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# Impact of Aircraft Size and Seat Availability on Airlines' Demand and Market Share in Duopoly Markets
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# ABSTRACT

In this paper, we focus on the analysis of the role of aircraft size on airlines' demand and market share in a duopoly competitive environment at the market level. While all previous studies assume that all the seats in an aircraft are available to local passengers, which is rare in reality, this research takes into account the situation in which some of the seats are taken by connecting passengers. Therefore, not only aircraft size but also the proportion of aircraft capacity available to local passengers are taken into consideration in our research.

We build a nested logit model to study the roles of aircraft size, together with operation frequency, seat availability and fare, in airlines' market share and total air travel demand in competitive non-stop duopoly markets. We find that airlines can obtain higher returns in market share from increasing service frequency than from increasing aircraft size, and our estimation result confirms previous findings of a S-curve effect of service frequency on airlines' market share.

We also find that, with the same net number of seats available to passengers, passengers like smaller aircraft with higher percentage of seat availability more than larger aircraft with lower percentage of seat availability. These results suggest that economies of scope realized by serving connecting and local passengers in the same flights are offset to a significant extent by reduction in service quality that results from serving both groups.

The findings in this paper are helpful for us to understand airlines' decisions regarding their operating network, and whether hub-and-spoke service or direct service is provided in the market.

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## Impact of Aircraft Size and Seat Availability on Airlines' Demand and Market Share in Duopoly Markets

### 1. Introduction

In the late 20th century, when most major airports in the United States were congested and the flight delays were a major concern to both passengers and carriers, the airlines often demanded airport capacity enhancement through building new runways or installing more sophisticated traffic control system, both of which were very expensive. In the meantime, the airport managers, government policy makers and aircraft manufacturers have been asking the questions of whether the airlines would increase aircraft sizes in their fleet, rather than increasing service frequency, to accommodate increasing travel demand, and how airlines' choice of aircraft size would influence their demand, market share and profit.

The tragedy of September 11 and the slowdown of the economy in both domestic and international markets in the new millennium have significantly changed the airline business. Travel demand has diminished due to security concerns and economy downturn; low cost carriers are competing more aggressively and penetrating in more markets; passengers are unwilling to pay for a premium price due to more transparent prices available on Internet. To account for these factors, most network carriers, such as American Airlines and United Airlines, are in the process of reconstructing their business models. Simplifying and reconstructing aircraft fleet is a critical component in these reorganization plans, in which only the most profitable aircraft type(s) will be retained in

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the fleet. Thus the same question about aircraft size, from a different perspective but now

taken more seriously by the airlines, has to be answered: what impact does aircraft size

have on airlines' demand and market share?

The recognition and study of the impact of aircraft size on airline's demand

started with the introduction of the concept of "schedule delay", which is implicitly

connected with aircraft size. The concept of "schedule delay" was first introduced by

Douglas and Miller (1974), and subsequently applied by Viton (1986) in a case study.

"Schedule delay" has two components. The first is frequency delay, which represents the

elapsed time between an individual traveler's preferred time and the time of a scheduled

flight. The second component is stochastic delay, which represents the additional time

that a traveler must spend to get a ticket when preferred flights are fully booked. Douglas

and Miller estimated empirical frequency and stochastic delay functions by using

regression and simulation methods. Frequency delay decreases with frequency, while

stochastic delay decreases with frequency and aircraft size, and increases with demand in

the market. The concept of "schedule delay" was used in a linear regression model by

Abrahams (1983) to estimate total air travel demand in a single market. In order to

specify "schedule delay," Abraham used the frequency delay function introduced by

Eriksen (1977), and the stochastic delay function introduced by Swan (1979). These two

functions have the same form as those proposed by Douglas and Miller (1974), but the

parameter values are different. Thus these models capture effects of both frequency and

aircraft size.

Instead of using the negative term "schedule delay," Eriksen (1977) and Russon

and Hollingshead (1988) used the terms "level of service" or "quality of service" – which

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are functions of service frequency and aircraft size in a format similar to "schedule delay" – in their models of air passenger travel demand.

