

PRICE DISCRIMINATION IN FREE-ENTRY MARKETS

by

Severin J. Borenstein

B.A. University of California, Berkeley  
(1978)

Submitted to the Department of Economics  
in Partial Fulfillment of the Requirements  
of the Degree of

DOCTOR OF PHILOSOPHY

at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

June 1983

© Massachusetts Institute of Technology 1983

Signature of Author \_\_\_\_\_

~~Department of Economics~~  
~~June 20, 1983~~

Certified by \_\_\_\_\_

~~Thesis Supervisor~~  
~~Richard L. Schmalensee~~

Accepted by \_\_\_\_\_

~~Head PhD. Committee~~  
~~Richard S. Eckstein~~

ARCHIVES  
MASSACHUSETTS INSTITUTE  
OF TECHNOLOGY

NOV 11 1983

LIBRARIES

# PRICE DISCRIMINATION IN FREE-ENTRY MARKETS

by

SEVERIN J. BORENSTEIN

Submitted to the Department of Economics on June 20, 1983  
in partial fulfillment of the requirements for the Degree of  
Doctor of Philosophy in Economics

## ABSTRACT

Economists usually associate price discrimination with monopoly markets. Yet, discrimination occurs commonly in markets that are reasonably competitive. Airlines offer restricted 'Super Saver' discounts; magazines are sold more cheaply to students; drugstores give discounts to senior citizens.

This thesis is a theoretical and empirical investigation of price discrimination in free-entry markets. Using a spatial model of monopolistic competition, it is shown that when brands are heterogeneous, competition does not present a barrier to discrimination. The power to earn economic profits is not necessary for a firm to maintain discriminatory prices.

The model treats formally the fact that consumers differ not only in the utility they derive from the good, but also in how strongly they prefer one brand over all others. When firms sort customers based on strength of brand preference, the output and welfare results are found to be generally less favorable than when sorting is more closely related to consumers' reservation prices.

The empirical section of the thesis is a study of price discrimination in the U.S. domestic airline industry. Since deregulation of the industry in 1978, discount air fares have flourished. Possible cost bases for the fare differentials are discussed, in particular, peak-load pricing. The effect of fare dispersion is then investigated by estimating the impact it has had on output. It is found that fare dispersion in 1982 probably did not increase air travel and may have actually caused less travel to take place. These results are then discussed in terms of discriminatory and peak-load pricing theories.

Thesis Supervisor: Richard L. Schmalensee  
Title: Professor of Applied Economics

### ACKNOWLEDGEMENTS

I would first like to thank Dick Schmalensee for all that he has taught me over the last four years. As his student, research assistant and thesis advisee, I have been lucky enough to have spent many hours discussing economic ideas with him. I have learned from him not just economics, but also the process of researching an idea and bringing it to fruition. He has been patient when I have struggled and supportive when I have succeeded.

Paul Joskow has also taught me a great deal of economics. His two courses in industrial organization were among the most enjoyable classes that I took while at MIT. As my second dissertation advisor, he has made many useful suggestions. His influence has helped to keep me looking at the real world when the temptation was great to get lost in models.

Garth Saloner acted as my third reader and helped me to improve the theoretical chapter of the thesis. He has been very encouraging in our discussions. As a first year assistant professor, he has also served as a friendly and sympathetic link to that other side of academic life.

They say that MIT's students are one of its strongest selling points to entering economics graduate students. I have certainly benefitted from many helpful classmates. Not surprisingly, the ones who have helped the most have also been my closest friends here. I could write a paragraph about each one, but at the end of a dissertation more writing is just too difficult. Those who have lent emotional and intellectual

support are Sue Collins, Donald Deere, Betsy Jensen, Rob Kahn, Jeffrey Miron, Niccie McKay, Mike Salinger, Dan Siegel, Bob Turner, and Ale Zanello. I would also like to thank Carol McIntire for her friendship and encouragement during this time.

In preparing the study of airlines, I received invaluable help from my former colleagues at the Civil Aeronautics Board. Dan Kaplan, director of the Office of Economic Analysis, discussed many of the tough issues with me. He was also a good friend when I was on the job market and was trying to decide where I wanted to go and what I wanted to be. Tadas Osmolskis and Steve Davis were extremely helpful when I was collecting data and trying to figure out what it meant. I have also received useful comments from Bob Frank, Steve Salop and John Woodbury.

Funding for this research has been provided by the Sloan Foundation for which I am very grateful. MIT also awarded tuition scholarships to me for my first two years in graduate school.

Finally, I wish to thank my family in California for their love and encouragement throughout the four years. My mother, who completed her PhD. dissertation 28 years ago, remembers that time clearly and was particularly understanding. I am sure that 28 years from now, this time will still be clear in my mind as well.



TABLE OF CONTENTS \*

Chapter One:	Introduction	6
Chapter Two:	A Theory of Price Discrimination in Free-Entry Markets	9
Chapter Three:	The Effect of Discount Fares in the U.S. Domestic Airline Industry	87
Chapter Four:	Conclusion	183
References		187

\* Footnotes are at the end of each chapter.

## Chapter One: Introduction

For more than 50 years, economists have recognized the important role that price discrimination can play in firms' marketing and sales strategies. It is a topic covered in most microeconomics courses and virtually all textbooks of industrial organization. Yet, there has been a persistent conflict between classroom theory and marketplace reality. Theories have described the behavior of a discriminating monopolist, but the practice occurs commonly in markets that are thought to be reasonably competitive. Firms that do not have the power to persistently earn supernormal returns do seem to be able to price discriminate.

This thesis is a theoretical and empirical investigation of price discrimination in free-entry markets. It is well understood that discrimination cannot occur in perfectly competitive markets. Yet, perfect competition requires that potential buyers view all brands in the market as identical. This is rarely the case in markets for consumer goods. Advertising, whether it is a cause or just a result of product differentiation, is surely an indication that brands are not considered to be identical in most consumer markets.

If price discrimination will occur in markets that are competitive (albeit, not perfectly so), there is little reason to believe that its effects can be predicted from models of monopoly price discrimination. Chapter 2 develops and analyzes a model of price discrimination in free-entry markets

where brands are heterogeneous. From this analysis, we see that price discrimination is likely to occur whenever brands are heterogeneous and firms can prevent resale. As is the case with monopoly price discrimination, the output and welfare effects of this pricing behavior are ambiguous.

Still, the model does give useful insights into the forms that price discrimination is likely to take. An important distinction is made between discriminatory discounts that are offered to people with low reservation prices and those that are targeted at consumers who are already buying the product, but are easily persuaded to switch brands. Not surprisingly, the latter strategy is less likely to affect total market sales of the product. The welfare effects of these two types of discrimination also differ in many cases.

With this framework for studying price discrimination, I examine the U.S. airline industry in chapter 3. Since deregulation in 1978, there have been many indications of the competitive nature of city-pair markets. Many new firms have entered, small carriers have successfully competed with the major airlines, and the market shares of the large firms has declined significantly. At the same time, discount fares have flourished. Some have argued that the price differences are cost based. Though real cost differences probably exist, certain aspects of the airlines' sorting criteria have no clear link to these differences. It appears that price dispersion in the airline industry is partially cost based, but also partially discriminatory.

The empirical analysis in chapter 3 focuses on the output effects of price dispersion in the industry. With a sample of over 1000 domestic city-pair markets, I estimate an air travel demand function including a variable for price dispersion. Samples from 1975, prior to deregulation, and 1982 are used. The results indicate that price dispersion increased output in 1975, but in its expanded use since deregulation, the effect has diminished or even reversed. These conclusions are discussed in light of the chapter 2 theory of price discrimination.

Together, chapters 2 and 3 comprise one of the first attempts to develop and apply a theory of price discrimination in free-entry zero-profit markets. The model clearly establishes that price discrimination can persist in this environment. It also sets up a useful framework for analyzing the different sorting criteria that might be used. Chapter 3 demonstrates that the theory can be quite helpful in interpreting the pricing behavior of firms in competitive industries. In chapter 4, the thesis concludes with a summary of findings and suggestions for theoretical extensions and other empirical applications of the work.

## Chapter Two: A Theory of Price Discrimination in Free-Entry Markets

### INTRODUCTION

Since Pigou [21] and Robinson [23], economists have associated price discrimination with monopoly or oligopoly markets. In 1978, with the signing of the Airline Deregulation Act that opened routes to new airlines, many economists predicted that discriminatory 'supersaver' discounts would soon give way to unrestricted coach fare competition. These restricted discounts remain, however, and are now much more widespread than they were in 1978. In fact, much of the pricing that appears to be discriminatory occurs in markets where entry and exit are commonplace and there is little or no coordination among firms. Magazine and journal subscriptions are sold more cheaply to students; hotels let 'kids stay free' yet charge a considerable fee for extra adults; drugstores advertise discounts on prescriptions for customers 59 years or older.

Despite the relative ease of entry in these industries, it should not surprise economists to see performance differ from the perfectly competitive ideal. Product homogeneity, a necessary condition for perfect competition, is not a realistic approximation in these markets. Chamberlin [5] demonstrated that heterogeneity in free entry markets can lead to a persistent differential between price and marginal cost.

In this essay, we see that heterogeneity can also lead to persistent price discrimination.

Using a spatial model of monopolistic competition, this essay examines third-degree price discrimination in free-entry, zero-profit markets. I focus on retail markets in which consumers are sorted into two groups using criteria that are imperfectly correlated with willingness-to-pay. If firms have available to them a usable, though perhaps noisy, signal of consumers' willingness-to-pay for their brand, I find that equilibrium prices will almost certainly be discriminatory. Usable, in this context, means that the usual problems with resale between groups, costs of imposing the sorting mechanism, or legal barriers are not so great as to prevent profitable use of the sorting mechanism. Competition alone will almost never prevent firms from sustaining discriminatory prices in this model. The primary barrier to discrimination, it thus appears, is the absence of a usable sorting mechanism, not low entry barriers or competition.

With the possibility of price discrimination in free-entry markets established, the study focuses on two broad questions. First, how do equilibria when discrimination is illegal differ from unconstrained equilibria in the same markets? Second, how do changes in the sorting mechanism affect the discriminatory equilibria? In particular, what factors increase or decrease the equilibrium price differential between groups? We find that extrapolations from theories of monopoly price discrimination ignore an important

basis for sorting customers in heterogeneous product markets: strength of preference among brands.

In monopoly markets, we might observe value-of-service discrimination; monopolists attempt to charge higher prices to consumers who receive higher utility from the product.<sup>1</sup> When differentiated brands are available, however, there is another basis for sorting buyers. People with very strong preferences among brands might be separated from those who are less choosy. I conclude that in free-entry markets, sorting based on strength of brand preference is often more effective than sorting based on how much consumers value the basic product; in many cases, the former leads to larger price differentials between the sorted groups. This concept of brand preference sorting is, of course, absent in traditional models of monopolistic price discrimination.

Section 2 reviews a familiar circular characteristic-space model of monopolistic competition, based on the seminal work of Lerner and Singer [19] and more recently set forth by Salop [26]. In section 3, this model is generalized in a way conducive to consideration of price discrimination. Whereas Salop assumed that consumers are identical (except for the location of their most preferred point in characteristic space), consumers are here assumed to be heterogeneous in their basic utility of the good (measured as reservation price for a hypothetical brand at the consumer's most preferred point in characteristic space) and in their strength of preference among brands (measured as the decline in reservation

price (per unit distance) for a brand away from the consumer's most preferred point).

With the heterogeneity of consumers made explicit, the study turns in section 4 to modeling the sorting criteria firms use when they discriminate. How do firms decide which customers will be offered a lower price? A firm observes characteristics that are correlated with willingness-to-pay for its brand. For instance, airlines realize that people who fly round trip and stay for more than 7 days are usually vacation travelers. They generally have lower reservation prices than business travelers, and tend to have weaker preferences among competing brands.<sup>2</sup> Thus, airlines sort customers by using minimum stay requirements, because length of stay is correlated with willingness-to-pay.

This example points out another important facet of many sorting criteria: self-selection. The firm offers two prices, but places restrictions on the low price that make it costly for customers to obtain the discount. Sellers recognize that the cost of qualifying for the low price differs among buyers and is correlated with their willingness-to-pay for the brand. Usually, the cost is inconvenience, such as rearranging travel plans or driving out to the company warehouse. Sorting criteria that are not self-selective, such as student and senior citizen discounts, are called 'absolute' in this paper. Models of both absolute and self-selective sorting are presented in section 4.



The models derived in sections 3 and 4, though quite general, are also mathematically intractable. With the aid of a computer, however, an equilibrium can be found numerically for given sets of parameters. Section 5 explains the problems of tractability and outlines the procedure used to find zero-profit symmetric equilibria iteratively with a computer simulation.

The results of simulations with absolute sorting are analyzed in section 6. I find that both sorting on reservation price and sorting on strength of brand preference can lead to persistent price discrimination. The two approaches, however, differ significantly in their effects on quantities sold, number of brands, and welfare.

Section 7 discusses the restrictions imposed by the simple functional forms of this spatial model and considers the robustness of the results. An intuitive explanation of the main conclusions is set forth. It indicates that changing the simple model of consumer demands would probably not change the important results.

Finally, the additional complexity of self-selection is explored in section 8. The results are similar to absolute sorting. The primary difference seems to be that self-selection dampens the effectiveness of discrimination; changes in number of firms, quantities and welfare that result from price discrimination are smaller with self-selection than with absolute sorting.

## SECTION 2

This section reviews the basic circular product-space model that is generalized in section 3. Brand characteristics and consumers' preferred products are represented as points around a 'characteristic' circle of unit circumference. Consumers' preferred points are uniformly distributed around the circle, while existing brands are discretely, evenly positioned. Each of the  $L$  consumers in the market buys 1 unit of the brand that gives him the highest positive consumer surplus. If no brand yields positive surplus for him, he buys none.<sup>3</sup>

The consumer surplus the customer at point  $z$  receives when he buys the brand at  $X$  is given by <sup>4</sup>

$$(1) \quad CS = A - P_x - c |z - X|$$

where

- $A$  is the person's reservation price for a hypothetical brand located at  $z$ ,<sup>5</sup>
- $P_x$  is the price charged for the brand at  $X$ ,
- $c$  is the decline in the consumer's reservation price for a brand per unit arc distance the brand is from point  $z$ , and

$|z - X|$  is the arc distance from  $z$  to  $X$ .

In this basic model, all consumers have the same  $A$  and  $c$  values.

Given this description of consumers, figure 1 shows the demand curve for brand  $X$  when each of the other  $N-1$  brands are priced at  $P'$ . When the price of brand  $X$ ,  $P_x$ , is high, the only people who buy it are consumers who are very close to brand  $X$  (figure 2(a), brackets are firm  $X$ 's market

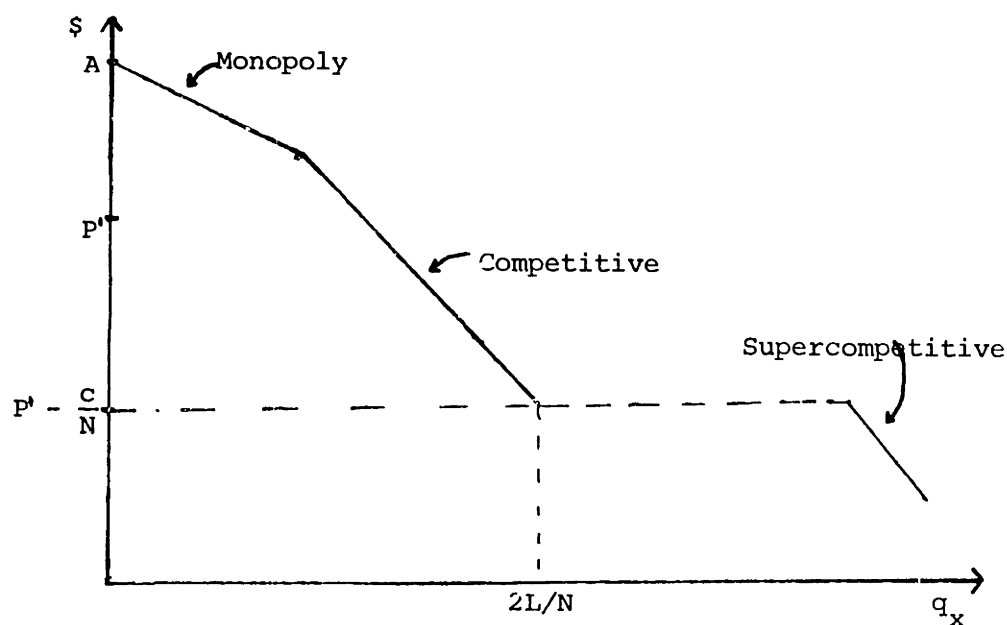


FIGURE 1

boundaries). These people would receive negative surplus from any other brand. So long as  $P_x$  is in this region, brand X is essentially a monopoly. Consumers at the edge of its market receive zero surplus from brand X and negative surplus from any other brand. This implies that there are 'gaps' between markets. Consumers located in these characteristic gaps do not purchase the good at all.

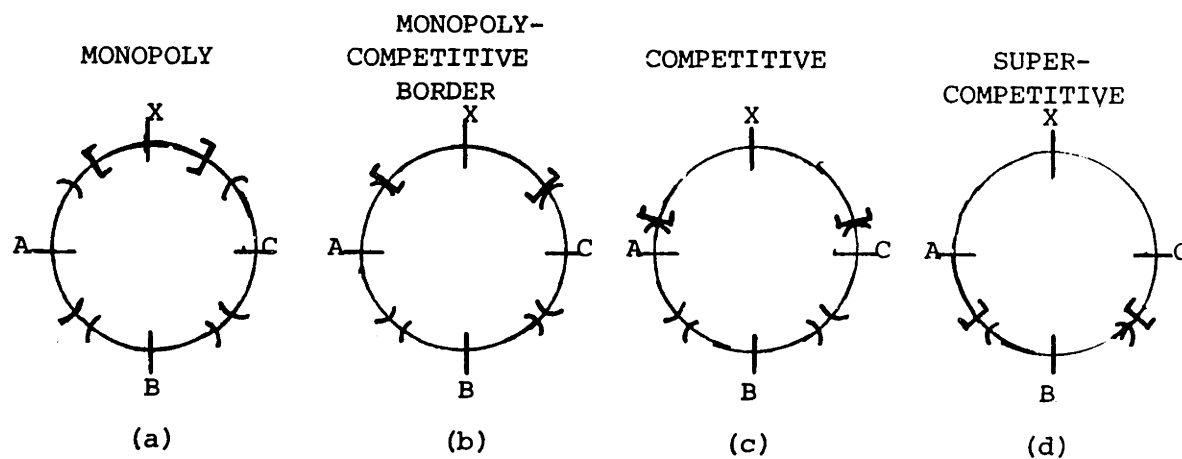


FIGURE 2

The quantity of brand X sold,  $q_x$ , is determined by calculation of the market boundaries,

$q_x = L \cdot (\text{arc distance between firm X's market boundaries})$ , since the L consumers in the market are uniformly distributed around the unit-circumference circle. In this region, the 'distance' from the brand X location to either boundary,  $d$ , can be calculated from the fact that consumer surplus is equal to zero at the monopoly market boundary.

$$A - P_x - cd = 0 \Rightarrow d = (A - P_x)/c$$

so, (2)  $q_x = 2Ld = 2L(A - P_x)/c$

As  $P_x$  declines, though, brand X's market boundaries eventually bump up against the boundaries of neighboring brands. The brands are competitive below this price in that marginal customers are choosing between brand X and a neighboring brand, rather than between brand X and no purchase. The  $P_x$  at which the switch to competition occurs is the one that causes the monopoly markets of brand X and its neighbors to exactly fill the space between brands ( $=1/N$  since brands are evenly spaced), (figure 2(b)).

$$(A - P_x)/c + (A - P')/c = 1/N$$

$\Rightarrow$  (3)  $P_x = 2A - P' - c/N$ <sup>6</sup>

In this competitive region, all customers who are between brand X and its neighbors purchase some brand. To increase sales, brand X must offer marginal customers not just positive surplus, but surplus greater than that which neighboring brands offer them.<sup>7</sup>

The function  $q_x(P_x)$  in this region is again calculated from the market boundaries of brand X (figure 2(c)). A customer on the boundary between brand X and a neighboring brand receives equal surplus from the two brands

$$A - P_x - cd = A - P' - c(1/N - d)$$

$$\Rightarrow d = (P' - P_x + c/N)/2c$$

$$\text{So, (4) } q_x = 2Ld = L(P' - P_x + c/N)/c = L(1/N + (P' - P_x)/c)$$

which has as one implication,

$$P_x = P' \Rightarrow q_x = L/N.$$

That is, if all brands sell for the same price and the price is in the competitive region, then all customers in the market purchase the good and each brand gets  $1/N$  of the market.

Finally, if  $P_x$  drops below  $P' - c(1/N)$ , then even consumers whose preferred point is exactly at the location of the neighboring brand will get greater consumer surplus from brand X. So will all the customers on the far side of the neighboring brand who had been buying it. This is the point of discontinuity in figure 1 and the jump to the supercompetitive region (figure 2(d)).<sup>8</sup>

Likewise, brand X will not have positive sales at a price greater than  $P' + c/N$  (not shown). If  $P_x > P' + c/N$ , neighboring brands dominate brand X for all consumers, even those whose ideal product is brand X.<sup>9</sup>

The cost side of this model is specified quite simply. All brands have the same costs of production regardless of location, a fixed cost plus constant marginal costs.

$$(5) \quad \text{Cost} = F + mq$$

This implies economies of scale in production of a brand. It is important to note, however, that there are no economies of scope; costs of producing different brands are entirely separate. It is this assumed absence of scope economies that allows treatment of each brand as a separate firm. On the other hand, declining average costs over some range are necessary to prevent an equilibrium with an infinite number of firms, together providing each customer with exactly the product she would most prefer.

### SECTION 3

In this section, the model is modified to make consumers heterogeneous in their reservation price at their most preferred points ( $A$ , hereafter referred to as simply 'reservation price') and their strength of preference for brands nearer to their ideal ( $c$ ). It is these characteristics that companies in consumer markets seem to look at when they price discriminate.<sup>10</sup> In discussing this model, a "type" of consumers refers to a group of individuals who have the same values of  $A$  and  $c$ . The consumers in each type are still assumed to be uniformly distributed around the circle. As before, firms are evenly spaced around the circle and entry is free. The ordered pairs  $(A, c)$  are distributed in the population according to a continuous bivariate density function,  $f(A, c)$ .

