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QUALITY OF SERVICE IN NONMONOPOLY AIR TRAVEL MARKETS: AN EMPIRICAL INVESTIGATION OF ALTERNATIVE MEASURES OF QUALITY

by

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ABSTRACT

QUALITY OF SERVICE IN NONMONOPOLY
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The primary objective of this dissertation is to compare the behavior of capacity related measures of quality to measures of quality that are not related to capacity in the airline industry during a period of falling fares. The dissertation differs from the existing literature in that a difference in the behavior of these variables is hypothesized. Previous studies have obtained comparative static predictions for quality in price-entry regulated industries. Among these is the prediction that a reduction in price-cost margin will lead to a reduction in quality. The specific form that quality has taken in studies of the airline industry is service convenience, or waiting time, and a common proxy for convenience is flight departure frequency, a variable closely related to capacity. This dissertation contends that quality closely associated with total output levels is determined differently from quality independent of output, and so questions the treatment of quality as a unidimensional variable. Flight frequency may rise during a period of falling fares due to an increase in the number of passengers flown, while other aspects of quality are reduced.

Proxies for various noncapacity elements of service quality are

identified in order to compare their behavior to flight freqency around the time of deregulation. This study finds that the proxies for other elements of service quality do indicate a reduction in quality during this period, while flight frequency shows an increase in quality. This indicates that the modeling of quality may be more complex than was previously thought.

This dissertation also examines the previously unsubstantiated claim that quality can be treated as unidimensional because all elements of quality are highly correlated. The correlations of the proxies identified in this study are found to be quite low, supporting the argument that unidimensional quality may be an oversimplification.

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CHAPTER I

INTRODUCTION

There has been much work over the past decade on product or service quality determination in price-entry regulated industries. More and more sophisticated models have been developed and various empirical studies have been based on these models. The primary conclusion of this work is that regulation can lead to "excessive" quality in nonmonopoly regulated industries because firms focus on quality rivalry instead of price competition. Competition via price is precluded, so firms compete in other, nonprice, areas. Quality competition has been recognized as a prime area for this nonprice competition for many years. But it is just over the last decade that explicit models have been developed in which quality is the equilibrating force in regulated markets. Since these models predict that quality competition will raise quality levels in regulated as compared to nonregulated industries, it follows that the deregulation of an industry will lead to lower quality levels as excessive quality is squeezed out due to lower average prices.

This dissertation studies the behavior of quality in one such deregulated industry, the airline industry, during the early period of deregulation. Most of the theoretical and empirical work in this field has used the airline industry as a specific example of an industry with nonmonopoly routes subject to price-entry regulation. The regulator, in this case the Civil Aeronautics Board or CAB, does not preclude rivalrous behavior among the different firms serving a given market. There are many areas where airlines can and have exibited this rivalrous behavior, but for reasons to be discussed in Chapter II service convenience has come to be identified as the primary, if not only, interesting element of service quality in studies of the airline industry. This has led to the exclusive focus of the literature on service convenience proxies as the variables to use in any quality of service study. The primary proxy for service convenience has come to be flight departure frequency, a capacity measure, to the exclusion of proxies for other possible elements of service quality.

It has long been recognized in both the real world and the nontechnical writing of economists that there are many elements included in the broad term service quality. The formal technical economic literature has converted this multidimensional variable into a unidimensional variable without empirical support. Empirical studies have confirmed that flight frequency did behave as one would expect a quality proxy to behave, but they did not analyze proxies for any other elements of service quality. This dissertation undertakes this more complete investigation of service quality.

There is reason to believe that a variable like flight frequency, which is closely related to total output, behaves in a different manner than other quality elements not dependent on total output. Changes in flight frequency depend at least in part on changes in the number of passengers carried, while changes in an amenity like the number of free drinks per passenger do not. Thus the treatment of service quality as a unidimensional variable may not be appropriate.

Jordan recognized the relationship between capacity and output when he questioned whether firm market share as measured by the percent of passengers carried on a route and firm capacity share are really two measures of the same thing.[1] Douglas and Miller also recognized this when they say that "the analysis can take as its output measure either passengers or capacity," and then go on to use passengers as output and capacity as quality.[2] All following work has focused exclusively on capacity measures of service quality.[3] This dissertation attempts to answer the question of whether capacity-convenience proxies behave as quantity or quality variables. The previous empirical work has analyzed quality in the airline industry during the regulated period when quality and quantity would be expected to move together. For a given regulated price, higher quality should be associated with higher quantity of passenger traffic. But in a period of free (or freer) price competition, price is expected to fall from the regulated level, leading to increased passenger traffic or quantity of output, but at the same time also leading to lower quality of service. The reduction in price squeezes out "excessive" service quality. Thus deregulation allows a test of the behavior of capacity variables, and their conformance to quantity or quality predictions. This study compares proxies over the period just prior to and just following deregulation of the airline industry.

The purpose of this dissertation is twofold. First an investigation is conducted to determine whether quality of service in the airline industry is property treated as a single dimensional variable. The correlation of various proxies for various aspects of quality are determined, and the behavior of these proxies is compared over time to see if they move in the same direction after the deregulation shock. The second purpose is to analyze the use of flight frequency, and other capacity measures, as quality proxies. If capacity variables behave as quantity of output variables, they may not show a reduction in service quality after deregulation when "excessive" service is expected to be eliminated.

This dissertation, then, is concerned with quality determination in the airline industry. The major premise of this work is that the treatment of quality as a unidimensional variable is an unjustified oversimplification. Different elements of quality may not be highly correlated, and may also have different comparative static predictions. Quality measures that depend upon output, and so elasticity of demand, will behave differently from those that do not. Thus it is contended that studies which have used flight frequency as quality in air travel markets are misspecified. In fact treating quality as any unidimensional variable may result in a misspecified model.

The main hypothesis to be tested in this dissertation is that capacity, as proxied by flight frequency, is so closely related to total output that it does not behave like other elements of quality. This work tests whether flight frequency behaves like an output variable or like other quality proxies. The findings of this work have broad implications for all studies that use capacity as quality.

Chapter II of this dissertation presents an overview of the literature on quality determination in regulated industries, both in general and for the airline industry in particular. This chapter points out the exclusive attention given to service convenience proxies in the literature as well as the treatment of quality as a unidimensional variable. It also is shown that competitive and oligopoly models give the same general predictions, the major one for the purposes at hand being that rivalry raises the level of service quality. The resumption of price competition will lead to a reduction in quality.

Chapter III develops a simple model consistent with the previous work that uses quality as the equilibrating force in price-entry regulated industries. This model is then applied to the airline industry in a way that closely follows Douglas and Miller's work showing how flight frequency becomes the equilibrating quality of service variable. Comparative static predictions are obtained which are used in the empirical chapters that follow.

Chapter IV identifies possible proxies for various elements of service quality, and analyzes the correlation between these proxies. A market share regression is run to identify these proxies, as well as to establish the multidimensional nature of quality.

Chapter V looks at the behavior of various air travel quality of service proxies in the pre and post deregulation period. The behavior of these proxies is compared over time to see if their behavior conforms to the predictions of the theory. Of special interest is the behavior of flight frequency. A rise in flight frequency after deregulation would indicate that this capacity variable moves with quantity of output rather than in the direction of reduced quality.

The contributions of this dissertation are as follows. First, it provides the most up to date analysis of quality of service in the airline industry of which the author is aware. All previous work has looked at quality during regulation, so this is the first study to empirically analyze the effects of deregulation on quality proxies. Second, the behavior of flight frequency is closely analyzed to determine whether this proxy of quality behaves in the same manner as proxies for other elements of quality. This analysis could provide insight into the use of capacity proxies in other regulated industries as well. Third, this is also the first attempt to look at the behavior of quality as a multidimensional rather than unidimensional variable.

CHAPTER I

FOOTNOTES

FOOTNOTES

CHAPTER I

[1]Jordan, p. 168-169.

[2]Douglas and Miller (1974b), p. 45.

[3]DeVany and Saving (1983) define quality as a characteristic that is a function of output and capacity. Specifically quality is the waiting time required before the customer obtains the product from the firm.

CHAPTER II

REVIEW OF THE LITERATURE ON QUALITY DETERMINATION IN THE AIRLINE INDUSTRY

In this chapter I review the relevant literature on quality determination in the regulated airline industry to demonstrate (1) that verifiable predictions about service quality have been obtained by previous authors, (2) that since 1972 there has been exclusive analysis of service convenience as the interesting element of quality in airline market studies, and (3) that there is reason to doubt this assumption that service convenience proxies all aspects of quality.

Section 2.1 looks at the basic reasoning behind models of quality determination under price regulation. The logic behind White's 1972 model is presented as well as some of the predictions of the model.

Section 2.2 looks at the idea that airline competition under regulation will lead to a specific form of service competition, schedule frequency competition. This section looks at why scheduling competition among airlines has preempted the analysis of all other types of service competition in airline market studies. I also look at the proxies used to indicate schedule competition, flight frequency and load factor.

Section 2.3 reviews the theoretical and empirical work that followed White's formalization of the idea of quality competition in regulated industries. The theoretical work looks at regulated airline markets as oligopolistic markets. We will see that the same general predictions are obtained from all the models reviewed. The review of the empirical work on service quality in regulated airline markets shows how completely schedule rivalry has taken over as the interesting element of service quality. This review will underscore the need to test some of the assumptions used in ignoring other quality variables.

2.1 Quality Determination in Regulated Industries

The determination of product quality has been an area of relative neglect in economics, but not because it is unimportant.[1] As Pazner has stated, "The scarcity of theoretical literature on what determines product quality testifies that the problem is analytically very difficult. Yet it is of great practical importance in both regulated and unregulated industries."[2] There has much been recent work on quality determination in regulated industries, at least in part due to the fact that it is easier analytically than the study of unregulated industries.[3] When price is fixed by the regulator, so the firm must take price as a parameter, the analysis is free to focus on the single variable of interest, in this case quality. Testable qualitative comparative static results can then be obtained for product quality in these regulated industries. It is the purpose of this dissertation to test some of the predictions obtained in the studies described below.

There has been some recent work done on quality in nonregulated industries. DeVany and Saving (1983) present a model of quality determination in a nonregulated market, with quality defined as the time a customer must wait to obtain the product. Quality is tied to capacity in this model enabling determinant results, but is subject to the criticism of capacity measures of quality given later in this dissertation. Quality not tied to capacity is still "analytically very difficult" in nonregulated markets.

Quality has been defined as features of a good or service that are desirable to buyers.[4] For this dissertation quality can be defined as some embodied attribute of the product or service that is desired by consumers and is not costless to the firm. This definition is consistent with the concept of quality in the models discussed below, and in the model presented in Chapter III.

Quality rivalry has long been recognized in the airline industry as well as other regulated industries. Kahn states, "In part because the doors to price competition are closed, airline companies compete very strenuously among themselves in the quality of service they offer."[5] Since all regulated firms in a market must charge the same price for the basic product or service, firms try to differentiate their product or service to improve their position vis-a-vis their rivals. These firms compete for market share via quality. Areas open for competition in the regulated airline industry are things like food, drink, leg room, convenience, and reliability among others. The literature makes much reference to regulated air carriers competing on these non-price elements.[6]

Despite the knowledge of quality competition in regulated industries, an explicit theoretical study of quality competition under regulation did not appear in the literature until relatively recently. Lawrence J. White (1972) provided the first such study. White reasoned that if price is taken as a parameter by the firm, and there is an unregulated variable under the firm's control that can be used to enhance demand, then the firm will use this unregulated variable to maximize profits. Quality of product or service and advertising are the two demand enhancing variables analyzed by White.

White developed a model of quality determination for regulated competitive and monopoly industries. A model similar to White's, using the same line of reasoning, is presented in Chapter III of this dissertation. A brief outline of White's logic, along with some of his more important conclusions, will be presented here. Those wanting a more formal treatment can skip ahead to Section 3.1.

The model assumes that firms facing a given regulated price will use quality to maximize profits. Both the monopolist and the competitive firm will set quality at the profit maximizing level. This is where the marginal revenue from providing more quality is equal to the marginal cost of providing that quality. The monopolist correctly sees changes in its quality affecting total market demand. But the competitive firm can gain customers not only from new customers in the market, but also from its rivals. Therefore the competitive firm will see the effect of a change in its product's quality as larger than the effect on the market on a whole.[7] This leads to the conclusion that competitive regulated markets will have higher average levels of quality than will a monopolist, other things equal, as the competitive firms compete vigorously for customers.

An important element in White's analysis is the fact that zero profits will exist in competitive long-run equilibrium due to quality competition. Any difference between regulated price and the cost of providing the basic product or service will disappear due to quality competition. In this case zero profits are not obtained by price rising or falling to the level of costs, but rather the costs expended on provision of quality will rise or fall to the level of price. This means that the regulator cannot provide firms in a competitive industry with above normal profits when there are unregulated variables with which the firms may compete. Zero long run profits also means that increases in regulated price will result in increases in average service quality, as firms compete away above normal returns with quality competition. Anything that causes a gap between price and average cost is predicted to cause quality to change in the same direction as the sign of profits. Positive profits will result in increases in quality, and negative profits will result in reductions in quality.

Some of the predictions of White's model are listed below:

(1) Product or service quality levels will be higher under competitive conditions than under monopoly.

(2) Quality and price will vary directly in competitive markets.

(3) Regulation will cause uniformity in quality among firms in a given market, while an unregulated industry will provide consumers a choice of different price-quality combinations.

(4) Because of (3) consumers are worse off when a competitive industry is regulated, due to loss of choice.

(5) Firms in regulated competitive industries compete away any potential above normal returns through quality competition.

(6) At the same regulated price a competitive industry will have a larger output than a monopolist will provide, since the competitive industry offers a higher quality product.

(7) A price regulated competitive industry would be expected to provide

a smaller quantity of output than a non-regulated industry because consumers lose choice with regulation.

(8) A regulator cannot provide a competitive industry with above normal profits if firms are free to compete on quality. Firms will compete away potential profits and "only the 'normal' profits built into the cost functions will prevail."[8]

When White applied his model to the airline industry the quality variables used are meals per passenger and advertising. He analyzed each separately and obtained essentially the same conclusions. The use of these two variables as illustrative examples is important because this is the last time a variable other than service convenience was used in a study of quality determination in the airline industry. When White re-presents his model in 1975, convenience is the quality of service variable analyzed. The next section of this chapter explains the reason for the shift to the study of convenience. Chapters IV and V of this dissertation look at whether this shift is warranted by the facts.

A weakness of White's theoretical model, as well as the models which followed, is that quality is treated as unidimensional. The previous non-theoretical work, as well as business practices, treat quality as multidimensional. This dissertation will determine if this simplification is appropriate for understanding the behavior of this industry. Another purpose is to determine whether the use of service convenience as the service quality indicator in air travel markets is theoretically and empirically valid. It is to the ascendence of convenience as the variable of interest that we now turn.

2.2 Schedule Convenience as Airline Service Quality

The work following White's 1972 paper, reviewed below in this section and the next, has been unanimous in its exclusive identification of service quality in the airline industry as schedule convenience. Other elements of service quality such as amenities, noise, and leg room may be mentioned in passing, but have not been analyzed either because they are thought to be unimportant, or because they are thought to vary closely with convenience so analysis would be redundant. The rationale behind the ascendence of convenience as quality in the airline industry as well as the reasoning behind the proxy variables used to measure convenience is given in this section.

Douglas and Miller (1974) and Panzar (1974) concurrently developed models of airline rivalry that used schedule convenience as service quality. Douglas and Miller build on White's general model and specifically apply it to the airline industry. Again, quality competition is the equilibriating force in the regulated airline market, and this schedule competition will reduce potential above normal profits until an equilibrium is reached. Panzar adds to White and Douglas and Miller with an explicit analysis of airline rivalry as oligopoly behavior. He develops a non-cooperative schedule rivalry game and searches for non-cooperative Cournot-Nash equilibrium.