Other researchers focused on "service frequency" or "frequency delay" to study the influence of airlines' service on travel demand. Hansen (1990) used service frequency, fare and flight distance to specify a passenger's utility function, and built a logit model for demand analysis. Norman and Strandens (1990) directly related service frequency to the waiting time and cost of passengers, and built a probabilistic air travel demand model under the assumption of uniform distribution for desired departure times over a time interval. Nikulainen (1992) built a similar model based on the assumption that passenger demand at any time is a function of the distribution of all flight departure times. But aircraft size was not explicitly taken into consideration in these models, which emphasized the role of service frequency in air travel demand.

More recently, Coldren et. al.(2003) built an itinerary level market share model using aggregate multinomial logit methodology. Aircraft size and type, together with such variables as fares, time of day, carrier market presence, itinerary level-of-service (nonstop, direct, single-connect, or double-connect) and connecting quality, are taken as independent variables in the model to measure various itinerary characteristics. Proussaloglou and Koppelman (1994) and Nako (1992) both applied the logit model to study airlines' demand using the survey data from individual passenger. They both investigated the effectiveness of the frequent flyer programs, but didn't take aircraft size or type as a factor influencing passengers' choice of airlines.

In this paper, we focus on the analysis of the role of aircraft size on airlines' demand and market share in a duopoly competitive environment at the market level, with

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one major airport in origin and one major airport in destination. Our studies will not only update previous estimates for the role of aircraft size in airlines' demand, but also obtain new estimation results for the specific case of duopoly market based on the data from the homogenous duopoly markets, where exactly two airlines compete with each other. We will study the roles of aircraft size both in an individual airline's market share and in total air travel demand in the market. While all previous studies assume that all the seats in an aircraft are available to local passengers, which is rare in reality, this research takes into account the situation in which some of the seats are taken by connecting passengers. Therefore, not only aircraft size but also the proportion of aircraft capacity available to local passengers will be taken into consideration in our research.

The rest of this paper is arranged as follows: section 2 describes in detail an air travelers' choice model; section 3 applies statistical methods to estimate the coefficients in the model, and discusses the implication and application of the developed model; and section 4 is a summary of this paper.

## 2. Air Travelers' Choice Model

We want to understand how aircraft size, together with other service attributes such as fare and frequency, could influence both the overall volume of air travel and each airline's share in an individual city-pair market. Since our ultimate aim is to model airlines' competitive behavior in a duopolistic setting, we will focus on markets where service is essentially provided by two airlines. Moreover, to further focus and simplify our analysis, we will exam cases in which the vast majority of traffic consists of direct flights as opposed to flights with one or more stops at an intermediate point.

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A simplified framework for air travelers' choice in a duopoly market is shown in Figure 1. Basically, our air travel demand and market share model is a two-level nested logit model, in which the upper nest is passengers' binary choice of whether or not to make a trip by air between a particular origin and destination, and the lower nest is passengers' choice of an airline for the trip. If we use the traditional notation $V_{im}$ to represent the deterministic travelers' utility of taking a trip through airline $i$ in market $m$, where $V_{im}$ is a function of airlines' service attributes, then at the lower level, the market share of airline $i$ at market $m$, $S_{im}$, is the exponential function of its utility divided by the sum for the two airlines:

$$S_{im} = \frac{\exp(V_{im})}{\sum_j \exp(V_{jm})} \tag{1}$$

At the upper level, in the standard nested logit framework, the total trips made in market $m$ are:

$$Q_m = D_m \frac{\left(\sum_j \exp(V_{jm})\right)^\theta}{\exp(V_{om}) + \left(\sum_j \exp(V_{jm})\right)^\theta} \tag{2}$$

$V_{om}$ is the utility of not making a trip in market $m$. $D_m$ can be regarded as saturation demand or total "potential" passenger demand in market $m$, which has been studied through the gravity-like models introduced by Verleger (1972) and Fridstrom and Thune-Larsen (1989), and the four methods summarized by O'Connor (1995). $\theta$, known as the "nesting coefficient", measures the degree of similarity of the elementary alternatives in the lower nest (making a trip in market $m$ by airline 1 or airline 2) relative

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to the alternative in the upper nest of not making a trip in market $m$ at all. If $\theta = 1$, then the model reduces to an unnested model, and the alternative of not traveling in market $m$ is treated essentially as another airline. If $\theta = 0$, market demand is totally insensitive to airline service attributes. For $0 < \theta < 1$, the total market demand is sensitive to airline service levels, but to a less degree than in the unnested model.