When there is diversity in consumers' reservation prices and strengths of brand preferences, service to all consumers will not lie on the same region of the (figure 1) demand curve. Figure 3 illustrates the simplest case, when firm  $X$  sets its price equal to the price charged by all other firms,  $P_x = P' (=P)$ . Types with reservation prices less than  $P$  (e.g., type  $R$ ) fall in the no purchase region; none of these people buy the product even if there is a brand located at exactly their most preferred point in product space.

Types with slightly higher  $A$ 's, but whose reservation

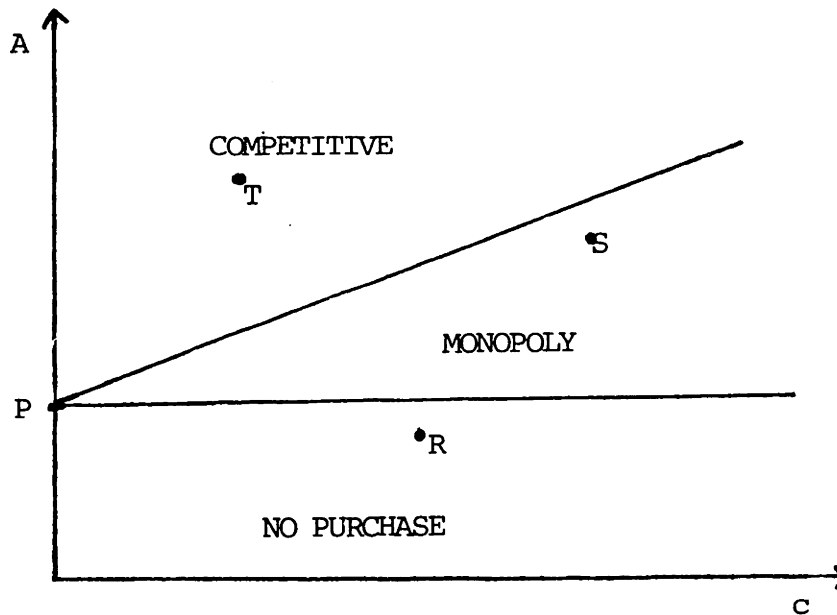


FIGURE 3

prices are still low relative to their strengths of brand preference ( $c$ ), are served monopolistically (e.g., type S). The consumers in these types who are located close to a firm buy the product. For others of the same type, however, no brand is close enough to their preferred point to give positive surplus at the going price. The proportion of a monopolistically served type which falls into these gaps between markets depends on the  $(A, c)$  pair. Nearly everyone in a type near the monopoly-competitive border buys the good, while in a type near the no-purchase line only those very close to a firm in product space will buy.

Types with large  $A$  values relative to  $c$  are served competitively (e.g., type T). Firm X's sales to these types are constrained by competition from nearby brands. For these types, there is no gap between X and its neighbors; everyone



in these types buys the good. Equation (3), which defines the monopoly-competitive border, can be rewritten as

$$(3)' \quad A = (P_x + P' + c/N)/2 \\ = P + c/(2N) \quad \text{when } P_x = P'.$$

The slope of the border in figure 3 is  $1/(2N)$ . As  $N$  increases, Ceteris Paribus, the monopoly region shrinks. This reflects the fact that a product space more crowded with brands will satisfy more people's tastes.

The quantity sold by firm  $X$  (and all other firms in this symmetric case) is found by integrating the monopoly and competitive demand functions (equations (2) and (4)) times the population density over the appropriate regions of the  $(A, c)$  space. With  $L$  consumers in the population,

$$(6) \quad q_x(P_x | P', N, f(A, c)) \Big|_{P_x = P'} = 2L \int_0^{P_x + \frac{c}{2N}} \int_{\frac{A-P}{c}}^{\frac{A-P_x}{c}} f(A, c) dA dc \\ + L \int_0^{P_x + \frac{c}{2N}} \int_{\frac{A-P_x}{c}}^{\infty} \frac{1}{N} \cdot f(A, c) dA dc$$

Calculation of quantity sold when  $P_x$  is not equal to  $P'$  is complicated by supercompetition for some types. The super-competitive condition when  $P_x > P'$ ,  $P_x + c/N > P'$ , can be stated as

$$(7) \quad c < N(P_x - P').$$

It is clear that for types with very weak preferences among brands (low  $c$ ), one brand will dominate a neighboring brand if there is even a small price differential. Capturing the strong-preference customers of a neighbor requires a larger differential. This simply reflects the reality that people

who are less picky about the characteristics of a product are more responsive to discount prices.

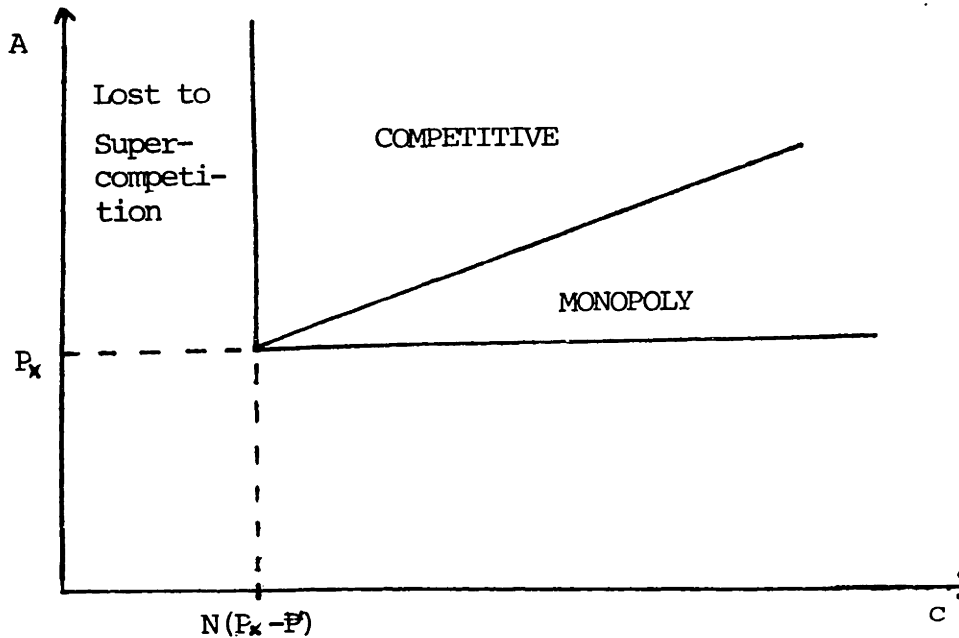


FIGURE 4

Figure 4 illustrates the role of the supercompetitive effect when  $P_x > P'$ . Besides losing all customers whose reservation price is less than  $P_x$ , firm X also completely loses the business of types that have weak preferences among brands. Even customers in these types who are located at brand X buy a neighboring brand. Furthermore, equations (2) and (4) show that a smaller proportion of each type remaining in the monopoly and competitive regions buy brand X as  $P_x$  increases. The demand equations for this and the  $P_x < P'$  case are derived in appendix A.

The supercompetitive region highlights the importance of

strength of brand preference in the price elasticity of the demand for a given brand. This is also clear from equation (4), the one-type competitive quantity equation. Thus, one should expect that firms who price discriminate might try to sort out low- $c$  types so price cuts can be targeted at them.

The demand function derived in appendix A is well-behaved (i.e., continuous and smooth) under reasonably general conditions. The most important restriction is that for all  $A$

$$(8) \quad 0 \leq c < t \quad \Rightarrow \quad f(A, c) = 0$$

for some arbitrarily small, positive  $t$ . If there were individuals with  $c=0$ , they could be won away from competitors by charging epsilon less than any other firm. In this case, no firm would ever be content to charge the same price as all others; no symmetric pure strategy equilibria would exist. In appendix A, it is shown that condition (8) is sufficient to assure that each firm's marginal revenue curve is continuous at  $P'$ , the price charged by all other firms. Uniqueness of an equilibrium is also demonstrated in appendix A.

## SECTION 4

Two kinds of price discrimination sorting mechanisms are discussed in this section. The first category is absolute sorting criteria. Customers are sorted into high-price or low-price groups depending on a characteristic that they cannot change at any reasonable cost. Common examples of this are senior citizen, student and child discounts.

The second category is self-selective sorting. Every customer can, at some cost, qualify for the low price. The cost of qualifying, however, differs for different customers. If the discount for qualifying is less than the cost a customer would incur to be put in the low-price group then she will forego the discount.

The usefulness of a sorting test depends critically on how strong the correlation is between a customer's probability of 'passing the test' (i.e., qualifying for the discount) and his reservation price,  $A$ , or his strength of brand preference,  $c$ . Ceteris Paribus, a firm would rather use the sorting mechanism depicted in figure 5(a) than the one in 5(b). Firms, however, cannot choose the exact probability function that would maximize profits. There are a limited number of legal and feasible ways of dividing up customers. Of these, some divisions are more costly to implement than others and some are more susceptible to resale between groups.<sup>11</sup> Because implementation problems are so important in choosing among sorting criteria, it would be shortsighted to study discrimination by modeling an optimal sorting mechanism. Instead, we

look at general classes of sorting criteria that can be described parametrically and varied by changing the parameters of the function.

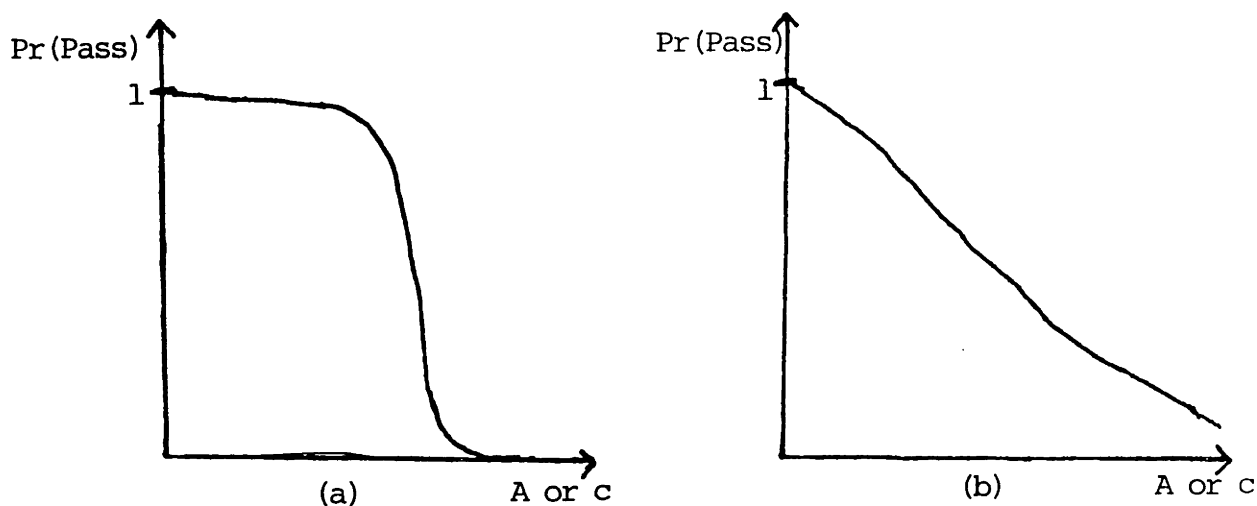


FIGURE 5

The first and simplest model (model I) is to assume that a consumer's  $(A, c)$  is drawn from one of two different bivariate distributions. Firms do not know a consumer's  $(A, c)$ , but they do know which group each consumer comes from. Ceteris Paribus, the more overlap there is between the two density functions, the less useful the distinction is to firms.

In the real world,  $A$  and  $c$  are probably correlated; the people who are more 'choosy' among brands, high  $c$ 's, are generally thought to be the consumers with higher reservation prices. (We see in section 6 that high  $A$ 's and high  $c$ 's usually increase the equilibrium price a group of consumers ends up paying). So, model I is an absolute sorting mechanism between two distinguishable groups of consumers. Reservation price,  $A$ , and strength of brand preference,  $c$ , are usually

positively correlated between and within groups. This model could describe, for instance, the situation that sellers of magazines and journals face when they offer lower prices to students.

Model II is a different approach to the same real world absolute sorting criteria. In model II, however, all consumers' (A,c) pairs come from one distribution. Firms still offer a lower price to people who meet some criteria, but the probability of 'passing the test' (i.e., meeting the criteria) is now an explicit function of a person's reservation price and strength of brand preference. This general 'test function' allows for different correlations between the probability of passing and A or c.

$$(9) \quad \Pr[\text{Pass}|(A,c)] = 0.5 \left[ 1 + \frac{u}{u+v} \frac{A_0 - A}{|A_0 - A| + SD(A)/u} + \frac{v}{u+v} \frac{c_0 - c}{|c_0 - c| + SD(c)/v} \right]$$

where

(A<sub>0</sub>,c<sub>0</sub>) is the 'center' of the test, the values that imply a 0.5 probability of passing.

u (>0) is a measure of how quickly the passing probability decreases (increases) as A becomes greater (less) than A<sub>0</sub>.

v (>0) is a measure of how quickly the passing probability decreases (increases) as c becomes greater (less) than c<sub>0</sub>.

The differences A<sub>0</sub>-A and c<sub>0</sub>-c are scaled by the standard deviations, SD(A) and SD(c), to give meaning to the relative values of u and v.<sup>12</sup> The test can then be characterized completely by u,v, and (A<sub>0</sub>,c<sub>0</sub>). Though the function is obviously ad hoc, it does have a number of useful properties:

- 1) If  $u(v)$  is very near 0, then the test gives no indication of a consumer's reservation price,  $A$  (strength of brand preference,  $c$ ).<sup>13</sup>
- 2) As  $u(v)$  gets large, the test becomes a nearly perfect indicator (fig. 5(a)) of whether a consumer's  $A(c)$  value is greater or less than  $A_0(c_0)$  (provided that  $v(u)$  is not also large).
- 3) Unless  $A$  and  $c$  are highly correlated in the population, one test cannot be a very good indicator of both characteristics. As a test gains power in sorting on  $A$ , it tends to lose power in sorting on  $c$  (ignoring correlation).

The primary advantage of model II over model I is that it allows comparison of the effects of different sorting devices on the same population; the sorting mechanism is not endogenous to the population. It also gives explicit measures ( $u$  and  $v$ ) of the noise in a certain sorting mechanism. Finally, models I and II serve as cross-checks of some results, a valuable property when mathematical proofs are not available.

The third model focuses on self-selective sorting. To qualify for the lower price, a customer must take some action that is costly. Most often, the low price requires advance purchase (e.g., airlines, stage performances) or greater time

to make the transaction (e.g., warehouse sales, newspaper coupons). These requirements are useful to the firm when the cost they impose on a buyer is correlated with her willingness-to-pay for the product. The model is complicated, though, by the fact that the two prices a firm sets (in particular, the difference between its high and low price,  $P_H - P_L$ ), determine how many people fall into each group. As the differential gets very small, for instance, almost no one will go to the trouble of qualifying for the lower price. This endogeneity of the group sizes complicates the analysis considerably, so the results of the third model are discussed separately in section 8.

In Model III, a person's cost of qualifying for the discount price,  $K$ , is a function of his  $(A, c)$  pair.

$$(10) \quad K(A, c) = \max \left\{ 0, r + \frac{s(A - A_0)}{SD(A)} + \frac{t(c - c_0)}{SD(c)} \right\}$$

where

- $r$  is the cost to the  $(A_0, c_0)$  type of qualifying for the discount,
- $s$  is the change in cost for people with  $A$  different from  $A_0$ ,
- $t$  is the change in cost for people with  $c$  different from  $c_0$ .

It is clear that all types of people with  $K(A, c) < P_H - P_L$  will obtain the low price if they buy the product.

The cost to types with  $K(A, c) < P_H - P_L$  is  $P_L + K(A, c)$ . These people are the newspaper coupon clippers and supersaver flyers of the economy. They pay the low purchase price plus their discount qualification cost in order to obtain the



product. Those whose  $K(a,c) > P_H - P_L$  are the types who find it too inconvenient or otherwise costly to qualify for the discount. These are the full-fare airline passengers, the people who cannot wait for a sale to buy that new dining room set, and, perhaps, the purchasers of small boxes of cereal.

It seems that firms would prefer to use a self-selective sorting device with a low basic cost,  $r$ , but high sorting power,  $s$  and/or  $t$ . Powerful tests, however, also tend to have high  $r$ 's. Airlines could lower the average qualification cost, for instance, by reducing advance purchase requirements to 2 days, but the sorting power of the test would also decline greatly. A recent 'advance' in this area is the airlines' 'stay over one Saturday' restriction, which has caught on because it is almost costless to most vacationers, but imposes a prohibitive cost on most business travelers.

Self-selective sorting is at least as common as absolute sorting in the U.S. economy. Again, however, the reason is probably not because it is an optimal sorting device. For one thing, it imposes a 'deadweight' loss on society. If firms could attain the same division with an absolute sorting mechanism, the people in the low group would be relieved of the  $K(A,c)$  cost. In the short run, the incumbent firms could share in that gain.<sup>14</sup>

## SECTION 5

This section outlines the method of computer simulation that was used to find symmetric equilibria in the models presented. The details of the simulation procedure are presented in appendix B. The assumption of a continuous bivariate distribution of  $A$  and  $c$  causes the model to be mathematically intractable.<sup>15</sup> When a discrete number of types are assumed, however, multiple demand curve kinks plague the analysis.<sup>16</sup> Besides the loss of realism when only a few types are assumed, the kinks induce so many pathological cases that the analysis ceases to be very informative. Though one can never be certain that simulation results are entirely general, the conclusions presented in section 6 are based on a very thorough scan of parameter values, over 2000 simulations, and are supported by two different models of absolute sorting. The discussion of self-selective sorting is based on approximately 500 simulations.

In all three models, the simulation procedure was basically the same. A bivariate normal distribution of  $A$  and  $c$  was assumed. (In model I two bivariate normal distributions were used.) Beside the simplicity and familiarity of the normal density, it was used because it allows us to study separately changes in the population means and variances. In order to avoid the problem of equilibrium existence discussed at the end of section 3,  $\mu_c$  was always set at least three standard deviations above zero.

No such positivity constraint exists on values of  $A$  so long as free disposal is not assumed. For the implied industry demand curve to be convex at all positive prices, it is necessary and sufficient that  $\mu_A$  be less than 0 (when  $A$  and  $c$  are uncorrelated). If, however, market satiation is an important factor at low prices, then the demand curve could become concave in this range. Setting  $\mu_A$  at a positive value approximates such situations. Positive and negative values of  $\mu_A$  were used in the simulations.

In discussing the  $(A,c)$  distribution and its effect on the market equilibrium, it is important to keep in mind that the assumption of at most one purchase per customer is merely a convenience. It is more realistic to view each unit of the population as a potential purchase, recognizing that a single person could be the source of many (or none) of these potential purchases. In the following sections, the term 'consumer' is replaced by 'potential purchase' where the latter term helps to clarify the relationship between the model and real markets.

Along with the parameters of the density function(s), the program was given the population size(s), and starting values for the prices and for  $N$ , the number of brands. A value representing firms' conjectural variation in price was also input.  $CNJV=0$  is a Nash-in-price (Bertrand) assumption. Values from 0 to 1 were simulated. Aside from increasing the equilibrium prices and equilibrium number of firms,  $CNJV$  had no important qualitative effect on the results discussed in

the following sections. Finally, in models II and III, the parameters of the sorting function were specified as well.

In all, between 10 and 20 parameters had to be specified for each simulation. However, two observations, which are confirmed mathematically in appendix B, simplify the analysis somewhat. First, population and fixed costs affect the results only through changes in the ratio population/fixed costs, so fixed costs were not varied. Second, marginal cost in the cost function  $C=F+mq$ , affects the results only in the difference between it and reservation prices. Thus  $m$  was set to equal to 0 and the difference was varied by changing  $\mu_A$ .

For each set of parameters, the discrimination-allowed and the discrimination-prohibited symmetric equilibria were calculated. In both procedures, the program output included:

- 1) Prices for each group
- 2) Equilibrium number of firms
- 3) Quantity sold per firm to each group
- 4) Total quantities sold to each group
- 5) Total consumer surplus of the purchasers in each group

## SECTION 6

The results of the computer-generated equilibria with absolute sorting are presented in this section. We assess the influence of different sorting criteria on (1) the equilibrium price differential between groups, (2) the number of brands (firms), (3) the quantities sold to each group, and (4) the total surplus of consumers in each group. The results when sorted groups differ primarily in their reservation prices are contrasted with the results when the groups differ primarily in the strengths of brand preference. For purposes of clarity, observations are presented in terms of the model II structure and sorting function. The equivalent statements for model I are presented in footnotes.

These 'unconstrained' equilibria are also compared to equilibria resulting from the same exogenous variables when discrimination is prohibited. It is useful to view prohibition in the model II analysis as a series of restrictions imposed by the government which allows use of only noisier and noisier sorting mechanisms until there are no sorts of any power that are legal. Thus, prohibition is equivalent to forcing  $u$  and  $v$ , the parameters of sorting power on  $A$  and  $c$ , to approach 0.

We look first at the effect of the sorting mechanism on the equilibrium price differential between the low and high price groups. This is an obvious measure of the degree to which discrimination is actually occurring.<sup>17</sup> Because scaling alone can affect the absolute difference  $P_H - P_L$ , it is more

useful to look at changes in the ratio  $P_L/P_H$  or, equivalently,

$$W = 1 - (P_L/P_H)$$

$W$  is the percentage discount to low-price buyers.

When the sorting mechanism is powerless or when discrimination is prohibited,  $W$  will be 0.<sup>18</sup> Many economists studying the airline industry in 1978 thought that competition would drive  $W$  to 0 even though sorting mechanisms of some power were available. The simulations indicate why this is not likely to occur.

Only if

- (1) sorting is based exclusively on  $A$ ,<sup>19</sup>
- (2)  $A$  is uncorrelated with  $c$ , and
- (3) all types are served competitively in the no-discrimination equilibrium

does competition force  $W$  to 0 in the simulations. Condition (3) is stated in terms of the no-discrimination equilibrium because after sorting, the proportion of consumers in each region depends on the sorting mechanism. Throughout this section, the no-discrimination distribution of consumers over regions is used as a point of reference because it characterizes a market independent of any sorting devices.

Analytic support for this apparent ineffectiveness of reservation price sorting can be found by studying a single type of consumers in the competitive region. When a type of consumers is served competitively, changes in firm  $X$ 's sales depend on the consumer surplus it offers its marginal customers in that type versus the surplus a neighboring firm offers those same customers. For a consumer located between firm  $X$  and its neighbor, distance  $d$  from  $X$  and  $(1/N)d$  from

its neighbor, the comparison is

$$(10) \quad A - P_x - cd \lesseqgtr A - P' - c((1/N) - d).$$

The solution is independent of  $A$ . In the competitive region, the profit maximizing price to charge a type of consumers is independent of their reservation price.

