of satisfaction. This viewpoint is broad and depends upon consumer theory, economic theory, utility theory, and other related but generally accepted concepts to be used as the basis for the selection of variables in the model. It is important that the theoretical basis of the model be understood so that an evaluation can be made of the causal or accidental relationships of the variables.

F.1.2. Classification of Data

The data used to calibrate these models is classified in two ways. The first is by time series, cross-section, or a combination of the two. Time series data represents a sample set of data over a period of time usually with fixed time intervals. Cross-sectional data refers to a sample representative of members of the target population taken at one point in time. Data that is taken from a representative sample of the target population over a period of time is a combination of time series and cross-section.

The second method of classification is aggregate or disaggregate data. This classification scheme is very general and is based upon a continuum of how specifically detailed the data has been summarized. For example, if one desired to gather time series data for the Boston to New York Air Shuttle, the total number of passengers flown each year would represent aggregate data. If this data were tabulated by time-of-day, purpose of trip, and socioeconomic characteristics of the passengers, the data would be considered disaggregated.

Government agencies are the primary source of both airline and socioeconomic data. The Civil Aeronautics Board provides financial and traffic data by carrier for major city pairs. The Department of Commerce and the Department of Labor provide statistics on income, income distribution, population, and various other demographic and economic variables which may be desired in a model.

F.1.3. Common Specifications

The majority of the work with demand models in air transportation has used the multiplicative functional form with either logarithmic transformations or "delta log" transformations, where in time series analysis one is not concerned with the absolute value of the log, but rather the change in the value of the log from one time period to the next. When time series data is used it is usually aggregated to a high degree and the major differences in the models relate to the selection of variables rather than the structural form. However, if quarterly or monthly time series data is used, quite frequently a "lagged variable" will be used. The lag can be employed in the dependent or independent variables or some combination of these and can be a simple step of one or more periods, or a series of steps according to some specified distribution function.

In the analysis of cross-sectional data in air transportation demand modeling, the most common model development has been the use of data that is disaggregated at various levels, usually related to city pairs, and one or more of the various forms of the "gravity model." The gravity model is a special case of the multiplicative structural form and is structured to resemble the equation for the gravitational attraction between two physical bodies. The concept is that the demand for air travel between two city pairs is directly proportional to the product of the two "masses", some socioeconomic measure of size, and inversely proportional to some power to the intercity distance.

F.1.4. Development of a Demand Model

While models, and results they produce, vary considerably, the procedure used in the development of a model follows the same general pattern which is segmented here into five steps. Step one is the selection of the explanatory variables based upon a set of stated assumptions, the predictability of the variables, and the availability of the data. Step two is the determination of the functional form. Steps one and two together determine the specifications of the model.

Step three is the calibration of the model through the use of regression analysis or some other technique and the determination using statistical tests of the significance and reliability of the individual variables and the overall goodness of fit. Steps one through three generally have to be repeated in an iterative process until the results of step three are deemed satisfactory.

If the model is to be used for forecasting purposes, step four is to test forecasting ability of the model. This is normally accomplished by calibrating with a subset of the historical data and then forecasting with past known values of the explanatory values. This forecast can then be compared with the actual historical values that were not used in the calibration.

Step five is the forecasting of the future by first forecasting the explanatory variables and then using their values in the model to forecast the demand.

F.1.5. Multiple Regression Using Least Squares

The most common technique used in the calibration of air transportation demand models is multiple regression using the least squares criterion. The conceptual simplicity and the ease of computation due to the availability of statistical computer packages which invariably includes multiple regression programs has rendered this technique very attractive to the researchers. However, the greatest pitfall is that the analysis is still in the hands of the user, and multiple regression using least squares involves many assumptions that are frequently overlooked or not adequately tested.

This is especially true when using time series data. The secular trends and the cyclical variations inherent in time series data frequently invalidate the assumptions made in least squares analysis. If the secular trend is the dominant characteristic with relatively small cyclical variations about the trend, then high multicolinearity (correlation between explanatory variables) can be expected. If the cyclical variations, which are serially correlated, are not accounted for by the independent variables, then autocorrelation (correlation between sequential residuals) will be a problem.