We assume that because time and money costs of air travel are inherently high, the actual demand in this market is far less than the total saturation demand, which implies that:

$$\left( \sum_j \exp(V_{jm}) \right)^{\theta} << \exp(V_{om}) \tag{3}$$

Then the formula for the total air travel demand, which is expressed in (2), can be approximated as:

$$Q_m \approx \frac{D_m}{\exp(V_{om})} \left( \sum_j \exp(V_{jm}) \right)^{\theta} = P_m \left( \sum_j \exp(V_{jm}) \right)^{\theta} \tag{4}$$

Where $P_m$, the social economic term capturing the total potential air travel demand in a market, is usually assumed to be a function of the population and income of both the origin and destination areas. It can be expressed as:

$$P_m = \exp(K_m)(Incom_m)^{\rho} \tag{5}$$

where:

$K_m$            is a characteristic coefficient for market $m$ ;

$Incom_m$       is the product of total income for all the population in the origin and destination areas;

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$\rho$ is an exponential coefficient for $Incom_m$, to be estimated.

We also use the notation $Util_m$ to represent the sum $\sum_j \exp(V_{jm})$, i.e.,

$$Util_m = \sum_j \exp(V_{jm}) \qquad (6)$$

Then, based on (5) and (6), the total air travel demand model in (4) can be expressed as:

$$Q_m = \exp(K_m)(Incom_m)^\rho (Util_m)^\theta \qquad (7)$$

In order to make the derived market share model (1) and travel demand model (2) operational, we need to specify the deterministic utility function, $V_{jm}$. We apply the following specification:

$$V_{jm} = \alpha \ln(Freq_{jm}) + \beta \ln(Size_{jm}) + \eta \ln(Aval_{jm}) + \gamma Fare_{jm} \qquad (8)$$

where:

$V_{jm}$ is passengers' deterministic utility if they take a flight from airline $j$ in market $m$;

$Freq_{jm}$ is the service frequency provided by airline $j$ in market $m$;

$Size_{jm}$ is the average aircraft size (seats per flight) used by airline $j$ in market $m$;

$Aval_{jm}$ represents "seat availability", the percentage of seats, provided by airline $j$ in market $m$, that are not occupied by connecting passengers;

$Fare_{jm}$ is the average fare charged by airline $j$ in market $m$.

This specification incorporates several effects. First, because the total number of seats available to local passengers is the product, $Freq_{jm} * Size_{jm} * Aval_{jm}$, it captures an

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overall capacity effect. Second, schedule delay is captured through $Freq_{jm}$ variable.

Third, the direct effects of aircraft size on service utility are incorporated through the

$Size_{jm}$ variable; such effects may include greater perceived safety and higher amenity

levels of larger planes, as well as their slightly higher cruise speeds. Fourth, the product,

$Size_{jm} * Aval_{jm}$, which equals to seats per flight available to local passengers, is related to

the likelihood that passengers can actually get a ticket in their preferred flights. Fifth, the

$Aval_{jm}$ variable captures the traffic mix effect, which may affect passengers' utility,

because the flight schedule can be oriented more toward serving either connecting or

local passengers. At last, the $Fare_{jm}$ variable captures the price effect.

Allowing different coefficients for $Aval_{jm}$ and $Size_{jm}$ will reveal whether utility

varies with different combinations of these two variables when they yield the same

number of seats per flight. For example, we ask whether the attractiveness of a 200-seat

aircraft with half its capacity available is the same as a 100-seat aircraft with all seats

available to the local market.

All these capacity terms, $Freq_{jm}$, $Size_{jm}$, and $Aval_{jm}$, take the logarithm form,

while the last term, $Fare_{jm}$, does not. There are two reasons for this specification: first,

we expect diminishing returns with respect to utility from increasing number of flights or

seats; second, travelers' choice of an airline can be conceived as aggregation of more

specific alternatives, including specific flights and seats. Ben-Akiva and Lerman (1985)

demonstrated that the logarithm form is the most appropriate for such attributes.