Thus, conditions (1)-(3) can be restated as, first, firms can only obtain information about reservation prices and, second, all potential purchases in the market (meaning, with  $A$ 's greater than marginal cost) are being made, so reservation prices are irrelevant. In fact, neither condition is ever likely to hold. Nonetheless, the discussion does indicate that  $A$ -sorting becomes less effective as more of the population is served competitively (without discrimination), an assertion fully supported by the simulations. The same is not true for sorting based on  $c$ . Competition from nearby brands does not stop discrimination when sellers can identify buyers who are less likely to switch to the competitor.

Figure 6 uses the model II sorting function to illustrate the relative effectiveness of reservation price ( $A$ ) sorting and strength-of-brand-preference ( $c$ ) sorting when most of the population is served in the competitive region. For equally noisy sorts (e.g.,  $(u=3, v \approx 0)$  and  $(u \approx 0, v=3)$ ), figure 6 shows that discrimination based exclusively on  $A$  yields a smaller  $W$  than  $c$ -based discrimination.

Besides economists' concentration on monopoly price dis-

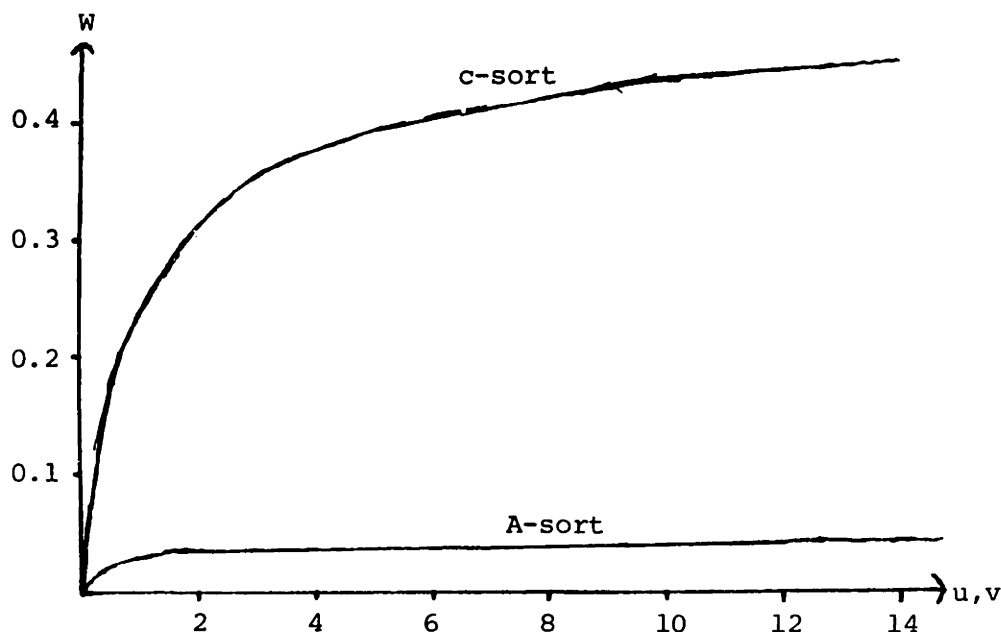


FIGURE 6

crimination, another possible reason that strength-of-brand-preference sorting has not been widely recognized is that A and c are probably highly correlated among consumers in many markets. In such instances, it is difficult (and, one might argue, pointless) to distinguish criteria that sort by reservation price from criteria that sort by strength of brand preference. Figure 7 points out that even when virtually all types are served competitively, sorting on A around the population mean,  $\mu_A$ , can be almost as effective as an equally reliable c-sort around  $\mu_c$  if A and c are highly correlated.

Though sorting based on strength of brand preference (c) is more effective when most potential purchases are in the competitive region, the situation reverses as more of the demand is in the monopoly or no-purchase region without dis-



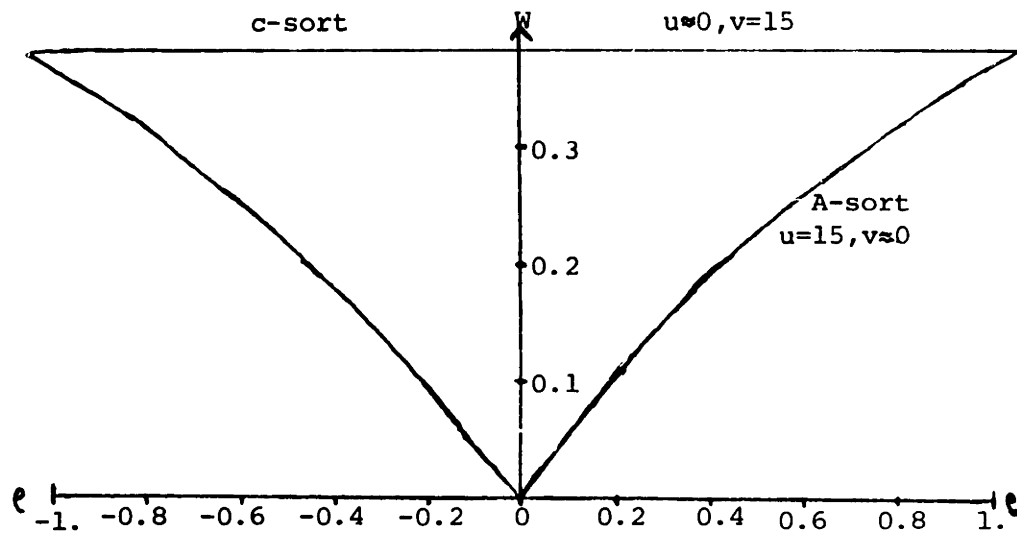


FIGURE 7

crimination. In such cases, the marginal purchase of a brand is based on a decision of whether or not to buy the product, not which brand to buy. Sorting on reservation price becomes more effective and the usefulness of c-sorting declines.

These conclusions are supported in table 1 which uses ordinary least squares regressions to summarize the results of 150 simulations. Seventy-five sets of parameters were run first with nearly noiseless sorting on reservation price ( $u=40, v \approx 0$ ) and then with strength-of-brand-preference sorting ( $u \approx 0, v=40$ ).<sup>20</sup>

These regressions must be interpreted carefully due to some obvious statistical problems. The most serious problem is that the model is not correctly specified. In fact, the true specification could be used only if a solution to the model existed in closed form. In that case, of course, the

TABLE 1 \*

Sorting on Reservation Price (A)  
(t-statistics in parentheses)

$$W = 0.065 - 0.97 * PPA + 0.085 * AMN + 0.023 * AC$$

(2.2)    (-0.9)                    (10.4)                    (3.6)

CRSQ = 0.65    F-stat = 45.8    SSR = 1.030    NOB = 75

$$PPA = \text{POPULATION} * SD(A) / 100000$$

$$AMN = (\text{PCTMON} + \text{PCTNOP}) * SD(A)$$

$$AC = \text{RHO} * \text{PCTCOM} * SD(c)$$

Sorting on Strength of Brand Preference (c)  
(t-statistics in parentheses)

$$W = 0.16 + 0.13 * PPC + 0.062 * BMN + 0.017 * BC$$

(5.8)    (1.3)                    (2.7)                    (6.2)

CRSQ = 0.36    F-stat = 14.89    SSR = 0.907    NOB = 75

$$PPC = \text{POPULATION} * SD(c) / 100000$$

$$BMN = \text{RHO} * (\text{PCTMON} + \text{PCTNOP}) * SD(A)$$

$$BC = \text{PCTCOM} * SD(c)$$

\* See appendix C for detailed definitions and summary statistics of the variables.

TABLE 2

Sorting on Reservation Price (A)  
(t-statistics in parentheses)

$$W = 0.30 - 0.65*PPA - 0.30*UAA + 0.15*UCA + 1.37*PPCR$$

(8.1) (-3.3) (-2.4) (1.5) (1.3)

$$- 0.49*UACR + 0.23*UCCR$$

(-0.8) (0.8)

CRSQ = 0.24    F-stat = 4.90    SSR = 2.148    NOB = 75

$$PPA = POPULATION*SD(A)/100000$$

$$UAA = UA*SD(A)/1000$$

$$UCA = UC*SD(A)/1000$$

$$PPCR = RHO*POPULATION*SD(c)/100000$$

$$UACR = RHO*UA*SD(c)/1000$$

$$UCCR = RHO*UC*SD(c)/1000$$

Sorting on Strength of Brand Preference (c)  
(t-statistics in parentheses)

$$W = 0.29 + 0.22*PPC + 0.56*UAC - 0.21*UCC - 0.29*PPAR$$

(11.0) (1.5) (4.7) (-3.4) (-0.4)

$$- 1.14*UAAR + 0.70*UCAR$$

(-1.9) (2.1)

CRSQ = 0.23    F-stat = 4.69    SSR = 1.046    NOB = 75

$$PPC = POPULATION*SD(c)/100000$$

$$UCC = UC*SD(c)/1000$$

$$UAC = UA*SD(c)/1000$$

$$PPAR = RHO*POPULATION*SD(A)/100000$$

$$UCAR = RHO*UC*SD(A)/1000$$

$$UAAR = RHO*UA*SD(A)/1000$$

simulations and their summarization would be superfluous. It should be explained that in all the regressions the terms involving the proportion of the population in the monopoly and no-purchase region have been summed because of the high correlation between these variables, .94 in the sample. The same forces that drive price down towards marginal cost, shrinking the no-purchase region, also cause  $N$  to be large, thus shrinking the monopoly region.

The regressions indicate that  $W$  is explained well by interactive terms between the proportion of the population in each region before discrimination (PCTCOM, PCTMON, and PCTNOP) and a measure of the diversity of the variable on which sorting is effective in that region. When  $A$  and  $c$  are correlated sorting on one of these characteristics also allows discrimination on the other, as discussed earlier, thus  $\rho$  acts interactively with the non-sorted characteristic. With these right-hand side variables included, the addition of population does not add very much explanatory power.

Closer examination of the structure of this model reveals why the information available from the population variable is already included in the other RHS variables. For a single  $(A, c)$  type within the monopoly or competitive region, a firm's profit maximizing price,  $P^*$ , is determined by the intersection of a flat marginal cost curve and the marginal revenue curve from a linear demand function. Due to this linearity on the cost and demand side,  $P^*$  for each type is unaffected by changes in the number of consumers in that type. The optimal

price for a group is presumably some function of the optimal price for each type in the group, so changes in population size (without changing the  $(A,c)$  distribution) have no short-run effect on the  $P^*$  for a group. The only effect would be from the long-run shifting of regions as increased (decreased) profitability from higher (lower) population brings entry (exit) of firms. This is captured in the region percentage variables.

This result does not mean that population or market density is not an important determinant of the degree to which discrimination is effectively carried out. Rather, it shows that the way in which population size affects  $W$  is best described by looking at its effect on the distribution of potential purchases over the three regions. In dense markets, fixed costs can be spread over more purchases, allowing a break-even price to be closer to marginal cost, thus shrinking the no-purchase region. Likewise, high population causes more, and more closely spaced, brands satisfying the tastes of more consumers and lessening the proportion of potential purchases that fall into the monopoly region. The total effect is that population increases tend to put more of the population into the competitive region by decreasing price and increasing variety. This makes sorting on reservation price less effective and sorting on strength of brand preference more effective.

The effects of population and the parameters of the density function are presented in table 2. Once again, a caveat regarding specification error is appropriate. As in the table 1 regressions, the impact of any parameter on  $W$  is limited by the diversity of the variable on which sorting is based, thus the interactions with  $SD(A)$  and  $SD(c)$ . Increases in the average strength of brand preference,  $\mu_c$ , puts more of the population in the monopoly and no-purchase regions (without discrimination). This increases the effectiveness of  $A$ -sorting and generally decreases the effectiveness of  $c$ -sorting. Increases in average reservation price,  $\mu_A$ , put more buyers in the competitive region and, thus, have the opposite effect. The insignificance of the terms that include  $\rho$  is probably explained by their collinearity due to the common  $\rho$  term. Tests of the joint significance of the three correlation-based terms were significant at the 5% level in both regressions.

Price discrimination affects the equilibrium number of firms in an unsurprising way. Discrimination causes there to be more firms than when the practice is prohibited or, equivalently, with the same number of firms, each earns positive profits. How strong this effect is depends on how effective the discrimination is. There is a clear correlation between  $W$  and the change in  $N$  when discrimination is permitted (among sorts that yield the same relative sizes of the low and high price groups). In the sample used in the regressions, this correlation was 0.89 when sorting was based on reservation

price, 0.80 when sorting was based on strength of brand preference.

It is interesting to observe that sorting based on A tends to have a greater impact on the equilibrium number of firms than sorting based on c. Though A-sorting on average yielded a smaller W in the 150 equilibria, 0.27 versus 0.32 with strength-of-brand-preference sorting, it resulted in a much larger mean increase in N, 6.22% versus 2.77%. The larger increase in N indicates that reservation price sorting is likely to be more profitable prior to entry of new firms. This is borne out in the simulations.

The change in total quantity sold when price discrimination is permitted has traditionally been of interest to economists studying this issue. In a monopolistic model, quantity increase is a necessary, but not sufficient condition for discrimination to improve resource allocation. In this model, where sorting need not have anything to do with reservation price, the condition is neither necessary nor sufficient.

Nevertheless, it is clear that, in the simulations, sorting on A has a more positive effect on quantity than sorting on c. When sorting was based on reservation price (in the sample of 150), quantity increased an average of 7.86% versus a 0.29% average increase when sorting was based on strength of brand preference. In all 75 parameter sets in the sample A-sorting raised quantity by a greater amount or lowered quantity by less.

TABLE 3

Sorting on Reservation Price (A)  
(t-statistics in parentheses)

$$QDIF = -0.018 - 0.010 * PPA + 0.048 * AMN - 0.0007 * AC$$

(-0.8)    (-0.1)                    (7.6)                    (-0.1)

$$CRSQ = 0.50 \quad F\text{-stat} = 25.9 \quad SSR = 0.616 \quad NOB = 75$$

$$QDIF = Q1/Q0 - 1$$

$$PPA = POPULATION * SD(A)/100000$$

$$AMN = (PCTMON + PCTNOP) * SD(A)$$

$$AC = RHO * PCTCOM * SD(c)$$

Sorting on Strength of Brand Preference (c)  
(t-statistics in parentheses)

$$QDIF = 0.024 + 0.010 * PPC + 0.021 * BMN - 0.16 * BC$$

(-1.3)    (1.4)                    (14.1)                    (-0.9)

$$CRSQ = 0.76 \quad F\text{-stat} = 73.73 \quad SSR = 0.0038 \quad NOB = 75$$

$$PPC = POPULATION * SD(c)/100000$$

$$BMN = RHO * (PCTMON + PCTNOP) * SD(A)$$

$$BC = PCTCOM * SD(c)$$



TABLE 4

Sorting on Reservation Price (A)  
(t-statistics in parentheses)

$$QDIF = 0.11 - 0.23*PPA - 0.22*UAA + 0.11*UCA + 0.11*PPCR$$

(4.2)    (-1.7)        (-2.6)        (1.7)        (0.2)

$$- 0.50*UACR + 0.15*UCCR$$

(-1.2)        (0.7)

$$CRSQ = 0.18 \quad F\text{-stat} = 4.67 \quad SSR = 0.976 \quad NOB = 75$$

$$\begin{aligned} QDIF &= Q1/Q0 - 1 \\ PPA &= POPULATION*SD(A)/100000 \\ UAA &= UA*SD(A)/1000 \\ UCA &= UC*SD(A)/1000 \\ PPCR &= RHO*POPULATION*SD(c)/100000 \\ UACR &= RHO*UA*SD(c)/1000 \\ UCCR &= RHO*UC*SD(c)/1000 \end{aligned}$$

Sorting on Strength of Brand Preference (c)  
(t-statistics in parentheses)

$$QDIF = 0.003 - 0.004*PPC - 0.005*UAC - 0.0054*UCC - 0.023*PPAR$$

(1.2)    (-0.3)        (-0.5)        (-0.9)        (-0.4)

$$- 0.27*UAAR + 0.19*UCAR$$

(-4.7)        (5.9)

$$CRSQ = 0.35 \quad F\text{-stat} = 7.52 \quad SSR = 0.0096 \quad NOB = 75$$

$$\begin{aligned} PPC &= POPULATION*SD(c)/100000 \\ UCC &= UC*SD(c)/1000 \\ UAC &= UA*SD(c)/1000 \\ PPAR &= RHO*POPULATION*SD(A)/100000 \\ UCAR &= RHO*UC*SD(A)/1000 \\ UAAR &= RHO*UA*SD(A)/1000 \end{aligned}$$

In the extreme case in which nearly all of the population is served competitively, c-sorting would have virtually no effect on quantity since few or none of the purchases would be on the margin of not purchasing the product at all. At the opposite extreme, with nearly all of the population in the monopoly or no-purchase regions, the situation closely resembles monopoly theory in the short run; A-based discrimination can raise or lower quantity. The profits from discrimination, however, attract new brands in this model, increasing variety and putting downward pressure on prices. Thus, discrimination would be more likely to increase quantity. In fact, sorting on reservation price lowered quantity in only 11 of the 75 cases. Tables 3 and 4 summarize the effects of different sorting devices on the change in quantity caused by discrimination. They strongly support the assertion that sorting based on reservation price, directly or indirectly through correlation, will tend to raise quantity. They also indicate that sorting on strength of brand preference has little effect on quantity.

A traditional welfare comparison, summing consumers' surplus since there are no profits in this model, yields a result similar to the quantity comparison.<sup>21</sup> As with quantity, this measure of welfare can increase or decrease with the introduction of price discrimination. In the sample studied, the average change was a 2.5% increase with A-sorting and a 0.3% decline with c-sorting.

Of course, the distributional effects of discrimination are always an important issue in policy making, so this simple welfare analysis is not sufficient information for choosing among policies. It is clear, though, that the increase in  $N$  and decrease in price for the low-price group imply that the sum of consumers' surplus in the low price group always increases with discrimination. In a few of the simulation cases, discrimination lowers the price charged to the high-price group as well. When this happens, the lower price and greater variety necessarily increase total surplus in that group. An extreme example of this effect is when no firm can earn positive profits without discrimination, so the price in the absence of discrimination is essentially infinite. Generally, though, discrimination brings price increases that outweigh the welfare gain from increased variety, causing total surplus for the high-price group to fall. It is noteworthy that all cases in which discrimination helped the high-price group occurred when sorting was based on reservation price either directly or indirectly through correlation. Regressions to explain the change in consumer surplus and the change in number of firms were also run. They are included in appendix C.

The results presented here point to a fundamental differences in the effects of reservation price sorting versus strength-of-brand-preference sorting. An intuitive explanation, one that argues for the robustness of these conclusions, is presented in the following section.

## SECTION 7

To interpret the simulation results, it is quite useful to relate them to traditional, elasticity-based discussions of price discrimination. Since the first-order condition for profit maximization can be stated as

$$(11) \quad \frac{P - MC}{P} = -\frac{1}{e}$$

studies of discrimination usually focus on differences in consumers' demand elasticities,  $e$ . In perfect competition, firms see each consumer's demand as infinitely elastic, so price is equal to marginal cost and the same for every buyer.

In this free-entry spatial approach, however, firms do not face infinitely elastic demand from any type of consumers. For discrimination to persist, then, it need only be the case that consumers can be sorted so that the resulting groups' demand curves have different elasticities at any given price. This rather weak condition is satisfied in most of the simulations, so firms do not charge all consumers the same price.

Elasticities also help explain the different effects of reservation price and strength of brand preference sorting. From the simulations, it was inferred that

- 1) Sorting on reservation price (A) is useless if the entire population is served competitively when there is no discrimination. Its effect increases the more consumers are in the monopoly or no-purchase region before sorting.

2) Sorting on strength of brand preference (c) is effective if most or all of the population is served competitively without discrimination, but loses its usefulness as more consumers are in the monopoly or no-purchase region.<sup>22</sup>

The fundamental difference between the monopoly and competitive regions is the choice facing the marginal consumers of a brand. In the competitive region, a brand's marginal customers are just indifferent between two brands, both of which give positive surplus. For these types, responses to (infinitesimal) changes in one brand's price come entirely from interbrand switching.<sup>23</sup> Total market sales to these types are unchanged. On the other hand, for types in the monopoly region, changes in quantity purchased of a given brand come entirely from changes in total market sales. Price increases lead to some of the people in each monopolistically-served type ceasing to purchase the product at all, while price decreases expand total market sales to these types.

The demand elasticity a firm faces can be broken down the same way. In the elasticity equation

$$e = \frac{P}{q} \frac{dq}{dP}$$

the derivative term has two components. When the price of brand X decreases, for instance, there are two sources of changes in q. First, total market sales of the product increase. Second, some purchases that were being made from a competing firm before the price change are now switched to

brand  $x$ .

$$\frac{dq_x}{dP_x} = \begin{array}{l} \text{change in total} \\ \text{market sales} \end{array} + \begin{array}{l} \text{sales that switch} \\ \text{from competing brands} \end{array}$$

In the airline industry and other markets, the first term is often referred to as 'demand creation' and the second term is called 'demand diversion'. In the competitive region, (infinitesimal) price changes result only in demand diversion. It is not surprising that the size of this effect is independent of reservation price, since demand for a given brand is independent of reservation price in the competitive region. Equation (4) is the demand function for a consumer type in the competitive region,

$$(4) \quad q_x = L ((P' - P_x)/c + 1/N)$$

$$\Rightarrow \quad dq_x/dP_x = -L/c$$

$$\Rightarrow \quad e_c = -P_x/(P' - P_x + c/N) \quad (<0)$$

where  $L$  is the number of people in that type.<sup>24</sup> At any given price, we can then show that the competitive region elasticity,  $e_c$ , is smaller in absolute value for types with stronger brand preferences;

$$de_c/dc = P_x/(P' - P_x + c/N)^2 + 1/N > 0.$$

As a result, firms want to discriminate against people with strong brand preferences.

Though the mathematics here are specific to the model, the results are probably much more general. When a firm is trying to gain customers who are buying competing brands or is concerned with losing customers to competing brands, reservation price is of little interest in pinpointing who those

'vulnerable' consumers are. Thus, sorting on A is ineffective. The buyers most likely to switch brands are ones with weak brand preferences. If these consumers can be identified, competition for them will be greater and the price they pay will be lower.

