Transitory Forecasting Methodology: Passenger/Revenue Share and Capacity Share (The S-Curve)

Marlene Marie Dugan
Embry-Riddle Aeronautical University - Daytona Beach

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TRANSITORY FORECASTING METHODOLOGY:
PASSenger/REVEnue SHARE AND CAPACITY SHARE (THE S-CURVE)

by
Marlene Marie Dugan

A Thesis Submitted to the
Applied Aviation Sciences Department
in Partial Fulfillment of the Requirements for the Degree of
Master of Aeronautical Science

Embry-Riddle Aeronautical University
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by

Marlene Marie Dugan

This thesis was prepared under the direction of the candidate's thesis committee chair, Dr. Marvin Smith, Department of Applied Aviation Sciences, and has been approved by the members of her thesis committee. It was submitted to the Department of Applied Aviation Sciences and was accepted in partial fulfillment of the requirements for the degree of Master of Aeronautical Science.

THESIS COMMITTEE:

Dr. Marvin Smith, Chair
Dr. Thomas Connolly, Member
Dr. Frank Richey, Member

MAS Graduate Program Chair
Department Chair, Aeronautical Sciences

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ABSTRACT

Author: Marlene Marie Dugan
Title: Transitory Forecasting Methodology: Passenger/Revenue Share and Capacity Share (The S-Curve)
Institution: Embry-Riddle Aeronautical University
Year: 2001

The purpose of this descriptive study was to explore the relationship between a carrier’s service/capacity share and passenger share to determine the presence of the s-curve. The author is unaware of a current, accepted analysis for understanding the s-curve with any degree of reliability. Regression analysis was used to correlate service/capacity share against passenger share for domestic, United States air carriers. Carrier ranking was then added as a predicting variable to gain further insight into the correlation between service share and passenger share. It is anticipated that this study will be beneficial to airline network planners in their analysis of city pair, service share, and fleet choices.
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LIST OF ABBREVIATIONS

ATL – Atlanta, Georgia, USA
ASM Available seat miles
CLT – Charlotte, North Carolina, USA
CVG – Cincinnati, Ohio, USA
DAL – Dallas/Ft. Worth – Love Field, Texas, USA
DEN – Denver, Colorado, USA
Dept Departure
DFW – Dallas/Ft. Worth – International Airport, Texas, USA
DTW – Detroit – Wayne County, Michigan, USA
EWR – Newark, New York, USA
IAD – Dulles, Washington DC, USA
IAH – Houston – George Bush, Texas, USA
Incl Including
JFK – New York - Kennedy, New York, USA
LAS – Las Vegas, Nevada, USA
LAX – Los Angeles, California, USA
MSP – Minneapolis/St. Paul, Minnesota, USA
O&D Origin and Destination
ORD – Chicago – O’Hare, IL, USA
Pax Passenger
PHL – Philadelphia, Pennsylvania, USA
PHX – Phoenix, Arizona, US
PIT  – Pittsburgh, Pennsylvania, USA

Props - Propeller driven aircraft

QSI  - Quality Service Index

RPM  - Revenue passenger miles

SEA  – Seattle/Tacoma, Washington, USA

SFO  – San Francisco, California, USA

SLC  – Salt Lake City, Utah, USA

STL  – St. Lois, Missouri, USA
CHAPTER I
INTRODUCTION

Planners and Schedulers in the airline industry often analyze the effect of fleet assignment and route consolidation or expansion as they strive to optimize schedule effectiveness and aircraft utilization. While there are a number of concessions made for maintenance, crew schedules, slots, gates and regulatory restrictions, the goal is always to maximize revenue on the network.

The flying public plays a key role in this analysis, as it is their decision regarding which carrier to fly that affects the goal of an airline to maximize revenue. There is considerable history in the use of Quality Service Indexes (path quality: nonstop, one-stop, two-stop, etc. service) and service offerings (frequent flyer programs, flight timing and number of departures, airline image, etc.) to predict a consumer’s choice among carriers. However, the author is unaware of any current, accepted s-curve methodology for predicting or measuring the relationship between service at a city and the resulting capacity share. With an understanding of s-curve characteristics in forecasting capacity share as a result of fleet and departure presence in a city, analysts would have an additional evaluation tool, enabling them to make more informed decisions regarding network strategy.

Statement of the Problem

The purpose of this study was to test the correlation between service characteristics and capacity share in an attempt to better understand s-curve effects when making airline network planning choices. This study is based on regression analysis and published Department of Transportation annual results. For the purpose of this study, carriers are defined as domestic, United States, airlines operating jet or propeller aircraft.
Customers and passengers refer to those individuals predisposed to choosing air travel as the preferred form of transportation. S-curve describes the phenomenon when a transportation provider receives either greater or less than their capacity share in a market as a result of a service characteristic.

Review of Related Literature

Patterns of social and economic activities influence the need for transportation. Understanding the interaction of these activities and their resulting behaviors render a framework for the delivery of transportation systems and facilities. Transportation demand analysis provides the mechanism for modeling, understanding, and forecasting the volumes of traffic that require a transportation infrastructure. A meaningful measure of the relationship between traffic volumes and transportation system characteristics, as influenced by socioeconomic factors, is essential in designing economically feasible transportation systems (Kanafani, 1983).

Consumer demand is the relationship between traffic volumes and transportation cost characteristics. Supply is the way in which transportation providers respond to this demand. The demand models are designed to explain how the variables contributing to demand interact and forecast future traffic volumes (Kanafani, 1983). Forecasters use these models to study the impact and recommend action regarding the demand and supply environments. As socioeconomic environments and traffic volumes alter, the scrutiny and adaptation of transportation models is required to capture dynamics affecting transportation systems (Kanafani, 1983).

The formal study of transportation demand analysis began as early as the middle nineteenth century. During this period, studies focused on the relationship between the geography of resources and the shape of transportation networks. Models followed with an analysis of migration patterns and the integration of different modes of travel to meet consumer demand. Analysts in the early twentieth century focused on urban travel activities and behavioral influences. The quantification of human attitudes, psychological
characteristics, and the incorporation of random elements constitute some of the recent advances in transportation demand analysis (Kanafani, 1983).

Congress passed the Civil Aeronautics Act in 1938, establishing the Civil Aeronautics Board (CAB) as the regulatory authority governing domestic and interstate passenger operations. Its objective was to curb the industry's huge financial losses by protecting airlines from excess competition and guaranteeing service to travelers (Dana & Schmitt, 1995). The CAB was given authority over all pricing and route decisions, mergers, acquisitions, and interline agreements (Dana & Schmitt, 1995).

The CAB created a route system independent of airline “network” considerations. Most of the flight segments were insulated and a point to point service network was established. An 80% rule applied to the airlines, where 80% of the flights had to be nonstop and 80% of the passengers needed to originate or terminate on the offered route. Airlines did not have an incentive to consider non-stop versus a multiple stop network (Ippolito, 1981). “Faced with suppressed routing and pricing options, the airlines competed on services such as meals, movies, and seating comfort” (Kou, 1995, p. 3).

At this time, analysts concentrated on air travel versus other modes of transportation. Early studies focused on evaluating when travelers and commodities progressed from sea to land to air transportation. It was found that as income increased, the value of an individual’s time increased (Russon & Hollingshead, 1989). As the value of time and willingness to pay increased, the progression from sea to land to air travel occurred. Therefore, as air travel became more economical in total travel cost, it replaced automobile travel (Russon & Hollingshead, 1989).

Total travel cost was identified as the out-of-pocket cost of transport plus the value travelers place on their personal travel time, where personal travel time is the interval between departure from home or office until arrival at a final destination (Gronau, 1970). In the case of air transport, this includes waiting time until the next flight, origin and transport time to airport, origin terminal processing time, flying time,
waiting at intermediate stops, baggage claim, and destination local transport time (Russon & Hollingshead, 1989).