Based on the specified utility functions, the roles of aircraft size and other service

attributes in market share and total air travel demand are demonstrated in the four

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coefficients in equation (8) and the three coefficients in equation (7). The estimation for

these coefficients and implications of the findings are discussed in the next section.

## 3. Model Estimation and Implications

Based on the utility function proposed in (8) and the derived market share

function in (1), the ratio of market size—which is also the ratio of market share—

between the two airlines can be expressed as follows:

$$
\frac{S_{im}}{S_{jm}} = \frac{\exp\left(\alpha \ln(Freq_{im}) + \beta \ln(Size_{im}) + \eta \ln(Aval_{jm}) + \gamma Fare_{im}\right)}{\exp\left(\alpha \ln(Freq_{jm}) + \beta \ln(Size_{jm}) + \eta \ln(Aval_{jm}) + \gamma Fare_{jm}\right)}
$$
$$
= \frac{(Freq_{im})^{\alpha}(Size_{im})^{\beta}(Aval)^{\eta}\left(\exp(Fare_{im})\right)^{\gamma}}{(Freq_{jm})^{\alpha}(Size_{jm})^{\beta}(Aval)^{\eta}\left(\exp(Fare_{jm})\right)^{\gamma}}
\qquad (9)
$$

If we take logarithmic operation on both sides of the equation (9), then we get a

log-linear format of market share model. We can use statistical techniques to estimate the

parameters in the market share model specified as follows:

$$
\ln\left(\frac{S_{im}}{S_{jm}}\right) = \alpha \ln\left(\frac{freq_{im}}{freq_{jm}}\right) + \beta \ln\left(\frac{Size_{im}}{Size_{jm}}\right) + \eta \ln\left(\frac{Aval_{im}}{Aval_{jm}}\right) + \gamma\left(fare_{im} - fare_{jm}\right) + \varepsilon \quad (10)
$$

$\varepsilon$ is a stochastic error term composed of two parts. The first part is unobserved

attributes of the alternatives that affect passengers' utility in a systematic way. For

example, a given service may have poor on-time performance or a particularly

convenient flight schedule. The second part is sampling error in the data source. Here we

assume that the sum of these two parts is independent, identically and normally

distributed; therefore we apply the conventional OLS technique to estimate the

coefficients in the model.

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The source data for the coefficient estimation for our market share and demand model come from the database products Onboard and O&D Plus. The data in Onboard are reported on a monthly basis to the U.S. Department of Transportation (USDOT) by all the U.S. certified carriers for all non-stop domestic U.S. market segments and broken down by equipment type. Onboard has such data as onboard passengers, number of departures, segment distance, available seats, revenue passenger miles, available seat miles, load factor and enplanements. The data in O&D Plus are derived primarily from the USDOT's Origin and Destination Survey, and come from flight coupons that carriers issue to passengers. Airlines report data of every tenth coupon ticket, and therefore the database is a 10% sample, which includes such information as number of passengers, the average number of coupons, coupon passenger miles, and average fare outbound and inbound. The data in O&D Plus are reported in each quarter.

Because our model focuses on market share and demand in non-stop duopoly markets, we need to identify such markets among all the U.S. domestic markets. To keep the "non-stop" property, we first filter out the markets where more than 3% passengers of the total traveling passengers have one or more stops at other airports. We are interested in markets where each airline has regular service of at least one flight everyday (i.e. 90 flights in a quarter) in average. Since our demand model will not be jointly estimated with a supply function, we only include markets in which both origin and destination airports are hub airports for at least one of the duopoly airlines. Since services provided on these segments are determined to a large extent by network considerations not related to traffic in the segment itself, this reduces the problem of supply endogeneity. Also we exclude those markets where there is more than one large airport in the origin or

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destination regions. After applying these filters, we find 13 markets as listed in Table 1. It is noticed that the stage lengths for most of the selected markets are less than 600 miles, and none of the markets has a stage length over 1000 miles. The airlines operating in these markets include six of the largest 10 airlines -- Southwest Airlines(WN), American West Airlines (HP), Delta Airlines (DL), Northwest Airlines (NW), Trans World Airlines (TW), USAir (US), excluding American Airlines (AA), United Airlines (UA), Alaska Airlines (AS) and Continental Airlines (CO).