In the monopoly region, all quantity changes come from changes in the total market sales; there is no diversion since no consumers in the region get positive surplus from more than one brand.<sup>25</sup> When a brand's marginal customers are deciding whether or not to purchase the product at all, it is to be expected that the value they place on the product, their reservation price, will play a key role. From equation (2), the one-type monopoly demand, we see that it does:

$$\begin{aligned}
 (2) \quad & q_x = 2L(A - P_x)/c \\
 \Rightarrow & dq_x/dP_x = -2L/c \\
 \Rightarrow & e_m = -P_x/(A - P_x) \\
 \Rightarrow & de_m/dA = P_x/(A - P_x)^2 > 0
 \end{aligned}$$

The monopoly region elasticity is a function of A and independent of c. Types with higher reservation prices have elasticities that are lower in absolute value at a given price. Thus, sorting monopoly region consumers by strength of brand preference (c) is ineffective (assuming no correlation between A and c), but sorting on reservation price will result in higher prices charged to the group with higher reservation prices.

This conclusion on A-sorting is probably quite general. It is the basis for most discussions of monopoly price discrimination. The result that c-sorting is ineffective is somewhat surprising since people with higher c's generally receive lower surplus from a brand (if there is no correlation between A and c). The reason this does not result in a lower price for high-c types in the monopoly region is that they are also less responsive to price cuts,  $dq/dP = -(2L/c)$ . Still, this conclusion is less likely to be robust to major changes in the model.

It is, however, robust to one important modification. In fact, all of the statements made in this section about A and c sorting hold true for the surplus equation

$$CS = A - P_x - c|z - X|^h$$

for all positive h. In this paper, h has been taken to be 1.

Finally, taken in the context of demand creation and diversion, the welfare results of section 6 are intuitively appealing. When discrimination only heightens the competition for purchases that were already being made, without creating any new sales, one would expect that it would hurt the groups not singled out for competition. On the other hand, sorting designed to expand total market sales, demand 'creation' in the monopoly region (and for finite price cuts, also the no-purchase region), allows firms to spread fixed costs over more buyers and can thus end up helping all buyers. Thus, sorting on strength of brand preference, which is generally demand diverting, is less likely to be welfare improving than



sorting on reservation price, which is more often demand creating.

## SECTION 8

In the industrial organization literature, studies of price discrimination have dealt almost exclusively with absolute sorting. In this section, the analysis is generalized to include self-selective sorting. The major conclusion of the previous two sections still holds with self-selection: sorting on strength of brand preference and sorting on reservation price still differ strongly in their effectiveness depending on whether more potential purchases are in the competitive or monopoly and no-purchase regions. However, the effects on equilibrium number of firms, quantities sold and the Marshallian welfare measure are changed somewhat by self-selection.

There are two important factors that help to explain the differences between absolute and self-selective sorting. First, as mentioned earlier, the two prices a firm sets are no longer independent. The price differential determines how many people fall into each group and thus affects the firm's profit-maximizing price for that group. Second, many or all of those who buy at the low price are incurring a total cost greater than the purchase price. Some types who pay the low price plus a qualification cost just slightly less than  $P_H - P_L$ , would incur a lower total cost without discrimination if the single price that resulted were less than  $P_H$ . Unless the variety,  $N$ , increased substantially with price discrimination, and in some cases it does not increase at all, these types are worse off with discrimination even though their

actual purchase price is less. The deadweight qualification cost is likely to make self-selective sorting less beneficial by most welfare measures.

To aid in comparing self-selective with absolute sorting, the same 75 sets of population parameters that were studied in section 6 with Model II were also simulated with model III. As introduced in section 4, the cost of qualifying for the low price was a function of a person's  $(A, c)$ .

$$K = \max \left\{ 0, r + \frac{s(A-A_0)}{SD(A)} + \frac{t(c-c_0)}{SD(c)} \right\}$$

The centers of the sorting,  $(A_0, c_0)$ , were again the median  $A$  and  $c$  values in the positive quadrant.

Each set of population parameters was simulated with  $r=0.1$ ,  $s=5.0$ ,  $t=0.001$ , and with  $r=1.0$ ,  $s=0.001$ ,  $t=5.0$ .<sup>26</sup> Setting the larger value in each case at 5.0 is rather extreme since the price differential with absolute sorting averaged \$1.23 and was greater than \$5.00 in only 1 of the 150 cases. It is useful to note, though, that as  $s$  gets large holding  $t$  near 0 or as  $t$  gets large holding  $s$  near 0, the sorting resembles more and more closely absolute sorting on  $A$  and  $c$  respectively. With  $s=5.0$  and  $t=0.001$ , the qualification cost for types with  $A$  more than 0.2 standard deviations below  $A_0$  would be 0 (since  $r=1$ ). If the price differential were \$1.23 in equilibrium, types with  $A$  more than 0.25 standard deviations above  $A_0$  would chose to pay the high price instead. Only about 18% of the potential purchases would incur a positive qualification cost if a purchase were made.<sup>27</sup> Thus, the high values of  $s$  or  $t$  are a way to examine the effect of a

small perturbation of the absolute sorting towards self-selection.

The effects of this small change are numerically small in some cases, but they are consistent across the various measures of the impact of price discrimination, as shown in table 3. Self-selection sorting is consistently less effective than price discrimination based on absolute sorting. The average discount to low price buyers is less, as well as the average change in number of firms, total quantity and consumer surplus. One possibly surprising result is that while sorting on strength of brand preference lowers consumer surplus on average, the effect is weaker with self-selective sorting. The fact that self-selection lowers the level of price discrimination that is viable seems to outweigh the deadweight loss from the qualification cost that some must pay. This is not always the case. In 3 of the 57 c-based discrimination cases in which absolute sorting lowered consumer surplus, self-selection lowered consumer surplus by a greater amount.

As was the case in Model II, sorting based on strength of brand preference yields larger price differentials on average in the sample, yet it has smaller effects on the number of firms, quantity sold, and consumer surplus. The effectiveness of A-based and c-based sorting is again explained well by the proportion of potential purchases in the competitive, monopoly and no-purchase regions. The summary regressions presented in section 6 were also run on the self-selection equilibria.

TABLE 5

MEASURING THE IMPACT OF PRICE DISCRIMINATION

(average change from discrimination-prohibited case)

	<u>Reservation Price (A)</u>		<u>Strength of Brand Pref(c)</u>	
	<u>Absolute Self-Selection</u> (75 obs)	<u>(75 obs)</u>	<u>Absolute Self-Selection</u> (75 obs)	<u>(75 obs)</u>
W	+26.8%	+16.3%	+32.5%	+19.9%
FIRMS	+6.22%	+4.22%	+2.77%	+1.51%
QUANTITY	+7.86%	+4.92%	+0.29%	+0.20%
CS	+2.48%	+1.07%	-0.25%	-0.08%

---

These are presented in tables 6, 7, 8, and 9. The results are consistent with the earlier regressions, though they are somewhat less significant.

These simulations of price discrimination based on self-selective sorting indicate that its effects are qualitatively the same as absolute sorting, though they are quantitatively smaller. It must be kept in mind, however, that the change from absolute sorting to the self-selection used here was small. However, simulations of cases in which a larger proportion of buyers pay some qualification cost have yielded similar results.

Finally, it is necessary to contrast this model of self-selection with the well-known work in the area by Spence. In his "Job Market Signalling" paper [31], Spence explores a perfectly competitive labor market in which workers differ in their productivity. This difference can be communicated by

TABLE 6

Sorting on Reservation Price (A)  
(t-statistics in parentheses)

$$W = 0.046 + -0.04 * PPA + 0.051 * AMN + 0.013 * AC$$

(1.8)      (-0.4)                      (6.9)                      (2.1)

CRSQ = 0.44      F-stat = 20.3      SSR = 0.850      NOB = 75

PPA = POPULATION \* SD(A)/100000  
AMN = (PCTMON + PCTNOP) \* SD(A)  
AC = RHO \* PCTCOM \* SD(c)

Sorting on Strength of Brand Preference (c)  
(t-statistics in parentheses)

$$W = 0.11 + 0.32 * PPC + 0.012 * BMN + 0.008 * BC$$

(5.8)      (1.3)                      (2.7)                      (6.2)

CRSQ = 0.27      F-stat = 10.27      SSR = 0.632      NOB = 75

PPC = POPULATION \* SD(c)/100000  
BMN = RHO \* (PCTMON + PCTNOP) \* SD(A)  
BC = PCTCOM \* SD(c)

TABLE 7

Sorting on Reservation Price (A)  
(t-statistics in parentheses)

$$W = 0.21 - 0.42*PPA - 0.18*UAA + 0.054*UCA + 1.17 *PPCR$$

(7.5)    (-2.9)        (-1.9)        (0.7)        (1.5)

$$- 0.43*UACR + 0.17*UCCR$$

(-0.9)        (0.8)

$$CRSQ = 0.20 \quad F\text{-stat} = 4.11 \quad SSR = 1.161 \quad NOB = 75$$

$$\begin{aligned} PPA &= POPULATION*SD(A)/100000 \\ UAA &= UA*SD(A)/1000 \\ UCA &= UC*SD(A)/1000 \\ PPCR &= RHO*POPULATION*SD(c)/100000 \\ UACR &= RHO*UA*SD(c)/1000 \\ UCCR &= RHO*UC*SD(c)/1000 \end{aligned}$$

Sorting on Strength of Brand Preference (c)  
(t-statistics in parentheses)

$$W = 0.18 + 0.36*PPC + 0.29*UAC - 0.16*UCC - 0.15*PPAR$$

(9.3)    (3.1)        (3.1)        (-3.4)        (-0.3)

$$- 0.39*UAAR + 0.25*UCAR$$

(-0.9)        (0.9)

$$CRSQ = 0.26 \quad F\text{-stat} = 5.29 \quad SSR = 0.617 \quad NOB = 75$$

$$\begin{aligned} PPC &= POPULATION*SD(c)/100000 \\ UCC &= UC*SD(c)/1000 \\ UAC &= UA*SD(c)/1000 \\ PPAR &= RHO*POPULATION*SD(A)/100000 \\ UCAR &= RHO*UC*SD(A)/1000 \\ UAAR &= RHO*UA*SD(A)/1000 \end{aligned}$$

unalterable attributes of the worker, which Spence calls indices and I have presented as the basis for absolute sorting, or by signals that are costly for the worker to convey, e.g., education, which I call self-selection. Just as Spence points out that the cost of signalling must be negatively correlated with productivity for the signal to be effective, the cost of qualifying for the discount price in this model,  $K$ , must be positively correlated with  $A$  or  $c$  for it to be an effective tool in discrimination.

The differences between the models, however, are crucial. Firms have no market power in Spence's model, but workers differ in the value of their service. The analogous case here would be perfectly competitive firms with consumers who are more or less costly to serve. Instead, all buyers are equally costly to serve, but firms face downward sloping demand curves due to product differentiation. Thus, the results here could be viewed as an extension on Spence's model in which employers have some monopsony power and are able to wage discriminate among workers of identical productivity. The discrimination could take place against workers who can less easily switch locations or companies, strength-of-firm-preference sorting, or reservation wage discrimination, such as against workers less likely to withdraw from the labor market or switch professions entirely.



TABLE 8

Sorting on Reservation Price (A)  
(t-statistics in parentheses)

$$\text{QDIF} = -0.009 - 0.011 * \text{PPA} + 0.029 * \text{AMN} - 0.001 * \text{AC}$$

(-0.6)    (-0.2)                    (6.7)                    (-0.2)

CRSQ = 0.44    F-stat = 20.4    SSR = 0.296    NOB = 75

$$\begin{aligned} \text{QDIF} &= \text{Q1/Q0} - 1 \\ \text{PPA} &= \text{POPULATION} * \text{SD(A)}/100000 \\ \text{AMN} &= (\text{PCTMON} + \text{PCTNOP}) * \text{SD(A)} \\ \text{AC} &= \text{RHO} * \text{PCTCOM} * \text{SD(c)} \end{aligned}$$

Sorting on Strength of Brand Preference (c)  
(t-statistics in parentheses)

$$\text{QDIF} = -0.001 + 0.006 * \text{PPC} + 0.013 * \text{BMN} - 0.0002 * \text{BC}$$

(-0.2)    (1.1)                    (10.6)                    (-1.6)

CRSQ = 0.64    F-stat = 44.2    SSR = 0.0026    NOB = 75

$$\begin{aligned} \text{PPC} &= \text{POPULATION} * \text{SD(c)}/100000 \\ \text{BMN} &= \text{RHO} * (\text{PCTMON} + \text{PCTNOP}) * \text{SD(A)} \\ \text{BC} &= \text{PCTCOM} * \text{SD(c)} \end{aligned}$$

TABLE 9

Sorting on Reservation Price (A)  
(t-statistics in parentheses)

$$\begin{aligned} \text{QDIF} = & 0.07 - 0.15*\text{PPA} - 0.13*\text{UAA} + 0.062*\text{UCA} + 0.091*\text{PPCR} \\ & (4.1) \quad (-1.7) \quad (-2.4) \quad (1.4) \quad (0.2) \\ & - 0.33*\text{UACR} + 0.10*\text{UCCR} \\ & (-1.2) \quad (0.7) \end{aligned}$$

$$\text{CRSQ} = 0.16 \quad \text{F-stat} = 3.32 \quad \text{SSR} = 0.427 \quad \text{NOB} = 75$$

$$\begin{aligned} \text{QDIF} &= \text{Q1/Q0} - 1 \\ \text{PPA} &= \text{POPULATION}*\text{SD(A)}/100000 \\ \text{UAA} &= \text{UA}*\text{SD(A)}/1000 \\ \text{UCA} &= \text{UC}*\text{SD(A)}/1000 \\ \text{PPCR} &= \text{RHO}*\text{POPULATION}*\text{SD(c)}/100000 \\ \text{UACR} &= \text{RHO}*\text{UA}*\text{SD(c)}/1000 \\ \text{UCCR} &= \text{RHO}*\text{UC}*\text{SD(c)}/1000 \end{aligned}$$

Sorting on Strength of Brand Preference (c)  
(t-statistics in parentheses)

$$\begin{aligned} \text{QDIF} = & 0.002 - 0.003*\text{PPC} - 0.007*\text{UAC} - 0.001*\text{UCC} - 0.008*\text{PPAR} \\ & (1.1) \quad (-0.3) \quad (-1.0) \quad (-0.1) \quad (-0.2) \\ & - 0.17*\text{UAAR} + 0.12*\text{UCAR} \\ & (-4.2) \quad (5.1) \end{aligned}$$

$$\text{CRSQ} = 0.28 \quad \text{F-stat} = 5.82 \quad \text{SSR} = 0.0050 \quad \text{NOB} = 75$$

$$\begin{aligned} \text{PPC} &= \text{POPULATION}*\text{SD(c)}/100000 \\ \text{UCC} &= \text{UC}*\text{SD(c)}/1000 \\ \text{UAC} &= \text{UA}*\text{SD(c)}/1000 \\ \text{PPAR} &= \text{RHO}*\text{POPULATION}*\text{SD(A)}/100000 \\ \text{UCAR} &= \text{RHO}*\text{UC}*\text{SD(A)}/1000 \\ \text{UAAR} &= \text{RHO}*\text{UA}*\text{SD(A)}/1000 \end{aligned}$$

## CONCLUSION

This paper has presented a spatial approach to modeling price discrimination in monopolistically competitive markets. Within this framework, we have found that free entry alone will generally not prevent price discrimination. The model treats formally the concept of brand preferences and finds it to be an important factor in understanding the nature of discrimination in these markets.

Sorting based on strength of brand preference is an idea not present in traditional models of price discrimination. In monopolistically competitive markets, however, it can be the most effective basis for sorting buyers. When a change in one brand's price results primarily in brand switching ('demand diversion'), rather than expansion or contraction of total market sales ('demand creation'), sorting based on strength of brand preference will be more effective than reservation price sorting; the former will yield larger price differentials, larger profits in the short run and more firms in long-run equilibrium.

On the other hand, when changes in one brand's sales are mostly associated with changes in total market sales, competition among firms is a less important factor. Hence, strength of brand preference will be a less effective basis for sorting customers. The situation is then more similar to monopoly models of price discrimination; effective discrimination is based on the value customers derive from the brand.

Discrimination affects total quantity sold more strongly when sorting is based on reservation price than when it is strength-of-brand-preference based. This is consistent with the 'creation' and 'diversion' terminology I have used to describe the effects of the sorting criteria. Sorting on reservation price can increase or decrease total quantity sold as it can in with monopoly discrimination. It appears, though, that increase are more likely under monopolistic competition than with monopoly as the short-run profits from discrimination bring entry and downward pressure on prices.

Both sorting criteria increase the sum of consumers' surplus in the resulting low-price group. However, only sorting based on reservation price, either directly or indirectly (through correlation between A and c), can raise the surplus of consumers in the high-price group. Total consumer surplus is also affected more favorably by reservation price sorting.

The analysis concluded by examining the model with self-selective sorting. The results closely parallel the previous findings, but the changes brought about by discrimination are, in general, smaller. The endogeneity of the group sizes appears to moderate the price spread that is sustainable. Large differentials would encourage a greater proportion of the population to pay the qualification cost, which is not revenue to the firms, and obtain the low price.

The simulations on which the findings of this paper have been based were extensive, but they could not be exhaustive. The results have been presented not as substitutes for mathematical proofs, but rather to provide a basis for developing further theories and empirical work on price discrimination. In the next chapter, the views of discrimination suggested by this essay are put to use as the basis for analyzing discounting practices in the U.S. airline industry.

## APPENDIX A

The demand function from the section 3 spatial model is derived in this appendix. This is done by calculating  $q_x$  for the cases  $P_x \geq P'$  and  $P_x < P'$ . Conditions under which the demand function and the associated marginal revenue function are continuous are then presented.

When brand X is priced equal to or above all other brands,  $P_x \geq P'$ , the region into which each (A,c) type falls is illustrated by figure 4 (figure 3, for  $P_x = P'$ ). The quantity demanded by each type in the monopoly region is given by equation (2):

$$(2) \quad q_x = 2L(A - P_x)/c,$$

where L is the number of people in the type. The demand of each type in the competitive region is calculated from equation (4):

$$(4) \quad q_x = L((P' - P_x)/c + 1/N)$$

The monopoly region is bounded by equation (3)',

$$(3)' \quad A = (P' + P_x + c/N),$$

the monopoly-competitive border, and by the monopoly-no purchase border,  $A = P_x$ . The borders intersect at  $c = N(P_x - P')$ , which is the lower bound on c. So, when there are L consumers in the entire population and a bivariate (A,c) density, the monopoly region demand is

$$(A1) \quad q_x^m(P_x | P', N, f(A, c)) \Big|_{P_x \geq P'} = 2L \int_{P_x}^{\infty} \int_{\frac{1}{2}(P_x + P' + \frac{c}{N})}^{\frac{A - P_x}{c}} f(A, c) dA dc$$

$$N(P_x - P')$$

The competitive region is bounded below on A by the monopoly-competitive border and below on c by the supercompetitive border,  $c=N(P_x-P')$ . A and c are unbounded above.

Thus, the competitive region demand is

$$(A2) \ q_x^c(P_x | P', N, f(A, c)) \Big|_{P_x > P'} = \frac{L}{N(P_x - P')} \int_{\frac{1}{2}(P' + P_x + \frac{c}{N})}^{\infty} \int_{\frac{P' - P_x}{c} + \frac{1}{N}}^{\infty} f(A, c) dA dc$$

Summing  $q_x^m$  and  $q_x^c$  gives the total quantity of brand X demanded when  $P_x \geq P'$ . Equation (6) is, of course, the case of  $P_x = P'$ .

When firm X charges a lower price than other firms,  $P_x < P'$ , the supercompetitive region must be studied more closely. Rather than losing all sales to types with weak brand preferences, brand X increases its sales in the supercompetitive region, capturing some or all of the market's sales to these low-c types. For a type whose c is very near 0, even a small price discount will allow brand X to capture all the sales to that type no matter where the buyer is located. Among types with slightly stronger brand preferences, the same discount will allow brand X to dominate brands similar to it, but members of these types who desire characteristics very different from X will still buy other brands. Figures A1(a) and A1(b) illustrate a  $P_x < P'$  situation when there are 6 brands in the market. With N brands in the market and  $P_x < P'$ , the quantity sold in the supercompetitive region is

$$(A3) \ q_x^{sc} = \sum_{w=1}^{\phi-1} \frac{N(P' - P_x)}{w+1} \int_{P'}^{\infty} \int_{\frac{P' - P_x}{c} + \frac{1+w}{N}}^{\infty} f(A, c) dA dc + \int_0^{\frac{N(P' - P_x)}{\phi}} \int_{P'}^{\infty} f(A, c) dA dc$$

where  $\phi = \text{INT}(N/2)$ .

The monopoly region must also be examined more closely when  $P_x < P'$ . Among the types that brand X serves monopolistically are all types with reservation prices  $P_x < A < P'$ . Equation (2) does not hold, however, if for a given type the distance calculated between brand X's market boundaries,  $2(A - P_x)/c$ , is greater than the circumference of the circle, one. In these cases, (2) would show more sales to a type than there are buyers in that type. Sales to these types are, in fact, equal to the number of consumers in the type. The condition for equation (2) to overcalculate quantity sold is

$$2d = 2(A - P_x)/c > 1$$

$$\Rightarrow A > P_x + c/2$$

This is shown in figure A1(a) as region 'V'. The upper c bound on the region is determined by

$$P' = P_x + c/2$$

$$\Rightarrow c = 2(P' - P_x)$$

So, monopoly quantity sold when  $P_x < P'$  is

$$(A4) \quad q_x^m = L \left[ \int_0^{P' - P_x} \int_{P_x + \frac{c}{2}}^{P'} f(A, c) dA dc + 2 \int_0^{P' - P_x} \int_{P_x}^{\frac{A - P_x}{c}} f(A, c) dA dc \right]$$

$$+ \frac{N(P' - P_x)}{2} \int_{P_x + \frac{c}{2}}^{P'} \int_{\frac{A - P_x}{c}}^{\frac{1}{2}(P + P_x + \frac{c}{N})} f(A, c) dA dc + 2 \int_0^{P' - P_x} \int_{P_x}^{\frac{A - P_x}{c}} f(A, c) dA dc \quad \Bigg]$$

The equation for the competitive region when  $P_x < P'$  is identical to the  $P_x \geq P'$  case, with one exception. As noted above, when  $P_x < P'$  the lower bound on c, the competitive-super-competitive border, is  $N(P' - P_x)$  rather than  $N(P_x - P')$ . Thus,



quantity sold in the competitive region is

$$(A5) \quad q_x^c = L \int_{N(P' - P_x)}^{\infty} \int_{\frac{1}{2}(P' + P_x + \frac{c}{N})}^{\infty} \left( \frac{P' - P_x}{c} + \frac{1}{N} \right) f(A, c) dA dc$$

Since  $q_x(P_x)$  when  $P_x < P'$  is equal to the sum of integrals of functions that are well-defined and continuous for all values of  $P_x < P'$ , the demand function is continuous in this domain. Likewise for  $P_x \geq P'$ , so long as for all  $A$ ,

$$(A6) \quad 0 < c < t \Rightarrow f(A, c) = 0$$

for an arbitrarily small positive  $t$ . From inspection, it is obvious that

$$\lim_{P_x \rightarrow P'_-} q_x(P_x) \Big|_{P_x < P'} = q_x(P') \Big|_{P_x \geq P'}$$

so the function is also continuous where its two separately defined domains meet.