In both of these studies quality rivalry takes the form of airline schedule rivalry, or rivalry over service convenience. The emphasis on convenience comes from the idea that the traveler in choosing a mode of transportation wants to minimize the "full cost" of travel, where full cost includes the monetary cost of the trip, the traveler's value of the actual trip time, and the value of the time needed to access and egress the mode of transportation. Earlier work had included the value of actual travel time as a determinant of air travel demand,[9] but delays encountered because scheduled transportation is available at discrete time intervals while the demand for transportation is continuous, had not been modeled. Low delay is high quality service and high delay is low quality service. If a traveler wants to leave at 1:00 p.m. and the closest available flight leaves at 3:00 p.m., he suffers a two-hour schedule delay. If the next available flight is at 2:00 there is a one-hour schedule delay and the traveler is better off. Less delay means higher quality service in these full cost models. Scheduling competition had been in the literature for some time,[10] but these works were the first efforts to formalize the relationship between regulated price and schedule delay. Douglas and Miller was the first attempt to quantify schedule delay itself.

These studies mention other elements of service quality in the airline industry, but dismiss them for various reasons. Douglas and Miller mention speed of baggage claim, the amount of personal attention, the types of on-board accommodations, and the noise of the aircraft, as other elements of service quality,[11] but justify their exclusion from analysis for three reasons. First they see scheduling competition as the most important form of quality competition in the airline industry, both to travelers, and so to firms. Second they assert that other elements of service quality are closely related to service convenience, so little new information could be obtained through the analysis of other variables. Third, proxies for service convenience are readily available and easily measured. In their own words:

On the one hand, the carriers compete in the traditional, highly visible forms of nonprice rivalry such as advertising and the provision of passenger amenities. But of far greater significance in terms of per passenger cost is their use of scheduling competition in establishing market shares.[12]

...each passenger has an ideal mix of these service amenities he would pick to have available. In the aggregate, he is faced with little real differentiation among carriers, either in terms of quality in terms of mix.[13]

...there exists little real difference among carriers regarding the passenger amenities offered.[14]

...observes typically that the extent of passenger service amenities varies closely with the extent of scheduling competition (i.e. both are means of attracting passengers).[15]

Since the level of expenditure on these kinds of quality aspects [amenities] appears to be very closely related to the capacity dimension of quality [schedule convenience], we feel justified in focusing on the latter in subsequent analysis.[16]

Convenience, moreover, can be measured.[17]

More important, the concept of convenience thus defined becomes measurable.[18]

Panzar focuses on schedule rivalry for the same basic reasons. In his words,

Nonprice, or quality competition is quite important in the industry. The types of quality in which the airlines compete include meals, free drinks, movies, leg room, aircraft type, reservations policy, and attractiveness of the stewardesses, to name just a few. However, from the point of view of economic impact, the most important non-price dimension is that of schedule quality, the number of flights per unit of time which each airline supplies to a given market. Schedule quality is so important because it is recognized to be the dominant consideration in the consumer's choice of airline, and because providing this quality, i.e., flying airplanes, is by far the greatest component of airline costs.[19]

Panzar cites Kahn to back up the statement that schedule quality is the major consideration in a consumer's choice of airline. Kahn states that "there is a general belief that the airline with the most flights between any two points is the one to which customers will turn first in making their reservations."[20]

Panzar criticizes White's 1972 work in that he "did not tackle the fundamental issue of schedule rivalry."[21] The arguments of Douglas and Miller and Panzar must have been persuasive to White, because when he presents his model in 1975 the analysis is in terms of schedule quality rather than meals. White states that

> From the consumer's viewpoint, several aspects of the airline service bundle in this area are partially relevant to his satisfactions. The likelihood of a convenient departure and of an available seat depends on the total number of flights (from all carriers), their distribution over the day, and the total seats available relative to typical demands. In addition, the airlines have shown they believe that consumers make choices about what airline to call for a ticket partly on the basis of these criteria. Many carriers have advertised heavily to depict in detail the convenience of their schedules for selected city-pair markets.[22]

White also says that proxies that measure convenience are easy to collect and compute and are "likely to be correlated with other dimensions of service quality."[23]

So, as we will see in the next section of this chapter, from 1974 on service quality in the airline industry meant schedule quality with other elements of quality assumed away as unimportant or irrelevant. The authors make this assumption but provide no empirical support. Consumers are assumed to be primarily interested in convenience, and the less delay, the more convenient is the air service between two points. Douglas and Miller define schedule delay as the absolute value of the difference between a traveler's desired departure time and their actual departure time. The traveler's expected schedule delay depends on the frequency of flights and their distribution over the period, the number of seats per flight, and the distribution of demand over the period. Schedule delay is divided into frequency delay and stochastic delay. Frequency delay is "the difference between a traveler's desired departure time and the closest scheduled departure."[24] But there may not be an available seat on the closest scheduled departure. Stochastic delay arises when there is excess demand for a traveler's most preferred scheduled depature. It is the time the traveler must wait until the next flight with an available seat. Frequency delay plus stochastic delay, then, equal schedule delay. Actions the airlines take to reduce frequency and stochastic delay improve schedule quality.

The above analysis suggests possible proxies for schedule delay. An increase in the number of flights between two points, other things equal, will result in a reduction of both types of delay, and so an increase in convenience. An increase in the total number of flights will reduce frequency delay, if they are offered at different times, since more gaps will be filled in the schedule. More flights means less stochastic delay since each passenger will have a higher probability of finding a seat on his or her most preferred flight. This means that higher flight frequency, other things equal, leads to lower load factors (# passengers/# available seats), and so lower stochastic delay. Flight frequency and load factor, then, are two proxies for expected schedule delay that have become very common in the literature. In fact they are the only proxies of service quality that have been used since 1974 in air travel studies.

Note must be made of the use of flight frequency as a variable under firm control. In the regulated U.S. airline industry both price and entry into city-pair markets were regulated. A carrier needed to be certified to serve a given route. But once a carrier was certified, it could offer as many or as few flights per period as it deemed appropriate.[25] So firms were able to control flight frequency, and thereby load factor, under regulation. In serving demand the carrier could provide few flights per period in large airplanes, or many flights per period in smaller airplanes. The above analysis would indicate that the latter method of serving demand gives the higher quality service. Quality competition among firms will, then, result in a larger number of flights than if there was no quality rivalry. High flight frequency and low load factors are associated with high service quality; that is, convenient service.

2.3 Extensions and Empirical Tests of the Basic Theory

This section reviews the theoretical and empirical work that has followed from White. The major extension of the theory has been more and more complete analysis of oligopoly in regulated markets, with an emphasis on airline markets. Panzar (1974), Schmalensee (1977) and Vander Weide and Zalkind (1981) model oligopoly behavior and develop comparative static predictions. We see that the predictions are much the same as those obtained from White's simple model. The empirical work reviewed here tests the validity of the models; that is, do flight frequency and/or load factor behave according to the predictions of the theory. All of these studies use schedule quality variables in the determination of air travel demand to the exclusion of other indicators.

2.3.1 Theoretical Studies

White and Douglas and Miller explicitly analyzed competitive and monopoly markets. Douglas and Miller get the same basic results as White except that service quality can be proxied by flight frequency and load factor, rather than meals and advertising.

Panzar's (1974) oligopoly analysis of airline rivalry as a non-cooperative schedule rivalry game enables him to obtain comparative static predictions about non-cooperative Cournot-Nash equilibria. Among his conclusions are:

(1) An exogenous increase in the costs of flying an airplane or of costs that vary directly with the number of passengers will reduce quality of service.

(2) An exogenous increase in demand will improve quality of service.

(3) "If price regulation is effective in the sense that an increase in p (price) would increase the net revenues yielded by pasenger transport, then said increase will result in an increase in schedule quality if an increase in Q (quality) does not make the market demand curve more price elastic."[3] He expects improved service quality would make other modes of transport worse substitutes, so he would expect demand to become less elastic.

(4) New entry into a city-pair market will increase the number of flights provided and so improve service quality.

The results are basically the same as White's. Reductions in price-cost margins will result in reduced service quality and increases in price-cost margins will result in improved service quality. Entry increases competitive rivalry in the oligopoly, and so will improve service quality.

There have been extensions to Panzar's oligopoly model. Schmalensee (1977) develops a model of scheduling rivalry under oligopoly similar to Panzar's, but with the comparative statics more fully developed. Using non-cooperative Cournot-Nash behavior and certain assumptions about demand and cost, he finds that:

(1) An increase in fares will decrease equilibrium load factors.

(2) An increase in fares will increase flight frequency if relative margin per passenger times the absolute value of the price elasticity of total demand is less than one.

(3) Entry would normally be expected to increase competitive rivalry and so improve service quality.

Schmalensee's finding number 2 is similar to Panzar's finding number 3 listed above. If an increase in fare causes profits to rise, then quality competition will improve service quality until a new equilibrium is reached.

Vander Weide and Zalkind (1981) also develop an oligopoly model of quality determination under regulation with the purpose of analyzing the effects of deregulation. The analysis is similar to Panzar and Schmalensee except with more generalized demand and cost functions. Flight frequency and load factor are quality for Vander Weide and Zalkind when they look at the regulated airline industry. Among the predictions of their model, if deregulation leads to lower fares and/or an increased number of firms, are:

(1) Deregulation of price alone is expected to lead to

  a. reduced fares

  b. reductions in total market flights

  c. increases in load factors

(2) Deregulation of entry alone is expected to lead to

a. reductions in flights per carrier

b. increased flights in the market

c. reductions in load factors

(3) Deregulation of both price and entry is expected to lead to

a. reduced fares

b. reduced flights per market

These oligopoly models give the same basic predictions, which are the same basic predictions White obtained. If price is deregulated, so that average price falls, then the models predict average quality to fall. Entry moves the market closer to the competitive market structure, so flights should rise and load factors should fall. If there is both price and entry deregulation, Vander Weide and Zalkind expect the price effects to dominate, and so they predict the number of flights in the market to fall. It is these predictions of Vander Weide and Zalkind that I will use to test the use of a capacity variable as a quality of service variable in Chapters IV and V.

2.3.2 Empirical Studies of Quality Determination in the Airline Industry

Early empirical work tested whether flight frequency and/or load factor behaved as theory would predict. One group of these studies looked at the effect of number of firms and distance on load factor. Using 1970 data Douglas and Miller (1974b) found that there is a negative relationship between the number of firms serving a city-pair and average load factor. This was confirmation that service quality rises as competition increases. Distance is included as a proxy for the

profitability of a route, since the fare structure resulted in fares per passenger mile falling more slowly than standardized costs per passenger mile. Douglas and Miller found that distance is negatively related to load factor, but not significantly. White (1975) and Eads (1975) also run similar regressions. They both find that load factors fall as the number of firms rise, the same result as Douglas and Miller. White found that load factor falls with distance, and Eads found that load factors are lower for long haul flights than for short haul flights. These results support the theory in that increased competition results in increased quality (low load factors), and higher potential profits result in higher service quality.

Panzar (1974) looks at whether flight frequency behaves as a quality of service variable. He tests his model by estimating the demand for air travel between New York City and most cities for which scheduled air travel is offered for the second quarter of 1972. Two stage least squares estimation was performed since two variables, flight frequency and number of passengers flying between two points, are simultaneously determined. Panzar finds support for his model in that weekly market flight frequency does have a statistically significant positive effect on the number of passengers flying per week. Panzar also estimates a reduced form quality equation and finds a statistically significant relation between flight frequency and the number of firms serving the city-pair. He says these results indicate that consumers respond to service quality, and also that increases in rivalry improve service quality.

De Vany (1975) conducts a test of the model also using flight frequency as quality. He finds that for 20 routes out of New York City, fare is positively related to flight frequency, with a larger coefficient in markets with more carriers. He also finds a negative relationship between costs and flight frequency, with larger coefficients in absolute value in markets with more carriers. His study suffers in that his sample size is very small (10 markets with one or two carriers and 10 markets with three or more carriers) and the t-statistics for the above relationships are not significant.

Later work used these earlier studies to attempt to improve the estimation of the demand for air travel by including quality of service variables in the estimating equation. Ippolito (1981) estimates the demand for air travel on 105 monopoly flight segments for 1976 to see if travelers respond to quality. He uses both flight frequency and load factor as service quality variables, and attempts to determine whether total market demand responds to service quality. Ippolito finds that flight frequency is significantly related to number of passengers in the expected positive direction. He also finds that load factor is negatively related to passengers with a t-statistic of -1.68. The conclusion is that there is an "apparent strong role played by quality of service variables in airline demand."[26]

Anderson and Kraus (1981) and Abrahams (1980) have estimated the demand for air travel with time series techniques using actual estimates of schedule delay, rather than proxies, to include as service quality in the model. Anderson and Kraus use Douglas and Miller's estimated schedule delay functions to come up with estimates of full trip price using three different values of time. They then estimate air travel demand for 16 city-pairs using monthly data from 1973 to 1976. They find that all short-run full trip price elasticities have the expected negative sign or are statistically insignificant. Twenty-five of 48 coefficients are statistically insignificant, with the rest significant at the 95 percent level.

Abrahams also estimates schedule delay and incorporates his estimated values into time series estimates of the demand for air travel within seven groups of relatively homogenous city-pairs. He finds a negative effect for schedule delay on air travel demand that is significant in two of the seven regressions.

These attempts to estimate schedule delay to obtain full trip price would be expected to give more meaningful results than studies with possible faulty proxies. But the estimates of schedule delay are very crude, which shows in the large number of insignificant results.

Trapani and Olson (1982) analyze the effect of entry and price variation on service quality in the airline industry. The authors want to see whether quality behaves according to the predictions of White's theory. They look at the tradeoff between price competition, which should reduce average service quality, and entry, which should improve average service quality. Trapani and Olson measure service quality by seat capacity, and so are subject to the criticisms of the other studies in the chapter.

Trapani and Olson find that low Herfindahl indexes, that is low levels of concentration, are associated with high quality of service (measured by seat capacity) due to quality competition. They also find that the effect of reductions in fares is to reduce the capacity brought to the market, and so reduce service quality. Reductions in fare will reduce quality and entry will improve quality. The theory is supported.

This section has reviewed all work on quality of service in the airline industry published to date. Every study since Douglas and Miller

has used a capacity measure as service quality. But is this single focus on capacity justified? Chapter V reports that capacity, as measured by flight frequency, does not behave in the same manner as other quality variables. Before moving on to this analysis, a simple model of quality determination is developed in Chapter III.

CHAPTER II

FOOTNOTES

CHAPTER II

FOOTNOTES

[1]For analysis of quality in the economy see Chamberlin (1933), Dorfman and Steiner (1954), Abbott (1955), Sitgler (1968). Quality was one of several methods that a firm could use to differentiate its product in Chamberlin's theory of monopolistic competition. He spent some time discussing the product as a variable. Abbott's book on quality competition focused on quality and not price competition as the interesting question for economics. Dorfman and Steiner develop some conditions for optimal quality levels. Stigler looks at cartels fixing price and allowing nonprice competition, and cartels fixing nonprice competition and allowing competiton on price. These studies are primarily illustrative and yield few, if any, testable predictions. See Footnote 3 for criticisms of the early work on quality competition.

[2]Panzer (1975), p. 3.