When Hansen (1988) performed his analysis of aircraft operating data and major airlines, he found that the airlines' use of a simple linear model was extremely accurate in identifying travel time for aircraft types. The only differences resulted between non-stop and one-stop activity and whether this one-stop activity resulted in a “fixed time component once (direct service) or twice (hubbed service)” (Hansen, 1988, p. 87). As intermediate stops increase the total travel time of air transport to the time required for driving, “the number of enplaned passengers would diminish to zero irrespective of population, income, or flight frequency” (Russon & Hollingshead, 1989, p. 302).

Russon and Hollingshead (1989) continued this analysis to include price and fare elements in the total travel cost. They found that even with a high amount of time efficiency, there was a fare threshold where passengers would no longer rule out competing modes of travel. They reported that “as air travel becomes more economical, it will be substituted for automobile travel.” (Russon & Hollingshead, 1989, p. 300).

The next logical step in the air transport analysis included a consideration of passenger income driving airline demand. Hansen (1988) hypothesized that increased income levels drove increased demand for leisure travel. He believed this would cause additional flight frequencies to be added, decreasing the time variable in total travel cost, and thereby continuing to increase the number of passengers seeking to travel by air.

Douglas and Miller (1974) identified two additional components of total travel time. The first component is “frequency delay” or the time between when a passenger wishes to travel and the actual departure time. The second component, “scholastic delay,” results from the possibility that the preferred flight is sold out. Since a passenger only recognizes that a flight is not available, the demand model variable becomes the sum of the delay times, known as schedule delay (Douglas & Miller, 1974).
From an airline perspective, this issue came down to flight frequency and average load factor. "The greater the flight frequency, the shorter the average waiting time between flights, and the lower the average load factor, the less likely any given flight will be sold out" (Abrahams, 1983, p. 385). It was at this time when the s-curve phenomenon was first documented. Airline analysts found examples where added capacity resulted in a disproportionate share of the available market traffic (Kou, 1995). "In 1975, the CAB described the 'so-called s-curve theory' as 'the claim that increases (or reduction) of marginal flights (those generating revenues covering out-of-pocket, but not fully allocated costs) result in a greater-than-proportional gain (or loss) of market share" (O’Connor, 1975, p. 89).

Studies by Fruhan (1972) supported this theory. He found "that for a carrier to increase (or maintain) its market share on the particular route it flies, the carrier must expand its seat capacity faster than (or at least as fast as) its competitors" (p. 132). The result was a fierce rivalry throughout the industry as airlines purchased aircraft to add frequency in an effort to capture that additional market share (Kou, 1995).

Analysts later learned that the market share advantage of capacity on highly competitive markets was short-term and often resulted in over-scheduling (O’Connor, 1989). There is a point where increased enplaned passengers will increase at a decreasing rate with flight frequency, until there is no longer productivity in adding an additional flight (Russon & Hollingshead, 1989).

Airlines also spent a considerable amount of money in competition over meals, movies, and the size and comfort of aircraft (Dana & Schmitt, 1995). Carriers began to show weakened earnings and balance sheets (Kou, 1995). During the 1970’s, the industry’s financial outlook worsened with a drop in consumer demand and the rise of fuel and labor costs. To address this issue, the CAB declared a policy of refusing to grant new route applications and allowing carriers to cooperatively reduce capacity in high-density markets (Kou, 1995). The result was approved fare increases with reduction of
service on popular routes. Consumers became extremely critical of regulation in the airline industry (Kou, 1995).

In 1976, the Kennedy Report concluded that deregulation would allow pricing flexibility, which would stimulate new and innovative offerings; allow passengers the range of price and service options dictated by consumer demand; enhance carrier productivity and efficiency; and increase industry health (Civil Aeronautics Board Practices and Procedures: Hearing before the Senate Subcommittee on Administrative Practice of the Judiciary Committee, 1976).

A trial period of liberalized entry and pricing mechanisms resulted in financial success, new demand, and lower fares (Kou, 1995).

In October 1978, President Carter signed the Airline Deregulation Act (Kou, 1995). Following deregulation, low-cost entrants challenged incumbents with low fares. The 1979 fuel crisis, the early 1980's recession, the 1981 air traffic controllers' strike, and intense price competition produced the worst financial losses in aviation history. More than 150 carriers declared bankruptcy while the average cost of an airline seat continued to decline (Kou, 1995). The economic situation thwarted customer traffic, causing airline seats to fly empty. It became clear that the longstanding presumption that adding flight frequency, and additional seats, in an effort to capture market share, did not work in the post regulatory environment (Ippolito, 1981).

Since seat inventory could not be stored for later use, carriers were losing both the value of the seat and the cost to fly the seat (Bamber, 1997). Airlines recognized that to stay in business, they needed to find ways to attract customers independent of lowering prices (Kou, 1995). This reaction to deregulation was far different from economists' original predictions (Peterpaul, 1993).

The value of filling airplane seats caused significant changes in airline marketing and scheduling practices. Passenger preference was hypothesized to be dependent upon
schedule convenience, fare, flight frequency, delay due to unavailability, and connection delays. Other factors thought to affect the profitability of routes were the population and per capita income at origin and destination points (Russon & Hollingshead, 1989).

An emphasis on quality service variables as they affect the number of enplaned passengers also became a factor in service offerings (Russon & Hollingshead, 1989). Non-stop flight frequencies with large and small aircraft and connecting flight frequencies were hypothesized to have different impacts on the number of enplaned passengers (Russon & Hollingshead, 1989). Differences in capacity, comfort, price and speed were all thought to be reasons a consumer would first choose a nonstop route in a large aircraft. Due to the time impact on total travel cost, connecting flights were thought to have a different (negative) impact on consumer choice, providing increased transit time, layovers, and a much lower driving/flying time differential (Russon & Hollingshead, 1989).

While most travelers would prefer nonstop service, the number of city-pair markets that can sustain nonstop service is quite small. In order to maximize revenue, major airlines abandoned point to point scheduling in favor of hub and spoke networks. A schedule that provides connections to large numbers of city-pairs allowed hub operators to achieve and maintain a higher load factor (percentage of occupied seats) than it would if each route were operated as a separate entity (Bamber, 1997). The hub and spoke network allowed airlines to provide more service offerings (origins and destinations) and make the best use of airplanes, air and ground crews, and gates. Consequently, cost per passenger could be reduced (Jeng, 1988).

Airlines began to consolidate activities over hub operations in an effort to increase load factors on flights in and out of the hub airport (Peterpaul, 1993). While this would seem to indicate that nonstop flight operations were nearly abandoned, the truth was that nonstop flight activity rose 4% from 1978 to 1983 (Civil Aeronautics Board, 1984). In fact, "the percentage of 145 cities connected with large, medium, and small cities (by
FAA's definition) by nonstop flights was 31%, 14%, and 5% for 1977. They increased to 34%, 17%, and 6% for 1984" (Ghafouri-Barzand, 1986, p. 12).

While airlines began to schedule hub and spoke systems in an effort to decrease the cost per passenger, airlines were still aware of the preference of passengers for non-stop to connecting flights (Peterpaul, 1993). Next to non-stop service, Peterpaul (1993) found that there was a preference among consumers for direct flights, followed by connecting to another flight on the same airline. A direct flight provides the convenience that a passenger does not need to deplane prior to the next flight segment and connecting on the same airline allows a passenger to transfer to another flight within the same terminal area. The passenger views these possibilities as decreased travel inconveniences, and decreased concern over baggage mishandling (Peterpaul, 1993).