Thus, the demand discontinuity when there is one type of consumer (at the supercompetitive price) disappears when there is a continuous distribution of types. For the profit function to be well-behaved, though, it must also be the case that the demand function is smooth, that is, continuous in its first derivative. Differentiating the  $P_x \geq P'$  quantity function gives

$$(A7) \quad \frac{dq_x}{dP_x} = -L \left[ \int_{N(P_x - P')}^{\infty} \left( \frac{1}{2} \frac{(P_x + P' + \frac{c}{N})}{P_x} \int \frac{f(A, c)}{c} dA + \int_{\frac{1}{2}(P_x + P' + \frac{c}{N})}^{\infty} \frac{f(A, c)}{c} dA \right) dc \right]$$

which is, again, continuous and well-defined so long as the density function is 0 in a neighborhood around  $c=0$ .

Differentiating equations (A3), (A4), and (A5) with

respect to  $P_x$  and summing gives

$$\begin{aligned}
(A8) \frac{1}{L} \frac{dq_x}{dP_x} \Big|_{P_x < P'} &= -2 \int_0^{2(P'-P_x) \frac{P_x + \frac{c}{N}}{P_x}} \int \frac{f(A, c)}{c} dAdx - 2 \int \frac{N(P'-P_x) \frac{P'}{P_x}}{2(P'-P_x) \frac{P'}{P_x}} \int \frac{f(A, c)}{c} dAdc \\
&- 2 \int \frac{\frac{1}{2}(P_x + P' + \frac{c}{N})}{N(P'-P_x) \frac{P_x}{P'}} \int \frac{f(A, c)}{c} dAdc - \frac{2}{P'-P_x} \int \frac{P'}{P_x} (A - P_x) f(A, N(P'-P_x)) dA \\
&- \int \frac{\frac{1}{2}(P'+P_x + \frac{c}{N})}{N(P'-P_x) \frac{P'}{P'}} \int \frac{f(A, c)}{c} dAdc - 2 \int \frac{P'}{P'} f(A, N(P'-P_x)) dA \\
&- \sum_{w=1}^{\phi-1} \left[ \int \frac{\frac{N(P'-P_x)}{w}}{\frac{N(P'-P_x)}{w+1} \frac{P'}{P'}} \int \frac{f(A, c)}{c} dAdc - 2 \int \frac{P'}{P'} f(A, \frac{N(P'-P_x)}{w+1}) dA \right. \\
&\left. + (2 + \frac{1}{w}) \int \frac{P'}{P'} f(A, \frac{N(P'-P_x)}{w}) dA \right] - \frac{N}{\phi} \int \frac{P'}{P'} f(A, \frac{N(P'-P_x)}{\phi}) dA
\end{aligned}$$

This function is continuous and well-defined for all  $P_x < P'$  so long as the (A6) condition holds. Thus,  $q'(P_x)$  is clearly continuous for all  $P_x$  not equal  $P'$ . To show that it is continuous at  $P_x = P'$ , we must show that

$$\lim_{P_x \rightarrow P'_-} \frac{dq_x}{dP_x} = \lim_{P_x \rightarrow P'_+} \frac{dq_x}{dP_x}$$

A kink in the demand curve at  $P_x = P'$  might be particularly believable, however. Intuitively, it would result from the firm's position of having the whole market to gain when it sets  $P_x < P'$  and only its share to lose when  $P_x > P'$ . If  $N$  is greater than 2, the potential gains are greater than the potential losses and an outward kink could exist at the point of equal prices. Such a kink implies an upward discontinuity in the marginal revenue function. This, of course, means that it would never be profit maximizing for a firm to charge the same price as all other firms; no symmetric equilibria would exist.

Fortunately, if there are no consumers who are indifferent between brands, this kink does not occur. As  $P_x$  approaches  $P'$  from below, all but the third and fifth terms of (A8) go to 0, so long as (A6) holds. With this assumption,

$$\lim_{P_x \rightarrow P'_-} \frac{dq_x}{dP_x} = -L \left[ 2 \int_0^{P' + \frac{c}{2N}} \int_{\frac{f(A,c)}{c}}^{\frac{P' + \frac{c}{2N}}{c}} dA dc + \int_0^{\infty} \int_{\frac{P' + \frac{c}{2N}}{c}}^{\infty} \frac{f(A,c)}{c} dA dc \right]$$

This is the same as the limit as  $P_x$  approaches  $P'$  from above, so  $q(P_x)$  is not kinked at  $P_x = P'$  and the marginal revenue function is continuous at this point.

Though this shows that the marginal revenue curve is continuous, it is still possible that it could curve upward and cause a local equilibrium to be globally unstable. The marginal revenue curve could slope upward, for instance, if the density of consumers were very high for a range of reservation prices below the apparent equilibrium price. Many

demand curves were simulated to search for upward sloping marginal revenue curves. None was found. So long as the marginal revenue curve is never upward sloping, condition (A6) is sufficient to assure existence of an equilibrium.

Uniqueness of the equilibrium is proven by contradiction. Assume that there are two equilibria,  $(N_0, P_0)$  and  $(N_1, P_1)$ , where  $N_0 > N_1$ . First, we show that  $(N_1, P_1)$  cannot be an equilibrium if  $P_1 > P_0$ . If  $P_1$  were greater than  $P_0$ , the  $(N_1, P_1)$  equilibrium could be broken by firm X charging  $P_0$ . With only  $N_1$  firms and all other firms charging  $P_1$ , firm X would sell a larger quantity with  $P_x = P_0$  than it did when all other firms also charged  $P_0$  and there were  $N_0$  firms. It is straightforward from equations (2) and (4) that sales to types in the monopoly region are unchanged while sales to types in the competitive region increase. Some types also switch from the competitive to the monopoly region of firm X, which increases firm X's sales to them so long as  $P_x$  stays at  $P_0$ . Thus, if  $(N_0, P_0)$  was a zero-profit equilibrium, then firm X charging  $P_0$  would earn positive profits with  $N_1$  firms and all others' prices equal to  $P_1$ . This argument also holds if  $P_1 = P_0$ . If  $(N_1, P_1)$  is also an equilibrium, it must be that  $P_1$  is less than  $P_0$ .

Next, we show that a decline in the number of firms (from  $N_0$  to  $N_1$ ) would never lower the price a firm would charge, so that  $P_1$  cannot be less than  $P_0$ . For types in the monopoly region, a change in  $N$  has no effect on the profit-maximizing price. In the competitive region,

$$q_x = L(1/N + (P' - P_x)/c)$$

$$\Rightarrow d\text{Revenue}/dP = L(1/N + P'/c - 2P_x/c)$$

$$\text{and, } d\text{Revenue}/dP = 0 \Rightarrow P_x^* = P' + c/N$$

When marginal cost is equal to 0, revenue maximization is identical to profit maximization (In appendix B, it is shown that there is no loss of generality from assuming  $MC = 0$ ). So, a decline in  $N$  always raises the profit-maximizing price to be charged to a type in the competitive region. The  $P_x^*$  function is continuous in  $N$  at the monopoly-competitive border (and constant in the monopoly region). So, the profit-maximizing price to types that switch to the monopoly region (as  $N$  declines from  $N_0$  to  $N_1$ ) also increases. Thus, a decrease in  $N$  increases or does not affect the profit-maximizing price to be charged to every type. Since the firm's profit function is just the sum of the profit functions from serving each type, profits increase as price increases. No firm would lower its price in response to a decline in the number of firms.

Calculation of consumer surplus in a symmetric equilibrium is very similar to calculation of quantities when  $P_x = P'$ . Surplus for a single type in each region is derived and then these functions are integrated over their respective regional areas. The consumer surplus of an individual who buys the product is given by equation (1). Because the consumers in each type are distributed uniformly around the circle, the average distance a buyer in a given  $(A, c)$  type travels is one-half the distance,  $d$ , from a brand to the edge of its

market for that type (equal for all brands in a symmetric equilibrium). This is  $1/4$  the distance between the brand's market boundaries for the type. For all types that are served competitively, each firm's market size is  $1/N$ . Hence, the total consumer surplus of the consumers in such a type is

(A9)  $CS_c = L(A - P - c/(4N))$

where  $L$  is the number of consumers in that type (all of whom purchase the product).

Among types that are served monopolistically, not all consumers buy the product. The distance between a firm's market boundaries for a given type depends on the type's  $(A, c)$ :

$$2d = 2(A-P)/c$$

Thus, the average product-space distance from a purchasing consumer to the brand he buys is

$$2d/4 = (A-P)/2c$$

Each of the  $N$  firms sells to  $2L(A-P)/c$  customers in that type, so surplus for monopolistically-served type is

(A10)  $CS_m = N ((2L(A-P))/c) (A - P - c(A-P)/2c)$   
 $= LN(A-P)^2/c$

Integrating (A9) and (A10) over the appropriate regions gives total surplus in the market,  $CS_t$ , for a symmetric equilibrium at price  $P$ .

$$(A11) \quad CS_t = L \int_0^{P+\frac{c}{2N}} \int_{\frac{(A-P)^2}{c}}^{\frac{(A-P)^2}{c}} f(A, c) dA dc + L \int_0^{\infty} \int_{P+\frac{c}{2N}}^{\infty} (A-P-\frac{c}{4N}) f(A, c) dA dc$$

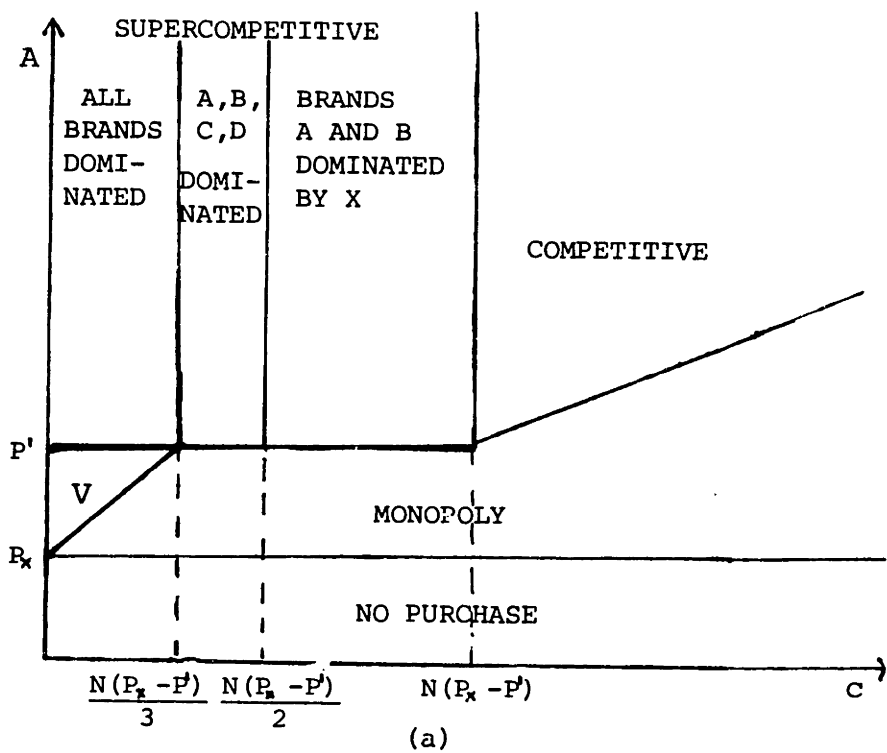
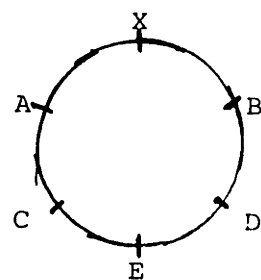


FIGURE (A1)



(b)

## APPENDIX B

This appendix describes in detail the procedure used for finding symmetric spatial equilibria by computer simulation. As stated in section 5, the parameters input to the computer were

Fixed cost	F
Marginal cost	m
Parameters of the normal densities $\mu_c, SD(c), \mu_A, SD(A), \rho$	
Population size(s)	L
Conjectural variation in price	CNJV
Values of the absolute sorting function (Model II only)	$A_0, C_0, u, v$
Values of the self-selective sorting function r, s, t (Model III only)	
Starting values for N and P's	NST, P1ST, P2ST.

For a given N, equilibria in the two groups were computed separately in models I and II. Model III required switching back and forth between the groups because of the relationship between the price differential and the sorting mechanism.

The program calculated firm X's MR if it were to respond to all other firms charging P' by also charging P'. The numerical approximation of MR at P' was

$$(B1) \quad MR = \frac{(P1^* \times q(P1^*, P1_0)) - (P' \times q(P', P'))}{q(P1^*, P1_0) - q(P', P')}$$

where  $P1^* = (1.001)P'$  and  $P1_0 = (1 + CNJV \times .001)P'$ .

The starting values for P' and N were chosen arbitrarily at first and later from the solutions to simulations with fairly close parameter values. If  $MR > (<) m$  the price charged by all other firms, P', was decreased (increased). The size of the change in P' was determined by linear extrapolation from the previous two step's P's and associated MR's. Eventually, the program arrived at the price for 'all other firms' at



which firm X's best response was to charge the same price.

When this short-run equilibrium was found for both groups of consumers, the number of firms was adjusted up or down depending on the sign of profits. Again, the step size was determined by linear extrapolation. With an updated N, the search for an equilibrium began again. This continued until the absolute value of profits in the short-run equilibrium was less than the convergence criterion.

It was useful to note that fixed costs and population affected the results only through their ratio. This comes from two conditions of the model.

- 1) Profits are homogeneous of degree one in F and L:

$$\pi = q_H(P_H - m) + q_L(P_L - m) - F$$

where  $q_H$  and  $q_L$  are homogeneous of degree 1 in L. Since equilibrium occurs when  $\pi=0$ , a zero-profit set of prices and N will still be so after L and F are multiplied by any positive real number.

- 2) MR is independent of L and F:

$$MR = P + q(P)/q'(P)$$

In this model  $q(P_x)$  and  $q'(P_x)$  are both homogeneous of degree 1 in L. Thus, if some  $P_x$  is profit maximizing given  $P'$ , N, and  $f(A, c)$ , it will still be so after any multiplicative change in L and F.

The analysis was also simplified by the observation that

a decrease (increase) in all A values (e.g., by changing  $u_A$ ) had the same effect on equilibria as an increase (decrease) in marginal cost. The only difference was in the level of the equilibrium prices. Quantities, number of firms and welfare were the same.

To prove this, it is sufficient to show that only the level of prices is affected if MC and all A values are increased or decreased by the same amount. If this proposition is true, then from MC=5 and A=10 for a type, changing to MC=5 and A=12 (increasing A by 2) is equivalent to changing to MC=3 and A=10 (decreasing MC by 2). A sketch of the proof is as follows:

For a type in the monopoly region,  $e_m = -P_x/(A-P_x)$  so the markup equation is

$$(P_x - MC)/P_x = (A - P_x)/P_x$$

$$\Rightarrow P = (A + MC)/2$$

Price increases by the increase in A and MC. But, this implies that

$$q_x = L((A - MC)/c).$$

Quantity is unchanged. In the competitive region,

$$(P_x - MC)/P_x = (P' - P_x + c/N)/P_x.$$

In equilibrium,  $P' = P_x$ , so

$$\Rightarrow P = MC + c/N.$$

Again, price increase by the increase in A and MC.

$$q_x = L(1/N + (P' - P_x)/c).$$

Again, quantity is unchanged.

The monopoly-no-purchase border,  $A=P$ , shifts up by the

increase in  $P$  as does the monopoly-competitive border,  
 $A = (P_x + P' + c/N)/2$ . Since the borders shift up by the same  
amount as the  $A$  values, all types remain in the same region.  
Since  $A$  and  $P$  increase by the same amount, consumer surplus  
for any purchase is unchanged. This implies that total CS is  
unchanged, because total quantity is also constant. Finally,  
the markup,  $P - MC$ , is unchanged, so firms profits remain the  
same. A zero-profit equilibrium occurs with the same number  
of firms as before the shift in  $A$  and  $MC$ .

## APPENDIX C

### DEFINITION OF VARIABLES

POPULATION = Population parameter used in the simulations  
times proportion of  $f(A,c)$  that lies in the  
positive  $(A,c)$  quadrant.

UA = A-mean of population in positive  $(A,c)$  quadrant.

UC = c-mean of population in positive  $(A,c)$  quadrant.

SD(A) = Standard deviation of A values in the positive  
 $(A,c)$  quadrant.

SD(c) = Standard deviation of c values in the positive  
 $(A,c)$  quadrant.

RHO = Correlation of A and c values in the positive  
 $(A,c)$  quadrant.

PCTNOP = Proportion of population in the no-purchase  
region in a discrimination-prohibited  
equilibrium.

PCTMON = Proportion of population in the monopoly  
region in a discrimination-prohibited  
equilibrium.

PCTCOM = Proportion of population in the competitive  
region in a discrimination-prohibited  
equilibrium.

PPA =  $POPULATION * SD(A)/100000$

AMN =  $(PCTMON + PCTNOP) * SD(A)$

AC =  $RHO * PCTCOM * SD(c)$

PPC =  $POPULATION * SD(c)/100000$

BMN =  $RHO * (PCTMON + PCTNOP) * SD(A)$

BC =  $PCTCOM * SD(c)$

UAA =  $UA * SD(A)/1000$

UCA =  $UC * SD(A)/1000$

PPCR =  $RHO * POPULATION * SD(c)/100000$

UACR =  $RHO * UA * SD(c)/1000$

UCCR =  $RHO * UC * SD(c)/1000$

UCC =  $UC * SD(c)/1000$

UAC =  $UA * SD(c)/1000$

PPAR =  $RHO * POPULATION * SD(A)/100000$

UCAR =  $RHO * UC * SD(A)/1000$

UAAR =  $RHO * UA * SD(A)/1000$

# SUMMARY OF DATA FOR REGRESSIONS

	MEAN	STND.DEV.	MIN	MAX
POP	893.71	1611.5	100.30	9330.7
UA	19.358	10.563	7.1800	55.900
UC	44.536	19.069	20.010	100.00
SD(A)	11.408	7.1471	5.4200	39.880
SD(c)	10.068	4.3591	2.0000	24.710
RHO	0.1639	0.2297	0.0000	0.9000
PCTNOP	0.1292	0.1478	0.0031	0.4580
PCTMON	0.1018	0.1358	0.0009	0.5216
PCTCOM	0.7690	0.2815	0.0200	0.9960

	<u>ABSOLUTE SORTING ON RESERVATION PRICE</u>			
W	0.2577	0.2039	0.0036	0.6243
QDIF	0.0786	0.1321	-0.0029	0.5997
NDIF	0.0622	0.9391	-0.0014	0.4575
CSDIF	0.0248	0.0675	-0.0018	0.4315

	<u>ABSOLUTE SORTING ON STRENGTH OF BRAND PREFERENCE</u>			
W	0.3249	0.1413	0.0025	0.7528
QDIF	0.0029	0.0147	-0.0162	0.0782
NDIF	0.0277	0.0327	-0.0043	0.2149
CSDIF	-0.0025	0.0065	-0.0209	0.0315

	<u>SELF-SELECTION ON RESERVATION PRICE</u>			
W	0.1629	0.1462	0.0034	0.5044
QDIF	0.0492	0.0864	-0.0028	0.3895
NDIF	0.0422	0.0677	-0.0029	0.3564
CSDIF	0.0107	0.0350	-0.0045	0.2407

	<u>SELF-SELECTION ON STRENGTH OF BRAND PREFERENCE</u>			
W	0.1989	0.1106	0.0000	0.6009
QDIF	0.0020	0.0101	-0.0139	0.0533
NDIF	0.0151	0.0250	-0.0118	0.1668
CSDIF	-0.0008	0.0085	-0.0216	0.0468

# REGRESSIONS OF CHANGE IN NUMBER OF FIRMS WITH DISCRIMINATION ABSOLUTE SORTING

## Sorting on Reservation Price (A) (t-statistics in parentheses)

$$\text{NDIF} = 0.009 - 0.015 * \text{PPA} + 0.035 * \text{AMN} + 0.001 * \text{AC}$$

(0.6)      (-0.3)                      (8.0)                      (0.2)

$$\text{CRSQ} = 0.52 \quad \text{F-stat} = 28.3 \quad \text{SSR} = 0.297 \quad \text{NOB} = 75$$

$$\begin{aligned} \text{NDIF} = & 0.082 - 0.18 * \text{PPA} - 0.16 * \text{UAA} + 0.083 * \text{UCA} + 0.11 * \text{PPCR} \\ & (4.6) \quad (-1.9) \quad (-2.7) \quad (1.8) \quad (0.2) \\ & - 0.28 * \text{UACR} + 0.075 * \text{UCCR} \\ & (-0.9) \quad (0.5) \end{aligned}$$

$$\text{CRSQ} = 0.18 \quad \text{F-stat} = 3.78 \quad \text{SSR} = 0.490 \quad \text{NOB} = 75$$

## Sorting on Strength of Brand Preference (c) (t-statistics in parentheses)

$$\text{NDIF} = 0.004 + 0.012 * \text{PPC} + 0.015 * \text{BMN} + 0.0024 * \text{BC}$$

(0.5)      (0.4)                      (2.3)                      (3.2)

$$\text{CRSQ} = 0.12 \quad \text{F-stat} = 4.37 \quad \text{SSR} = 0.0669 \quad \text{NOB} = 75$$

$$\begin{aligned} \text{NDIF} = & 0.022 + 0.026 * \text{PPC} + 0.06 * \text{UAC} - 0.02 * \text{UCC} - 0.065 * \text{PPAR} \\ & (3.2) \quad (0.7) \quad (1.9) \quad (-1.3) \quad (-0.4) \\ & - 0.22 * \text{UAAR} + 0.13 * \text{UCAR} \\ & (-1.4) \quad (1.5) \end{aligned}$$

$$\text{CRSQ} = -0.01 \quad \text{F-stat} = 0.87 \quad \text{SSR} = 0.074 \quad \text{NOB} = 75$$