[3]Archibald (1961) and (1964) is very pessimistic about finding any useful predictions in models with nonprice variables such as product quality. This is due to the indeterminancy of the model of monopolistic competition. Archibald shows that the model of monopolistic competition does not give useful qualitative predictions, and that quantitative magnitudes must be known before anything meaningful can be said about quality in unregulated markets. He does, however, say that "if the number of varibles is restricted, as it may be in some cases of special application, the model may yield some useful results." (1961, p. 20). Fixing price through regulation does reduce the number of varibles and so may allow for qualitative predictions.

For a good discussion of criticisms of monopolistic competition theory see Archibald (1961) and his references.

[4]Abbott (1955), p. 125.

[5]Kahn (1971), p. 211.

[6]See Kahn (1971), p. 209-220 for a discussion of quality competition in the airline industry. Footnote 106 pages 209-210 tells of the relation between quality and profit as certain elements of quality were reduced when profits fell in 1969-1970. Also see Footnotes 112 and 113 pages 211-212 for examples of money and effort spent by airlines in providing service quality. Also see Scherer's (1970) discussion of the International Air Transport Association's meeting to define a sandwich in 1958, in an attempt

to reduce quality competition.

[7]This is the firm's demand curve in the theory of monopolistic competition. When White talks of the competitive case he is talking about competing with differentiated products. He makes an identical firm assumption so that in equilibrium all firms provide the same level of service quality.

[8]White (1972), p. 431.

[9]For instance see Gronau (1970).

[10]See Kahn (1971), Caves (1962), Jordan (1970).

[11]Douglas and Miller (1974a), p. 71.

[12]Douglas and Miller (1974b), p. 657-658.

[13]Douglas and Miller (1974a), p. 71.

[14]Douglas and Miller (1974b), p. 660, footnote 8.

[15]Ibid.

[16]Douglas and Miller (1974a), p. 71-72.

[17]Douglas and Miller (1974b), p. 658.

[18]Douglas and Miller (1974a), p. 30.

[19]Panzar (1974), p. 26.

[20]Kahn (1971), p. 211.

[21]Panzar (1974), p. 3.

[22]White (1975), p. 24.

[23]Ibid..

[24]Douglas and Miller (1974b), p. 663. The division of schedule delay into frequency and stochastic delay is a contribution of Douglas and Miller.

[25]See Panzar (1974) Chapter 2 for a discussion of the regulated UI.S. airline industry.

[26]Ippolito (1981), p. 14.

CHAPTER III

A THEORETICAL MODEL FOR THE ANALYSIS OF QUALITY DETERMINATION IN REGULATED INDUSTRIES

The work described in the previous chapter is based on the idea that product or service quality is the equilibrating force in a market where price cannot change. The response of demand and cost to changes in quality will be important to the determination of market equilibrium. This chapter presents a simple model of quality determination in a regulated industry. The model will be used to yield testable predictions consistent with the previous work in the field.

Section 3.1 follows the logic of White (1972) and presents a general model of quality determination in a regulated market for both the monopoly and competitive cases. The comparative statics are derived for both cases and testable predictions are obtained. Oligopoly comparative statics are taken to be somewhere between the monopoly and competitive outcomes, which gives predictions consistent with the predictions of the more explicit oligopoly models reviewed in the previous chapter.

Section 3.2 shows how the basic model developed in Section 3.1 can be applied to the airline industry. Following Douglas and Miller, this section shows how the identification of service convenience as the major element of service quality leads to the use of flight frequency as a proxy for quality of service. This section also questions the use of flight frequency as the primary quality of service variable, as well as the propriety of the use of unidimensional quality variables in the model.

3.1 The Theoretical Model

A simple model can be developed to analyze quality determination by a regulated monopolist.[1] Assume that consumers respond to two variables associated with the product or service; price and quality. Further assume that the regulated monopolist is not free to vary price. The regulator sets price, which we will assume the firm takes as an exogenous parameter.[2] Calling the regulated price $\bar{P}$ and quality Q, the demand function faced by the regulated monopolist is

$$X = X(\bar{P}, Q) \tag{3.1}$$

where X is the level of output demanded per period.

The firm's costs depend on the amount of output produced per period and the quality level of that output.

$$C = C(X, Q) \tag{3.2}$$

The regulated monopolist facing the given regulated price, $\bar{P}$, will then vary quality to attain maximum profits. The demand function (3.1) and the cost function (3.2) can be used to obtain the following profit function for the regulated monopolist.

$$\pi = \bar{P} \cdot X(\bar{P}, Q) - C(X, Q) \tag{3.3}$$

The profit maximizing level of quality is given by

$$\frac{\partial \pi}{\partial Q} = \bar{P} \cdot \frac{\partial X}{\partial Q} - \frac{\partial C}{\partial X} \cdot \frac{\partial X}{\partial Q} - \frac{\partial C}{\partial Q} = 0$$

Combining and rearranging terms we get the following profit maximizing condition:

$$(\bar{P} - \frac{\partial C}{\partial X}) \frac{\partial X}{\partial Q} = \frac{\partial C}{\partial Q} \tag{3.4}$$

Thus the regulated monopolist sets the marginal revenue received from additional quality equal to the marginal cost of providing that quality.

Comparative Statics

A regulator needs to understand the effects of any policies it may pursue if it is to make well-informed decisions. Since quality is an important unregulated variable in price regulated industries, a regulator needs to know the effects of its policies on quality. In particular an understanding of the relationship between regulated price and the level of quality provided can aid in the regulator's decision process. The actual outcome from a change in price may be entirely different from the intended outcome, if the regulator ignores the possibility of quality variation.[3]

The effect of a change in regulated price on the monopolist's level of quality can be obtained by totally differentiating equation (3.4). Appendix A shows that the following result is obtained:

$$\frac{dQ}{d\bar{P}} = \frac{[1 - (\frac{\partial^2 c}{\partial X^2})(\frac{\partial X}{\partial \bar{P}})](\frac{\partial X}{\partial Q}) + (\bar{P} - \frac{\partial c}{\partial X})(\frac{\partial c}{\partial \bar{P}\partial Q})(\frac{\partial X}{\partial \bar{P}})}{(\frac{\partial c}{\partial X\partial Q})(\frac{\partial X}{\partial Q}) - \{[(-\frac{\partial^2 c}{\partial X^2})(\frac{\partial X}{\partial Q}) - (\frac{\partial c}{\partial Q\partial X})](\frac{\partial X}{\partial Q}) + (\bar{P} - \frac{\partial c}{\partial X})(\frac{\partial^2 X}{\partial Q})\}} \qquad (3.5)$$

The sign of $\frac{dQ}{d\bar{P}}$ is indeterminant. The response of quality to changes in regulated price cannot be determined a priori for the monopolist because the signs of the cross partial derivatives in the above equation are not known. The direction of change depends on how consumers respond to changes in quality and price, as well as how costs change when quality and price change.

This may seem like an unsatisfactory result, but at least we now know that quality changes are indeterminate when regulated price is changed. This knowledge will be helpful when we test predictions in Chapter V.

3.1.2 Nonmonopoly Markets

The monopolist correctly perceives $\frac{\partial X}{\partial Q}$ in equation (3.4) as the response of the market to additional quality. When two or more firms serve a market, a given firm's perception of its own $\frac{\partial X}{\partial Q}$ changes. By adding to quality a firm can not only increase total market demand, but it can also win customers from its rivals. It is differentiating its product or service from that of its rivals. So a firm's $\frac{\partial X}{\partial Q}$, the change in its sales brought about from a change in its quality, will be seen as larger in multifirm markets than in monopoly markets. An individual firm will perceive the response to a change in its quality as greater than the response of the market demand curve, with the result that firms in non-monopoly markets will offer higher quality output than will monopoly firms. Rivalrous behavior among firms attempting to differentiate their product will result in higher average quality levels than in a monopoly market where this rivalrous behavior does not exist.[4]

Following White, assume that all firms in the market are identical. Then equation (3.4) becomes the following profit maximizing condition for the representative firm:

$$\frac{\partial \pi i}{\partial Qi} = (\bar{P} - \frac{\partial Ci}{\partial Xi}) \frac{\partial Xi}{\partial Qi} = \frac{\partial Ci}{\partial Qi} \tag{3.6}$$

This can be rewritten as

$$\bar{P} = \frac{\partial Ci}{\partial Xi} + \frac{\frac{\partial Ci}{\partial Qi}}{\frac{\partial Xi}{\partial Qi}} \tag{3.7}$$

The value of $\frac{\partial Xi}{\partial Qi}$ in (3.6) and (3.7) is seen by the firm to be larger than the market response alone. The larger is the perceived response of demand to changes in quality, the smaller will be the last term in (3.7), and so the larger will be the level of quality offered to maximize profits. Under competitive conditions the firms will continue to expand quality until zero profits are earned by all firms in the long run.[5] This is where

$$\bar{P} \cdot Xi\ (\bar{P},\ Qi) = C\ (Xi,\ Qi) \tag{3.8}$$

which, if we have a separable cost function, can be rewritten as

$$[\text{Cost }(Qi)] \cdot Qi = Xi \cdot [\bar{P} - \text{Cost }(Xi)] \qquad (3.9)$$

In long run equilibrium the total cost of quality offered is equal to the difference between total revenue and the cost of providing the basic output. Firms will compete away any potential above-normal profits by providing more and more quality.

In noncompetitive cases, the larger the firm perceived $\frac{\partial X}{\partial Q}$, the more quality that firm will provide. The competitive case, with zero long run profits, is the upward bound on how far quality rivalry can go. A traditional assumption in industrial organization is that rivalry for profits becomes more intense as the concentration in a market falls.[6] This assumption allows the model to tell us something about oligopoly behavior; that the results are somewhere between the monopoly and competitive outcome. This assumption will give us the same basic results as the more formal oligopoly models discussed in Chapter II.

Comparative Statics

Equation (3.9) says that expenditures on quality will eat up any potential above normal profits from the provision of the basic product or service in long run equilibrium. The level of quality, provided by the firm, Q_i, depends on the regulated price, $\bar{P}$, the unit cost of the basic output, X_i, and the unit cost of providing the amount of quality Q_i. The model predicts that a change in the price cost margin will result in a change in quality. The change in quality brought about by a change in regulated price depends on the response of quantity demanded to the change in price (the price elasticity of demand), the response of the unit cost of the basic output to the change in quantity demanded, and the change in the unit cost of quality to the change in quality. Assuming for simplicity that there are constant costs we obtain

$$a\ Q_i = X_i\ (\overline{P} - b) \tag{3.10}$$

from equation (3.9), where a is the constant unit cost of quality, and b is the constant unit cost of the basic product or service.[7]

If (3.10) is correct, then an increase in $\overline{P}$ will increase the price-cost margin, but will also cause a change in X_i. The increase in $\overline{P}$ will cause a reduction in X_i as long as demand is not perfectly price inelastic, and as long as price elasticity of demand is larger than quality elasticity of demand. These are two very plausible assumptions that are common in this field. Thus an increase in price will result in an indeterminant change in Q_i. If consumers respond to the total number of flights, then the change in quality depends on the price elasticity of demand, and cannot be determined a priori. In this case quality depends on output, and changes in quality depend on both the change in regulated price and the elasticity of demand.

Equation (3.10) can be differentiated to obtain the following result,[8]

$$\frac{dQ_i}{d\overline{P}} = \frac{(Q[1+\varepsilon_d(1-b/P)])}{(a-(\frac{\partial X_i}{\partial Q_i})\ (P-b))}\ .$$

where ε_d is the price elasticity of demand.

The change in quality brought about by a change in price is indeterminate. The sign depends both on the elasticity of demand and the

response of output to quality. It is possible for quality defined in total units of quality, Q_i, to rise or fall or remain unchanged after a change in regulated price. Examples of the type of quality where consumers respond to the total level of the variable are flight frequency and schedule reliability.

As White and others have noted there are many instances where the definition of quality as the total amount of some attribute provided by the firm does not make econmic sense. Consumers do not respond to the total number of free drinks served by an airline, but rather to the number of free drinks the individual will receive. The relevant quality variable is in per unit of output terms. In this case equation (3.10) will give an indeterminate prediction of $\frac{dQ_i}{d\bar{P}}$, the change in total quality units resulting from a change in price (total number of free drinks offered by the airline), but the change in the relevant quality variable, quality per unit of output is determinant. Quality varies directly with price, That is

$$\frac{Q_i}{X_i} = \frac{(\bar{P}-b)}{a} \tag{3.11}$$

$$\frac{d\left(\frac{Q_i}{X_i}\right)}{d\bar{P}} = \frac{1}{a} \tag{3.12}$$

The level of quality that each individual experiences is independent of the total number of passengers flying for this type of quality.

The above analysis implies that the regulator cannot provide this competitive industry with above normal returns in the long run. Under the conditions of our model, an attempt by the regulator to do so will be futile. One reason this model was developed was to make clear to regulators the relationship between regulated price, product quality, and

firm profits, so that regulators would not continue to raise price when profits fell due to increases in costs brought about by increases in quality.[9] There is a continuum of price-quality combinations of just normal profits earned by firms. The regulator can indirectly control quality level through changes in price, and it was argued that regulators were allowing firms to charge too high prices and that the firms were providing "excessive" service quality. Consumers would be willing to pay lower prices and receive lower quality service. This is an empirical question taken up in Chapter V.

Entry would be expected to increase rivalry and so increase $\frac{\partial X}{\partial Q}$ in equations (3.6) and (3.7). This would increase the level of quality offered in the market.

Conclusion

We have developed a very simple model of firm behavior in price-entry regulated industries where there is a demand enhancing variable under the firm's control. This variable is something called quality in the abstract. Some useful predictions can be obtained from the model. First, from equation (3.7) we would expect quality to be lowest under monopoly and highest under competitive conditions, due to competitive rivalry. Second, the comparative statics of equation (3.8) predict that price and per unit quality move in the same direction in competitive markets, while a change in price will lead to an indeterminant change in the total units of quality. Total differentiation of equation (3.4) shows that no prediction can be made about the change in quality brought about by a change in price under monopoly. The signs of the cross effects are not known. Third, we would expect entry to increase rivalry, and so increase the level of quality offered.

The model does not obtain comparative static results for oligopoly. A useful assumption is that the oligopoly result is somewhere between the monopoly and competitive results, and closer to the competitive case as concentration falls. This will allow us to use the predictions of the model in Chapters IV and V.

3.2 Application of the General Model to the Airline Industry

In this section I make the model more specific by looking at how it has been applied to the airline industry. As we saw in the last chapter a particular element of service quality, convenience, has come to be the element of service quality of interest for theoretical and empirical work in this field.

Douglas and Miller have operated under the assumption that quality is best proxied in the airline industry by expected schedule delay, the difference between a person's desired departure time and their actual departure time.[10] So the general model above becomes

$$X = X(\bar{P}, SD) \tag{3.13}$$

$$C = C(X, SD) \tag{3.14}$$

where

SD = expected schedule delay

Schedule delay, in turn, depends on departure frequency, slack capacity, and the distribution of demand. So

$$SD = SD\ (X,\ \sigma_X,\ F,\ S) \tag{3.15}$$

where

σ_X = dispersion of demand

F = flight frequency

S = average aircraft capacity

Douglas and Miller assume that

$$\sigma_X = \sigma_X(X) \tag{3.16}$$

so that we can substitute (3.16) and (3.15) into (3.13) to obtain the following demand equation

$$X = X\ (\bar{P},\ F,\ S) \tag{3.17}$$

The next assumption is that aircraft capacity is exogenous for each particular market. This is allowed by the empirical observation that carriers fly the same type of plane, by and large, on any given route.[11] This last assumption allows the following demand equation for air service between two points:

$$X = X\ (\bar{P},\ F) \tag{3.18}$$

Flight frequency thus becomes the sole interesting quality of service variable for an air travel market. High flight frequency means low schedule delay, and so high quality of service. Demand responds positively to this high quality of service.