As a function of service quality, Hansen (1988) described an s-curve effect for direct service at a market share ratio of 2.45 to 1. A clear advantage for airlines offering direct service. He also found a 2.19 to 1 market share ratio for increased frequencies. His studies concluded that a minimum frequency is more important than the maximum, but that having the maximum frequency did provide more market share as consumers in a hubbed service "can diminish layover times and thereby improve service quality” (Hansen, 1988, p. 91).

Airlines strove to offer a service advantage by providing direct and on-line flight connections. This strategy also served to maximize the amount of traffic flowing over the hub (Ghobrial & Kanafani, 1995). By 1990, 52% of passengers on trips over 1,500 miles changed planes to complete their flight, this rose from 42% in 1978. Over the same time period, “the percentage of all trips that included a change of airline fell from 11.2% in 1978 to 1.2% in 1990” (Dana & Schmitt, 1995, p. 5).

These studies also resulted in a competitive mindset for short and medium haul feeder markets. The strategy included providing the most frequency into the hub, thereby making it harder for a competitor to route traffic away from a hub and spoke system
This created a new issue for airlines who had been focusing on purchasing numerous large aircraft to meet passenger service quality requirements. When an airline operates with more frequencies, unless the market size continues to increase, the average size of the required aircraft gets smaller. However, the conduit routes continued to create a need for larger aircraft (Ghobrial & Kanafani, 1995).

The fare equation in total travel cost also began to show deregulation variance. Travelers appeared to react to fares charged for air travel; showing elasticity in a large number of city-pairs (Abrahams, 1983). An econometric analysis performed by Ghobrial and Kanafani (1995) found that when comparing flight frequency during peak periods, aircraft size, and travel times, “the demand was elastic with respect to airfare and was highly dependent on flight schedule and travel time (Ghobrial & Kanafani, 1995). Long-haul and vacation travelers showed more elasticity than short-haul and business traffic. However, there was a threshold for short-haul routes when the cost of airline travel approached the total travel cost for driving. At this point, levels of traffic in both the business and vacation segments declined (Abrahams, 1983).

Ghobrial and Kanafani (1995) showed that airfare was influenced by market concentration and level of service. Markets served predominately by a single carrier tended to have higher fares. However, they also depended upon whether the predominant trip purpose was business or non-business, and the capacity constraints of the utilized airports (Ghobrial & Kanafani, 1995). Airlines recognized that business travelers were willing to pay for frequent departures and last minute seat availability (Abrahams, 1983). “Service characteristics for this customer segment include flight schedule and load factor rather than amenities such as food and drinks. Other segments of the public prefer a lower fare, even though this meant a reduction in the quality of service” (O’Connor, 1989, p. 91). The overall result was that in 1986, 90% of all airline passengers flew at a fare discount averaging 61% (Gourdin, 1988).
Due to runway lengths, gate space, airport improvement charges, and allowed
hours of operation, airline analysts became interested in what factors caused a passenger
to choose one airport over the other. Airports farther away from the main population can
produce service improvements due to a decrease in the amount of airspace congestion
and a lower operating cost to the airline, thereby reducing the overall fare to consumers

Elasticity demand models performed by Ashford and Benchemam (1987) showed
that airport choice was not equally responsive to changes in access time, flight frequency
and airfare. The accessibility variable was more important than flight frequency for all
passengers. The fare variable was found only to be significant for leisure and domestic
passengers. Therefore, leisure and domestic passengers could be attracted to one airport
or another by a lower fare, but business travelers were much more influenced by changes
in flight frequency (Ashford & Benchemam, 1987).

Russon and Hollingshead (1989) expanded this theory to include the use of small
aircraft as a service variable. They found that for service to cities with multiple airports,
other quality of service characteristics needed to improve for passengers to choose an
airport with airlines utilizing smaller aircraft. Similarly, they found that the frequency,
delay, and overall transport time needed to be adjusted for price and discomfort variables,
otherwise, passengers would not choose to fly from the secondary airport.

Airlines could not cost effectively provide high levels of customer service while
meeting the consumer demand for increased frequency, lower overall travel times, and
lower fares. It became unreasonable for travelers to expect a great deal of personal
service, fancy food, or spacious seating at low rates. Airlines increased focus on the first
and business class products to meet needs in this segment of the market (Conine, 1987).

It was at this point that airlines recognized that consumers choose airlines based
on their perceived level of overall service (Ashford & Benchemam, 1987).
O’Connor (1989) found that if

there are two airlines in the market and one has 60 percent of the capacity,
prospective passengers will tend to think first of this dominant carrier when they
decide to reserve space on a flight. They will also be more likely to find the most
desirable departure time and available space on that carrier. Thus, the airline with
60 percent of the total capacity will win more than 60 percent of the traffic (p. 88-
89).

Beginning in the mid-1990s, United States and European carriers adopted a
predominant competitive strategy of adding frequencies and retaining a passenger
throughout the entire trip (Bamber, 1997). Alliances with foreign carriers allowed an
airline to develop a worldwide network. Efficiency was obtained because there were
very few city-pairs in the world which generated enough passengers to support nonstop
services. Carriers explored connections with alliance partners to increase the share of
traffic between partner carriers. While there was the potential to increase market share,
the advantages of joint mileage programs, handling each other’s flights, and sharing
terminal and sales environments was believed to provide substantial savings for both
carriers (Bamber, 1997).

There has also been a trend towards teaming up with feeder airlines specializing
in the utilization of 19 to 72 seat aircraft. In some cases, the hub carrier may have a
partial or complete financial holding in the feeder carrier. Traditionally, the partnership
involves the feeder carrier adopting the hub carrier’s flight designator, rescheduling its
flights to connect into the hub carrier’s banks, and implementing marketing programs to
include through check-in, joint use of lounges, and mileage credits. In most cases, the
smaller aircraft are repainted in the larger carrier’s colors and employees will wear the
larger carrier’s uniform. The result is to give breadth to an airline by providing access to
smaller regional markets and increase overall load factor by bringing more passengers
through a hub carrier’s system (Bamber, 1997).
The evolving worldwide trend towards a less regulated environment has created renewed interest in the applicability of the s-curve. As governments review the competitive environment for carriers to enter new markets and new carriers to make an impact on operating systems, the s-curve has provided some insight for decision makers on this subject.

The October 2000 decision by Mexico’s Federal Competition Commission regarding the separate public sale of Aeromexico and Mexicana cites a competitive response deficiency in the s-curve. In a statement of points presented by the Commission, it assumed the effect of the s-curve was limited to flow versus local markets. In part, the commission used this argument to defend the potential for Aeromexico and Mexicana to successfully coexist with headquarters operations at Mexico City Airport (Federal Competition Commission, 2000).

At nearly the same time, the U.S. Department of Transportation began an investigation into predatory practices in the commercial aviation industry. In the federal notice dedicated to this investigation, the s-curve was described as existing in “local markets served by more than one carrier, where the major carrier’s higher frequency attracts a greater share of the local traffic than that carrier would otherwise carry” (Hunnicutt, 1998). The Boyd Group/ASRC, Inc. (1998) identified the difficulty carriers have entering new markets as a result of the effects of the s-curve. They noted that “very rarely does a new carrier have capacity available to establish itself in a position of strength in a market large enough to support the service” (p. 11).

Finally, when the Canadian Government recommended changes to its aviation policy, general understandings of the s-curve were used to describe concern for predatory practices. Based on these concerns, it was recommended that the Governor-in-Council be given the authority to issue cease and desist orders to air carriers (von Finckenstein, 1999).
Models for describing the behavior of individuals in choice situations have wide applicability for established and new airlines, governments, and regulatory environments. Bruzelius and Magnus (1981) cite the benefits of economic modeling to “study the effect on traffic flow of some hypothetical or expected change in the cost of transportation from one city to another when more than one alternative is open to the traveler.” Ghobrial and Kanafani (1995) support this conclusion, adding that modeling needs to include more quality of service variables.