One approach to combatting these problems is to take first differences to eliminate the trend and minimize the serial correlation. Another approach is to use detrended variables which minimizes the multicolinearity but not the serial correlation.

Most regression programs in addition to the regression equation will provide the following information necessary for the analysis of the results: the means and standard deviations of all variables, the correlation matrix of the variables, the t ratio of the regression coefficients which measure the explanatory value of each independent variable, and the F and $\overline{R}_2$ values which are measures of overall goodness of fit. Some of the more comprehensive programs also provide the Durbin-Watson or Von Neumann statistics which are measures of the degree of autocorrelation, and the analysis of variance table which is useful in the analysis of the results when using only a small number of data points. Many programs also provide the probabilities associated with the t and F ratios. These probabilities are computed from t and F functions preprogrammed into the statistical package. The t and F tests are valid only if the assumption that the residuals are normally distributed with constant variance (homoscedastic) and uncorrelated, which in many cases is not true. All of the above measures should be carefully reviewed in the analysis of the results to insure that the inherent assumptions in least squares analysis are not violated and that the statistical tests of significance are valid.

F.2. Simultaneous Equation Models

In the general linear model, $Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n + \varepsilon$ (F.8) one major assumption for the validity of ordinary least squares (OLS) solution of the estimates of the β_i's is that $\mathrm{Cov}(X_i, \varepsilon) = 0$ for all i. In other words, the independent variables, X_i, must be uncorrelated with the error term. If this assumption is violated the following unsatisfactory results will occur:

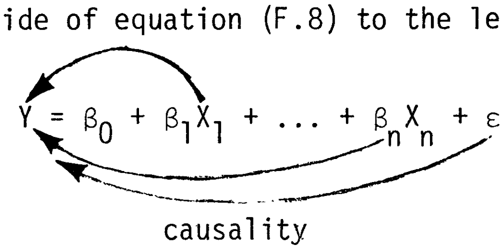
a. the estimates of the β_i's will be biased,

b. the estimates of the β_i's will be inconsistent,

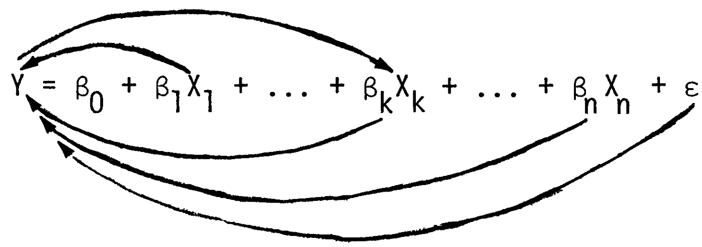
c. the estimate of the variance of the disturbance term, ε, will be biased, and

d. the usual t and F tests will be inappropriate.

A necessary condition for $\mathrm{Cov}(X_i, \varepsilon) = 0$ for all i is that each X_i be an <u>explanatory</u> or <u>exogenous</u> variable regarding Y, the <u>dependent</u> or <u>endogenous</u> variable. In other words, all causality must go from the right side of equation (F.8) to the left side, $X_i \Leftrightarrow Y$.



Consider the case in which variables Y and X_k are <u>jointly dependent</u>, $X_k \Leftrightarrow Y$, or there is a two way causality between X_k and Y. Since $\varepsilon \Rightarrow Y$ and $Y \Rightarrow X_k$, then logically $\varepsilon \Rightarrow X_k$, and OLS is inappropriate.



causality

In this case we say that <u>both</u> Y and X_k are endogenous variables, while the other X_1's are the exogenous variables.

Consider as an econometric model:

$$D = \beta_{10} + \beta_{11}F + \beta_{12}BPI + \beta_{13}LOS + \varepsilon_1 \qquad (F.9)$$

where

D = log of demand in passengers flown between two particular cities (or regions),

F = log of the fare,

BPI = log of the product of the Buying Power Index of the two cities (regions), and economic factor,

LOS = log of a quantified Level of Service factor, concerning frequency of flights offered between the cities (regions), time of day of departures, number of intermediate stops, etc.,

β_{10} = some constant,

β_{11}, β_{12}, and β_{13} = respective elasticities,

and

ε_1 = disturbance term (assumed normally distributed with mean of zero and constant variance).