REGRESSIONS OF CHANGE IN CONSUMER SURPLUS WITH DISCRIMINATION  
ABSOLUTE SORTING

Sorting on Reservation Price (A)  
(t-statistics in parentheses)

$$\text{CSDIF} = -0.015 + 0.016 * \text{PPA} + 0.019 * \text{AMN} - 0.0005 * \text{AC}$$

(-1.1)      (0.3)                      (4.9)                      (-0.1)

$$\text{CRSQ} = 0.27 \quad \text{F-stat} = 10.2 \quad \text{SSR} = 0.240 \quad \text{NOB} = 75$$

$$\begin{aligned} \text{CSDIF} = & 0.028 - 0.07 * \text{PPA} - 0.11 * \text{UAA} + 0.067 * \text{UCA} + 0.070 * \text{PPCR} \\ & (2.1) \quad (-1.0) \quad (-2.4) \quad (1.8) \quad (0.2) \\ & - 0.16 * \text{UACR} + 0.035 * \text{UCCR} \\ & (-0.7) \quad (0.3) \end{aligned}$$

$$\text{CRSQ} = 0.06 \quad \text{F-stat} = 1.85 \quad \text{SSR} = 0.290 \quad \text{NOB} = 75$$

Sorting on Strength of Brand Preference (c)  
(t-statistics in parentheses)

$$\text{CSDIF} = -0.0026 + 0.0092 * \text{PPC} + 0.0057 * \text{BMN} - 0.0003 * \text{BC}$$

(-1.9)      (1.9)                      (5.1)                      (-2.1)

$$\text{CRSQ} = 0.32 \quad \text{F-stat} = 12.71 \quad \text{SSR} = 0.0021 \quad \text{NOB} = 75$$

$$\begin{aligned} \text{CSDIF} = & -0.003 + 0.003 * \text{PPC} - 0.006 * \text{UAC} - 0.0001 * \text{UCC} \\ & (-2.2) \quad (0.4) \quad (-1.0) \quad (-0.1) \\ & + 0.003 * \text{PPAR} - 0.076 * \text{UAAR} + 0.054 * \text{UCAR} \\ & (0.1) \quad (-2.6) \quad (3.2) \end{aligned}$$

$$\text{CRSQ} = 0.11 \quad \text{F-stat} = 2.57 \quad \text{SSR} = 0.0026 \quad \text{NOB} = 75$$

## FOOTNOTES

- 1 In this paper, 'product' refers to the good produced by all firms in the market. 'Brand' refers to a particular firm's output.
- 2 Competing brands refers here to flights that differ by departure time, airline, in-flight amenities, etc.
- 3 The model can be generalized to downward sloping demand curves. The modifications made in section 3 are an example of such a generalization.
- 4 Throughout this paper, customer location refers to the customer's most preferred point in product space.
- 5 Salop does not consider reservation prices explicitly, but his reference to an outside good is equivalent. Salop's condition for purchase of a unit is  

$$U - P - c|z - X| > v,$$
where  $v$  is the surplus derived from the outside good. It is clear that  $A$  in this model is equal to  $U - v$ .
- 6 The kink at the competitive-monopoly switch point can lie above or below  $P'$  depending on whether neighboring firms distances to their monopoly borders,  $(A - P')/c$ , are greater or less than half the distance between firms.
- 7 Furthermore, luring away customers of neighboring brands gets more and more difficult since those closer to a neighboring brand are receiving greater net surplus from it. Thus, a unit decline in  $P_x$  brings in fewer extra customers in this region.
- 8 There is another jump at  $P_x < P' - 2c/N$  as firm  $X$  also takes over the market of brands adjacent to its neighbors. Another jump exists at  $P_x < P' - 3c/N$ , etc.
- 9 Footnote 8 does not apply here since all sales are lost at  $P_x > P' + c/N$ .
- 10 Greenhut and Ohta [13] have studied price discrimination when buyers differ only in location. They find that each firm will discriminate against buyers nearer to itself. This is an important guide to studying producer markets, where sellers are likely to know the geographic location of their customers. In consumer markets, however, the producer of a given brand is unlikely to know, or have a good signal of, which of his customers are located closer to the firm in geographic or product space. It would, for instance, be very difficult for a drug store to determine accurately how far customers drove to get to the store, particularly once customers knew that the answer would affect their purchase price. Similarly, an airline would



be hard pressed to find out which of two passengers on the 6 p.m. flight wanted to leave at 6 p.m. and which would have preferred a 5 p.m. departure. Signals of A and c are, on the other hand, more commonly available, as illustrated by the airline example in section 1. For this reason, we look at an economy in which people have different ordered pairs, (A,c).

- 11 For instance, resale between groups is probably much less of a problem for department stores when they discriminate intertemporally with sales than if they were to offer lower prices to, say, senior citizens. If older people could buy appliances more cheaply, many people would have their grandmother buy their new dishwasher.

$$12 \quad \frac{A_0 - A}{|A_0 - A| + SD(A)/u} = \frac{(A_0 - A)/SD(A)}{|A_0 - A|/SD(A) + 1/u}$$

- 13 If v is also small, the  $u/(u+v)$  term may not be near zero, but the second expression in the term goes to 0 independent of the value of v.

- 14 Perhaps, the best explanation for the widespread use of self-selection is a legal one. Firms find it easier to cost justify a lower price for some customers, if those people have gone to some inconvenience to obtain the discount. In many cases, there is, in fact, some cost differential. Airlines might do some rescheduling and aircraft repositioning based on advanced purchases for flights. It has also been suggested that supersaver seats are partially a peak-load pricing scheme since their number is very limited on busy flights. But, even if there is no cost basis, the appearance of selling a "different product" accompanies self-selection as it hardly ever could with sorting based on age, student status, or some other absolute criterion.

- 15 The marginal revenue function at  $P_x = P'$ , for instance, is calculated as  $(d\text{Revenue}/dP)/(dq/dP)$  since equation (6) cannot be inverted. The denominator of this expression is the derivative of (6) with respect to P and the revenue function differentiated in the numerator is P times equation (6).

- 16 Borenstein [3] presents a much simplified example in which there are two types who differ only in their A values. In that model, there are 9 distinct regions of discriminatory equilibria.

- 17 This is true at least when group sizes resulting from different sorts are about the same. Clearly, large W's can result when a small tail of the distribution is sorted out as one group. It would only be useful to compare the W from such a sort with other sorts that yield equally

imbalanced group populations.

- 18 In model I, sorting is powerless when the density functions of the two populations are identical.
- 19 In model I, this means that the populations have the same distribution of  $c$  values.
- 20 In the regressions, the parameters of the population,  $PP$ ,  $UA$ ,  $SD(A)$ ,  $UC$ ,  $SD(c)$ , and  $RHO$  are those values calculated from the portion of the density function in the positive  $(A, c)$  quadrant.
- 21 The usual caveat regarding interpersonal utility comparisons is, of course, relevant to this discussion of welfare. Since there are no economic profits, however, welfare analysis can be focused entirely on the consumer surplus of the people in each group. Calculation of the total surplus of each group is a straightforward extension of the quantity equations in appendix A and is also presented there.
- 22 Not all consumers can be served monopolistically, however, in a zero-profit equilibrium. This would mean that there would be gaps between firms' (largest) markets. Except for the integer constraint on firms or the zero-probability event that such firms are just breaking even, such gaps would bring new entry until firms' markets for some types were constrained by neighboring brands.
- 23 Finite price changes require consideration of movements of some consumer types between the monopoly, competitive and no-purchase regions. A consumer type could, for instance, go from the competitive region to the monopoly region and some in the type would stop buying.
- 24 These and the following calculations assume that  $dP'/dP_x = 0$ . The reasoning, however, is not changed by a conjectural variation in price that is greater than 0.
- 25 Again, this statement is strictly correct only for infinitesimal price changes.
- 26 For technical reasons in the computer program, neither  $s$  nor  $t$  could be set equal to 0.
- 27 This calculation assumes that the entire distribution lies in the positive quadrant so that the relevant distribution is normal and the median is equal to the mean.

## Chapter Three: The Effect of Discount Fares in the U.S. Domestic Airline Industry

### INTRODUCTION

With a theory of price discrimination in free-entry markets established in chapter 2, we now examine price discrimination in the U.S. domestic airline industry. The U.S. airlines have been undergoing a process of deregulation for the last five years. In that time, one carrier has gone bankrupt, at least three have merged into larger airlines and 11 new scheduled carriers have begun operating.<sup>1</sup> Deregulation has also greatly increased the flexibility airlines have with their fare structures and the restrictions they can place on discount fares. As a result, the variety of fares available on most routes has grown substantially. Many of the fares have restrictions attached that make them too costly for certain segments of the market to use, usually business travelers.

It has been suggested that the discount fares currently available are cost based, either on a peak-load pricing basis or as a result of direct cost differences in serving different types of customers. These explanations are examined and compared to the theory that price dispersion in the airline industry is an example of monopolistically competitive price discrimination. (Throughout this chapter, 'price dispersion' refers to different prices that a carrier charges to different groups of customers for flights on the same route.) We find

that discount fares cannot be explained by the direct cost differences that are usually suggested. Peak-load pricing, however, is very difficult to distinguish from price discrimination. In both cases, certain joint costs of production are distributed across groups of consumers according to the strength of demand in each group. Though the effect of the airline fare structure is to charge higher prices at times of peak demand, this could also result from recognition that the demand characteristics of individual customers at peak times differ from those of the average off-peak traveler. Furthermore, advance-purchase, minimum-stay and other observed restrictions cannot easily be explained in peak-load pricing terms.

Whether price dispersion on a route is primarily peak-load pricing or simply price discrimination, it can be beneficial to society. One measure of these benefits is the effect on industry output. After a description of the widespread use of discounts, we turn to estimating the effect of price dispersion on industry output. The results are surprising.

Though output was apparently increased by the few discounts that were allowed in 1975, by 1982 the effect seems to have changed. The evidence for 1982 indicates that routes with substantial price dispersion generate less traffic, all else equal, than those with unrestricted low coach fares. These findings come from estimating air travel demand functions for 1975 and 1982 markets. The result of decreased

output due to price dispersion is not robust, but in no case do the 1982 regressions indicate that dispersion raises output in a market in comparison to a market with the same average fare and no price dispersion. The 1975 results, on the other hand, are quite robust.

Sections 2 and 3 describe the structure of the airline industry and the nature of competition before and after deregulation. In section 4, the explanations for the persistence of multi-tier fare structures are examined. The data for the statistical analysis and their sources are described in section 5. In section 6, I present a summary overview of price dispersion before and after deregulation. This is done by examining sample correlations between measures of dispersion and route characteristics such as distance, average fare and concentration. In section 7, the demand function to be estimated is set forth and the results of the estimation are analyzed. In the conclusion of the chapter, the results are related back to the model of price discrimination in chapter 2.

## SECTION 2

To understand the nature of the airline industry during and since deregulation, it is useful to follow the developments in the industry in the previous years. What could be called the modern era of airlines and airline regulation began around 1964 when jet aircraft became the primary equipment in the fleets of the major carriers. The new planes were faster, more efficient and more reliable than propeller planes. They lowered airlines' operating expenses substantially; carriers costs per available seat-mile (ASM) fell 21% between 1960 and 1969. In conjunction with the strong economic growth of the mid 60's, lower operating costs brought about large increases in carriers' profits. In the six years from 1964 to 1969, the trunk airlines had an average return on equity of 13.3% versus a 3.9% average in the six years prior to 1964.<sup>2</sup>

During the 1960's, the structure of the industry was quite stable due in great part to regulation. There were three tiers of firms: the 12 large trunk carriers, which provided about 95% of all revenue passenger-miles (RPM's) and all service on longer routes; the local service airlines, which served some short profitable routes and all city-pairs on which the government subsidized service; and over 200 commuter air carriers that were restricted to propeller aircraft with no more than 30 seats and were almost never allowed to compete with the bigger firms. Commuter carriers have always provided specialized short-hop service and have

had very limited reporting requirements from the CAB. Even with their rapid growth that has followed deregulation, they still account for only 1% of the RPM's in the industry.

There were also a number of intrastate carriers, primarily in California, Alaska, Texas and Florida, that operated completely outside the CAB's jurisdiction prior to deregulation. State governments imposed some restrictions on their behavior, but the regulations were much less stringent than those that the interstate carriers had to follow. These firms operated in a much more competitive environment than CAB regulated carriers and they were generally acknowledged to have lower costs and more efficient management.<sup>3</sup>

The trunk airlines that existed in 1969 were 12 of the 16 that had been operating in 1937 when regulation of commercial aviation began. Though the CAB received many applications for certification of new trunk airlines, not a single one was granted between 1937 and 1975. The local service carriers were certificated following World War II for the sole purpose of providing service on subsidized routes. Soon after, however, the Board realized that allowing them also to operate on some profitable routes would permit the government to pay out smaller subsidies without threatening the financial health of this second tier of carriers. Thus began the time-honored and publicly acknowledged CAB policy of cross-subsidization among routes.

Not only was the number of firms in the industry constant through the 60's and early 70's, each carrier's market share was also virtually unchanged. This was the result of route regulation and the absence of price competition. In order to enter a new market, a carrier had to show that there was a public need for additional service on the route. In many cases the applicant was also required to demonstrate that incumbent carriers on the route would not be harmed by the new entry. These requirements assured that any attempt by an airline to change its route network would be difficult, costly and slow. In 1969, the Board went further, imposing an informal route moratorium (Graham & Kaplan [34], p.13). Though it was never publicly stated as policy, the Board stopped reviewing routine applications for new route authority. From 1969 until 1976, virtually no new route authority was granted.

Coach and first-class air fares were also nearly frozen during the 1960's. Though carrier costs per ASM declined with the introduction of jet aircraft, the only adjustment to standard fares was a periodic \$1 per ticket increase. As operating costs declined and fares did not, carriers increased their quality of service in order to attract more customers. They scheduled additional flights and stressed convenient service in promotional campaigns. Also, in 1969 the first wide-bodied jets, Boeing 747's, were introduced, adding to the emphasis on service quality and further boosting the number of seats airlines had available. After 6 years of relatively



stable 53% to 57% load factors, the increased service started a decline in 1966 that bottomed out in 1971 at 48.3%. Table 1 demonstrates that beginning in 1967 growth in available seats outpaced the growth in sales. The result was lower load factors.

The airlines also received permission to offer discounts to restricted segments of the traveling public. Some of the discounts were new, while others were expansions of the use of previously existing fares. Some seemed at least partially cost based, such as youth standby and night coach, but many made it clear even in the name that they were designed solely to target the discretionary traveler. Family, child, youth and military discounts sorted customers based on marital status, age and occupation, hardly cost justified distinctions. Also, there were 'Discover America' excursion fares in many markets. These were the early self-selective discounts, sorting customers with advance-purchase and minimum-stay requirements. Overall, the discounts brought about an 11% decline in trunk carriers' average yield (fare per mile) during the 1960's despite a slight increase in the standard coach fares.

Then in 1969, the growth in demand for air travel slowed suddenly. With their increased fleet sizes and frequent flights, carriers' profits began to slide. In response, the CAB began the Domestic Passenger Fare Investigation (DPFI). A 1982 CAB report by David Graham and Daniel Kaplan, Competition and the Airlines: an Evaluation of Deregulation [34],

TABLE1

## CHANGES IN RPM's, ASM's, AND LOAD FACTORS, 1960-81

## Domestic Operations, Trunk Airlines

YEAR	CHANGE RPM's	CHANGE ASM's	LOAD FACTOR	YEAR	CHANGE RPM's	CHANGE ASM's	LOAD FACTOR
1960	3.9%	7.3%	59.5%	1971	1.9%	4.1%	48.3%
1961	1.0	6.9	56.2	1972	10.7	2.0	52.4
1962	7.8	13.7	53.3	1973	6.6	7.7	51.9
1963	14.3	13.2	53.8	1974	2.0	-5.1	55.7
1964	14.5	11.3	55.4	1975	1.6	3.3	54.8
1965	17.6	17.9	55.2	1976	10.0	8.1	55.8
1966	16.0	9.5	58.5	1977	7.5	7.2	55.9
1967	25.0	27.8	57.2	1978	16.2	6.6	61.2
1968	15.0	23.9	53.0	1979	10.1	6.6	63.2
1969	9.3	16.1	50.3	1980	-6.9	0.8	58.3
1970	0.3	2.3	49.3	1981	-5.4	-3.6	57.3

---

Source: CAB, Air Carrier Traffic Statistics

describes the DPFI as 'the first time in the Board's thirty-year history that it explicitly considered the structure of fares' (Graham & Kaplan [34], p.68).

One result of the DPFI was to curtail drastically the airlines' use of discount fares. All restricted fares, with the exception of night coach, were found to be discriminatory and, in general, not in the public interest. The Board did not prohibit night coach discounts, but did rule that further off-peak discounts would not be permitted. The Board argued that expansion of off-peak discounts would harm travelers because they would be confusing to the public and costly for the airlines to administer (DPFI [36], Phase 9).

The DPFI had wideranging impact on the fare structure.

For the first time, fare levels were tied to a target load factor, 55%. Also, the new fare formula recognized explicitly that per-mile costs of flight decline on longer flights. The 'fare taper' adopted was based on a fixed cost per passenger plus a per-mile cost that was lower after 500 miles and declined again beyond 1500 miles. Though the concept was correct, it was widely agreed at the time that the taper was not significant enough to completely end the overpricing of long flights and underpricing of shorter flights. The investigation also failed to recognize any possible economies of scale that might affect costs on relatively dense routes, e.g., from increased aircraft utilization, use of larger aircraft or more intense use of a carriers' airport facilities.

The DPFI ended in 1974. Within a year, however, carriers were again proposing new discount fares. Calls for deregulation of the industry were also spreading, not from the airlines, but from economists, politicians and public interest groups. Though most of the carriers opposed deregulation, they quickly took advantage of the flexibility in fare structures that was the first significant result of the deregulation movement.

### SECTION 3

Though the Airline Deregulation Act (ADA) was not passed until late in 1978, CAB policies began to reflect its spirit as much as two years earlier. The rapid success of these policies, measured by lower fares, traffic growth and increased carrier profits, is widely recognized as having smoothed the path of the ADA through congress. The existence of successful intrastate carriers with substantially lower fares and higher load factors was also a strong indication that CAB regulation was producing an inefficient price/quality mix.

The first move the CAB took towards increased competition was in 1976, when it substantially liberalized the requirements for charter air transportation. Scheduled carriers saw the threat that this posed and responded with their own discount proposals. In early 1977, American Airlines was granted permission for the first 'Super Saver' fares, capacity-controlled discounts (i.e., limited to a fraction of the seats on each flight) of up to 45% with advance-purchase and minimum-stay requirements. Other scheduled carriers quickly followed with similar discounts. In 1978, the Board further loosened charter restrictions, allowing individual ticket sales, which led to the short-lived term 'scheduled charters.' These changes brought widespread discounting. Though unrestricted coach fares remained at the DPFI levels, average yield (fare per mile) adjusted for inflation declined by 8.9% from 1977 to 1978. The proportion of all passengers

paying the standard coach fare declined by nearly 10% (Graham & Kaplan [34], p.72f).

The Board had much less freedom to change its route authority policies, since any new authority had to meet the public necessity test. Still, it managed to make strides in this area by approving virtually all applications on certain newly designated routes. In particular, routes involving two secondary airports near big cities, Oakland airport in the San Francisco Bay Area and Midway airport near Chicago, were designated for 'Multiple Permissive Entry.' These cases gave birth to two new scheduled airlines, Midway Airlines and the former charter World Airways which had failed in at least three previous attempts to receive certification for scheduled service.

With passage of the ADA in October, 1978, the effect of competitive forces increased substantially. Hearings on new route authority were changed to 'show-cause' procedures, under which the burden of proof lay with the party protesting new authority for a carrier. The complaining party had to show that granting of authority to a carrier would substantially harm the public interest. At about the same time, fare regulation was further liberalized by imposition of a 'suspend-free zone'; an airline could set its coach fare as much as 70% below or 10% above the DPFI level without formal hearings.

The year of deregulation, 1978, was the carriers' most profitable in many years. Trunk airlines reported a 17.7% return on equity, the highest in more than a decade. Their 16.2% increase in RPM's was the largest gain since the boom years of the late 1960's. Though part of this was due to a recovering economy, many carriers saw the increases as evidence that they had seriously underestimated the price elasticity of demand.<sup>4</sup> They stepped up orders for new aircraft and some expanded their route systems very rapidly. A few airlines instituted unrestricted low coach fares, while practically all carriers expanded the range of restricted discounts available.

The five years since 1978 have been marked by a number of disruptive events in the airline industry that have clouded economic analysis. There have been major strikes against United in 1979 and Northwest Orient in 1982. The investigation and temporary groundings of all DC-10 aircraft in 1979 seriously affected many carriers. Finally, the firing of 70% of the nation's air traffic controllers in the summer of 1981 has had the most serious and lasting effects on the deregulated industry. Departures were curtailed by as much as 15% during the second half of 1981 and early 1982. In the second quarter of 1982, domestic departures were still only 89% of the 1981 level. Yet, industrywide load factors were about the same as in the second quarter of 1981, indicating that by then the cutback in flights was probably due more to the deepening recession than the PATCO strike. Though the

restrictions on flights affected all airports, the impact was greater at the large and crowded airports. At major hubs where the number of available departure and landing 'slots' was already constraining flights the effect was most severe.

These events have surely slowed the evolution of the deregulated airline industry. It would be absurd to assert that the industry is near a long run equilibrium. Yet, though the airlines continue to change in their number and their strategies, some directions of this evolution are becoming clear. Throughout the analysis in the following section, I assume that these patterns are permanent structural components of the airline industry. In fare structures, a number of persistent strategies are evident. Some carriers, generally ones in short, densely traveled markets, have moved towards unrestricted low coach fares. In most markets, though, low fares still have restrictions attached; advance-purchase, minimum-stay and round-trip requirements remain the most common means of sorting travelers for discounts. In these cases, though, the discounts are capacity-controlled. Airlines vary the proportion of discount seats on different flights over the same route. This has prompted speculation that the airlines are using capacity-controlled discounts as a peak-load pricing system. This theory is explored further in section 4.