Understanding the forces that affect demand for carrier service is critical to effective carrier decisions on operating, pricing, yield management, and marketing/promotional strategies. Measuring the factors affecting air traffic growth at the market level is critical to effective decisions on route structure, expansion to new markets, fleet size and composition, and the level of carrier service by origin market and city pair (Proussaloglou, 1994, p. 2).

Statement of the Hypothesis

Since the early 1970’s, airline analysts have speculated that an s-curve phenomena exists; so that as a carrier increases service/capacity on an origin and destination or in a city, that carrier will receive a passenger/revenue share greater than its capacity share. The researcher is unaware of any current, accepted methodology, for measuring this effect with any degree of reliability. Therefore, the researcher asked the following questions. “Does the s-curve exist?” If so, “Is the s-curve a route phenomenon or a city phenomenon?” And, “Do rankings for service levels affect the s-curve?”
CHAPTER II

METHOD

Samples

The samples for this study were composed of origin and destination (O&D) operations in the United States (U.S.) as operated by U.S. air carriers for the 1995 and 1996 calendar years. Four quarters worth of data were evaluated for the two years selected. While this constitutes an enormous amount of raw data, the sample selection represents 10% of the carrier operations in the United States.

The data reported to the US Department of Transportation (DOT), Bureau of Transportation Statistics, is based on an industry comprised of 260 U.S. airlines and 215 foreign reporting airlines. The Office of Airline Information (OAI) compiles 12,000 paper financial reports and 2,100 computer disks/tapes of financial and market/traffic statistics annually to prepare the DOT data. The information is currently gathered from passenger tickets collected at the airport gate using a sample of approximately 10 percent of domestic and international air travel trips on U.S. carriers. For example, of the nearly 35 million tickets sold each quarter, approximately 2.5 million records, both paper and computer, are generated by the airlines, compiled, and sent to the department’s Bureau of Transportation Statistics for review.

Instrument

The samples for this study were obtained through the O&D Plus Database as published by Data Base Products, Inc. The information for this database is derived from the comprehensive financial and market/traffic statistical economic data reported from the air transportation industry via a quarterly survey of airline passenger traffic. This
data is then published by the U.S. Department of Transportation’s Office of Airline Information.

The O&D data provided includes the point of origin, the air carrier of each flight segment, the fare basis code (i.e., first class, coach, and discount coach fares), stopover points, the destination, the number of passengers, and the actual airfare. The DOT requires a 95% accuracy rate on this data from the air carriers. The information is used by the government to analyze airline competition, select and approve air carriers for international routes, monitor airfares, and make decisions on the distribution of grants to airports. In addition, this data is used by airlines and aircraft manufacturers in the industry to make route, fleet, and demand decisions.

In 1997, an audit was conducted by the Inspector General which found that 69% of the 8,894 city-pairs reviewed did not meet the 95% accuracy criteria sought by the department (Office of the Inspector General, 1998). For example, in 643 flight segments, the O&D passenger counts were misreported in a range extending from 31% to 40%. While the Inspector General found the data collection system obsolete and the data collected unreliable, this is the only data currently available to analyze large scale O&D traffic in the U.S. airport system.

Design

The research method used in this study was Correlational, as outlined in the textbook *Educational Research*, by Gay (1992). This method of research was chosen because it was necessary to establish whether or not a relationship exists between service variables and the resulting market/passenger share in order to determine if an s-curve exists. The critical variables that were controlled include the resulting market share, whereas uncontrolled variables were cities of origin, route O&D’s, connections, nonstops, the weighting of data points by size, carrier dominance in the market, low cost carriers, and total passengers.
Procedure

Industry speculation has been that as a carrier increases its service/capacity share on a route or at a city, that carrier will receive a passenger/revenue share greater than its capacity share. Figure 1 depicts the theoretical s-curve which represents this theory.

![Theoretical S-Curve](image)

**Figure 1.** Theoretical S-Curve. Percentage of Market Share by Service Share.

In order to identify the existence and shape of the s-curve, O&D data for the years 1995 and 1996 was analyzed with the least squares regression model to determine the line fitted to the data. Regression analysis allows us to determine which line best fits or models the data (Jaisingh, 2000).

This regression model was chosen because our hypothesis assumes there is a relationship between the values of X and Y. The least-square criterion is described by Pindyck and Rubinfeld (1976, pp. 6-10) as

- minimizing the total spread of y values from the line; creating the line of best fit.

The linear equation is as follows:
$Y = a + bX,$

$Y$ is the dependent variable and $X$ the independent variable. Since we wish to minimize the vertical sum of the squared deviations from the fitted line, the equation is restated as:

$$\text{Minimize } \sum_{i=1}^{N} \left( Y_i - \hat{Y}_i \right)^2$$

$$\hat{Y}_i = a + bX_i,$$

is the fitted value of $Y$ corresponding to a particular observation $X_i$, and $N$ is the number of observations.

The least-squared slope estimate is determined as:

$$b = \frac{\sum x_i y_i}{\sum x_i^2}$$

The least-squares intercept can be obtained through:

$$A = \bar{Y} - b\bar{X}$$

The values for $\bar{X}$ and $\bar{Y}$ are the means for $X$ and $Y$, derived from:

$$\bar{X} = \frac{\sum x_i}{N} \quad \text{and} \quad \bar{Y} = \frac{\sum y_i}{N}$$
Following these computations, an Analysis of the Variance (ANOVA) must be performed to determine if the line produced is actually a good fit. This means that the data plotted on the scatter plot has a small deviation, as compared to the total spread of data points, to the line (Gonick & Smith, 1993).

The squared correlation of this data is defined as:

\[ R^2 = \frac{\sum (\hat{y}_i - \bar{y})^2}{\sum (y_i - \bar{y})^2} \]

The closer \( R^2 \) is to 1, the tighter the fit of the curve (Pindyck & Rubinfeld, p. 35).

\( R^2 \) values close to 1 imply that the model is explaining most of the variation in the dependent variable and may be a very useful model. \( R^2 \) values close to 0 imply that the model is explaining little of the variation in the dependent variable and may not be a useful model (Jaisingh, 2000, p. 91).

\( R^2 = 1 \) corresponds to a perfect fit of the dependent variable. Therefore, if an \( R^2 \) is described as .822, 82% of the variation is explained by the X variable and the other 18% is error. A negative \( R^2 \) indicates that the X variable is negatively related to Y (Gonick & Smith, 1993, p. 195-196).

The second method used to test the validity of the linear regression model is testing of the null hypothesis. The null hypothesis will be accepted if the slope of the regression line is 0. By rejecting the null hypothesis, we accept that the alternative hypothesis is accepted, until additional testing is performed (Pindyck & Rubinfeld, 1976).

The third procedure for testing the regression equation includes testing the existence of a linear relationship between X and Y. A strong statistical relationship between X and Y will result in a large ratio of explained to unexplained variance (Pindyck & Rubinfeld, 1976). In testing the null hypothesis, a high value for the F statistic is rationale for rejecting the null hypothesis. "If the value is close to 0, it must be
concluded that the explanatory variables do little to explain the variation of $Y$ about its mean" (Pindyck & Rubinfeld, 1976, p. 60).
CHAPTER III

ANALYSIS

In testing the hypothesis for the existence of the s-curve, the first step was to identify where there was a high level of data relevance. Once a positive correlation between data could be determined, testing for factors which influence the existence of the s-curve could begin.