Since fare and BPI are fixed determined variables not dependent upon air traffic demand, they can be classified as exogenous variables. However, Level of Service is dependent to some extent upon air passenger demand (if the demand were suddenly to increase, the airlines would correspondingly improve their schedules). Hence LOS is an endogenous variable and OLS is inappropriate in this model.

Suppose after further consideration of this system, it is conceived that Level of Service is not only determined by demand, but is also a function of the competition structure of the city (region) pair. If more than one carrier is competing for market share on this particular route, they may be engaged in a scheduling war. So, a second model is hypothesized

$$LOS = \beta_{20} + \beta_{21}D + \beta_{22}COMP + \varepsilon_2 \qquad (F.10)$$

where

COMP = log of some measure of competition on this route (perhaps number of certified carriers),

and

β_{20}, β_{21}, β_{22}, and ε_2 are analogous to the constants in (F.9).

Equations (F.9) and (F.10) comprise a system of two simultaneous linear equations in two endogenous variables and three exogenous variables. Neither of these equations by themselves can validly be solved using OLS.

However, since we have two equations in two endogenous variables, these variables may be each expressed in terms of the exogenous variables, F, BPI and COMP by the standard procedure of solving two simultaneous linear equations in two unknowns. The result is

$$D = \frac{\beta_{10} + \beta_{13}\beta_{20}}{1-\beta_{13}\beta_{21}} + \frac{\beta_{11}}{1-\beta_{13}\beta_{21}} F + \frac{\beta_{12}}{1-\beta_{13}\beta_{21}} BPI + \frac{\beta_{13}\beta_{22}}{1-\beta_{13}\beta_{21}} COMP$$

$$+ \frac{\beta_{13}\varepsilon_2 + \varepsilon_1}{1-\beta_{13}\beta_{21}} \qquad (F.11)$$

$$LOS = \frac{\beta_{20} + \beta_{21}\beta_{10}}{1-\beta_{21}\beta_{13}} + \frac{\beta_{21}\beta_{11}}{1-\beta_{21}\beta_{13}} F + \frac{\beta_{21}\beta_{12}}{1-\beta_{21}\beta_{13}} COMP + \frac{\beta_{21}\varepsilon_1 + \varepsilon_2}{1-\beta_{21}\beta_{13}} \qquad (F.12)$$

Making the obvious substitutions yields

$$D = \gamma_{10} + \gamma_{11} F + \gamma_{12}BPI + \gamma_{13}COMP + \delta_1 \qquad (F.13)$$

$$LOS = \gamma_{20} + \gamma_{21}F + \gamma_{22}BPI + \gamma_{23}COMP + \delta_2 \qquad (F.14)$$

Two important observations may be made by inspecting equations (F.13) and (F.14). The endogenous variables D and LOS are now expressed strictly in terms of the exogenous variables F, BPI, and COMP. Furthermore, the two disturbance terms in these equations,

$$\delta_1 = \frac{\beta_{13}\varepsilon_2 + \varepsilon_1}{1-\beta_{13}\beta_{21}} \qquad (F.15)$$

and

$$\delta_2 = \frac{\beta_{21}\varepsilon_1 + \varepsilon_2}{1-\beta_{21}\beta_{13}} \qquad \text{(F.16)}$$

are linear combinations of variables that are (assumed) normally distributed with zero mean and constant variance. Hence they themselves will have zero mean and constant variance. Thus, OLS may be applied to estimate the regression coefficients of (F.13) and (F.14). The resulting estimated model is:

$$D = g_{10} + g_{11}F + g_{12}BPI + g_{13}\ COMP \qquad \text{(F.17)}$$

$$LOS = g_{20} + g_{21}F + g_{22}BPI + g_{23}COMP \qquad \text{(F.18)}$$

where D and LOS are the expected values of demand and level of service given the observed values of the exogenous variables. However, they are independent of the observed value of each other.

The first stage in the solution of equations (F.9) and (F.10), the so-called <u>structured form</u> (SF) of the model, is to solve using OLS for the coefficient estimates of equations (F.13) and (F.14), the so-called <u>reduced form</u> (RF). Then for each observation, the values of the exogenous variables may be substituted into equations (F.17) and (F.18) to obtain "observed" values of D and LOS.