The above assumptions transform the cost function (3.14) to

$$C = C(X, F) \qquad (3.19)$$

Profit maximization requires

$$\frac{\partial \pi}{\partial F} = (\bar{P} - \frac{\partial C}{\partial X}) \frac{\partial X}{\partial F} - \frac{\partial C}{\partial F} = 0$$

The marginal revenue gained from additional flights must equal the marginal cost of providing those flights. All of the results of the previous section now apply in this section with Q replaced by F since flight frequency is now quality. We would expect competitive markets to provide more flights than monopoly markets. We would also expect entry to increase rivalry, and so increase the number of flights in the market. These testable results will be of great value in the next chapter.

Conclusion

The analysis of the previous section leads to the conclusion that quality is more complex than has been previously assumed. Some elements of quality, like flight frequency, depend on the level of output, while other like free drinks and other amenities per passenger do not. We would expect a reduction in price to led to a reduction in amenities per passenger, but it could lead to an increase in flight frequency if demand is sufficiently responsive to price. This suggests that the assumption of a high correlation among the various elements of service quality may not be justified. This question is taken up in the next chapter.

The comparative statics of service convenience are also indeterminant. Recall that scheduling competition consisted of adding flights to reduce frequency delay, which resulted in lower load factors which reduced stochastic delay. Converting equations (3.18) and (3.19) into the form of equation (3.10) we have

$$a\,F_i = X_i\,(\overline{P}-b)\;. \qquad (3.20)$$

A reduction in price will lead to an indeterminant change in the number of flights, depending on the elasticity of demand, while the number of people per flight, $\frac{X_i}{F_i}$, would be expected to increase, raising the load factor. If flight frequency rose after a reduction in price, while load factor also rose, then the net change in convenience cannot be determined. Consumers would have more flights to choose from, and thus lower frequency delay, but the flights would be more crowded resulting in more stochastic delay. The empirical analysis of changes in proxies for various elements of service quality is taken up in Chapter V.

CHAPTER III

FOOTNOTES

CHAPTER III

FOOTNOTES

[1]The model presented in Section 3.1 closely follows the logic of White (1972).

[2]By law a regulator can mandate a minimum quality level to the regulated firm(s). But the cases we are interested in are where this minimum level is met and the firm is free to choose the level of quality it will provide. For simplicity I assume that Q is an unrestricted variable to the firm.

[3]For instance we will see in Section 3.1.2 that an increase in regulated price to raise firms' profits will raise quality and leave profits unchanged under competitive conditions.

[4]See Chamberlain (1933) and Abbott (1955) for discussions of the use of product differentiation to insulate the firm from market forces to improve profits. This theory is basically monopolistic competition where price cannot vary. There are many ways to differentiate a product, and the concentration on a single element may be misleading. See Chapter 4.

[5]See Chamberlain (1933) for a discussion of zero long run profits under monopolistic competition.

[6]See any or all of the studies linking concentration and profitability. Scherer (1970) and (1980) gives a useful summary and list of references.

[7]A function of this type is traditional in the literature. See White (1972) (1975), Douglas and Miller (1974a) (1974b), Schmalensee (1977).

[8]This derivation can be found in Douglas and Miller (1974b), p. 57-58.

[9]See White (1972) and Douglas and Miller (1974a) and (1974b).

[10]This section closely follows Douglas and Miller (1974a).

[11]This is the traditional assumption of studies in this field. See Douglas and Miller (1974a) and Abrahams (1980).

CHAPTER IV

THE IDENTIFICATION OF PROXIES FOR VARIOUS ELEMENTS OF SERVICE QUALITY

This chapter identifies proxies for various elements of air travel service quality and analyzes the correlation between these proxies. The proxies identified in this chapter then are analyzed over time in Chapter V.

Section 4.1 looks at the relationship between market share and the various proxies for service quality. Since firms compete for market share and profits via service competition in the regulated airline industry, we would expect a quality proxy to be positively related to market share. This section identifies various proxies consistent with this behavior to be used in further analysis.

Section 4.2 looks at the correlation between the proxies to determine whether quality is best treated as multidimensional or unidimensional. Previous work has assumed high correlations between various elements of service quality, but has not provided empirical support for this assumption. Low correlations would indicate that quality may be more complex than was previously thought.

4.1 Market Share

As we saw in Chapters 2 and 3, regulated firms are modeled as competing for market share and profits through quality competition. The purpose of this section is to determine whether market share and various quality of service proxies are related in the manner that theory would predict. Also, the assumption that quality can be thought of as unidimensional is tested by determining the correlation of various proxies of different elements of service quality. The work in this section will give support to the use of various quality of service proxies in Chapter V.[1]

The theory developed previously assumes that firms that provide higher quality service can steal customers away from firms that provide lower quality service, other things equal, and therefore the former should have larger market shares than the latter. A regression of various potential quality proxies on market share will allow the evaluation of the usefulness of these variables as proxies for elements of quality in the rest of the chapter.

We saw in Chapter II that service convenience has become the major element of service quality in the theoretical and empirical literature. The traditional view is that a traveler choosing a particular flight will place primary importance on convenient departure. Since all flights had the same price, the most important element in the consumer's choice of firm is which firm provides a flight closest to the desired departure time.[2] The firm with the most flights is most likely to have a flight leaving at the right time from the consumers' point of view, and so firms will engage in flight frequency competition to provide the most convenient service.[3]

There is, however, reason to doubt this equation of quality with flight frequency. First, as was stated in the last chapter and as will be tested in the next chapter, given the fixed size of aircraft flight frequency contains logical elements of both a quantity of output variable and a quality of service variable. But second, even if flight frequency is a very good proxy for service convenience, an inspection of the Offical Airline Guide shows that airlines concentrate departures at the same times of the day, especially on the highly-traveled routes (which make up the sample used below).[4] So flight frequency is subject to the same criticism leveled by Douglas and Miller of other quality elements; that they do not vary enough among firms to allow for substantial differences in service quality.[5]

Given the structure of take-offs, it is entirely possible for a traveler who wants to leave New York City for Chicago at 5:00 p.m. to have many flights to choose from. The actual choice of airline could result from random chance, experience (either good or bad) with a particular airline's quality of service, perceived differences in quality brought about by advertising, or many other factors. It seems that there is at least as much opportunity for consumers to discriminate between airlines based upon other elements of quality of service as there is to choose among airlines based on convenience.

If quality is multidimensional, then many elements of quality should be related to market share. This section describes some of these other elements of quality, and looks at the correlation of various quality measures to see if the concentration on a single variable as an index of quality is warranted.

The elements of service quality in addition to convenience analyzed in this section are service reliability and the level of amenities. These elements were chosen because they are frequently mentioned in the literature and data on these factors were readily available. Firms that meet their scheduled arrivals and departures offer better service than those firms that are frequently not on schedule. A consumer facing the choice of two otherwise equal flights would presumably choose the flight of the firm with the best schedule performance on the route in question.[6] The provision of amenities is another form of airline service rivalry. A consumer choosing between two otherwise equal flights will choose the firm with the higher level of amenities.

Proxies for Reliability and Amenities

One of the reasons that flight frequency has been used as a proxy for quality is that it can be easily measured. But other elements of service quality can be quantified as well. Reliability and amenities were chosen for analysis in this chapter because quantifiable proxies can be obtained for them. The neglect of other aspects of service quality in previous analysis should not be taken to mean that they are less important. Reliability is a variable where, Q_i, the total level is important to consumers, while amenities are variables where, $\frac{Q_i}{X_i}$, the level per person are important.

The CAB keeps data on the number of non-stop flights that are on-time plus 15 minutes each month by carrier for the top 200 non-stop U.S. airline markets. The percentage of flights that a carrier completes on-time should be a good indicator of the reliability of that carrier on a given route. We would expect consumers to choose the firm with the best relative on-time percentage, other things equal. The relative on-time percentage for firm k on route ij should, then, be a good proxy for the ability of the firm to meet its schedules relative to its competitors. So one proxy to compare to flight freqency is relative on-time percentage of firm k on route ij,

$$ROTPijk = OTPijk/\text{Route Mean On-Time Percentage}$$

where OTPijk is the on-time percentage of firm k on route ij. A firm with ROTPijk greater than one provides better than average reliability on that route, while a firm with ROTPijk less than one provides worse than average reliability. This variable is expected to be positively related to market share.

A way to quantify amenities is through analysis of complaint letters. The CAB keeps a file on air carrier consumer complaint letters and publishes data every month. Lower quality airlines would be expected to experience more incidents of consumer dissatisfaction than higher quality airlines.[7] The number of complaints received concerning a firm, adjusted for total passengers enplaned, should give some indication of the ability of various firms to please its customers. Firms with large numbers of complaints per passenger should have smaller market shares than firms that generate few complaints.

A traveler contemplating otherwise equal flights is interested in the relative level of amenities offered by these firms. The firm with the highest level should generally gain this traveler's patronage. If complaint letters is a good proxy for amenities, then relative complaint letters per passenger should be a good proxy for relative amenities. So relative complaint letters per 1,000,000 enplanements is the proxy used for this element of service quality in this section.

Complaint letter data is published by the CAB on a system-wide basis rather than on a market by market basis like flight frequency and on-time performance. Since airplanes and crews shift between routes there is reason to believe that amenities are related to companies rather than routes. In the following empirical work complaint data concerning a firm from all of its passenger operations is attributed to that firm on any city-pair market it serves. It is implicitly assumed that firms with large numbers of complaints per passenger overall provide poorer service than those that receive few complaints overall, and this will show up on each individual route. So relative complaint letters is defined for firm k as,

$$\text{RLetters } k = \frac{\begin{array}{c}\text{complaint letters received by firm k per 1,000,000}\\ \text{enplanements on a system-wide basis}\end{array}}{\begin{array}{c}\text{route mean complaint letters received per 1,000,000}\\ \text{enplanements on a system-wide basis}\end{array}}$$

Firms with small RLetters are expected to have larger market shares than firms with large RLetters.

Time Period, Data, and Sample

The relationship between market share and quality of service proxies is analyzed for the second quarter of 1978. A quarter was chosen because the passenger traffic data used are reported on a quarterly basis. A second quarter was chosen because previous cross section air travel studies have used the second quarter of a year.[8] The year 1978 was chosen because it is the last second quarter before the Airline Deregulation Act of 1978 went into effect in October of 1978. Chapter V compares service quality in the second quarter of 1979, after deregulation, to service quality in the second quarter of 1978, before deregulation, to see if the various quality proxies move in the directions predicted by theory. The purpose of this section is to show that the proxies are related to market share before they are used in further analysis.

The data were obtained from the following sources:

1. City Pair Passenger Traffic was gathered from the CAB's Origin-Destination Survey of Domestic Airline Passenger Traffic for the second quarters of 1978 and 1979. The number of outbound plus inbound passengers was obtained for each market by firm from Table 10 of this publication. Firm market share was obtained by dividing each firm's local passenger traffic by total local passenger traffic for the quarter.

2. Nonstop Flight Traffic was obtained from the CAB's Schedule Arrival Performance: Top 200 Markets by Carrier for the months of April, May, and June of 1978 and 1979. The top 200 markets ranked by number of nonstop flights performed are included in this report each month. Firm flight share was obtained by dividing the number of nonstop flights performed by a given carrier on a given route by the total number of nonstop flights performed on the route for the three-month period. Flight share, then, is nonstop flight share on the top nonstop routes in the country.

3. On-Time Performance data was obtained from the CAB's Schedule Arrival Performance: Top 200 Markets by Carrier for the months of April, May, and June in 1978 and 1979. This publication lists the number of nonstop flights performed, the number of those nonstop flights on-time plus 15 minutes, and the percent of nonstop flights on-time plus 15 minutes by firm for the top 200 nonstop domestic city-pair markets. Firm on-time percentage was obtained by dividing the number of nonstop flights on-time plus 15 minutes by the total number of nonstop flights performed for each carrier in each market for the quarter.

4. Complaint Letter data was obtained from the CAB's Consumer Report. This publication lists the number of complaint letters received each month by carrier on a system-wide basis. The raw complaint data for the quarter was divided by the total enplanements of a firm for the quarter to get the number of complaints per 1,000,000 enplanements.

The market share sample consists of 143 city-pair markets taken out of the top 200 nonstop markets. Fifty-seven markets were discarded for one or more of the following reasons. First, all intrastate routes with intrastate carriers providing service were eliminated from the sample since the CAB did not collect data on these intrastate carriers. In many cases non-reported intrastate carriers provided a majority of the flights in the market. These routes were identified by comparing the Schedule Arrival Performance list of firms with the list of firms providing nonstop service in the mid-May issue of the Official Airline Guide. Second, all routes with more than a token presence of Northwest Orient Airlines were discarded because Northwest pilots went on strike April 28, 1978. The strike lasted until August 15, 1978. Inclusion of this truncated data could distort the market share results. Finally, all monopoly routes were discarded, since a study of the choice among firms will not be furthered when there is only one firm to choose from. Furthermore, comparative static predictions about quality are indeterminant under monopoly, and so monopoly routes cannot be used in the next chapter.

Table I lists the routes used along with the data for each route. The means, standard deviations, and correlation of variables are also shown.

Empirical Results

This section presents the results of ordinary least-squares regressions run with market share as the dependent variable and three quality proxies, flight share, relative on-time percentage, and relative complaint letters, as the independent variables. This is a test of whether these proxies conform to the assumption that firms gain market

TABLE 1

Data Used in Market Share Section

Route	Airline	Local Passenger Market Share	Nonstop Flight Share	On-Time Percentage	Relative On-Time Percentage	Complaint Letters	Relative Complaint Letters
Albuquerque	TW	62.0	40.4	87.6	1.30	51.38	1.12
-Los Angeles	TI	38.0	59.6	53.7	.80	40.31	.88
Atlanta	DL	37.6	46.6	66.0	.97	15.58	.64
-Boston	EA	62.4	53.4	69.5	1.02	32.85	1.36
Atlanta	DL	43.1	44.0	71.2	1.01	15.58	.64
-Charlotte	EA	56.9	56.0	69.9	.99	32.85	1.36
Atlanta	DL	78.0	53.0	62.5	.94	15.58	.64
-Dallas-Fort Worth	EA	22.0	47.0	70.3	1.06	32.85	1.36
Atlanta	DL	72.1	54.1	72.4	1.00	15.58	.64
-Ft. Lauderdale	EA	27.9	45.9	72.9	1.00	32.85	1.36
Atlanta	DL	68.8	55.0	65.0	1.04	15.58	.64
-Houston	EA	31.2	45.0	59.1	.95	32.85	1.36
Atlanta	EA	37.8	51.7	76.2	1.10	32.85	1.36
-Jacksonville	DL	62.2	48.3	61.7	.89	15.58	.64
Atlanta	DL	58.9	51.2	49.1	.99	15.58	.64
-Los Angeles	EA	41.1	48.8	49.6	1.00	32.85	1.36
Atlanta	EA	12.6	19.5	73.7	1.06	32.85	1.36
-Memphis	DL	87.4	80.5	68.5	.99	15.58	.64
Atlanta	EA	21.2	36.2	73.3	1.07	32.85	1.36
-New Orleans	DL	78.8	63.8	65.9	.96	15.58	.64
Atlanta	EA	37.6	45.7	63.4	1.07	32.85	1.36
-New York	DL	62.4	54.3	55.7	.94	15.58	.64
Atlanta	DL	61.8	51.2	68.3	.96	15.58	.64
-Orlando	EA	38.2	48.8	73.8	1.04	32.85	1.36
Atlanta	EA	40.5	48.6	57.3	1.01	32.85	1.36
-Philadelphia	DL	59.5	51.4	56.5	.99	15.58	.64
Atlanta	DL	66.5	56.9	64.0	1.03	15.58	.64
-Washington, D.C.	EA	33.5	43.1	59.1	.95	32.85	1.36
Baltimore	AM	2.5	5.6	90.1	1.12	35.90	1.28
-Boston	DL	44.2	40.3	81.2	1.01	15.58	.55
	ALL	53.3	54.1	78.8	.98	32.95	1.17
Baltimore	UN	74.9	85.5	78.0	1.02	25.82	.67
-Chicago	TW	25.1	14.5	67.7	.88	51.38	1.33
Baltimore	NA	1.1	2.7	96.6	1.26	55.34	1.48
-New York	EA	3.1	3.7	95.0	1.24	32.85	.88
	AM	8.8	18.1	88.6	1.16	35.90	.96
	TW	7.3	6.3	78.7	1.03	51.38	1.38
	ALL	65.8	50.0	74.3	.97	32.95	.88
	DL	13.9	19.2	63.1	.83	15.58	.42
Boston	AM	40.8	33.8	78.9	1.05	35.90	.95
-Chicago	TW	32.4	32.0	77.6	1.03	51.38	1.36
	UN	28.8	34.2	70.1	.93	25.82	.68
Boston	AM	62.6	43.9	88.3	1.10	35.90	1.01
-Detroit	NC	37.4	56.1	77.5	.96	35.02	.99