Initial testing was conducted at a city level, comparing frequency and passenger share. The data was simplified through the elimination of path quality factors by focusing on routes with no nonstop service. Table 1 indicates the progression of the testing for the s-curve at the city level. Testing all of the markets resulted in a very poor relevance between data (Table 1, Trial 1). Table 1, Trial 2, dealt with the elimination of very small markets and their high sampling errors; however, it also resulted in a bad fit of data. Table 1, Trial 3, dealt with limiting the size of the market even further, with the result that market thresholds do not improve the data relevance. Table 1, Trial 4, eliminates Southwest Airlines under the theory that this carrier caters to passengers that are fare hunters and are not service driven. This did not improve the data relevance. Table 1, Trail 5, tried to identify whether or not there was something unique about being the top carrier in the market. The results of this analysis were not good. Table 1, Trail 6, tests a large carrier with many markets. By focusing on one airline, the theory was that data noise due to differences in marketing strategies was eliminated. Limiting the data field worsened the results. Table 1, Trial 7, combined the theories behind Trials 5 and 6 by focusing on an airline where it was number one in the market. The data results were even less relevant. Table 1, Trial 8, sought to answer the question of whether path quality was integral to the process of understanding the s-curve. While the results were
slightly more promising, with an $R^2$ of .64, the multi-variant regression required to continue testing was outside the scope of this project.

In Step 2 of Table 1, experimentation with different types of data-weighting was tried to assist with the correlation. Weighting was introduced to account for differences in city size. Weighting of the cities gave small cities less total value. The results for city-based data weighting improved slightly. In Table 1, Trials 14 and 15, markets were eliminated with a theoretical or actual share of the market at less than 20% and greater than 80%. This was done in an effort to eliminate outlying data and improve data correlation. This effort failed and it was then understood that most of the data being evaluated was in markets with less than a 20% share. By eliminating this segment of the market, most of the testable data was eliminated and the data relevance diminished. The conclusion from Table 1 was that there is no pattern identifying an s-curve on a passenger origin and destination basis at the city level.
Table 1

**Frequency Versus Passenger Share for Origins and Destinations with No Nonstops**

<table>
<thead>
<tr>
<th>Step 1</th>
<th>Variable</th>
<th>R²</th>
<th>Slope</th>
<th>Intercept</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>All carriers, all markets</td>
<td>.498</td>
<td>.87</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>2.</td>
<td>Carriers with ≥50 pax per market</td>
<td>.538</td>
<td>.80</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>3.</td>
<td>Carriers with ≥20 pax per market</td>
<td>.510</td>
<td>.80</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>4.</td>
<td>All carriers without Southwest Airlines</td>
<td>.470</td>
<td>.72</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>5.</td>
<td>Top Carrier in each market</td>
<td>.394</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>6.</td>
<td>American Airlines, all markets</td>
<td>.360</td>
<td>.68</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>7.</td>
<td>American Airlines where leading in market share</td>
<td>.260</td>
<td>.48</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>8.</td>
<td>Quality Service Index (QSI)</td>
<td>.640</td>
<td>.90</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>versus connection share</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>All carriers, all markets incl. props, weighted by size</td>
<td>.56</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>10.</td>
<td>All carriers, all markets, weighted by size</td>
<td>.54</td>
<td>.97</td>
<td>.04</td>
<td>--</td>
</tr>
<tr>
<td>11.</td>
<td>All carriers, all markets, weighted by pax</td>
<td>.536</td>
<td>.91</td>
<td>.007</td>
<td>--</td>
</tr>
<tr>
<td>12.</td>
<td>All carriers, all markets, weighted by pax, market, and</td>
<td>.533</td>
<td>.93</td>
<td>.087</td>
<td>--</td>
</tr>
</tbody>
</table>
In Table 2, combinations of service and passenger share at hub cities were compared to determine if there was a correlation between data. If the fit was good, that would indicate that the s-curve exists at the hub level. To accomplish this testing, data was collected by airline, by route, and summed to a hub basis. For example, American Airlines flights from Dallas to Albuquerque, Dallas to Denver, and Dallas to Seattle were summed and used as one Dallas data point. The tests performed in Table 2 show that the relevance of the data was good no matter the form of the model tested. The conclusion from Table 2 was that the data relevance is much improved on a hub basis versus a passenger origin and destination basis.

Note. Dashes indicate the field was not estimated. Step 1 data includes jet and propeller driven aircraft. Step 2 data contains no propeller driven aircraft and is weighted (where indicated) by data point size at the rate of 1x the size of the sample. For example, a market with 1000 passengers counted 10 times as much as a market with 100 passengers. From Form 41, 3rd Quarter 1995, Origin and Destinations (O&O) with connections.

*a See Appendix A.  
*b Elimination of markets with a share less than 20% and greater than 80% of overall data totals.  
*c Elimination of markets with a share less than 20% and greater than 80% by O&D.

airline presence

13. All carriers, all markets, no weights
   .517  .92  .007  --

14. Theoretical 20/80\(^b\), no weights
   .340  .90  .015  --

15. Actual 20/80\(^c\), no weights
   .251  .51  .228  --
Table 2
Service Share Versus Passenger Share Combinations by Hub City

<table>
<thead>
<tr>
<th>Variable</th>
<th>R^2</th>
<th>Slope</th>
<th>Intercept</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>16. Pax share vs. dept. share, weighted by total seats^a</td>
<td>.910</td>
<td>1.05</td>
<td>-.0038</td>
<td>344,160*</td>
</tr>
<tr>
<td>17. Pax share vs. dept. share, weighted by departures</td>
<td>.920</td>
<td>0.00</td>
<td>.98</td>
<td>--</td>
</tr>
<tr>
<td>18. Pax share vs. dept. share, weighted by dept. in Seattle^b</td>
<td>.904</td>
<td>1.03</td>
<td>-.003</td>
<td>--</td>
</tr>
<tr>
<td>19. Pax share vs. seat share, weighted by total seats</td>
<td>.977</td>
<td>1.004</td>
<td>-.0008</td>
<td>--</td>
</tr>
<tr>
<td>20. Pax share vs. seat share, weighted by total seats^a</td>
<td>.992</td>
<td>1.01</td>
<td>-.0012</td>
<td>4,021,576*</td>
</tr>
<tr>
<td>21. Pax share vs. ASM share, weighted by total ASMs</td>
<td>.938</td>
<td>.954</td>
<td>.0034</td>
<td>516,585*</td>
</tr>
<tr>
<td>22. RPM share vs. dept. share, weighted by total seats</td>
<td>.796</td>
<td>1.01</td>
<td>-.0011</td>
<td>132,288*</td>
</tr>
<tr>
<td>23. RPM share vs. seat share, weighted by total seats</td>
<td>.920</td>
<td>1.01</td>
<td>-.0008</td>
<td>388,201*</td>
</tr>
<tr>
<td>24. RPM share vs. ASM share, weighted by total ASMs</td>
<td>.997</td>
<td>1.02</td>
<td>-.0013</td>
<td>12,558,676*</td>
</tr>
</tbody>
</table>

Note. Dashes indicate the field was not estimated. Hub cities include ATL, CLT, CVG, DAL, DEN, DFW, DTW, EWR, IAD, IAH, JFK, LAS, LAX, MSP, ORD, PHL, PHX, PIT, SEA, SFO, SLC, STL. All data is weighted by data point size at the rate of lx the size of the sample. For example, a market with 1000 passengers counted 10 times as much as a market with 100 passengers. From T100 Domestic Segments, Year 1995 and 1996, by airline, by route, summed
to the origin level with hub cities only. Elimination of carriers with 0, 1, or 100 observations.

Arbitrary city choice to test city phenomenon.