The second stage of the solution is to perform OLS on the <u>modified structured form</u> (MSF), which is

$$D = \beta_{10} + \beta_{11}F + \beta_{12}BPI + \beta_{13}LOS + \varepsilon_1 \qquad \text{(F.19)}$$

and

$$LOS = \beta_{20} + \beta_{21}D + \beta_{22}COMP + \varepsilon_2 \qquad (F.20)$$

to obtain consistent estimates for the regression coefficients of the original model, equations (F.9) and (F.10). This procedure is known as Two Stage Least Squares (2SLS).

Appendix G. Empirical Results

Listed below are the numerical results of all regression analyses referred to in Section 5, but not presented therein. The figures in parentheses are the appropriate t ratios.

Effect of Competition

Monopolistic Markets:

$$\widehat{LND} = 12.1335 - \underset{(7.390)}{0.4444}LNFARE + \underset{(5.098)}{0.1652}LNBPI + \underset{(16.104)}{1.2638}LNLOS$$

$$R^2 = 0.65$$

$$n = 284$$

Competitive Markets:

$$\widehat{LND} = 12.0422 - \underset{(5.708)}{0.3787}LNFARE + \underset{(8.616)}{0.3322}LNBPI + \underset{(13.553)}{1.3399}LNLOS$$

$$R^2 = 0.74$$

$$n = 269$$

Remaining Markets:

$$\widehat{LND} = 10.3490 - \underset{(2.296)}{0.1650}LNFARE + \underset{(14.252)}{0.5390}LNBPI + \underset{(14.265)}{0.8676}LNLOS$$

$$R^2 = 0.77$$

$$n = 322$$

Effect of Length of Haul

Ultra-short Markets (less than 260 km (160 miles)):

$$\widehat{LND} = 6.7478 + 0.9346LNFARE + 0.3817LNBPI + 0.6890LNLOS$$

$$(3.340) \qquad (9.511) \qquad (7.049)$$

$$R^2 = 0.79$$

$$n = 153$$

Short Markets (260 km (160 miles) to 560 km (350 miles)):

$$\widehat{LND} = 15.1588 - 1.2076LNFARE + 0.1050LNBPI + 1.4464LNLOS$$

$$(3.624) \qquad (2.952) \qquad (19.819)$$

$$R^2 = 0.76$$

$$n = 210$$

Medium Markets (560 km (350 miles) to 880 km (550 miles)):

$$\widehat{LND} = 12.9191 - 0.6669LNFARE + 0.2717LNBPI + 1.1833LNLOS$$

$$(1.811) \qquad (4.327) \qquad (17.161)$$

$$R^2 = 0.76$$

$$n = 177$$

Long Markets (880 km (550 miles) to 1850 km (1150 miles)):

$$\widehat{LND} = 13.4404 - 0.7051LNFARE + 0.4330LNBPI + 1.2583LNLOS$$

$$(3.467) \qquad (13.157) \qquad (14.677)$$

$$R^2 = 0.86$$

$$n = 171$$

Ultra-long Markets (over 1850 km (1150 miles)):

$$\widehat{LND} = 15.2093 - 1.3379LNFARE + 0.6332LNBPI + 0.9272LNLOS$$

(7.293) (15.802) (11.857)

$R^2 = 0.82$

$n = 164$

Cross-Sectional Analysis

1959 - 1962:

$$\widehat{LND} = 11.8327 - 0.4021LNFARE + 0.3130LNBPI + 1.2212LNLOS$$

(5.827) (7.884) (12.543)

$R^2 = 0.70$

$n = 217$

1963 - 1966:

$$\widehat{LND} = 10.6165 - 0.2746LNFARE + 0.3668LNBPI + 0.8482LNLOS$$

(3.504) (8.342) (8.185)

$R^2 = 0.61$

$n = 205$

1967 - 1970:

$$\widehat{LND} = 12.0570 - 0.4613LNFARE + 0.3396LNBPI + 1.1884LNLOS$$

(5.843) (8.687) (13.621)

$R^2 = 0.73$

$n = 228$

1971 - 1974:

$$LND = 11.4721 - 0.3221LNFARE + 0.3852LNBPI + 1.0593LNLOS$$

(3.478) (9.327) (12.362)

$R^2 = 0.73$

$n = 225$

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