TABLE 1

Data Used in Market Share Section

Route	Airline	Market Share	Nonstop Flight Share	On-Time Percentage	Relative On-Time Percentage	Complaint Letters	Relative Complaint Letters
Boston	AM	60.5	55.8	74.0	1.08	35.90	.82
-Los Angeles	TW	39.5	44.2	61.7	.90	51.38	1.18
Boston	DL	59.7	63.0	62.2	.97	15.58	.64
-Miami	EA	40.3	37.0	66.8	1.05	32.85	1.36
Boston	EA	77.1	56.2	82.0	1.05	32.85	.91
-New York	AM	15.9	23.3	79.0	1.01	35.90	.99
	TW	2.7	6.3	72.0	.92	51.38	1.42
	UN	.3	2.5	71.9	.92	25.82	.71
	DL	3.7	10.0	65.0	.83	15.58	.43
	NA	.3	1.7	64.5	.82	55.34	1.53
Boston	AM	3.0	4.9	81.7	1.22	35.90	1.28
-Philadelphia	ALL	48.1	53.2	68.0	1.01	32.95	1.17
	DL	48.9	41.9	63.5	.95	15.58	.55
Boston	TW	31.6	34.5	72.5	1.10	51.38	1.22
-Pittsburgh	ALL	68.4	65.5	62.7	.95	32.95	.78
Boston	UN	42.9	55.3	77.1	1.00	25.82	.67
-San Francisco	TW	57.1	44.7	77.8	1.01	51.38	1.33
Boston	EA	27.3	30.9	81.7	1.09	32.85	1.36
-Tampa	DL	72.7	69.1	72.3	.96	15.58	.64
Boston	AM	40.7	38.9	83.8	1.08	35.90	1.28
-Washington, D.C.	EA	22.1	26.9	78.6	1.01	32.85	1.17
	DL	37.2	34.2	70.3	.90	15.58	.55
Buffalo	AM	62.2	44.7	82.2	1.09	35.90	1.04
-New York	ALL	37.8	55.3	70.5	.93	32.95	.96
Charlotte	EA	88.5	80.3	76.0	1.04	32.85	1.36
-New York	DL	11.5	19.7	61.9	.84	15.58	.64
Chicago	AM	27.9	31.9	80.0	1.06	35.90	1.39
-Cincinnati	DL	72.1	68.1	73.4	.97	15.58	.61
Chicago	TW	75.5	65.1	84.0	1.04	51.38	1.33
-Columbus, Ohio	UN	24.5	34.9	75.4	.93	25.82	.67
Chicago	AM	54.9	46.4	83.2	1.07	35.90	.93
-Dallas-Ft. Worth	BR	45.1	53.6	72.9	.94	41.71	1.07
Chicago	TW	18.3	30.7	68.9	1.13	51.38	1.36
-Denver	CO	38.9	35.6	56.0	.92	35.73	.95
	UN	42.8	33.7	59.2	.97	25.82	.69
Chicago	AM	24.3	27.0	81.3	1.03	35.90	1.22
-Des Moines	UN	71.0	59.7	80.3	1.02	25.82	.87
	OZ	4.7	13.3	69.3	.88	26.92	.91
Chicago	TW	12.6	16.9	89.7	1.11	51.38	1.36
-Hartford	AM	36.0	36.4	83.0	1.02	35.90	.95
	UN	51.4	46.7	76.3	.94	25.82	.68
Chicago	BR	47.1	55.5	71.7	1.00	41.71	1.46
-Houston	DL	52.9	44.5	72.2	1.00	15.58	.54

TABLE 1

Data Used in Market Share Section

Route	Airline	Market Share	Nonstop Flight Share	On-Time Percentage	Relative On-Time Percentage	Complaint Letters	Relative Complaint Letters
Chicago	EA	2.2	3.2	91.8	1.13	32.85	1.12
-Indianapolis	AM	44.2	37.1	86.4	1.07	35.90	1.22
	DL	12.0	15.7	77.0	.95	15.58	.53
	ALL	41.6	44.0	77.3	.95	32.95	1.12
Chicago	TW	61.3	56.4	78.3	1.02	51.38	1.20
-Kansas City	BR	35.1	41.7	76.1	.99	41.71	.97
	CO	3.6	1.9	56.9	.74	35.73	.83
Chicago	UN	50.2	46.4	81.1	1.00	25.82	.67
-Las Vegas	TW	49.8	53.6	81.7	1.00	51.38	1.33
Chicago	AM	31.9	30.5	76.4	1.04	35.90	.96
-Los Angeles	TW	10.5	10.9	76.0	1.04	51.38	1.38
	UN	29.5	31.4	71.6	.98	25.82	.69
	CO	28.1	27.2	70.4	.96	35.73	.96
Chicago	PD	16.3	36.4	78.7	1.05	30.15	1.32
-Louisville	DL	83.7	63.6	72.9	.97	15.58	.68
Chicago	DL	71.1	50.6	78.0	1.27	15.58	.50
-Memphis	SO	28.9	49.4	44.6	.73	47.27	1.50
Chicago	AM	43.1	36.8	78.2	1.04	35.90	.95
-New York	TW	30.6	33.2	75.0	1.00	51.38	1.36
	UN	26.3	30.0	72.1	.96	25.82	.68
Chicago	AM	33.8	33.9	81.3	1.02	35.90	1.16
-Omaha	UN	66.2	66.1	78.9	.99	25.82	.84
Chicago	DL	56.4	49.5	78.9	1.02	15.58	.64
-Orlando	EA	43.6	50.5	75.8	.98	32.85	1.36
Chicago	TW	53.1	53.1	76.0	1.04	51.38	1.33
-Philadelphia	UN	46.9	46.9	69.8	.95	25.82	.67
Chicago	AM	64.8	48.4	78.8	1.00	35.90	.82
-Phoenix	TW	35.2	51.6	78.5	1.00	51.38	1.18
Chicago	TW	39.3	24.9	76.5	1.07	51.38	1.40
-Pittsburgh	ALL	29.5	49.6	71.9	1.00	32.95	.90
	UN	31.2	25.5	66.7	.93	25.82	.70
Chicago	DL	59.9	53.6	72.9	1.10	15.58	.73
-St. Louis	OZ	40.1	46.4	56.6	.86	26.92	1.27
Chicago	AM	53.6	51.1	83.6	1.03	35.90	1.16
-San Diego	UN	46.4	48.9	78.5	.97	25.82	.84
Chicago	TW	17.8	27.4	81.7	1.06	51.38	1.36
-San Francisco	AM	37.3	35.4	78.0	1.02	35.90	.95
	UN	44.9	37.1	72.1	.94	25.82	.68
Chicago	TW	26.1	27.8	76.3	1.00	51.38	1.36
-Washington, D.C.	UN	32.2	37.4	76.4	1.00	25.82	.68
	AM	41.7	34.8	77.1	1.01	35.90	.95
Cincinnati	TW	46.4	50.3	82.8	1.04	51.38	1.18
-New York	AM	53.6	49.7	76.5	.96	35.90	.82

TABLE 1

Data Used in Market Share Section

Route	Airline	Market Share	Nonstop Flight Share	On-Time Percentage	Relative On-Time Percentage	Complaint Letters	Relative Complaint Letters
Cleveland	WR	38.7	31.6	89.7	1.06	35.06	1.26
-Detroit	NC	55.7	55.0	82.2	.97	35.02	1.26
	UN	3.7	5.8	85.5	1.01	25.82	.93
	DL	1.9	7.6	80.1	.95	15.58	.56
Cleveland	AM	49.0	54.0	82.2	1.08	35.90	1.16
-Los Angeles	UN	51.0	46.0	68.5	.90	25.82	.84
Cleveland	AM	21.8	18.7	80.4	1.04	35.90	.95
-New York	UN	71.5	76.2	77.5	1.00	25.82	.68
	TW	6.7	5.1	61.5	.80	51.38	1.36
Columbus, Ohio	TW	73.3	68.6	84.7	1.02	51.38	1.18
-New York	AM	26.7	31.4	79.9	.96	35.90	.82
Dallas	FR	32.7	38.1	67.9	1.13	40.21	.98
-Ft. Worth-Denver	BR	67.3	61.9	55.4	.92	41.71	1.02
Dallas	FR	10.0	16.9	78.2	1.03	40.21	.98
-Ft. Worth-Kansas City	BR	90.0	83.1	75.8	.99	41.71	1.02
Dallas	CO	3.6	1.0	80.8	1.00	35.73	1.23
Ft. Worth-Los Angeles	AM	52.2	58.3	88.2	1.10	35.90	1.23
	DL	44.2	40.7	69.5	.86	15.58	.54
Dallas	BR	31.2	44.1	76.2	1.04	41.71	1.46
-Ft. Worth-New Orleans	DL	68.8	55.9	70.6	.97	15.58	.54
Dallas	AM	54.0	46.7	78.1	1.06	35.90	.93
-Ft. Worth-New York	BR	46.0	53.3	70.3	.95	41.71	1.07
Dallas	FR	5.3	6.7	80.8	1.04	40.21	1.02
-Ft. Worth	AM	27.5	29.3	86.9	1.12	35.90	.91
-Oklahoma City	BR	67.2	64.0	73.1	.94	41.71	1.06
Dallas	AM	52.3	37.6	88.8	1.14	35.90	1.14
-Ft. Worth-St. Louis	OZ	47.7	62.4	71.1	.92	26.92	.86
Dallas	AM	59.2	60.5	86.8	1.07	35.90	1.39
-Ft. Worth	DL	40.8	39.5	72.1	.89	15.58	.61
-San Francisco							
Dallas	AM	40.1	31.9	87.0	1.06	35.90	1.03
-Ft. Worth	BR	54.0	52.6	83.8	1.02	41.71	1.20
-Tulsa	OZ	5.9	15.5	67.9	.82	26.92	.77
Dallas	AM	47.4	59.9	89.7	1.04	35.90	.93
-Ft. Worth	BR	52.6	40.1	80.9	.94	41.71	1.07
-Washington, D.C.							
Denver	CO	62.9	35.8	66.4	1.01	35.73	.94
-Houston	TI	37.1	64.2	65.5	1.00	40.31	1.06
Denver	UN	50.3	41.4	65.3	.99	25.82	.78
-Las Vegas	FR	49.7	58.6	66.8	1.01	40.21	1.22
Denver	UN	45.4	47.5	55.7	.97	25.82	.84
-Los Angeles	CO	54.6	52.5	58.8	1.03	35.73	1.16
Denver	WE	69.6	60.8	53.8	1.04	23.85	.81
-Minneapolis	NC	30.4	39.2	48.8	.94	35.02	1.19

TABLE 1

Data Used in Market Share Section

Route	Airline	Market Share	Nonstop Flight Share	On-Time Percentage	Relative On-Time Percentage	Complaint Letters	Relative Complaint Letters
Denver	UN	71.0	82.0	54.3	1.01	25.82	.67
-New York	TW	29.0	18.0	52.4	.97	51.38	1.33
Denver	WE	60.5	51.0	62.6	.98	23.85	.74
-Phoenix	FR	39.5	49.0	64.9	1.02	40.21	1.26
Denver	UN	14.0	22.1	73.0	1.08	25.82	.79
-Salt Lake City	FR	37.1	33.0	70.9	1.05	40.21	1.24
	WE	24.4	24.2	64.4	.95	23.85	.73
	TI	24.5	20.7	60.1	.89	40.31	1.24
Denver	TW	13.4	24.3	75.5	1.13	51.38	1.53
-San Francisco	WE	13.4	12.1	77.3	1.16	23.85	.71
	UN	73.2	63.6	61.1	.92	25.82	.77
Denver	TW	24.8	24.9	88.4	1.33	51.38	1.33
-Washington, D.C.	UN	75.2	75.1	58.9	.89	25.82	.67
Detroit	DL	93.5	90.5	82.4	1.02	15.58	.64
-Ft. Lauderdale	EA	6.5	9.5	64.0	.79	32.85	1.36
Detroit	AM	22.3	32.3	90.8	1.06	35.90	1.39
-Indianapolis	DL	77.7	67.7	83.0	.97	15.58	.61
Detroit	AM	70.2	60.3	83.8	1.03	35.90	1.16
-Los Angeles	UN	29.8	39.7	77.3	.95	25.82	.84
Detroit	DL	60.9	63.7	68.1	1.03	15.58	.64
-Miami	EA	39.1	36.3	62.3	.94	32.85	1.36
Detroit	UN	41.6	47.5	79.6	.93	25.82	.84
-San Francisco	AM	58.4	52.5	90.4	1.06	35.90	1.16
Detroit	EA	23.7	52.0	78.9	1.02	32.85	1.36
-Tampa	DL	76.3	48.0	76.0	.98	15.58	.64
Ft. Lauderdale	DL	32.1	28.9	69.4	1.08	15.58	.45
-New York	NA	25.2	26.0	60.6	.94	55.34	1.60
	EA	42.7	45.1	63.7	.99	32.85	.95
Ft. Lauderdale	DL	67.9	57.4	74.0	.97	15.58	.64
-Philadelphia	EA	32.1	42.6	79.9	1.04	32.85	1.36
Greensboro/High Point	UN	35.6	41.9	82.3	1.12	25.82	.88
-New York	EA	64.4	58.1	67.2	.91	32.85	1.12
Hartford	EA	12.6	14.4	83.3	1.06	32.85	1.00
-Washington, D.C.	ALL	87.4	85.6	77.8	.99	32.95	1.00
Houston	CO	67.5	47.7	74.8	1.10	35.73	.78
-Los Angeles	NA	32.5	52.3	61.7	.91	55.34	1.22
Houston	CO	49.9	50.2	74.7	1.08	35.73	.78
-Miami	NA	50.1	49.8	64.2	.93	55.34	1.22
Houston	EA	5.1	10.2	75.1	1.12	32.85	.89
-New Orleans	TI	29.5	29.6	64.6	.97	40.31	1.09
	DL	24.3	20.2	67.4	1.01	15.58	.42
	NA	26.8	24.2	67.4	1.01	55.34	1.50
	CO	13.8	15.1	64.7	.97	35.73	.97
	BR	.5	.7	57.7	.86	41.71	1.13