* $p < .0001$

The testing conducted for Table 3, Step 1, was to identify whether or not passenger share is disproportionately larger in cities with greater capacity share. Testing data on a city basis resulted in a good data relevance. Trial 30 (Table 3, Step 1), compared total RPM share versus ASM share, weighting total ASMs. Trial 26 (Table 3, Step 1), compared passenger share and seat share, weighting total seats. The results from both of these tests showed a strong correlation between the data and a slope greater than 1; indicating the potential for the s-curve to exist. Having achieved a high level of data relevance for these two tests, the next step was to identify whether or not the relationships were different at different share levels. In Table 3, Steps 2 and 3, continued refinement of RPM share versus ASM share was conducted to identify the s-curve more finely. The results of Table 3, Step 2, identify an S-curve. The $R^2$s are good and the slopes are greater than 1 in many instances. The poor results in Step 3 suggest that a 10 zone evaluation of the data cuts the data too narrowly, resulting in poor dispersion and the inability for the model to fit a good slope line and, consequently, results in a poor $R^2$. 
Table 3

Service Share Versus Passenger Share Combinations for All Cities

<table>
<thead>
<tr>
<th>Step 1</th>
<th>Variable</th>
<th>$R^2$</th>
<th>Slope</th>
<th>Intercept</th>
<th>$F$</th>
</tr>
</thead>
<tbody>
<tr>
<td>25.</td>
<td>Pax share vs. dept. share,</td>
<td>.777</td>
<td>.94</td>
<td>.0099</td>
<td>118,316*</td>
</tr>
<tr>
<td></td>
<td>weighted by total seats</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26.</td>
<td>Pax share vs. seat share,</td>
<td>.960</td>
<td>1.01</td>
<td>-.0009</td>
<td>805,212*</td>
</tr>
<tr>
<td></td>
<td>weighted by total seats</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27.</td>
<td>Pax share vs. ASM share,</td>
<td>.853</td>
<td>.95</td>
<td>.0091</td>
<td>195,977*</td>
</tr>
<tr>
<td></td>
<td>weighted by total ASMs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28.</td>
<td>RPM share vs. dept. share,</td>
<td>.604</td>
<td>.83</td>
<td>.0279</td>
<td>51,665*</td>
</tr>
<tr>
<td></td>
<td>weighted by total seats</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29.</td>
<td>RPM share vs. seat share,</td>
<td>.832</td>
<td>.93</td>
<td>.0105</td>
<td>167,499*</td>
</tr>
<tr>
<td></td>
<td>weighted by total seats</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30.</td>
<td>RPM share vs. ASM share,</td>
<td>.978</td>
<td>1.01</td>
<td>-.0015</td>
<td>1,529,054*</td>
</tr>
<tr>
<td></td>
<td>weighted by total ASMs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Step 2

<table>
<thead>
<tr>
<th>Step 2</th>
<th>Variable</th>
<th>$R^2$</th>
<th>Slope</th>
<th>Intercept</th>
<th>$F$</th>
</tr>
</thead>
<tbody>
<tr>
<td>31.</td>
<td>RPM share vs. ASM share,</td>
<td>.985</td>
<td>1.01</td>
<td>-.0008</td>
<td>1,680,903*</td>
</tr>
<tr>
<td></td>
<td>weighted by total ASMs:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0-20% ASM share</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32.</td>
<td>RPM share vs. ASM share,</td>
<td>.911</td>
<td>1.01</td>
<td>-.0052</td>
<td>47,318*</td>
</tr>
<tr>
<td></td>
<td>weighted by total ASMs:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>21-40% ASM share</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33.</td>
<td>RPM share vs. ASM share,</td>
<td>.841</td>
<td>1.07</td>
<td>-.0265</td>
<td>12,653*</td>
</tr>
<tr>
<td></td>
<td>weighted by total ASMs:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>41-60% ASM share</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
34. RPM share vs. ASM share, weighted by total ASMs: 
   61-80% ASM share
   .914 .97 .0402 13,791*
35. RPM share vs. ASM share, weighted by total ASMs: 
   81-100% ASM share
   .970 .93 .0721 23,384*
Step 3
36. RPM share vs. ASM share, weighted by total ASMs: 
   0-10% ASM share
   .905 1.00 -.0008 185,892*
37. RPM share vs. ASM share, weighted by total ASMs: 
   11-20% ASM share
   .506 1.03 -.0043 5387*
38. RPM share vs. ASM share, weighted by total ASMs: 
   21-30% ASM share
   .314 .96 .0059 1314*
39. RPM share vs. ASM share, weighted by total ASMs: 
   31-40% ASM share
   .247 1.07 -.0296 575*
40. RPM share vs. ASM share, weighted by total ASMs: 
   41-50% ASM share
   .208 1.03 -.0112 355*
41. RPM share vs. ASM share, weighted by total ASMs: 
   51-60% ASM share
   .208 1.08 -.0347 274*
42. RPM share vs. ASM share, weighted by total ASMs: 
   51-60% ASM share
   .214 1.15 -.0792 216*
61-70% ASM share

43. RPM share vs. ASM share, \( .086 \quad .77 \quad .1802 \quad 47^* \)
weighted by total ASMs;

71-80% ASM share

44. RPM share vs. ASM share, \( .132 \quad .84 \quad .1320 \quad 61^* \)
weighted by total ASMs;

81-90% ASM share

45. RPM share vs. ASM share, \( .448 \quad .95 \quad .0466 \quad 267^* \)
weighted by total ASMs;

91-100% ASM share

Note. All data is weighted by data point size at the rate of 1x the size of the sample. For example, a market with 1000 passengers counted 10 times as much as a market with 100 passengers. From T100 Domestic Segments, Year 1995 and 1996, by airline, by route, summed to the origin level with all cities.

* \( p < .0001 \)

Table 4 shows the further refinement of the s-curve data regarding passenger share versus seat share. These trials measured spent capacity and produced capacity; meaning that it measured the seat share allocated by a carrier against that carrier’s resulting passenger share. Again, the poor results in Table 4, Step 2, suggest that a 10 zone evaluation of the data cuts the data too narrowly, resulting in poor dispersion and the inability for the model to fit a good slope line and, consequently, results in a poor R².

A comparison of Table 3, Step 1, and Table 4 shows that the s-curve was more robust when determined by seats rather than departures. This indicates that a marginal investment in seats results in more passengers. Airlines may be more focused on having the right size aircraft, conceding the right number of departures to the perceived competitive environment. There is a need for further research to investigate this phenomenon with the use of QSI and airline image measures.
Table 4