From the database products, we used the time series quarter data for the selected markets from $1^{st}$ quarter, 1989 to $4^{th}$ quarter, 1998 to do OLS regression. The estimation results are shown in Table 2.

The signs of estimated coefficients are expected, and all are significant at the 5% level. The fare coefficient, however, is suspiciously low. Based on the estimated coefficients, a doubling of frequency has an impact on utility equivalent to a fare reduction of $446. There are two possible explanations for this. First, the model does not control for service quality variables (such as cabin class, advance purchase requirements, and refundability) that affect fare. Second, as the result of yield management practices, flights, and therefore services, with more traffic tend to have higher fares, all else equal.

We find that the coefficient for frequency is 1.287, which means that, in a duopoly market, the carrier with higher frequency share will have an even higher market share, all else equal. Also the frequency coefficient is much higher than aircraft size coefficient, 0.185. Therefore we expect that airlines can obtain higher returns in market share from increasing frequency than from increasing aircraft size. These findings are demonstrated graphically in Figure 2, which shows how airlines' market share ratio

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changes with their capacity share ratio in two circumstances: 1. when two airlines use the same aircraft size and operate with different frequencies; 2. when two airlines operate with the same frequency but use different sizes of aircraft. The chart shows clearly that market share ratio increases much faster with the increase of capacity share ratio resulting from fixed aircraft size and varying frequency than from fixed frequency and varying aircraft size. The coefficient for seat availability, 0.849, is considerably larger than that for aircraft size, indicating that not only the net number of available seats in an aircraft but also the traffic mix can influence air travelers' choice of airlines. For example, the attractiveness of service with a 100-seat aircraft and no connecting passenger is higher than that of a 200-seat aircraft with half of its seats occupied by connecting passengers. These results suggest that economies of scope realized by serving connecting and local passengers in the same flights are offset to a significant extent by reduction in service quality that results from serving both groups.

After we estimate the coefficients for the market share model, we can subsequently estimate the coefficients for the total travel demand model in (7). By taking logarithmic operation on both sides of this equation, we can get a log-linear format of the total demand model, and use statistic techniques to calibrate the model as follows:

$$\ln Q_m = K_m + \rho \ln Incom_m + \theta \ln Util_m + \mu \tag{11}$$

All the dependent and independent variables are defined as in (5), (6), (7) and (8), and $\mu$ is assumed to retain the property of the error term for the conventional OLS estimations. The term of "log-sum" utility for each market, $Util_m$, is calculated according to (6) and based on the estimated coefficients above in the utility function. The market characteristic coefficient for market $m$, $K_m$, is assumed to be a constant in the whole

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time period, and thus taken as a dummy variable in the estimating process. Then, based on the same source data used in the coefficient estimation for market share model, OLS regression is used to estimate the parameters in (11). The estimation results are shown in Table 3.

It is noticed that all the estimates are statistically significant. The parameter for the variable $Util_m$, also known as "nested coefficient" in nested logit model, is estimated to be 0.333. This implies that, while the utilities of the nested airline alternatives are indeed correlated, market demand is also fairly sensitive to service supply. Besides the income index, $Incom_m$, which plays as significant a role in total air travel demand as conventionally believed, the variation in estimates for market fixed effects shows that market specific features, such as distance, economic base of the origin and destination regions, historical affinities, and demographic features also play important roles.