TABLE 1

Data Used in Market Share Section

Route	Airline	Market Share	Nonstop Flight Share	On-Time Percentage	Relative On-Time Percentage	Complaint Letters	Relative Complaint Letters
Houston	DL	39.0	37.7	75.5	1.07	15.58	[illegible]
-New York	EA	61.0	62.3	67.9	.96	32.85	1.36
Houston	AM	45.3	40.1	85.1	1.37	35.90	.79
-San Francisco	NA	54.7	59.9	46.3	.75	55.34	1.21
Houston	EA	59.3	67.7	76.8	1.07	32.85	1.36
-Washington, D.C.	DL	40.7	32.3	61.4	.86	15.58	.64
Indianapolis	TW	70.6	58.5	78.9	1.12	51.38	1.22
-New York	ALL	29.4	41.5	58.9	.83	32.95	.78
Jacksonville	NA	33.1	33.5	67.8	.91	55.34	1.26
-New York	EA	66.9	66.5	78.2	1.05	32.85	.74
Kansas City	TW	61.8	59.5	80.8	1.03	51.38	1.36
-Los Angeles	CO	26.0	29.7	73.8	.94	35.73	.95
	UN	12.2	10.8	81.1	1.03	25.82	.69
Kansas City	TW	95.0	83.0	85.9	1.02	51.38	1.12
-St. Louis	FR	5.0	17.0	76.2	.90	40.21	.88
Las Vegas	TW	.4	1.3	91.4	1.06	51.38	1.60
-Los Angeles	HU	26.0	23.3	87.6	1.02	27.66	.86
	WE	69.8	65.3	85.3	.99	23.85	.74
	UN	3.8	10.1	85.2	.99	25.82	.80
Las Vegas	TW	60.4	45.6	73.7	1.09	51.38	1.33
-New York	UN	39.6	54.4	61.3	.90	25.82	.67
Las Vegas	HU	4.9	6.4	90.3	1.07	27.66	1.07
-San Diego	WE	95.1	93.6	83.9	1.00	23.85	.93
Las Vegas	WE	60.1	51.8	84.0	1.01	23.85	.65
-San Francisco	TW	25.9	28.0	88.8	1.07	51.38	1.41
	DL	4.9	5.3	70.3	.84	15.58	.43
	NA	9.1	14.9	75.0	.90	55.34	1.51
Los Angeles	WE	41.6	50.5	54.7	1.05	23.85	.60
-Miami	NA	58.4	49.5	49.0	.95	55.34	1.40
Los Angeles	DL	38.9	28.9	57.1	1.05	15.58	.44
-New Orleans	NA	61.1	71.1	53.1	.98	55.34	1.56
Los Angeles	UN	27.2	29.1	73.3	1.03	25.82	.68
-New York	TW	28.9	37.0	72.0	1.01	51.38	1.36
	AM	43.9	33.9	68.9	.97	35.90	.95
Los Angeles	AM	32.1	36.9	69.3	1.04	35.90	.95
-Philadelphia	TW	47.3	33.6	64.4	.97	51.38	1.36
	UN	20.6	29.5	65.6	.98	25.82	.68
Los Angeles	WE	22.0	22.0	93.5	1.13	23.85	.65
-Phoenix	TW	20.9	24.7	86.2	1.04	51.38	1.40
	AM	24.8	16.4	85.9	1.03	35.90	.98
	CO	32.3	36.9	73.3	.88	35.73	.97
Los Angeles	UN	63.5	58.5	79.9	1.04	25.82	1.04
-Portland	WE	36.5	41.5	71.9	.94	23.85	.96

TABLE 1

Data Used in Market Share Section

Route	Airline	Market Share	Nonstop Flight Share	On-Time Percentage	Relative On-Time Percentage	Complaint Letters	Relative Complaint Letters
Los Angeles	AM	34.7	41.3	83.6	1.05	35.90	.82
-St. Louis	TW	65.3	58.7	76.8	.96	51.38	1.18
Los Angeles	UN	73.6	64.0	85.1	.99	25.82	.97
-Salinas/Monterey	HU	26.4	36.0	86.9	1.01	27.66	1.03
Los Angeles	WE	85.1	66.9	79.5	1.00	23.85	.93
-Salt Lake City	HU	14.9	33.1	78.6	.99	27.66	1.07
Los Angeles	UN	65.3	66.5	78.3	1.04	25.82	1.04
-Seattle	WE	34.7	33.5	68.4	.91	23.85	.96
Los Angeles	HU	45.8	51.9	81.9	1.02	27.66	.72
-Tucson	CO	48.8	37.1	76.9	.96	35.73	.93
	TW	5.4	11.0	83.7	1.04	51.38	1.34
Los Angeles	AM	42.8	32.8	82.3	1.04	35.90	.95
-Washington, D.C.	TW	27.6	30.6	81.3	1.03	51.38	1.36
	UN	29.6	36.6	74.4	.94	25.82	.68
Louisville	AM	73.1	63.5	77.3	1.02	35.90	1.04
-New York	EA	26.9	36.5	73.1	.96	32.85	.96
Miami	EA	35.2	36.9	72.8	1.09	32.85	.74
-New Orleans	NA	64.8	63.1	63.0	.95	55.34	1.26
Miami	DL	12.2	14.5	62.5	1.04	15.58	.45
-New York	EA	56.1	51.5	60.6	1.01	32.85	.95
	NA	31.7	34.0	58.6	.97	55.34	1.60
Miami	EA	78.4	74.9	65.0	1.00	32.85	1.36
-Philadelphia	DL	21.6	25.1	64.2	.99	15.58	.64
Miami	NA	92.1	88.8	42.7	1.03	55.34	1.56
-San Francisco	DL	7.9	11.2	30.8	.74	15.58	.44
Miami	NA	33.7	38.5	73.4	1.04	55.34	1.26
-Washington, D.C.	EA	66.3	61.5	68.6	.97	32.85	.74
Nashville	BR	35.7	31.6	63.7	.88	41.71	1.07
-New York	AM	64.3	68.4	76.1	1.05	35.90	.93
New Orleans	EA	44.8	49.9	68.2	1.07	32.85	1.36
-New York	DL	55.2	50.1	58.9	.93	15.58	.64
New York	PD	55.3	61.1	81.1	1.04	30.15	.71
-Norfolk	NA	44.7	38.9	73.8	.94	55.34	1.29
New York	EA	66.0	69.1	71.3	1.03	32.85	.74
-Orlando	NA	34.0	30.9	64.5	.93	55.34	1.26
New York	AM	65.5	65.5	78.5	1.06	35.90	.82
-Phoenix	TW	34.5	34.5	66.0	.89	51.38	1.18
New York	UN	15.7	18.7	76.1	1.08	25.82	.70
-Pittsburgh	TW	49.7	39.9	73.3	1.04	51.38	1.40
	ALL	34.6	41.4	64.8	.92	32.95	.90

TABLE 1

Data Used in Market Share Section

Route	Airline	Market Share	Nonstop Flight Share	On-Time Percentage	Relative On-Time Percentage	Complaint Letters	Relative Complaint Letters
New York -Providence	NA	4.3	6.1	91.1	1.17	55.34	1.41
	AM	40.8	32.6	83.5	1.07	35.90	.91
	ALL	43.4	44.5	74.7	.96	32.95	.84
	EA	11.5	16.8	71.2	.91	32.85	.84
New York -Raleigh/Durham	UN	19.6	33.0	88.8	1.13	25.82	.88
	EA	80.4	67.0	73.8	.94	32.85	1.12
New York -Richmond	PD	32.4	35.9	79.4	1.02	30.15	.96
	EA	67.6	64.1	77.1	.99	32.85	1.04
New York -Rochester	ALL	28.5	31.5	87.3	1.04	32.95	.96
	AM	71.5	68.5	82.5	.98	35.90	1.04
New York - St. Louis	AM	19.2	26.3	79.7	1.01	35.90	.82
	TW	80.8	73.7	78.2	.99	51.38	1.18
New York -San Francisco	AM	32.4	30.3	76.9	1.08	35.90	.95
	UN	32.9	34.6	73.8	1.03	25.82	.68
	TW	34.7	35.1	64.2	.90	51.38	1.36
New York -Syracuse	AM	65.2	48.3	80.9	1.10	35.90	1.04
	ALL	34.8	51.7	67.2	.91	32.95	.96
New York -Tampa	NA	19.1	24.5	65.8	.96	55.34	1.60
	EA	47.1	49.5	73.5	1.07	32.85	.95
	DL	33.8	26.0	62.5	.91	15.58	.45
New York -Washington, D.C.	BR	6.0	14.5	79.5	1.03	41.71	1.11
	EA	73.6	47.1	84.9	1.10	32.85	.88
	TW	2.0	4.9	82.3	1.07	51.38	1.37
	PD	.1	.5	80.0	1.04	30.15	.80
	AM	12.6	14.8	79.8	1.04	35.90	.96
	DL	.2	.8	67.1	.87	15.58	.42
	NA	4.0	8.1	54.0	.70	55.34	1.48
	SO	.9	5.4	39.2	.51	47.27	1.26
	OZ	.6	3.9	55.5	.72	26.92	.72
New York -West Palm Beach	EA	64.2	63.6	76.5	1.11	32.85	.74
	NA	35.8	36.4	54.9	.80	55.34	1.26
Philadelphia -Pittsburgh	TW	30.7	33.1	69.8	1.03	51.38	1.22
	ALL	69.3	66.9	66.4	.98	32.95	.78
Philadelphia -San Francisco	TW	55.0	53.1	79.4	1.04	51.38	1.33
	UN	45.0	46.9	72.8	.95	25.82	.67
Phoenix -San Francisco	TW	50.8	52.3	84.7	1.00	51.38	1.18
	AM	49.2	47.7	85.0	1.00	35.90	.82
Portland -San Francisco	UN	75.2	61.4	85.3	1.02	25.82	1.04
	WE	24.8	38.6	81.5	.97	23.85	.96
Reno -San Francisco	UN	92.9	83.2	90.7	1.02	25.82	1.04
	WE	7.1	16.8	81.8	.92	23.85	.96
St. Louis -Washington, D.C.	TW	92.5	88.2	80.9	1.02	51.38	1.22
	EA	7.5	11.8	69.7	.88	32.85	.78
Salt Lake City -San Francisco	UN	44.2	43.0	82.8	1.01	25.82	1.04
	WE	55.8	57.0	81.3	.99	23.85	.96

TABLE 1

Data Used in Market Share Section

Route	Airline	Market Share	Nonstop Flight Share	On-Time Percentage	Relative On-Time Percentage	Complaint Letters	Relative Complaint Letters
San Francisco -Seattle	UN	62.1	49.9	89.9	1.08	25.82	1.04
	WE	37.9	50.1	76.3	.92	23.85	.96
San Francisco -Washington, D.C.	UN	57.7	61.9	83.2	1.02	25.82	.67
	TW	42.3	38.1	79.0	.97	51.38	1.33
Mean		41.1%	41.1%	73.4%	1.00	34.00	1.00
Standard Deviation		22.8%	19.7%	10.3%	.09	11.74	.29
Minimum		.1%	.5%	30.8%	.51	15.58	.42
Maximum		95.1%	93.6%	96.6%	1.37	55.34	1.60

Correlation Coefficients

Market Share	1	.92	-.003	.11	-.15	-.14
Flight Share		1	-.04	.07	-.12	-.07
On-Time Percentage			1	.62	.07	.08
Relative On-Time Percentage				1	.08	.12
Complaint Letters					1	.81
Relative Complaint Letters						1

Airline Codes

ALL - **Allegeny**

AM - **American**

BR - **Braniff**

CO - Continental

DL - Delta

EA - Eastern

FR - Frontier

HU - Hughes Air West

NA - National

NC - North Central

OZ - Ozark

PD - Piedmont

SO - Southern

TI - Texas International

TW - Trans World

UN - United

WE - Western

WR - Wright

share through offering higher quality service, which is the motivating force behind the discussion in Section 3.1.2. A good proxy would indicate that firms with higher quality will have larger market shares than firms with lower quality.

Table II shows the regression results of the various quality proxies on market share, both separately and together. Flight share, relative on-time percentage, complaint letters per enplanement, and relative complaint letters are all significantly related to market share with the expected signs. This provides some evidence that choice of airline does depend upon various elements of service quality, and that the proxies for convenience, punctuality, and amenities behave as expected.

There is a very strong positive relationship between market share and flight share. This confirms the findings of the previous authors in the field. The R^2 of the flight share-market share equation is over 40 times as large as the R^2 for any other single variable. This may indicate, as Douglas and Miller and Panzar and others asserted, that service convenience is a very strong determinant of firm demand. Alternatively this very large R^2 may mean that flight share is measuring more than service quality. This very large R^2 is also consistent with the view of capacity brought to the market as another possible measure of quantity of output. The analysis of the next chapter will allow us to decide which view of flight frequency is more likely to be correct.

Relative on-time percentage is significantly related to market share with the expected positive sign. Firms that give more reliable service relative to other firms in the market enjoy higher market shares. This finding not only supports the use of this proxy for

TABLE II

Ordinary Least Squares Test of Relationship Between Firm Market Share and Various Quality of Service Variables: Cross Section Study - 143 City-Pair Markets for the Second Quarter of 1978

	(1) MS_{ijk}	(2) MS_{ijk}	(3) MS_{ijk}	(4) MS_{ijk}	(5) MS_{ijk}	(6) MS_{ijk}
Intercept	-2.76 (-2.50)	41.54 (4.71)	12.75 (.95)	50.90 (13.70)	52.39 (12.05)	-11.08 (-2.13)
FS_{ijk}	1.07*** (44.08)					1.06*** (44.74)
OTP_{ijk}		-.006 (-.05)				
$ROTP_{ijk}$			28.42** (2.13)			15.68*** (3.06)
$Letters_k$				-.29*** (-2.79)		
RLetters					-11.30*** (-2.70)	-6.83*** (-4.25)
R^2	.85	.000008	.01	.02	.02	.86

t-statistics in parentheses # observations = 348

MS_{ijk} = market share of firm k for city pair ij.

FS_{ijk} = flight share of firm k for city pair ij.

OTP_{ijk} = percent of firm k's flights on time plus 15 minutes on route ij.

$ROTP_{ijk}$ = relative on time percentage for firm k on route ij. OTP_{ijk}/Route mean OTP

$Letters_k$ = complaint letters received by firm k.

$RLetters_k$ = relative complaint letters received by firm k. Complaint letters received by firm k/Route mean complaint letters

* - significant at the .90 level, ** significant at the .95 level, *** significant at the .99 level.

reliability, but also lends support to the view that quality should be treated as a multidimensional variable. Concentration on a single element of quality may be an oversimplification and thus give erroneous results.

Relative complaint letters are also significantly related to market share, in the expected negative direction. This lends support to its use as a proxy for amenities. Firms with relatively many complaints per passenger have lower market shares than firms with relatively few complaints, when they meet head to head in a given market.

Equations (2) and (4) in Table II regress unadjusted on-time percentage and unadjusted complaint letters per enplanement, respectively, on market share. Equation (2) shows no relationship. This is not surprising, since many heterogeneous routes are being compared. Routes of different distances, congestion, etc., will have different mean on-time performances around which the firms will vary. This variability among firms on a given route does affect the firms' market shares. But when all routes are taken together there is no relationship between market share and on-time performance.

The significant negative relationship between complaint letters and market share is interesting. Across all routes in the sample, firms with many complaints per passenger will tend to have smaller market shares than firms with few complaints. This gives added support to the use of complaint letters as a proxy for amenities. The complaint data is on a system-wide basis and the high complaint firms will tend to have smaller market shares across all these routes than the low complaint firm.

Equation (6) in Table II is a multiple regression of three

different quality proxies on market share. The t-statistics increase for each of the three variables when all are included as explanatory variables, with the largest increases shown by relative on-time percentage and relative complaints. This indicates that once flight share explains its large portion of the variation of market share, the other two variables do a better job of explaining the remaining variation than when they are included as single explanatory variables. This suggests a more complex relationship among various elements of quality than has previously been hypothesized in the literature.