Spent Capacity Versus Produced Capacity in All Cities

<table>
<thead>
<tr>
<th>Step 1</th>
<th>Variable</th>
<th>( R^2 )</th>
<th>Slope</th>
<th>Intercept</th>
<th>( F )</th>
</tr>
</thead>
<tbody>
<tr>
<td>46.</td>
<td>Pax share vs. seat share, weighted by total seats: 0-20% seat share</td>
<td>.956</td>
<td>1.01</td>
<td>-0.005</td>
<td>536,279*</td>
</tr>
<tr>
<td>47.</td>
<td>Pax share vs. seat share, weighted by total seats: 21-40% seat share</td>
<td>.697</td>
<td>0.90</td>
<td>0.0210</td>
<td>10,624*</td>
</tr>
<tr>
<td>48.</td>
<td>Pax share vs. seat share, weighted by total seats: 41-60% seat share</td>
<td>.770</td>
<td>1.13</td>
<td>-0.0535</td>
<td>7937*</td>
</tr>
<tr>
<td>49.</td>
<td>Pax share vs. seat share, weighted by total seats: 61-80% seat share</td>
<td>.778</td>
<td>0.93</td>
<td>0.0693</td>
<td>4945*</td>
</tr>
<tr>
<td>50.</td>
<td>Pax share vs. seat share, weighted by total seats: 81-100% seat share</td>
<td>.915</td>
<td>0.95</td>
<td>0.0595</td>
<td>6521*</td>
</tr>
<tr>
<td>Step 2</td>
<td>Variable</td>
<td>( R^2 )</td>
<td>Slope</td>
<td>Intercept</td>
<td>( F )</td>
</tr>
<tr>
<td>51.</td>
<td>Pax share vs. seat share, weighted by total seats: 0-10% seat share</td>
<td>.942</td>
<td>1.02</td>
<td>-0.008</td>
<td>326,756*</td>
</tr>
<tr>
<td>52.</td>
<td>Pax share vs. seat share, weighted by total seats: 11-20% seat share</td>
<td>.614</td>
<td>1.01</td>
<td>-0.0024</td>
<td>7775*</td>
</tr>
<tr>
<td>Weighted Seat Share (%)</td>
<td>Pax Share vs. Seat Share</td>
<td>Coefficient</td>
<td>T-Value</td>
<td>Degrees of Freedom</td>
<td>p-Value</td>
</tr>
<tr>
<td>-------------------------</td>
<td>--------------------------</td>
<td>-------------</td>
<td>---------</td>
<td>-------------------</td>
<td>---------</td>
</tr>
<tr>
<td>21-30%</td>
<td>.397</td>
<td>.84</td>
<td>.0371</td>
<td>1663*</td>
<td></td>
</tr>
<tr>
<td>31-40%</td>
<td>.340</td>
<td>1.04</td>
<td>-.0260</td>
<td>1073*</td>
<td></td>
</tr>
<tr>
<td>41-50%</td>
<td>.442</td>
<td>1.20</td>
<td>-.0851</td>
<td>911*</td>
<td></td>
</tr>
<tr>
<td>51-60%</td>
<td>.508</td>
<td>1.29</td>
<td>-.1424</td>
<td>1157*</td>
<td></td>
</tr>
<tr>
<td>61-70%</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>71-80%</td>
<td>.365</td>
<td>.88</td>
<td>.1013</td>
<td>509*</td>
<td></td>
</tr>
<tr>
<td>81-90%</td>
<td>.547</td>
<td>.79</td>
<td>.1720</td>
<td>633*</td>
<td></td>
</tr>
<tr>
<td>91-100%</td>
<td>.787</td>
<td>.98</td>
<td>.0292</td>
<td>998*</td>
<td></td>
</tr>
</tbody>
</table>

**Note.** Dashes indicate the field was not estimated. All data is weighted by data point size at the rate of 1x the size of the sample. For example, a market with 1000 passengers counted 10 times.
as much as a market with 100 passengers. From T100 Domestic Segments, Year 1995 and 1996, by airline, by route, summed to the origin level with all cities.

* $p < .0001$

Tables 5 and 6 sought to identify the existence of the s-curve by carrier strength in the market. This would indicate whether or not being the strongest carrier in a market provided an advantage with the s-curve. Table 4 results showed strong data relevance and s-curve indicators without city weighting, therefore, testing for Tables 5 and 6 was completed without this weighting. The $R^2$'s fall as the zone share gets higher because there was less data, resulting in increased randomness.

A comparison of the results from Tables 5 and 6 indicated that the stronger an airline was in a market, the greater its ability to benefit from the s-curve. When the data was examined by carrier ranking, RPM versus ASM received much more robust results than passenger share versus seat share. This may be due to airlines being much more careful with the allocation of ASMs than the allocation of seats. When confronted with a fleeting decision, a carrier would be much more careful allocating the correct sized aircraft on the Chicago to Kona route and less careful with the Chicago to Seattle route.

Table 5

**Passenger Share Versus Seat Share for All Cities by Carrier**

<table>
<thead>
<tr>
<th>Variable</th>
<th>$R^2$</th>
<th>Slope</th>
<th>Intercept</th>
<th>$F$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>61. Pax share vs. seat share, Carrier #1: 0-20% seat share</td>
<td>.212</td>
<td>.92</td>
<td>.0477</td>
<td>22*</td>
</tr>
<tr>
<td>62. Pax share vs. seat share, Carrier #1: 21-40% seat share</td>
<td>.401</td>
<td>.94</td>
<td>.0412</td>
<td>1037*</td>
</tr>
<tr>
<td>63. Pax share vs. seat share, Carrier #1: 41-60% seat share</td>
<td>.382</td>
<td>.94</td>
<td>.0675</td>
<td>1135*</td>
</tr>
<tr>
<td>Carrier #1: 41-60% seat share</td>
<td>64. Pax share vs. seat share,</td>
<td>.329</td>
<td>.94</td>
<td>.0657</td>
</tr>
<tr>
<td>Carrier #1: 61-80% seat share</td>
<td>65. Pax share vs. seat share,</td>
<td>.605</td>
<td>.85</td>
<td>.1329</td>
</tr>
<tr>
<td>Carrier #1: 81-100% seat share</td>
<td>Step 2</td>
<td>66. Pax share vs. seat share,</td>
<td>.744</td>
<td>1.01</td>
</tr>
<tr>
<td>Carrier #2: 0-20% seat share</td>
<td>67. Pax share vs. seat share,</td>
<td>.327</td>
<td>.710</td>
<td>.0662</td>
</tr>
<tr>
<td>Carrier #2: 21-40% seat share</td>
<td>68. Pax share vs. seat share,</td>
<td>.073</td>
<td>.41</td>
<td>.1976</td>
</tr>
<tr>
<td>Carrier #2: 41-60% seat share</td>
<td>69. Pax share vs. seat share,</td>
<td>.134</td>
<td>-.69</td>
<td>.8718</td>
</tr>
<tr>
<td>Carrier #2: 61-80% seat share</td>
<td>70. Pax share vs. seat share,</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Carrier #2: 81-100% seat share</td>
<td>Step 3</td>
<td>71. Pax share vs. seat share,</td>
<td>.775</td>
<td>.91</td>
</tr>
<tr>
<td>Carrier #3: 0-20% seat share</td>
<td>72. Pax share vs. seat share,</td>
<td>.020</td>
<td>.17</td>
<td>.1410</td>
</tr>
<tr>
<td>Carrier #3: 21-40% seat share</td>
<td>73. Pax share vs. seat share,</td>
<td>1.0</td>
<td>-.91</td>
<td>.594</td>
</tr>
<tr>
<td>Carrier #3: 41-60% seat share</td>
<td>74. Pax share vs. seat share,</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Carrier #3: 61-80% seat share</td>
<td>75. Pax share vs. seat share,</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Carrier #3: 81-100% seat share</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Note. Dashes indicate the field was not estimated. From T100 Domestic Segments, Year 1995 and 1996, by airline, by route, summed to the origin level with all cities.  
* $p < .0001$, ** $p < .0157$, *** $p < .0026$