Before concluding this discussion, we need to address simultaneity issues related to the estimation of the market share and demand models. First of all, the market share model and the total demand model here are estimated sequentially rather than simultaneously, which make the estimation process easier, but may reduce the efficiency of derived estimation results for the total demand model. Given that the estimation results have fairly high t-statistics, this is not a major concern. Secondly, neither the market share model nor the total demand model is jointly estimated with a supply model, in which airlines' service attributes such as service frequency or charged fare are considered as dependent on perceived air travel demand. Originally we did attempt to use simultaneous estimations of demand and supply functions, as was done by Eriksen (1977), Meyer (1985), and Abrahams (1983). The results were not satisfactory, however,

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due to the unavailability of suitable instrument variables on the supply side. Recall, however, that in choosing the sample for estimation, we only included markets with both the origin and destination airports being hubs for one or two operating airlines. Thus it is reasonable to assume that airlines' strategic decisions in these markets, such as the choice of service frequency and aircraft size, depend mainly on demand on the whole hub-and-spoke network rather than on local traffic, so that supply-side decisions can be regarded as exogenous in our models. While this strategy reduces the risk of biased estimates, further research in this area is clearly called for.

## 4. Summary

In this paper, we build a nested logit model to study the roles of aircraft size, together with operation frequency, traffic mix and fare, in airlines' market share and total air travel demand in competitive non-stop duopoly markets. We find that airlines can obtain higher returns in market share from increasing service frequency than from increasing aircraft size, and our estimation result confirms previous findings of a S-curve effect of service frequency on airlines' market share, i.e., airline's market share is superproportional to airline frequency share. Therefore, we conclude that airlines have no economic incentives to use aircraft larger than the least-cost aircraft, since for the same capacity provided in the market, increase of frequency can attract more passengers than increase of aircraft size.

We also find that schedule convenience is more important for passengers than other service attributes such as flying speed or cabin amenity. With the same net number of seats available to passengers, passengers like smaller aircraft with higher percentage of

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seat availability more than larger aircraft with lower percentage of seat availability.
These results suggest that economies of scope realized by serving connecting and local
passengers in the same flights are offset to a significant extent by reduction in service
quality that results from serving both groups. The findings in this part are helpful for us
to understand airlines' decisions regarding their operating network, and whether hub-and-
spoke service or direct service is provided in the market.

Based on the derived demand model in this paper and the cost model such as that
in Wei and Hansen (2003), which studied the cost economies of aircraft size and explore
the influence of aircraft size on airlines' cost, we can analyze airlines' choices of aircraft
size in their operations under various circumstances. If we assume that our duopoly
demand model also applies in monopoly markets, we can identify a monopoly airline's
optimal choice of aircraft size by solving a profit maximization problem. We can also
find the optimal combination of size and frequency that provides service of a given utility
at least cost. Given the strong effect of frequency on service utility found in this paper,
these optima are likely to involve aircraft smaller than those that minimize cost per seat-
mile, which are identified in Wei and Hansen (2003). Besides the applications in these
two special cases, the derived demand models can be applied with the game-theoretical
analysis approach to systematically study airlines' choice of aircraft size in a general
competitive environment, where one carrier's market share and revenue depend not only
on its own service but also on the services provided by all other airlines in the market.
The details of this part are discussed in Wei (2001).

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# List of Figures and Tables

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### TABLE 1 Selected Markets for Parameter Estimation for Market Share and Demand Model

| No. of Market | Origin Airport | Destination Airport | Flight Distance | Airline 1 | Airline 2 |
|---|---|---|---|---|---|
| 1 | ABQ | PHX | 328 | WN | HP |
| 2 | ATL | CLT | 227 | DL | US |
| 3 | ATL | MEM | 332 | DL | NW |
| 4 | ATL | STL | 484 | DL | TW |
| 5 | CLT | STL | 575 | TW | US |
| 6 | DTW | PIT | 201 | NW | US |
| 7 | IND | STL | 229 | WN | TW |
| 8 | LAS | PHX | 256 | WN | HP |
| 9 | MSP | SLC | 991 | DL | NW |
| 10 | MSP | STL | 448 | NW | TW |
| 11 | ONT | PHX | 325 | WN | HP |
| 12 | PHX | SAN | 129 | WN | HP |
| 13 | PIT | STL | 553 | TW | US |