4.2 Correlation of Quality Proxies

As we saw in Chapter II the concentration of analysis of service convenience as the sole element of quality has been based on the untested assertion that all elements of service quality behave the same. A look at the correlation of the proxies identified in this section is a good test of this assumption. The correlation of the data presented in Table I is reprinted here as Table III.

There is not much support for the assumption of high correlation in this data. The coefficients range from .07 to .12, hardly large enough to call the relationships close. And in fact the largest coefficient, .12 between relative on-time percentage and relative complaint letters, is in the wrong direction. Good on-time performance is weakly associated with relatively more complaint letters. It appears as though the relationship among different elements of quality is more complex than has previously been assumed. Quality should perhaps not be treated as a unidimensional variable.

TABLE III

Correlation Coefficients of Various Quality of Service Proxies

	Market Share	Flight Share	On-Time Percentage	Relative On-Time Percentage	Complaint Letters	Relative Complaint Letters
Market Share	1	.92	-.003	.11	-.15	-.14
Flight Share		1	-.04	.07	-.12	-.07
On-Time Percentage			1	.62	.07	.08
Relative On-Time Percentage				1	.08	.12
Complaint Letters					1	.81
Relative Complaint Letters						1

Source: Table I

Conclusion

This chapter provides support for the use of the above variables as proxies for various quality attributes. Highly significant results are obtained that do not allow the rejection of these variables as quality of service variables. This section also indicates that the relationship between different quality variables may not be as simple as previous studies have assumed.

The next section analyzes the behavior of the above identified proxies and an additional traditional service convenience variable, load factor, over time to (1) test the conformance of these proxies to the predictions of the model developed in Chapter III, and (2) provide further insights into the relationship among the various elements of service quality. This will indicate some problems with previous work in the field as well as some areas for future research.

CHAPTER IV

FOOTNOTES

CHAPTER IV

FOOTNOTES

[1]For other market share studies see Taneja (1968), Renard (1970), Douglas and Miller (1974b), Miller (1979). These studies are primarily interested in the relationship of capacity to passenger traffic.

[2]See Chapter II for references to the primary importance of convenience.

[3]The so-called S-curve relationship found in the market share studies leads to increased rivalry for flight share since after a certain point firms gain more than a proportionate share of passenger traffic for a given increase in flight share. See Fruhan (1972), Douglas and Miller (1974b), and Eads (1975) for a discussion of the S-curve.

[4]For example in May 1979 there were 5 nonstop flights offered by three carriers leaving Chicago for New York at 7:00 a.m. Source: Official Airline Guide, May 15, 1979.

[5]See Douglas and Miller quote in Chapter III.

[6]That firms believe this is true is born out by Lufthansa ads in various issues of the Wall Street Journal in 1981, touting their reputation for punctuality. Wright Airlines has recently run a radio advertising campaign guaranteeing on-time flights on a new route out of Detroit.

[7]See Oster (1981) for another study that uses complaints as a proxy for product quality.

[8]See Panzar (1979) and Jung and Fujii (1976). The second quarter of the year has the least amount of vacation travel. Panzar states that vacation travel is "notoriously difficult to explain cross sectionally." (p. 65).

CHAPTER V

AN EMPIRICAL TEST OF QUALITY DETERMINATION IN THE REGULATED AIRLINE INDUSTRY

This chapter uses the construction of Chapter III to test whether flight frequency is a good proxy for service quality in the airline industry. The change in the values of the proxies identified in Chapter IV over the transition period of deregulation is used to determine whether improved or reduced service quality is indicated for each proxy.

Section 5.1 tests whether flight frequency and the other proxies move in the same direction after deregulation. This section tests whether each proxy used in Chapter IV shows a reduction in service quality when price fell after deregulation. The model predicts that excessive service quality will be eliminated, with consumers receiving lower average price-lower average quality of service. A proxy that does not exhibit this behavior may not be a proper proxy for service quality in general.

Section 5.2 improves the analysis of Section 5.1 by controlling for the effects of entry and exit of firms. Deregulation allowed for easier entry and exit of firms as well as more pricing freedom. Markets are placed into three categories, those that experienced entry, those that experienced exit, and those with neither entry nor exit, and the tests of Section 5.1 are then repeated for each of these categories. Of major interest is the behavior of proxies in markets with no entry or exit over the period.

5.1 Comparison of Variables Before and After Deregulation

So far we have identified proxies for three elements of quality of service, and have shown that they are not highly correlated. This section provides analysis of these proxies over time to see if they behave according to the assumptions and predictions of the model developed in Chapter III.

The theory developed in the previous chapter predicts that a reduction in price-cost margin will result in a reduction of service quality per unit of output in a price regulated nonmonopoly industry.[1] A way to test the proxies' conformance to theory is to analyze the behavior of quality at a time when prices are falling and/or costs are rising. The period around the deregulation of the airline industry provides a time when this was happening. Deregulation was predicted to lead to average fare reductions at a time when the costs of providing air travel service were rising. In competitive situations the model predicts that deregulation would, then, result in reduction in service quality until the left-hand side of equation (3.9) comes to equal the right-hand side. By looking at the actual behavior of the proxies for various elements of quality during in this period we can test conformance of these proxies to the theory.

The Airline Deregulation Act of 1978 was signed into law on October 24, 1978. Firms had some pricing freedom before this, but the bill provided much more freedom for the air carriers.[2] Firms were free to lower prices and increase the use of discount fares. Trapani and Olson found that revenue per passenger mile fell from 8.24¢ in 1977 to 8.02¢ in June of 1979.[3] The new law also greatly eased entry restrictions on firms wanting to enter new markets.[4] With price competition causing reductions in average fares and costs rising over the period we expect quality to fall over the period.

Time Period

Comparing values of variables from the second quarter of 1978 to those from the second quarter of 1979, before and after deregulation, may present problems for two reasons. First, the gasoline crisis following the Iranian revolution was in full swing by the spring of 1979. Fuel shortages could bias the results of the comparison, especially for flight frequencies. The inability to obtain fuel may have forced firms to cut back on flights that would have been profitable otherwise. This does not seem to be a problem, however, as the U.S. airlines were found to be virtually unaffected by fuel shortages in the second quarter of 1979.[5] Rising fuel prices in the spot market brought about by the Iranian oil crisis reinforces the effect of falling average fares and so should result in reductions in per unit service quality.

The second problem with this time period is that as of June 6, 1979 all DC-10's were grounded after the crash of an American Airlines DC-10 in Chicago.[6] This grounding lasted through the remainder of the quarter. Routes with DC-10 service would then give biased results on flight frequency. If no replacements were flown, then flight frequency would fall drastically in June, 1979. If smaller planes were used to pick up the service, then more flights would be needed than before to carry the same number of passengers. Of the routes used in this section, only five, Atlanta-Los Angeles, Boston-Los Angeles, Houston-Los Angeles, Los Angeles-Miami, and Miami-San Francisco had appreciable DC-10 service. The number of flights rose over the quarter for the Boston-LA, LA-Miami, and Boston-San Francisco routes, and fell for the other two routes. In each case the change in April and May, before the grounding, was in the same direction as the total change, and so the results should not be biased.

Aggregate Level Empirical Results

The behavior of complaint letters indicates that this element of service quality, the ability to satisfy customers, fell after deregulation. The data is not available on a route-by-route basis, but taking all firms on all routes there was an increase in the number of complaints per passenger after deregulation. Table IV shows that complaints rose dramatically over the period of deregulation.

There was a 74 percent increase in all passenger related complaints from the second quarter of 1978 to the second quarter of 1979, while total enplanements rose by 9 percent. This compares with a 68 percent increase in complaint letters from the second quarter of 1975 to the second quarter of 1978. Total enplaned passengers rose by 37 percent over this period. Complaints per passenger, then, increased over and above the trend of the earlier four years. The earlier trend would have resulted in a 17 percent jump in complaints when passengers

TABLE IV

Total Complaints, Total Enplanements, Complaints Per 1,000,000 Enplanements All Carriers - Second Quarter 1975 to 1979

Second Quarter	Total Complaints	Total Enplanements (000)	Complaints Per 1,000,000 Enplanements
1975	1416	50,914	27.81
1976	1711	56,872	30.09
1977	1394	60,893	22.89
1978	2382	69,606	34.22
1979	4148	75,974	54.60

Source: Consumer Report, CAB.

boarded went up by 9 percent. The actual increase in complaints is over twice that amount. This indicates that there was a reduction in these elements of service quality after deregulation, as accords with the model in Chapter III.

Disaggregate Level Empirical Results

A look at the behavior of quality proxies in specific markets will allow a disaggregate test of the effect of deregulation on those quality variables. Proxies for convenience and reliability are tested in this section. Market flight frequency and market on-time percentage were obtained from the sources outlined above. Average market load factor, the other commonly used proxy for convenience, was also calculated for each of the markets.[7]

Table V shows the changes in flights, on-time percentage, and load factor for 93 of the 143 routes used in the preceeding section. Fifty of these 143 routes cannot be used here because United Airlines was on strike during the second quarter of 1979 and did not resume full operations until June. The routes used in this section represent nonmonopoly routes not served by intrastate carriers that were not affected by strikes in either period.

The number of flights went up between the two quarters in 52 of the 93 markets. Flight frequency fell, the direction of reduced service quality, in only 44 percent of the markets. This element of service convenience showed an increase in the majority of markets.

On-time percentage fell in 82 percent of the markets. This is the expected direction if service quality fell after deregulation. Load

TABLE V

Changes in Selected Variables - Second Quarter 1978 to Second Quarter 1979

	Change in Flight	Change in On-Time Percentage	Change in Load Factor
Albuquerque - Los Angeles	+62	+17.7	+2.3
Atlanta - Boston	-64	-9.9	+5.5
Atlanta - Charlotte	+50	-6.4	+2.9
Atlanta - Dallas - Ft. Worth	+402	-9.0	-.5
Atlanta - Ft. Lauderdale	+55	-5.7	+2.1
Atlanta - Houston	+2	-3.0	+5.6
Atlanta -Los Angeles	+18	-6.9	-1.5
Atlanta - Memphis	+161	-6.7	+1.4
Atlanta - New Orleans	+127	-7.1	+2.2
Atlanta - New York	+246	-3.4	+2.1
Atlanta - Orlando	-84	-15.3	+1.6
Atlanta -Philadelphia	-180	+2.7	+5.8
Atlanta - Washington, D.C.	+579	+2.0	-3.9
Baltimore - Boston	-396	-16.5	+8.8
Baltimore - New York	-772	-3.2	+14.9

TABLE V (cont'd.)

Changes in Selected Variables - Second Quarter 1978 to Second Quarter 1979

	Change in Flight	Change in On-Time Percentage	Change in Load Factor
Boston -Detroit	+362	-13.3	-6.0
Boston - Los Angeles	+115	-8.3	-15.5
Boston - Miami	-56	-6.5	+17.8
Boston - New York	-1521	-6.1	+18.2
Boston -Philadelphia	+17	-3.0	+3.5
Boston - Pittsburgh	+228	-6.6	-2.7
Boston -Tampa	+70	-10.4	+6.4
Boston - Washington, D.C.	-173	-9.3	+8.4
Buffalo - New York	-255	-7.4	+14.3
Charlotte - New York	-99	-2.8	+8.2
Chicago - Cincinnati	-310	+2.7	+14.5
Chicago - Dallas - Ft. Worth	-47	-10.6	+4.3
Chicago - Houston	+285	-12.6	-3.5
Chicago - Indianapolis	-203	-.7	+2.5
Chicago - Kansas City	-594	-2.1	+11.8

TABLE V (cont'd.)

Changes in Selected Variables - Second Quarter 1978 to Second Quarter 1979

	Change in Flight	Change in On-Time Percentage	Change in Load Factor
Chicago - Louisville	-120	+2.8	+5.1
Chicago - Memphis	-279	-1.9	+7.6
Chicago - Orlando	+1	-3.7	+25.2
Chicago - Phoenix	-62	-3.1	+12.2
Chicago - St. Louis	-100	-5.9	+5.7
Cincinnati - New York	+60	-.4	-.3
Cleveland - Detroit	+121	-3.4	-2.0
Columbus, Ohio - New York	-36	-6.8	+12.4
Dallas-Ft. Worth - Denver	+244	+4.3	+1.1
Dallas-Ft. Worth - Kansas City	+446	-22.0	+3.0
Dallas-Ft. Worth - Los Angeles	+320	-16.0	+6.8
Dallas-Ft. Worth - New Orleans	+294	-7.1	-1.9
Dallas-Ft. Worth - New York	+98	-10.3	+2.0

TABLE V (cont'd.)

Changes in Selected Variables - Second Quarter 1978 to Second Quarter 1979

	Change in Flight	Change in On-Time Percentage	Change in Load Factor
Dallas-Ft. Worth - Oklahoma City	-207	-22.3	-.6
Dallas-Ft. Worth - St. Louis	-185	-19.0	+7.2
Dallas-Ft. Worth - San Francisco	-3	-16.7	+5.7
Dallas-Ft. Worth -Tulsa	-477	-24.6	+8.3
Dallas-Ft. Worth - Washington, D.C.	-12	-20.5	-1.3
Denver - Houston	+350	+5.1	+4.2
Denver - Phoenix	+94	+16.7	-4.2
Detroit - Ft. Lauderdale	+192	-9.4	-20.7
Detroit - Miami	+40	+2.2	+16.9
Detroit - Tampa	+167	-5.3	+12.6
Ft. Lauderdale - New York	-379	-4.0	+4.3
Ft. Lauderdale - Philadelphia	+153	-6.7	-1.0
Hartford - Washington, D.C.	+116	-2.8	+.3

TABLE V (cont'd.)

Changes in Selected Variables - Second Quarter 1978 to Second Quarter 1979

	Change in Flight	Change in On-Time Percentage	Change in Load Factor
Houston -Los Angeles	-105	-4.0	+1.2
Houston - Miami	+101	-.7	-1.1
Houston - New Orleans	-442	+2.5	-3.2
Houston - New York	+161	-6.4	+4.7
Houston - San Francisco	+203	-3.3	-6.6
Houston - Washington, D.C.	+195	+4.4	-21.7
Indianapolis - New York	+2	-3.0	+5.9
Kansas City - St. Louis	-552	-9.1	+6.5
Las Vegas - San Diego	+481	+1.2	-24.6
Las Vegas - San Francisco	-29	-5.1	-2.8
Los Angeles - Miami	+128	-15.3	-3.0
Los Angeles - New Orleans	+147	-4.4	-7.8
Los Angeles - Phoenix	-78	-.1	-.8
Los Angeles - St. Louis	+4	-17.5	+2.9
Los Angeles - Salt Lake City	-834	+.2	+6.4

TABLE V (cont'd.)

Changes in Selected Variables - Second Quarter 1978 to Second Quarter 1979

	Change in Flight	Change in On-Time Percentage	Change in Load Factor
Los Angeles - Tucson	+83	-5.5	+5.6
Miami - New Orleans	+246	+.8	-3.8
Miami - New York	-290	-4.6	+10.9
Miami - Philadelphia	-57	-1.3	+15.5
Miami - San Francisco	+353	-9.1	-23.8
Miami - Washington, D.C.	-40	-7.5	+1.4
Nashville - New York	+122	-4.1	-6.1
New Orleans - New York	+254	+2.8	-8.0
New York - Norfolk	-272	-16.2	+1.6
New York - Orlando	+121	-3.0	+19.7
New York - Phoenix	+2	+5.6	+6.7
New York - Providence	-552	-2.3	+3.6
New York - Richmond	+5	-12.1	-3.8
New York - Rochester	-34	-7.3	+.9
New York - St. Louis	+180	-17.5	-1.5

TABLE V (cont'd.)