Explicit peak/off-peak fare structures have been imposed

on many routes. The off-peak periods are usually Saturdays, Sundays, and late morning to early afternoon on weekdays, as well as the established nighttime discounts. In most cases, a new airline has been the catalyst for peak-load pricing on a route, often then being copied by the incumbent carriers (Graham & Kaplan [34], p.29).

While the discounts discussed so far are clearly targeted at discretionary pleasure travel, one category is intended to attract business travelers. 'Frequent Flyer' programs, first instituted by American in 1978, are obviously intended to compete with other carriers for the fairly inelastic business travel market. The 'bonuses', such as free flights or upgrading of coach tickets to first class, are given to the individual flying while the flight is usually paid for by the firm. These discounts bear a striking resemblance to 'kickbacks' paid to purchasing agents in some industries.

Of course, deregulation has brought many changes to the industry that are not directly related to fare structures. The Board's comprehensive study of deregulation ([34]) made a number of observations on route structures, cost characteristics, capacity utilization, entry barriers and the effects of new entrants into the industry.

#### On Route Structures:

- The established trunk airlines have developed more fully 'hub-and-spoke' systems, increasing operations at their major hubs and routing more traffic through these airports (pp.46-50).



- Local service airlines have expanded from their 'feeder' routes to medium and long haul service. They have some advantage over trunks because their smaller aircraft are more economical for small feeder routes while they are still efficient for medium length flights (pp.47,173).
- New entrants, the former intrastates and charter carriers as well as newly formed companies, have tended to specialize in point-to-point service on high density routes where feed traffic is less important (p.126).

#### On Airline Costs:

- Though the larger carriers may have some cost advantages through economies of scale in maintenance or administration, these have not been shown to be very large (pp.102-124).
- New entrants have lower costs in some areas, particularly labor costs where they are not tied into expensive union contracts that were established during regulation (pp.102-124).
- Large carriers have made some gains in worker productivity since deregulation, but in general, small airlines and new entrants are more efficient (pp.118-124).

#### On Capacity Utilization:

- Load factors have increased on virtually all routes despite the weakness in the U.S. economy since 1979.

This indicates that the inefficient service competition first discussed by Douglas and Miller [9] was quite widespread (pp.166-167).

- Average utilization of aircraft increased rapidly in 1978 and 1979, but has declined with the softening of demand. There is now a glut of aircraft. The lower prices make it less advantageous to keep only a small fleet and maximize utilization. The newer and smaller carriers have maintained higher utilization rates over the years since deregulation (p.178).

#### On New Entrants:

- New carriers have generally entered dense markets, often offering service from a secondary airport, such as Oakland, Midway or Hobby in Houston (pp.126).
- The new airlines often offer service with few amenities: no meals, less convenient ticketing, extra charges for baggage and snacks or drinks on board (pp.126-127).
- Financial success has varied among these firms, with the greatest success coming to the low-cost, short-route operations, particularly Southwest and People Express. Carriers that have gone head-to-head with established trunks, especially in long-haul markets, have not fared as well (pp.130-131).

### On the Effects of Competition:

- The study finds that increased competition has lowered concentration on many routes and that the threat of competition has affected fares on routes that are still fairly concentrated (p.218).
- Competition has lessened carrier reliance on frequent flights to attract customers and has increased emphasis on price competition (pp.208-214).

The study strongly supports the longstanding assertion that entry by an airline into a city-pair is not very costly and that incumbent carriers have little competitive advantage. Since deregulation, the 'local' carriers have increased their share of domestic RPM's from 9% to 12%, primarily by expanding into medium-length routes that are also served by trunk carriers. Between 1978 and 1981, local carriers' RPM's on routes of less than 500 miles have declined by 2.5%, while their RPM's on longer routes increased by 308%. These airlines carried 18% of their passengers on routes of more than 500 miles in 1981, up from 7% in 1978 (Graham & Kaplan [34],p.51).

At the same time, the local airlines have had a consistently higher profit margin, averaging 4.9% since 1978 versus -1.6% for trunk airlines. Year-to-year changes in profit margin have also been higher for the local carriers in every year since deregulation (Graham & Kaplan [34], Appendices A and B).

Though not all of the newly certificated carriers have been profitable, their overall performance has also shown that new entrants can compete successfully. By June of 1981, the new airlines, including former charters and intrastate carriers, carried 7.7% of the domestic traffic and were operating with an average 2.1% profit margin. That was lower than the 6.6% margin of the local airlines, but well above the 0.1% figure that the trunk carriers reported in 1981.<sup>5</sup>

Aggregate data on entry also indicate that it is not difficult. Between 1978 and 1981, entry occurred in 122 of the 200 largest city-pair markets (Graham & Kaplan [34], p.53). High capital mobility and ease of entry are important assumptions in my later analysis of price dispersion. Throughout the following sections, carriers are assumed to exercise no effective power to prevent entry into profitable routes.

## SECTION 4

More than four years after passage of the ADA, it now seems clear that discounting practices are not an artifact of regulation and will not be eliminated by competitive forces. Since 1977, the proportion of passengers paying the standard coach fare has declined in every year, reaching just 25% for the first six months of 1982 (Graham & Kaplan [34], p.72f).

This section presents three possible explanations for the persistence of restricted discount fares in competitive airline markets. The first theory is drawn directly from the previous chapter of this thesis. Airlines are seen as monopolistically competitive firms that sort customers based on reservation price and/or strength of preference among flights or carriers. The second theory explains the observed price differentials as peak-load pricing. On some routes, peak-load pricing is explicit. But even when it is not so obvious, capacity-controlled discounts that are restricted to very few seats during times of heavy demand could fulfill the same purpose. The third explanation is that price differentials could reflect differences in 'no-show' rates among classes of customers. An unclaimed reservation is costly to airlines if it causes a carrier to turn away another customer who would have paid for the seat. Carriers offer full-refund insurance to customers who fail to show up for their flight. If customers vary in their probability of exercising the full-refund option, then in a competitive market we would expect prices to reflect this difference in costs.

## PRICE DISCRIMINATION

In the previous chapter, it was shown that product differentiation can lead to price discrimination, even in free-entry markets with no economic profits. Depending on certain characteristics of the population, firms could target potential customers who have either low reservation prices or weak preferences among the available brands. When these attributes are positively correlated, as they are generally thought to be among airline customers<sup>6</sup>, one sorting device could be effective in making both distinctions.

Furthermore, use of more than one sorting criterion could allow firms to sort customers based on both attributes. This possibility was not considered explicitly in chapter two, but airlines clearly use many criteria simultaneously to sort customers. Whether or not they are cost-based, the plethora of discount fares available on most routes serve to segment the market into many groups. As was shown in chapter two, this ability to segment the market, along with the power to prevent resale, will almost surely lead to some price discrimination.

Using the terminology of the characteristic-space model of chapter 2, it is likely that most of the business travel demand is in the competitive region. Virtually all studies of airlines have assumed that business travelers have a much higher reservation price than those people traveling for personal or tourist reasons.<sup>7</sup> It is generally acknowledged

that few of the marginal buyers of airline services are people traveling on business. Though business travel demand is not very price elastic, it is probably more responsive to scheduling convenience than is personal or tourist travel demand. The common reasoning for this is that business people value their time more highly and therefore find delays from inconvenient scheduling more costly.

There is also reason to think that business travelers have stronger preferences among airlines than other customers. Business people fly most frequently and talk to others who fly frequently. Therefore, they are likely to have better information about differences in product quality. They know which airlines have poor on-time arrival records, which are more likely to lose luggage or which serve the best food. Most business people who fly frequently can name at least one airline that they would avoid.

People who are not traveling on business are less likely to have strong firm or flight preferences, both because the value of their time is lower and because they have less information about quality differences. In terms of the characteristic-space model, their  $c$  values are lower on average. Likewise, their reservation prices are thought to be lower for two reasons. First, payment comes directly out of the customer's income, while business travelers are spending their companies' money. Second, for tourists at least, different destinations are better substitutes for one another. Though high air fares might have some influence on company decisions,

about where to hold meetings for instance, the destination of most business trips is not flexible.

Though lower reservation prices mean that non-business customers are more likely to be marginal buyers, weak brand preferences imply that few such potential purchases would lie in the monopoly region. A lack of variety in flights is not likely to have much influence on the travel decisions of personal and tourist travelers.

If the primary source of differentiation is thought to be departure time, then the overall importance of the monopoly region corresponds to the elasticity of demand with respect to 'frequency delay' (as it was called by Douglas & Miller [9]) This effect is difficult to estimate directly, however, due to the extreme endogeneity of the frequency variable. In a CAB study of air travel demand by Brown & Watkins [4], the effect of scheduling inconvenience was not included for this reason.

Ippolito [14] and Devany [7] tried to estimate the effect of schedule delay. In both cases, the elasticity was not significantly different from 1. An elasticity of 1 implies an unstable market on which profitable flights could be added indefinitely. Thus, these studies illustrate the estimation difficulties more than the importance of flight frequency. Douglas & Miller [9] assert the theoretical importance of frequency delay, but they do not attempt to measure its actual impact on demand. Though it surely has some impact, it seems likely that the number of flights is of far less importance than many other factors.



Even a flight elasticity of 0.2 implies rather unbelievable effects. On a route with six flights (the average in the sample studied) carrying, say, 900 passengers per day, the addition of just one flight would attract 30 extra customers to the route. The new passengers would be people who previously chose not to take this trip because the other six flights did not depart at convenient times. With the addition of a seventh flight, however, (and, possibly, rescheduling of the original six departures) they find a departure time that is so much more convenient that they are induced to take the trip. The number for whom this scenario would hold is certainly very small.

If the monopoly region is assumed to be insignificant, then the market consists of two groups: those purchasing, who will switch carriers if the price differential is large enough, and those whose reservation price is below the market price, but above the marginal cost of carrying an additional passenger.

Of those in the purchasing group, if buyers with weaker carrier or flight preferences can be identified, they are likely to receive discriminatory discounts. If non-purchasers can be sorted out, they will be offered reservation-price based discounts. In chapter 2, it was shown that the effect of either type of sorting on output or welfare is ambiguous, though discrimination based on reservation prices is more likely to have a positive impact.

Of the numerous discounts currently available on domestic flights, most appear to be intended for people with both flexible flying schedules and low reservation prices. Advance-purchase and minimum-stay requirements indicate vacation travel. Simple round-trip restrictions have the same effect because they generally do not allow rebooking of the return flight should the traveler's plans change during the trip.

Not all discounts are good indicators of both characteristics. The 'Take Me Along' fares of the 60's and early 70's allowed a full-fare passenger to bring another adult along for a significantly lower fare. Since the full-fare passenger was usually a businessman, the accompanying adult had equally inflexible travel plans. This was clearly a reservation-price discount.

The current frequent flyer 'clubs' demonstrate the opposite effect. Few would claim that these 'bonuses' generate very much additional traffic, except for the free flights awarded, but they do significantly influence some business travelers' choice of airlines.<sup>8</sup> Those who adjust their plans for this reason are probably business travelers with somewhat less rigid schedules. The president of a large corporation probably would not adjust his itinerary in order to earn a free flight, but a middle-level manager whose time is less valuable is quite likely to respond to these offers.

## Peak-Load Pricing

As stated earlier, one outgrowth of airline deregulation has been the expanded use of peak-load pricing. Night coach has existed for 20 years, but weekend and some midday discounts are also available now. Salop [25] and Graham & Kaplan [34] have further suggested that many of the discounts that are not explicitly for off-peak travel might be used for this purpose by carriers.

The key to this assertion is the capacity controls on nearly all discount fares that are not explicitly off-peak fares. The airline determines how many seats on each flight will be available for sale at the discount price. Under regulation, 'Super Saver' discounts were limited to 35% of available seats and carriers used the 35% figure as a guideline for most flights. Since deregulation, airlines have made expanded use of their option to vary the number of discount seats available on each flight. By doing this, airlines are able to raise the average fare for flights at peak times and lower the average fare on off-peak flights.

In a 1978 CAB memo [25], Salop discussed the use of such capacity-controlled discounts:

'...Efficiency improves in two ways: First, since off-peak fares are effectively lower, load factors rise on these flights; fewer seats are wasted. Second, the higher fare paid by the marginal passengers at peak times serves to ration scarce seats to those passengers with greater willingness-to-pay.'

'Consider the following example in which price elasticity effects are ignored. A carrier designates 50 discount seats and 50 full-fare seats on a 100 seat airplane. Half the potential passengers have high

willingness-to-pay. Suppose that off-peak demand is 50 passengers, half low value and half high value. Since there are 50 discount seats, all pay the discount price. Suppose the peak-demand is 150 passengers, half with each willingness-to-pay level. If neither group reserves earlier on average, the discount seats will be purchased, half (25) by low value and the rest (25) by high value passengers. If the full-fare is set somewhere between the two values, all 50 full-fare seats will be purchased by high value passengers. Thus, 75 high value and 25 low value passengers actually fly.'

'In contrast, a single price system would have 50 high and 50 low value passengers; thus, welfare rises in the two price system.'

But if airlines want to adjust prices during peak times, why don't they do it explicitly? One explanation is offered by Graham & Kaplan ([34], p.93f). They point out that demand fluctuations are so numerous that an appropriate pricing scheme would be too difficult to administer. For instance, not only is demand higher around 5 p.m. on weekdays than at other hours, it is greater during the rush hour on Thursday than on Monday, Tuesday or Wednesday, and greater still on Friday (Douglas & Miller [9], p.34-35). Carriers would need a separate price structure for virtually every flight. Furthermore, practically any change in booking would alter the price a passenger pays and thus require rewriting of his or her ticket. With the capacity-controlled discounts, changes that approximate optimal pricing can be made internally by the airline.

Another advantage of the two price system is that it

adjusts to stochastic as well as predictable demand fluctuations. As Salop points out, the cost of the marginal seat rises as the flight fills up. Of course, this adjustment could also be made by auctioning, or allowing resale of tickets for each flight. But, again, administrative costs, as well as the uncertainty imposed on all passengers (not just the marginal buyer), make such a scheme unattractive to carriers.

Though the argument is convincing that these fares could be peak-load pricing, this by no means weakens the assertion that they are also discriminatory. All the peak-load effects discussed here could be realized without attaching advance-purchase, minimum-stay, round-trip or other restrictions. Of course, even without the additional restrictions, any capacity-controlled discount carries an implicit advance-purchase requirement. If the first  $N$  seats on a flight are sold at a lower price, then customers who buy tickets closer to the departure time would pay a higher price on average. This could be purely peak-load pricing though. The implicit advance-purchase requirement would adjust with demand, while the fixed 7 or 14 day advance-purchase restriction does not. The current restrictions on most capacity-controlled discount fares have no clear connection to peak-load pricing.

In addition, if time of demand is a good signal of a customer's reservation price and/or strength of brand preference, then we should expect that airlines might be able to use that signal to price discriminate. They could establish price

differentials that exceed the peak-load based cost differentials. This argument applies to explicit peak-load prices as well as capacity-controlled discounts. Say, for example, that carriers know that people who prefer to fly at rush hour tend to be business travelers and thus would have a higher cost of switching flights than do other customers. These people can be identified as having stronger flight preferences and, as the model in chapter two indicates, they would be less likely to receive competitive price cuts from rival airlines.

Still, the price cuts offered on some off-peak flights would never cause prices to be below the marginal cost of those flights. Rather, each passenger on those flights would just make a smaller contribution towards covering fixed costs, such as aircraft depreciation, periodic maintenance, or company overhead. This is the case whether the discounts are peak-load pricing or price discrimination based on the signal given by the timing of demand. Likewise, no matter what the basis for these discounts, they will have the effect of diverting some demand from peak to off-peak periods.

The essence of this discussion is an age-old issue of allocating joint costs over multiple outputs. By allocating joint costs according to the strength of demand for each output, are competitive firms price discriminating? Ramsey pricing, for instance, is second-best for a declining cost firm, yet it is generally agreed to be discriminatory. Kahn [17] discusses this issue at length.<sup>9</sup> He claims that there is a clear distinction between cost-based and discriminatory

allocation of joint costs. Youth standby discounts were discriminatory, he argues, even though they offer an inferior service, because the fare was offered 'selectively.' Yet, he then states that '[t]he market for seats on each flight could be further differentiated, without discrimination, by letting passengers bid and pay varying prices, depending on the amount of advance assurance they require with respect to their having a reserved seat' (Kahn [17], p.76f). Since any customer has the option of paying a lower price for a less assured seat, he seems to argue, the pricing is not discriminatory. This association of self-selection with cost-based pricing is not uncommon, but as chapter two points out, it is incorrect.

Robert Frank offers another interpretation of 'cost-based' discounts in a paper entitled "When are Price Differentials Discriminatory?" ([10]). Frank argues that discounts for people with flexible travel plans are 'cost based'. It is the customers with strong preferences among departure times who prevent carriers from operating fewer flights with larger, more economical planes. Thus, it is efficient for those passengers to pay higher fares. Though Frank offers no rigorous support for his assertion, i.e., the cost basis is not shown mathematically, his argument is certainly compelling for its equity considerations. If a group of customers demand a higher quality product and economies of scale make it more efficient to produce only one quality level, then customers who do not value the higher quality should not be required to pay the additional cost for

the quality increase.

In theory, however, the issue of which discounts are discriminatory is not of direct interest. We know that there is a set of prices that maximizes welfare (either according to the Marshallian measure or some other social welfare function). The question of interest is what those prices are or, at least, among the alternative pricing schemes, which yields the highest welfare. In chapter two, however, it was made clear that when products are heterogeneous, sorting customers according to criteria that are not cost based can have positive effects on output and welfare. The distinction between discrimination and peak-load pricing is useful only if it aids in determining the direction of output and welfare effects. In this case, price dispersion is probably the result of both price discrimination and peak-load pricing. Empirical separation of the effects is probably not possible.

For this reason, I do not discuss further the peak-load versus discriminatory pricing issue. Of greater interest is the effect of price dispersion on the allocation of resources. In section 7, this question is addressed by estimating the effect of price dispersion on quantity, that is, total traffic on a route. Keeping in mind the peak-load pricing and discrimination theories, we attempt to study the welfare effects of price dispersion by looking at its results rather than its causes.



### 'No-show' Insurance

One theory suggested to explain price differentials is rooted in the direct cost differences between serving the average discount and full-fare passengers. When airlines confirm reservation, they agree to refund the price of the ticket and charge no penalty if a customer fails to show up for the flight.<sup>10</sup> As with any other insurance contract, if there are characteristics of the consumer that signal the cost of supplying insurance to her, the insurer will want to use that information to set prices. Carriers argue that business travelers have higher 'no-show' rates. A vacation traveler who plans months ahead, and has hotel or tour reservation at her destination, is much less likely to miss her flight.

Though the theory is surely correct in pointing out a source of some cost differential, it is difficult to believe that the cost could be very large. Consider the situation under which a 'no-show' is costly to the carrier. Assume that there is no overbooking. Since carriers overbook only when it is expected to lower the losses due to 'no-shows', ignoring overbooking can only bias upward the estimated cost of 'no-shows.'

'No-show' insurance is costly to the carrier when a reserved seat that goes unclaimed could have been sold to another customer. Immediately this rules out all flights that never reach capacity in reservations. Since average load-factors are around 60%, it is almost surely the case the half of all flights never fill.<sup>11</sup> When a business person holds

a reservation on a full flight, assume that there is a 0.15 probability that he or she will not show up.<sup>12</sup> In such cases, assume that there is a 0.8 probability that the seat cannot be sold to someone else who is 'standing by' (currently, standby discount fares are virtually nonexistent on domestic flights, so the replacement passenger would pay full fare). This probability is likely to be much too high since full flights usually occur at predictable peak demand times when many business travelers just arrive at the airport and take the next available flight. If the seat goes unsold, the carrier loses the full fare, but it also saves costs that are directly passenger related, e.g. food, drinks, baggage handling and some of the ticketing costs. Passenger related costs are estimated to be about 22% of the price of a ticket. (Graham & Kaplan [34], p.78) However, this includes advertising and other costs that cannot be eliminated in response to a late cancellation. So, assume that carriers costs decline by 5% of the ticket price.

The expected lost net revenue due to a 'no-show', with no overbooking allowed, would then be

$$\begin{aligned} E[\text{No-show cost}] &= 0.5 * 0.15 * 0.8 * 0.95 * (\text{ticket price}) \\ &= 0.057 * (\text{ticket price}) \end{aligned}$$

Under these extreme assumptions and assuming that discount flyers always show up, the cost-justified discount would be 5.7%. If overbooking alleviates some of the cost, as we would surely expect it to do, the figure is even lower. Thus, it seems extremely unlikely that the cost of no-show insurance

could account for more than a very small fraction of the 20% to 50% discounts available in most markets.

## SECTION 5

Data for the statistical analysis in sections 6 and 7 came from numerous sources. This section reviews those sources briefly and explains the construction of the indexes used in the analysis. Detailed descriptions and references for each data series are presented in appendix A. Statistical summaries of the data are also in the appendix.

Table 2 summarizes the definitions of all the variables. All of the airline industry data were for the second quarter of 1975 and 1982. The year 1975 was chosen as a pre-deregulation base because it was the last year before any of the changes associated with deregulation were made and because in the second quarter of both 1975 and 1982, the economy was in the midst of a recession. The second quarter of 1982 was the most recent period for which all necessary data were available when this study began.

All of the traffic data and the fare data for 1982 came from the CAB Origin and Destination Survey (O&D Survey). The O&D Survey is a 10% sample of all airline tickets. The traffic variables OD7 (for 1975) and OD8 (for 1982) came from Table 8 of the survey, which includes only 'local' passengers, those who begin and end their trips at the cities listed. 'Through traffic', passengers traveling on the route as part of a longer itinerary, are not included. A subsample of the survey was the source for the fare and traffic breakdowns, by fare classification and carrier, for 1982. This data set is on a CAB computer tape referred to as the O&D 'Dollar Amount

TABLE 2  
DEFINITIONS OF VARIABLES\*

<u>NAME</u>	<u>DEFINITION</u>
OD7,OD8	'Local' Traffic, 2nd quarter
CR8	Number of airlines carrying more than 0.5% of passengers on the route.
HF8	Herfindahl index, by share of passengers. (range: 0-1)
DT	Route distance (miles)
NR	Dummy variable for airports less than 100 miles from a larger hub airport.
FR7,FR8	Average fare of included fare categories: Y,YD,YE,YN,K
YLD7,YLD8	Fare per mile (FR/DT)
S07,S08	Nonstop flights per week -- one direction
S17,S18	One-stop flights per week -- one direction
NEWSH8	Share of passengers carried by an airline that was certificated after deregulation (0-1)
TGR	Proportion of hotel revenues in state the SMSA is in that derive from customers classified as 'Tourist' or 'Group/Convention' (0-1) - by SMSA
TRISM	Hotel revenues from customers classified as 'Tourist' or 'Group/Convention' (dollars) - by SMSA TRISM = SMSA Hotel Revenues * TGR
TRPCT	Proportion of Total SMSA business revenues derived from 'Tourist' or 'Group/Convention' hotel revenues (0-1) - by SMSA TRPCT = TRISM/SMSA business revenues
TRISX	Weighted average of endpoint TRISM's (dollars)
TRINX	Weighted average of endpoint TRPCT's (0-1)

---

\* Variables end in '7' when they are for the 1975 sample, in '8' when they are for the 1982 sample.