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## TABLE 2 Estimation Results for Market Share Model

| Variables | Estimations | t statistics |
|---|---|---|
| $\ln\left(\dfrac{freq_1}{freq_2}\right)$ | 1.287 | 41.43 |
| $\ln\left(\dfrac{Size_1}{Size_2}\right)$ | 0.185 | 2.45 |
| $\ln\left(\dfrac{Aval_1}{Aval_2}\right)$ | 0.849 | 15.92 |
| $\left(fare_1 - fare_2\right)$ | -0.002 | -2.79 |

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## TABLE 3  Estimation Results for Total Air Travel Demand Model

| Variable | Coefficient Estimate | t statistics |
| --- | --- | --- |
| ln $Util$ | 0.333 | 10.21 |
| ln $Incom_m$ | 0.425 | 9.51 |
| $K_1$ (Market1) | 4.876 | 12.03 |
| $K_2$ (Market2) | 4.077 | 10.89 |
| $K_3$ (Market3) | 4.378 | 11.67 |
| $K_4$ (Market4) | 4.154 | 11.45 |
| $K_5$ (Market5) | 3.204 | 9.61 |
| $K_6$ (Market6) | 3.507 | 9.68 |
| $K_7$ (Market7) | 3.838 | 10.43 |
| $K_8$ (Market8) | 5.113 | 11.95 |
| $K_9$ (Market9) | 3.578 | 10.66 |
| $K_{10}$ (Market10) | 3.922 | 10.54 |
| $K_{11}$ (Market11) | 4.962 | 12.13 |
| $K_{12}$ (Market12) | 5.158 | 12.40 |
| $K_{13}$ (Market13) | 3.321 | 9.68 |

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14        Not Air Travel                    Air Travel
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19              Firm 1            Firm 2
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24        FIGURE 1  Air travelers' choice in a duopoly market.
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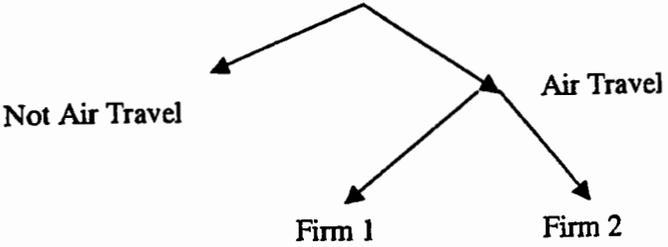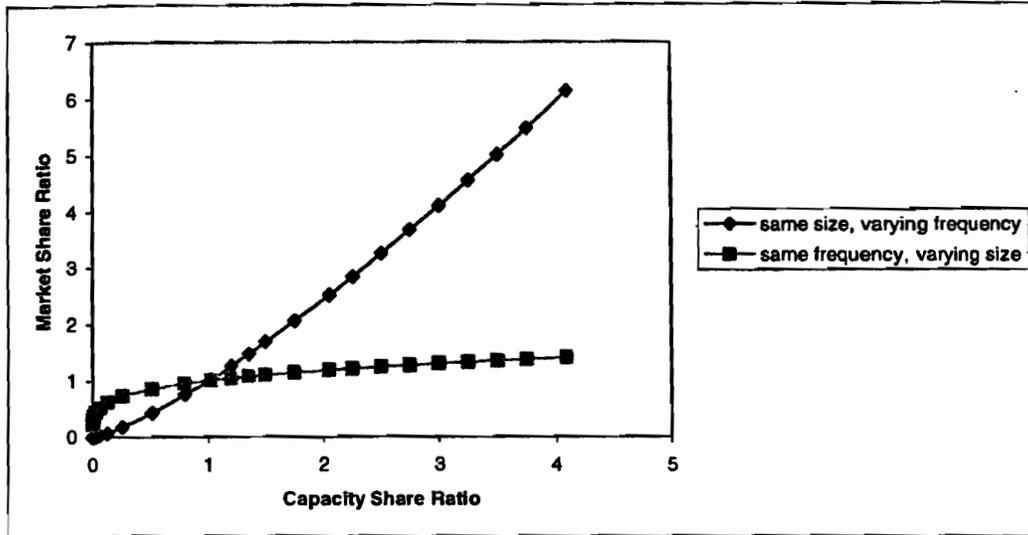**FIGURE 2  Changes of market share ratio with capacity share ratio based on increase of service frequency vs. increase of aircraft size.**

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