Changes in Selected Variables - Second Quarter 1978 to Second Quarter 1979

	Change in Flight	Change in On-Time Percentage	Change in Load Factor
New York - Syracuse	-169	+2.4	+5.4
New York - Tampa	+87	-1.2	+11.5
New York - Washington, D.C.	-903	-.4	+15.1
New York - West Palm Beach	+253	-9.6	+14.0
Philadelphia - Pittsburgh	-330	-1.6	+4.1
Phoenix - San Francisco	-182	-4.2	+2.6
St. Louis - Washington, D.C.	+315	-14.0	-9.3
Number of Increases	52	17	62
Number of Reductions	41	76	31
% of Changes that move in the predicted direction	44%	82%	67%
Sign Test Statistic	-1.14	6.17***	3.22***

*** Indicates significant at .99 level.

factor rose in 67 percent of the markets, so a majority of markets showed a reduction in this element of service convenience.

A sign test was conducted to test whether the direction of movement of these variables is significantly different from random changes. The results are shown at the bottom of Table V. The null hypothesis of no change in quality cannot be rejected for the flight frequency variable. The negative sign of the test statistic indicates that less than half of the markets exhibit reductions in flights. Both on-time percentage and load factor show highly significant test statistics. The direction of change is significantly in the direction of reduced service quality.

This simple sign test along with the behavior of complaint letters shows that service quality probably did fall after deregulation. Three out of four variables show reductions in quality over the period. Only the flight frequency variable did not conform to the expectations. The above results lend support to the model of Chapter III, and cast doubt on the usefulness of number of flights as a quality of service variable.

5.2 Controlling for Entry and Exit Over the Period

Deregulation of the airline industry led to reductions in price-cost margins, which theory predicts will result in reduced service quality. But deregulation also eased restrictions on entry into and exit from city-pair markets. Entry and exit will affect the competitiveness of the market and so may influence service quality rivalry in a specific market. For instance entry into a market may increase service rivalry, while at the same time price competition would tend to reduce quality competition. For this reason the 93 markets tested above were divided into three groups, (1) those routes that experienced the exit of one or more firms from the nonstop city-pair market between the second quarter of 1978 and the second quarter of 1979, (2) those routes that experienced entry over the period, and (3) those routes that experienced no exit or entry in the nonstop market between the two quarters. The analysis of the behavior of service quality proxies within these three more homogeneous groups will allow us to strengthen the conclusion of the previous section. The effect of the deregulation of price can be studied in isolation from the effects of the deregulation of exit and entry.

Table VI lists the 10 markets from the previous section that experienced exit over the period. All variables move in the predicted direction of lower service quality a majority of the time, but again flight frequency does not show a statistically significant difference from random changes. On-time percentage and load factor again do show statistically significant reductions in service quality. Routes that experienced exit exhibit substantially the same results as all routes taken together.

It is interesting to note that the mean distance of the routes in Table VI is much smaller than the mean distance of all 93 routes. In fact the maximum distance of these exit routes is 170 miles less than the average distance for all routes. It was the short-haul routes, which experience the most intense intermodal competition, that saw the

TABLE VI

Routes from Table V that Experienced Exit of Firms
Second Quarter 1978 to Second Quarter 1979

Baltimore
- New York
Boston
- New York
Charlotte
- New York
Chicago
- Indianapolis
Chicago
- Kansas City
Cleveland
- Detroit
Dallas
-Kansas City
Los Angeles
- Salt Lake City
Los Angeles
- Tucson
New York
- Providence

	Flight Frequency	On-Time Percentage	Load Factor
Number of Increases	3	1	9
Number of Reductions	7	9	1
% of changes that move in the direction of reduced quality	70%	90%	90%
Sign Test Statistic	1.27	2.53**	2.53**

TABLE VI (cont'd.)

	Change in Flights	Change in On-Time Percentage	Change in Load Factors	Distance
Mean	-392.5	-4.8	7.2	373.4
Standard Deviation	576.7	6.3	6.2	210.3
Minimum	-1521.0	-22.0	-2.0	173.0
Maximum	446.0	2.0	18.2	727.0

Correlation Coefficients

	Change in Flights	Change in On-Time Percentage	Change in Load Factors	Distance
Change in Flights	1	-.45	-.78	.17
Change in On-Time Percentage		1	.12	-.11
Change in Load Factor			1	.004
Distance				1

exit of firms over this period. Evidentally some firms found more profitable alternatives to serving these short-haul routes.

Table VII lists the 22 routes that experienced entry over the period. On-time percentage shows a statistically significant reduction in service quality, while flight frequency shows a statistically significant increase. Load factor shows an improvement in service quality that cannot be rejected as random. In this case two possible service quality proxies move in opposite directions. Entry of new firms results in improvements in the proxy identified with convenience, while the proxy for reliability shows, as it has in each previous case, a reduction in quality. Either entry increases quality competition enough so that the quality reducing tendency of price competition is overcome in the case of flight frequency, or as seems more likely the increase in flight frequency reflects an increase in output resulting from new entry. The consistent behavior of on-time percentage casts doubt on the conclusion that entry improves quality. Entry did not result in improvement in service reliability. The behavior of on-time percentage indicates that the effect of price competition override increases in nonprice rivalry brought about by entry.

Table VIII shows the results for the 61 routes that experienced no entry or exit over the period. The results of this table isolate on the effects of pricing freedom alone with the same firms competing in each period. This should give the best indication of the effects of pricing freedom on the proxies involved.

The results for this group are substantially the same as the result for all 93 routes taken together. On-time percentage and load factor move in the direction of reduced service quality in a nonrandom

TABLE VII

Routes from Table V that Experienced Entry of Firms
Second Quarter 1978 to Second Quarter 1979

Atlanta
-Dallas
Atlanta
- Washington, D.C.
Boston
- Detroit
Boston
- Tampa
Boston
- Washington, D.C.
Chicago
- Houston
Dallas
- New Orleans
Denver
- Houston
Ft. Lauderdale
- Philadelphia
Hartford
- Washington, D.C.
Houston
- Miami
Houston
- New Orleans
Houston
- New York
Houston
- San Francisco
Miami
- New Orleans
Miami
- New York
Miami
- San Francisco
Miami
- Washington, D.C.
New Orleans
- New York
New York
- Orlando
New York
- St. Louis
New York
- Washington, D.C.

TABLE VII (cont'd.)

	Flight Frequency	On-Time Percentage	Load Factor
Number of Increases	17	5	9
Number of Reductions	5	17	13
% of changes that move in the direction of reduced quality	23%	77%	41%
Sign Test Statistic	-2.55**	2.55**	-.85

	Change in Flights	Change in On-Time Percentage	Change in Load Factors	Distance
Mean	108.3	-5.0	.3	1050.1
Standard Deviation	323.8	5.9	8.9	624.3
Minimum	-903.0	-17.5	-23.8	222.0
Maximum	579.0	5.1	19.7	3068.0

Correlation Coefficients

	Change in Flights	Change in On-Time Percentage	Change in Load Factors	Distance
Change in Flights	1	-.16	-.53	.34
Change in On-Time Percentage		1	.11	-.17
Change in Load Factor			1	-.50
Distance				1

TABLE VIII

Routes from Table V that Experienced No Entry or Exit of Firms
Second Quarter 1978 to Second Quarter 1979

	Flight Frequency	On-Time Percentage	Load Factor
Number of Increases	32	11	44
Number of Reductions	29	50	17
% of changes that move in the direction of reduced quality	48%	82%	72%
Sign Test Statistic	-.38	4.99***	3.45***

	Change in Flights	Change in On-Time Percentage	Change in Load Factors	Distance
Mean	-16.8	-5.9	2.9	933.6
Standard Deviation	200.0	8.2	9.0	652.1
Minimum	-552.0	-24.6	-24.6	205.0
Maximum	481.0	17.7	25.2	3013.0

Correlation Coefficients

	Change in Flights	Change in On-Time Percentage	Change in Load Factors	Distance
Change in Flights	1	.18	-.43	.33
Change in On-Time Percentage		1	-.02	-.04
Change in Load Factor			1	-.12
Distance				1

manner, while flight frequency shows a majority of routes with improved service quality.

Conclusion

This chapter casts doubt upon the use of a capacity measure of quality, flight frequency, as a single proxy for something called quality. The results of this chapter, like the results of Chapter IV, indicate that not all quality proxies behave the same. The model of Chapter III predicts that quality will fall under deregulation for a quality variable that is associated with each unit of output. Amenities and load factors are variables of this type, and both show a reduction in service quality over this period. Reliability and flight frequency are variables where the total level on any route is expected to influence demand. The model predicts indeterminant results in these cases, and we find that reliability falls and flight frequency rises after deregulation. All variables do not move in the same direction after deregulation. These results cast doubt upon the treatment of quality as a unidimensional variable.

Determinant results are much more difficult to obtain in a model with multidimensional quality, which is one reason why quality is treated as unidimensional in economic models. A general quality determination model, like the model of Vander Weide and Zalkind, which predicts a reduction in flight frequency with deregulation of the airline industry is not supported by actual experience. The problem may be that a total capacity variable, like flight frequency, is so closely related to output that it does not behave like a quality variable is assumed to behave in the model.

CHAPTER V

FOOTNOTES

CHAPTER V

FOOTNOTES

[1]See equations (3.8) and (3.9) in Chapter III.

[2]For a discussion of what competition was allowed before formal deregulation see Meyer, et. al. (1981). Formal deregulation did not start until October 1978, but a transition to less regulation began in 1976. From 1976 to 1978 firms gained some freedom to price compete, and after the Act became law there was much more affected by the passage of the deregulation bill. See the above source, especially Chapters 3-7.

[3]Trapani and Olson (1982), p. 67.

[4]See Meyer, et. al.

[5]New York Times, May 28, 1979, Section D, p. 1-3.

[6]New York Times, June 7, 19789, p. 1-6.

[7]Load factor was calculated by identifying the predominant airplane flown on a route from the Official Airline Guide and dividing the average number of passengers per flight by the average number of seats on the predominant airplane used. Due to the rough nature of this calculation I am much more confident of the reliability of measurement of changes in this variable than in levels of this variable.

CHAPTER VI

CONCLUSIONS

This dissertation investigates the use of various proxies of quality of service in the airline industry. The principal findings are:

(1) There is some evidence that the traditional treatment of quality as a unidimensional variable is an oversimplification. The correlation of the various proxies is not high.

(2) The traditional measure of service quality in air travel studies, flight frequency, does not behave as the other quality proxies behave in the period immediately following deregulation.

(3) Other quality proxies indicate that there was a reduction in these elements of quality in the period following deregulation.

This study differs from previous works in several respects. First, the inclusion of proxies for nonconvenience aspects of quality is unique in that it breaks with the earlier works' exclusive analysis of this aspect of service quality. Second, the work is the first to question empirically the use of a capacity measure as a quality proxy. The behavior of capacity as quantity of output may lead to erroneous conclusions in earlier work. Third, the time frame of this study is much more recent than the earlier work. The comparison of pre and post

deregulation periods is unique.

The major policy implication of this dissertation comes from the conclusion that flight departure frequency may not behave like other quality elements. Policy made on the assumption that it behaves like other quality variables may arrive at an unanticipated outcome. For instance, a policy whose goal is to induce a reduction in flights, for congestion or other reasons, through deregulation and price reductions, may result in increased flight frequency as flights are added to serve the increase in air travel.

This study also opens up the question of whether quality can be correctly treated as a unidimensional variable. Since correlations are not high among the various proxies studied here, policy made on the basis of any single element may not translate into similar effects on other elements of quality.

There are many areas open for future research. Work can be done on the price elasticity of demand for air travel between city pairs to identify determinants of flight frequency. Elastic markets would be more likely to experience more flights after a price reduction than would inelastic markets. Also, if adequate price and cost data could be obtained a study relating specific cost price margins to different elements of quality may be fruitful.

Other scheduled transportation industries can be analyzed to see to what extent departure frequency differs from other quality proxy behavior. Any regulated industry for which a capacity measure has come to be a quality proxy could be a subject of a similar study.

Another area of future research may be the expansion of the time frame of the study. This study is limited to the time period right around the formal deregulation of the airline industry. This could be a time of disequilibrium, and the results of this study could be strengthened with a longer term analysis. The inherent time constraints of a dissertation preclude this analysis here, however. The 1979 oil price shocks greatly increased plane fares immediately after the time period of this study, which would have to be accounted for somehow. Very dissimilar periods would be compared. Also the PATCO strike resulted in the CAB's suspension of keeping track of on-time performance of airlines, so the use of this variable would be limited.

APPENDIX A

Total Differentiation of Equation 3.4

APPENDIX A

Total Differentiation of Equation 3.4

Equation (3.4) $$(\bar{P} - \frac{\partial C}{\partial X}) \frac{\partial X}{\partial Q} = \frac{\partial C}{\partial Q}$$

Let $$[(\bar{P} - \frac{\partial C}{\partial X}) (\frac{\partial X}{\partial Q})] \equiv H(\bar{P},Q)$$

Let $$\frac{\partial C}{\partial Q} \equiv G(\bar{P},Q)$$

Totally differentiating gives:

$$\frac{\partial H}{\partial \bar{P}} d\bar{P} + \frac{\partial H}{\partial Q} dQ = \frac{\partial G}{\partial \bar{P}} d\bar{P} + \frac{\partial G}{\partial Q} dQ$$

$$\frac{\partial G}{\partial \bar{P}} = \frac{\partial}{\partial \bar{P}} (\frac{\partial C}{\partial Q} (X(\bar{P},Q), Q)) = \frac{\partial C}{\partial X \partial Q} \frac{\partial X}{\partial \bar{P}}$$

where

$$\frac{\partial G}{\partial Q} = \frac{\partial C}{\partial X \partial Q} \frac{\partial X}{\partial Q} + \frac{\partial C}{2Q^2}$$

$$\frac{\partial G}{\partial Q} = \frac{\partial C}{\partial X \partial Q} \frac{\partial X}{\partial Q} + \frac{\partial C}{2Q^2}$$

$$\frac{\partial H}{\partial \bar{P}} = \frac{\partial}{\partial \bar{P}} ((\bar{P} - \frac{\partial C}{\partial X})(\frac{\partial X}{\partial Q}))$$

$$= [1 - \frac{\partial}{\partial \bar{P}} (\frac{\partial C}{\partial X})] (\frac{\partial X}{\partial Q}) + (\bar{P} - \frac{\partial C}{\partial X})(\frac{\partial X}{\partial P \bar{\partial} Q})$$

$$\frac{\partial}{\partial \bar{P}} (\frac{\partial C}{\partial X}) = \frac{\partial}{\partial \bar{P}} (\frac{\partial C}{\partial X} (X(\bar{P},Q),Q)) = (\frac{\partial^2 C}{\partial X^2})(\frac{\partial X}{\partial \bar{P}})$$

$$\frac{\partial H}{\partial Q} = \frac{\partial}{\partial Q} ((\bar{P} - \frac{\partial C}{\partial X})(\frac{\partial X}{\partial Q}))$$

$$= [- \frac{\partial}{\partial Q} (\frac{\partial C}{\partial X})] (\frac{\partial X}{\partial Q}) + (\bar{P} - \frac{\partial C}{\partial X})(\frac{\partial^2 X}{\partial Q})$$

$$\frac{-\partial}{\partial Q} (\frac{\partial C}{\partial X}) = [- \frac{\partial}{\partial Q} (\frac{\partial C}{\partial X} (X(\bar{P},Q), Q))$$

$$= (- \frac{\partial^2 C}{\partial X^2})(\frac{\partial X}{\partial Q}) - \frac{\partial C}{\partial Q \partial X}$$

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