Table 6  
Service Share Versus Passenger Share for All Cities by Carrier

<table>
<thead>
<tr>
<th>Step</th>
<th>Variable</th>
<th>$R^2$</th>
<th>Slope</th>
<th>Intercept</th>
<th>$F$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1</td>
<td>RPM share vs. ASM share,</td>
<td>.952</td>
<td>1.17</td>
<td>-.0123</td>
<td>1618*</td>
</tr>
<tr>
<td>Carrier #1: 0-20% ASM share</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>77. RPM share vs. ASM share,</td>
<td>.914</td>
<td>1.06</td>
<td>-.0070</td>
<td>16,532*</td>
<td></td>
</tr>
<tr>
<td>Carrier #1: 21-40% ASM share</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>78. RPM share vs. ASM share,</td>
<td>.912</td>
<td>1.08</td>
<td>-.0171</td>
<td>19,052*</td>
<td></td>
</tr>
<tr>
<td>Carrier #1: 41-60% ASM share</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>79. RPM share vs. ASM share,</td>
<td>.896</td>
<td>1.05</td>
<td>-.0208</td>
<td>11,817*</td>
<td></td>
</tr>
<tr>
<td>Carrier #1: 61-80% ASM share</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>80. RPM share vs. ASM share,</td>
<td>.736</td>
<td>1.15</td>
<td>-.1483</td>
<td>1685*</td>
<td></td>
</tr>
<tr>
<td>Carrier #1: 81-100% ASM share</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step 2</td>
<td>RPM share vs. ASM share,</td>
<td>.875</td>
<td>1.09</td>
<td>-.0016</td>
<td>16,172*</td>
</tr>
<tr>
<td>Carrier #2: 0-20% ASM share</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>82. RPM share vs. ASM share,</td>
<td>.908</td>
<td>1.02</td>
<td>-.0153</td>
<td>25,180*</td>
<td></td>
</tr>
<tr>
<td>Carrier #2: 21-40% ASM share</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>83. RPM share vs. ASM share,</td>
<td>.835</td>
<td>1.05</td>
<td>-.0650</td>
<td>2686*</td>
<td></td>
</tr>
<tr>
<td>Carrier #2: 41-60% ASM share</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step</td>
<td>RPM share vs. ASM share</td>
<td>Carrier</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------</td>
<td>-------------------------</td>
<td>---------</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>84.</td>
<td>.770  .92  -.0268</td>
<td>Carrier #2: 61-80% ASM share</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>85.</td>
<td>--   --    --</td>
<td>Carrier #2: 81-100% ASM share</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>86.</td>
<td>.937  1.06  -.0052</td>
<td>Carrier #3: 0-20% ASM share</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>87.</td>
<td>.852  .94    -.0194</td>
<td>Carrier #3: 21-40% ASM share</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>88.</td>
<td>1.0   1.24  .1065</td>
<td>Carrier #3: 41-60% ASM share</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>89.</td>
<td>--   --     --</td>
<td>Carrier #3: 61-80% ASM share</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>90.</td>
<td>--   --     --</td>
<td>Carrier #3: 81-100% ASM share</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>91.</td>
<td>.929  .97    -.0008</td>
<td>Carrier #4: 0-20% ASM share</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>92.</td>
<td>.774  .93    -.0047</td>
<td>Carrier #4: 21-40% ASM share</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>93.</td>
<td>--   --     --</td>
<td>Carrier #4: 41-60% ASM share</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>94.</td>
<td>--   --     --</td>
<td>Carrier #4: 61-80% ASM share</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>95.</td>
<td>--   --     --</td>
<td>Carrier #4: 81-100% ASM share</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Carrier #4: 81-100% ASM share

Step 5

96. RPM share vs. ASM share,  .922  .97  .0010  31,158*

Carrier #5: 0-20% ASM share

97. RPM share vs. ASM share,  .752  .37  .1541  15*

Carrier #5: 21-40% ASM share

98. RPM share vs. ASM share,  --  --  --  --

Carrier #5: 41-60% ASM share

99. RPM share vs. ASM share,  --  --  --  --

Carrier #5: 61-80% ASM share

100. RPM share vs. ASM share,  --  --  --  --

Carrier #5: 81-100% ASM share

Note. Dashes indicate the field was not estimated. From T100 Domestic Segments, Year 1995 and 1996, by airline, by route, summed to the origin level with all cities.

* $p < .0001$
CHAPTER IV

CONCLUSIONS

The s-curve exists for dominant carriers in a market and can be most effectively analyzed with RPM share versus ASM share at the city level, summed to the origin.

All Carriers

![Graph showing RPM Share versus ASM Share for all Carriers and all Cities, Summed to the Origin.](image)

**Figure 2.** RPM Share versus ASM Share for all Carriers and all Cities, Summed to the Origin.

The data indicates that if you are the number 1 carrier in a city, you will get a positive marginal value for an investment in capacity.

36
Figure 3. RPM Share versus ASM Share for the #1 Carrier in all Cities, Summed to the Origin.

The number 2 carrier in a city also has some potential for receiving a positive marginal value for investment in capacity. Especially if they own nearly 30% of the capacity share.
Beginning with the third carrier in a city, carriers generally do not receive a fair share of revenue passengers for the capacity they offer to the market.

Figure 4. RPM Share versus ASM Share for the #2 Carrier in all Cities, Summed to the Origin.

Figure 5. RPM Share versus ASM Share for the #3 Carrier in all Cities, Summed to the Origin.
Figure 6. RPM Share versus ASM Share for the #4 Carrier in all Cities, Summed to the Origin.

Figure 7. RPM Share versus ASM Share for the #5 Carrier in all Cities, Summed to the Origin.

ASM was most likely a better measure of capacity because airlines are more careful with ASMs than with seats. This means that when faced with a fleeting decision,
an airline would usually take greater care flying the correct size aircraft on Chicago to Kona than it would on Chicago to Detroit.

While the most robust results could be found through an analysis of RPM share versus ASM share, passenger share versus seat share also showed positive results. The results of the passenger share versus seat share testing indicated that by adding more seats to the market, you would obtain a greater share of passengers. It does not appear that adding more departures has the same effect. This is contrary to the assumptions of most air carriers.

The s-curve could not be identified at a passenger origin and destination level. The data relevance improved significantly when analyzed at the hub level and the city level, summed to the origin.

In conclusion, the s-curve does exist. The s-curve is a city phenomenon and rankings for service levels have a significant impact on its affect on passenger/revenue share.
CHAPTER V
RECOMMENDATIONS

This author recommends continued evaluation of the s-curve phenomenon through a multi-variant regression analysis, including the use of QSI characteristics. Applying actual revenue data against the service share offered in a market would be an interesting comparative analysis for the s-curve. As the market continues to evolve with the emergence of alliance networks, it would also be of considerable interest to test the effects of the s-curve and the effectiveness of joint carriers to gain more than their fair share of the market. Finally, the ability to forecast the effects of carriers owning faster than current aircraft would be an interesting new test for the s-curve.
REFERENCES


Civil Aeronautics Board practices and procedures: Hearing before the Senate Subcommittee on Administrative Practice of the Judiciary Committee, 96th Cong., 1st Sess. (1976).


APPENDIX
## APPENDIX A

### QSI COEFFICIENTS

<table>
<thead>
<tr>
<th>Types of Service</th>
<th>Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonstop</td>
<td>1.0000</td>
</tr>
<tr>
<td>One-stop (&quot;Good&quot;)</td>
<td>0.4500</td>
</tr>
<tr>
<td>Two-stop</td>
<td>0.1500</td>
</tr>
<tr>
<td>Single connection (&quot;Good&quot;)</td>
<td>0.1500</td>
</tr>
<tr>
<td>Double connection</td>
<td>0.0250</td>
</tr>
<tr>
<td>Triple connection</td>
<td>0.00416666</td>
</tr>
<tr>
<td>Nonstop/through</td>
<td>0.0500</td>
</tr>
<tr>
<td>Connection/through</td>
<td>0.0017</td>
</tr>
<tr>
<td>Double connection/through</td>
<td>0.00002833</td>
</tr>
<tr>
<td>Commuter nonstop</td>
<td>0.2500</td>
</tr>
<tr>
<td>&quot;Good&quot; connection to commuter</td>
<td>0.0375</td>
</tr>
<tr>
<td>&quot;Bad&quot; one-stop</td>
<td>0.189</td>
</tr>
<tr>
<td>&quot;Bad&quot; connection</td>
<td>0.063</td>
</tr>
<tr>
<td>&quot;Bad&quot; connection to commuter</td>
<td>0.016</td>
</tr>
</tbody>
</table>

"Good" = service with elapsed time within 75 minutes of shortest elapsed time in market.

"Bad" = elapsed time more than 75 minutes longer than shortest elapsed time in market.