TABLE 2 (cont.)

## DEFINITIONS OF VARIABLES\*

<u>NAME</u>	<u>DEFINITION</u>
PPG7,PPG8	Geometric mean of endpoint SMSA populations
PIA7,PIA8	Mean of endpoint per capita incomes (dollars)
ENP7,ENP8	Total enplanements at an airport, 2nd quarter
D1A7,D18 D1A8	Dispersion index -- spread of fares (0-1)
D27,D28	Dispersion index -- Average Discount from Standard Coach Fare

---

\* Variables end in '7' when they are for the 1975 sample,  
in '8' when they are for the 1982 sample.

of Fares, DB1 Summary Computer Tape.' The five primary coach classifications were included in the study:

- 1) Y - Standard Coach
- 2) YD - Discount Coach
- 3) YE - Excursion Coach
- 4) YN - Night Coach
- 5) K - Economy

These data were used to construct FR8 and the 1982 dispersion indexes. The 1063 routes used in the sample were all city-pairs on which the DB1 summary included over 500 observations in these 5 fare categories combined. Local traffic on the routes, according to the O&D Survey, Table 8, ranged from an average of 42 per day to 7200 per day.

Though there is a great deal of inconsistency in reporting, capacity-controlled discounts are usually reported in the YD and YE categories. Unrestricted fares that are well below the standard coach levels in the market generally are counted as K-fares. Excluded from this study were all first-class, military and other less common fare classifications. The computer tape includes the revenue collected and passengers by route, by carrier, by fare classification. Thus, for every route, the average fare in each class for each carrier could be calculated.

The Official Airline Guide (OAG), the standard industry source for flight information, provided the number of flights per week (S07,S08,S17,S18). In 1975, when fares structures were much less complicated, the OAG also contained all fares. The proportion of traffic in each fare classification for 1975 came from the O&D Survey, Table 13. From these data, FR7 and

the 1975 dispersion indexes, D1A7 and D27, were calculated.

Information about cities, such as population (PPG7,PPG8), per capita income (PIA7,PIA8), hotel revenues (used in TRISM), and business revenues (used in TRPCT), came from the U.S. Census. The direct sources were the State, City and County Data Book, 1975 and the State and Metropolitan Area Data Book, 1982. The data that were used were for the Standard Metropolitan Statistical Area (SMSA) in which each airport was located.

The NR variable indicates airports that are within 100 miles of a significantly larger airport. Not all such facilities are included because the CAB groups data for some airports that are close together. Love field and Dallas-Ft. Worth Airport are reported together, for instance, while Oakland and San Francisco airports are reported separately. The Board has found that there is reluctance by passengers to using the smaller airport when a larger hub is nearby.<sup>13</sup> This variable and the enplanements data (ENP7,ENP8) came from the Federal Aviation Administration's, Airport Activity Statistics.

The Census of Service Industries provided a very useful measure of tourist activity. Table 10 of the 'Hotels, Motor Hotels, and Motels' section is 'Principal Class of Customer for the United States and States: 1977.' For each state, the table gives a breakdown of total hotel revenues into 'Commercial', 'Tourist', 'Group/Convention', and 'Other/Unknown'. From these data, the TGR variable was



constructed. Data are not reported for Idaho or Rhode Island, so the 10 routes that involved these states were eliminated from the sample.

Indexes had to be created in two instances in the analysis. Two indexes were created to measure the amount of price dispersion on a route. In addition, an index was formed to measure the proportion of travel on a route that would be tourist.

The first dispersion index, D1, is a measure of the spread of fares around the average fare. The mean absolute deviation (MAD) from a carrier's average fare on a route was calculated for each carrier serving the route. The deviation of each fare was weighted according to the proportion of the carrier's passengers using the fare. This MAD was divided by the carrier's average fare on the route FR. Thus, the index is the average percentage difference between a carrier's various fares and its average fare. This does not correspond to the W measure in chapter 2, but it also indicates the size of price differentials relative to the absolute level of the prices. The D1 for the route was then a weighted average of each carrier's MAD/FR where the weights were each carrier's market share.

$$(1) D1 = \sum_{i=1}^{CR} \frac{OD_i}{\sum_{k=1}^{CR} OD_k} \frac{MAD_i}{FR_i}$$

where CR is the number of carriers serving the route.

The second dispersion index, D2, corresponds more closely to W in chapter 2. D2 is the average discount from the standard coach fare. With the fare structures so complicated, though, the standard coach fare is difficult to quantify. The weighted average of the carrier's Y-fare and all fares that were at least 95% of the Y-fare was taken to be the standard coach fare (SCF). The index was then the ratio of the carrier's average fare to its standard coach fare.

$$(2) D2 = \frac{\sum_{i=1}^{CR} \frac{OD_i}{\sum_{k=1}^{CR} OD_k}}{SCF_i} \quad \frac{FR_i}{SCF_i}$$

D1 and D2 differ from the W measure in chapter 2 because they take into account both the dispersion of prices and the proportion of customers paying each price. In the characteristic-space model, the criteria used to sort customers were assumed to be exogenous, so firms had no control over the proportion of customers who pay each price (except, with self-selection, through the price differential). In fact, carriers consider the sorting effects of different criteria quite carefully. Though the theory in chapter 2, ignores this, the D1 and D2 indexes do not. If a discount fare is used by a very small proportion of all passengers, then no matter how low the fare is, it has little effect on the indexes. Low fares that few passengers pay will have very little effect on the average fare or the mean absolute deviation. The assumptions made here are that the results from chapter 2 carry over to tests that yield varying size groups, and that the output and welfare changes become smaller as the sizes of

the two sorted groups become more imbalanced. Obviously, this is true in the extreme cases when all consumers are sorted into one of the two possible groups.

Both indexes range from 0 to 1. In its equation (2) form, however, D2 increases as price dispersion declines. Therefore, the D2 used was one minus the D2 in equation (2). Another difficulty arose with the 1975 data because breakdown of traffic by fare classification was not available by carrier. Thus, the indexes were calculated with data aggregated across carriers. In 1975, the SCF of each carrier was the DPFI formula coach fare<sup>14</sup>, so this aggregation does not affect D2. It does affect D1, however, so the equivalent index was constructed for 1982 and both were called D1A. The correlation between D1 and D1A for the 1982 fare data (D18 and D1A8) is 0.85. The correlation between D18 and D28 is 0.71 (see table 6 in section 6).

Though both indexes provide some indication of the price dispersion on a route, D1 is probably a more reliable measure. The D2 index requires the rather arbitrary distinction of what is the standard coach fare. In some cases the SCF applied to a very small proportion of all passengers. On average, 40% of the sampled fares on a route were Y-fares, but on 12% of the routes less than 10% were Y-fares. In such cases D2 is probably not a very good measure on discounting.

As is the case with price dispersion, there is no obvious

measure of the importance of tourist travel on a route. Thus, an index was also constructed to measure this effect. For each of the 132 SMSA's in the sample, an estimate was calculated of the proportion of the total business revenues in the SMSA that came from tourist plus group/convention hotel revenues. The measure is

(3)  $TRPCT = (Hotel\ Revenues * TGR) / (Total\ Business\ Revenues)$   
where TGR is the proportion of hotel revenues from tourist and group/convention in the state in which the SMSA was located. The index ranged from 0.0012, Cedar Rapids/Iowa City, to 0.3724, Las Vegas. Table 3 presents the SMSA's in the sample along with their tourism measure, TRPCT. The third column is just the numerator of (3), the estimate of tourist hotel revenues. Starred cities are those for which the NR dummy variable is equal to 1.

The TRINX variable used to assess the importance of tourism on a route is a weighted average of the TRPCT's of the endpoint cities. The weight for each endpoint, which is explained fully in Appendix A, is approximately the proportion of trips on the route that originate at the other endpoint. For instance, since most trips on the Albany, NY-Miami route originate in Albany, the tourist attractiveness of Miami gets greater weight than that of Albany. The index is the proportion rather than the level of SMSA revenues from tourist hotel expenditures due to the demand equations that are estimated in section 7. The multiplicative form of the function implies that the tourism measure will scale up the value resulting

from the other variables, such as population, per capita income and fare. If other variables provide accurate estimates of the demand for business and personal travel on a route<sup>15</sup>, then the tourist index should be a measure of the tourist demand in proportion to the other demand.

TABLE 3

## CITIES IN SAMPLE AND TOURIST INDEXES

CITY	TRPCT	TRISM	CITY	TRPCT	TRISM
AKRON, OH	0.0020	13.8	FRESNO, CA	0.0050	17.4
ALBANY, NY	0.0045	22.5	GAINESVILLE, FL*	0.0088	7.2
ALBUQUERQUE, NM	0.0089	24.3	GRND RAPIDS, MI	0.0024	10.9
ALLENTOWN, PA*	0.0024	10.4	GREAT FALLS, MT	0.0103	5.4
AMARILLO, TX	0.0070	7.9	GREEN BAY, WI	0.0033	4.0
ANCHORAGE, AK	0.0100	20.6	GREENSBORO, NC	0.0052	22.5
ASHEVILLE, NC	0.0120	11.4	GREENVILLE, SC	0.0039	18.5
ATLANTA, GA	0.0114	173.6	HARLINGEN, TX	0.0166	9.6
AUGUSTA, GA	0.0058	10.7	HARRISBURG, PA*	0.0071	24.9
AUSTIN, TX*	0.0053	17.1	HARTFORD, CT*	0.0022	26.8
BALTIMORE, MD*	0.0025	38.1	HONOLULU, HI	0.0569	310.9
BANGOR, ME	0.0125	9.2	HOUSTON, TX	0.0043	115.1
BATON ROUGE, LA*	0.0040	12.1	HUNTSVILLE, AL*	0.0042	8.0
BILLINGS, MT	0.0172	12.8	INDIANAPOLIS, IN	0.0031	30.9
BIRMINGHAM, AL	0.0035	20.1	PALM SPRNGS, CA*	0.0104	13.7
BOSTON, MA	0.0049	136.1	JACKSON, MS	0.0051	11.3
BROWNSVILLE, TX	0.0168	2.9	JACKSONVILLE, FL	0.0119	53.6
BUFFALO, NY	0.0036	29.9	KANSAS CTY, MO	0.0046	48.4
BURBANK, CA*	0.0046	18.5	KNOXVILLE, TN	0.0093	27.6
BURLINGTON, VT	0.0142	11.5	LAFAYETTE, LA*	0.0040	5.0
CASPAR, WY	0.0143	10.1	LAS VEGAS, NV	0.3724	1214.0
CEDAR RAPIDS, IA*	0.0014	3.8	LEXINGTON, KY	0.0103	21.9
CHARLESTON, SC	0.0102	22.8	LINCOLN, NE*	0.0054	7.3
CHARLESTON, WV	0.0033	6.6	LITTLE ROCK, AR	0.0058	16.3
CHARLOTTE, NC	0.0041	20.7	LONG BEACH, CA*	0.0047	1.3
CHARLOTTSVILLE, VA*	0.0147	9.9	LONG ISLAND, NY*	0.0021	27.7
CHICAGO, IL	0.0049	316.4	LOS ANGELES, CA	0.0049	297.2
CINCINNATI, OH	0.0036	42.0	LOUISVILLE, KY	0.0062	40.1
CLEVELAND, OH	0.0027	44.2	LUBBOCK, TX	0.0054	6.9
COLUMBIA, SC	0.0068	17.3	MEDFORD, OR*	0.0069	4.7
COLUMBUS, OH	0.0040	31.4	MELBOURNE, FL*	0.0122	18.7
CRPS CHRSTI, TX	0.0059	11.9	MEMPHIS, TN	0.0089	52.8
DALLAS/FT.W, TX	0.0049	111.7	MIAMI, FL	0.0270	297.4
DAYTON, OH	0.0026	18.6	MIDLAND/ODSS, TX	0.0056	8.9
DAYTONA BCH, FL*	0.0782	71.6	MILWAUKEE, WI*	0.0032	36.5
DENVER, CO	0.0066	86.9	MINNEAPOLIS, MN	0.0027	48.6
DES MOINES, IA	0.0047	13.8	MCALLEN, TX	0.0075	6.2
DETROIT, MI	0.0026	104.1	MOBILE, AL	0.0047	14.1
EL PASO, TX	0.0056	12.7	NASHVILLE, TN	0.0105	58.2
EUGENE, OR	0.0066	11.0	NEW ORLEANS, LA	0.0117	92.5
FARGO, ND	0.0041	3.7	NEW YORK, NY	0.0043	517.2
FT. LAUDERDALE, FL*	0.0272	129.9	NORFOLK, VA	0.0101	50.3
FT. MYERS, FL*	0.0378	32.2	OAKLAND, CA*	0.0102	26.7
FT. WAYNE, IN	0.0023	7.0	OKLAHOMA CITY, OK	0.0039	22.6

TABLE 3 (cont.)

## CITIES IN SAMPLE AND TOURIST INDEXES

CITY	TRPCT	TRISM
OMAHA, NE	0.0042	17.8
ONTARIO, CA*	0.0104	62.1
ORANGE CO., CA*	0.0078	106.8
ORLANDO, FL	0.0537	219.9
PASCO, WA	0.0050	6.0
PENSACOLA, FL	0.0084	12.5
PHILADLPHIA, PA	0.0034	133.2
PHOENIX, AZ	0.0132	128.5
PITTSBURG, PA	0.0036	59.8
PORTLAND, ME	0.0134	21.3
PORTLAND, OR	0.0046	44.3
RALEIGH, NC	0.0045	17.1
REDDING, CA	0.0134	8.3
RENO, NV*	0.1464	252.4
RICHMOND, VA	0.0065	33.0
ROANOKE, VA	0.0138	21.6
ROCHESTER, NY	0.0026	18.5
SACRAMENTO, CA*	0.0051	34.5
ST. LOUIS, MO	0.0046	81.5
MONTEREY, CA*	0.0210	45.8
SALT LAKE C, UT	0.0059	34.0
SAN ANTONIO, TX	0.0057	33.6
SAN DIEGO, CA	0.0134	155.5
SAN FRNCSCO, CA	0.0102	270.2
SAN JOSE, CA*	0.0035	42.1
SNTA BRBARA, CA*	0.0129	26.4
SARASOTA, FL*	0.0200	30.1
SAVANNAH, GA	0.0144	18.7
SEATTLE, WA	0.0037	62.8
SHREVEPORT, LA	0.0039	8.5
SIOUX FALLS, SD	0.0055	4.5
SPOKANE, WA	0.0066	14.1
STOCKTON, CA*	0.0025	5.5
SYRACUSE, NY	0.0044	18.3
TALLAHASSEE, FL	0.0142	13.0
TAMPA, FL	0.0209	154.6
TOLEDO, OH*	0.0037	19.6
TUSCON, AZ*	0.0133	35.5
TULSA, OK	0.0029	14.3
UTICA, NY*	0.0037	6.2
WASHINGTON, DC	0.0076	218.2
WST PLM BCH, FL*	0.0237	72.5
WHT E PLAINS, NY*	0.0037	0.7
WICHITA, KS	0.0033	10.9

\* = Airport designated as near a larger hub airport (NR)

## SECTION 6

Using the price dispersion indexes described in section 5, this section examines characteristics of a route that are correlated with dispersion. No causality is inferred from the correlations. Statistical implementation of the model in chapter 2 is not feasible. As explained earlier, the dispersion indexes do not correspond to  $W$  in the model. Since the indexes also take into account the proportion of people paying each price, they are not likely to be predicted well by the model. Furthermore, many variables on which data are not available, such as demand characteristics and administrative costs of sorting, are important in determining price dispersion. Regressions of the indexes on plausible sets of variables, e.g., population, per capita income, tourism, and route density, have yielded very poor results. The parameters from instrumental variable regressions do not explain the index as well as the simple mean does (i.e., the  $R^2$  is negative). These results are presented in appendix B (Tables B1 and B2).

Table 4 shows estimated correlation coefficients from the 1975 sample of 1023 routes (Forty routes had to be eliminated for 1975 because of service by intrastate carriers; these firms did not report traffic or financial data to the CAB) Kendall & Stuart ([18], p.293) derive an equation for the large-sample variance of these estimates.<sup>16</sup> In table 5, the same statistics are presented for 1982 as well as additional variables that were available only in 1982.



TABLE 4  
CORRELATIONS BETWEEN DISCOUNTING AND OTHER 1975 VARIABLES  
(1023 routes)

	D1A7	D27	NR	DT	OD7	TRINX
D1A7	1.000					
D27	0.956 <sup>+</sup>	1.000				
NR	-0.013	0.014	1.000			
DT	0.339 <sup>+</sup>	0.200 <sup>+</sup>	-0.075 <sup>*</sup>	1.000		
OD7	0.183 <sup>+</sup>	0.217 <sup>+</sup>	-0.147 <sup>+</sup>	-0.049	1.000	
TRINX	0.114 <sup>+</sup>	0.160 <sup>+</sup>	0.058	0.095 <sup>+</sup>	-0.039	1.000
TRISX	0.190 <sup>+</sup>	0.220 <sup>+</sup>	-0.060	0.202 <sup>+</sup>	0.160 <sup>+</sup>	0.925 <sup>+</sup>
EPA7	0.157 <sup>+</sup>	0.127 <sup>+</sup>	-0.196 <sup>+</sup>	0.144 <sup>+</sup>	0.514 <sup>+</sup>	-0.100 <sup>+</sup>
YLD7	-0.509 <sup>+</sup>	-0.471 <sup>+</sup>	0.055	-0.785 <sup>+</sup>	-0.037	-0.073 <sup>+</sup>

	TRISX	EPA7	YLD7
TRISX	1.000		
EPA7	0.194 <sup>+</sup>	1.000	
YLD7	-0.166 <sup>+</sup>	-0.146 <sup>+</sup>	1.000

\* = Significantly different from 0 at 5% level

+ = Significantly different from 0 at 1% level

The patterns of price dispersion were quite clear in 1975. Carriers offered discount fares on long-haul, high-density, tourist-oriented routes. The routes had lower yields (average fare/distance) both because of the discounts (from the DPFI standard fare) and because the discounts were on long routes on which the DPFI fare taper prescribed a lower yield. Though there was not significantly less dispersion of fares at small airports near larger hubs (the NR variable), the average enplanements variable (EPA7, the average of the two endpoints of a route) shows that larger airports were more likely to be an endpoint for discount travelers.

By 1982, however, most of the patterns had disappeared. Though the use of secondary airports has grown under deregulation, price dispersion is less present there (NR). Perhaps the greater use of these facilities by low-coach-fare new airlines explains this change (There is a positive correlation between NEWSH and NR). The correlation between the size of endpoints and the dispersion of prices on a route is much weaker in 1982 than it was in 1975, but it is still significant for the D2 measure.

It is clear from table 5 that high-density, long-haul routes are no longer the primary domain of multi-tier fare structures. Discounting is also no longer targeted at tourist routes. Table 5 shows a significant negative correlation between the estimated proportion of demand that is tourist (TRINX) and both dispersion indexes. Though the effect is weaker, the negative correlation also seems to hold with the

TABLE 5

## CORRELATIONS BETWEEN DISCOUNTING AND OTHER 1982 VARIABLES

(1063 routes)

	D18	D28	NR	DT	OD8	TRINX
D18	1.000					
D28	0.720 <sup>+</sup>	1.000				
NR	-0.183 <sup>+</sup>	-0.139 <sup>+</sup>	1.000			
DT	-0.013	0.013	-0.107 <sup>+</sup>	1.000		
OD8	-0.004	0.054	-0.105 <sup>+</sup>	-0.037	1.000	
TRINX	-0.126 <sup>+</sup>	-0.093 <sup>+</sup>	0.034	0.102 <sup>+</sup>	-0.024	1.000
TRISX	-0.098 <sup>+</sup>	-0.044	-0.077 <sup>+</sup>	0.207 <sup>+</sup>	0.153 <sup>+</sup>	0.924 <sup>+</sup>
HF8	0.028	-0.043	0.275 <sup>+</sup>	-0.319 <sup>+</sup>	-0.082 <sup>+</sup>	-0.068 <sup>+</sup>
CR8	0.019	0.039	-0.241 <sup>+</sup>	0.446 <sup>+</sup>	0.225 <sup>+</sup>	0.108 <sup>+</sup>
EPA8	0.003	0.060 <sup>+</sup>	-0.242 <sup>+</sup>	0.170 <sup>+</sup>	0.465 <sup>+</sup>	-0.088 <sup>+</sup>
YLD8	0.044	0.012	-0.044	-0.661 <sup>+</sup>	-0.073 <sup>+</sup>	-0.159 <sup>+</sup>
NEWSH	0.013	0.063 <sup>+</sup>	0.116 <sup>+</sup>	-0.271 <sup>+</sup>	0.135 <sup>+</sup>	-0.030

	TRISX	HF8	CR8	EPA8	YLD8	NEWSH
TRISX	1.000					
HF8	-0.138 <sup>+</sup>	1.000				
CR8	0.198 <sup>+</sup>	-0.663 <sup>+</sup>	1.000			
EPA8	0.200 <sup>+</sup>	-0.183 <sup>+</sup>	0.193 <sup>+</sup>	1.000		
YLD8	-0.208 <sup>+</sup>	0.318 <sup>+</sup>	-0.489 <sup>+</sup>	-0.019	1.000	
NEWSH	-0.099 <sup>+</sup>	0.270 <sup>+</sup>	-0.111 <sup>+</sup>	-0.173 <sup>+</sup>	-0.015	1.000

\* = Significantly different from 0 at 5% level

+ = Significantly different from 0 at 1% level

measure of the absolute size of tourist demand (TRISM).

Price dispersion appears to be uncorrelated with the amount of actual competition in a market. Neither D18 or D28 are significantly correlated with Herfindahl index (HF8) or the number of carriers (CR8). Nor are they correlated with yield, the average fare per mile. The presence of discount fares on a route does not indicate that the overall average fare is particularly low. Though Graham & Kaplan [34] found that newly certificated carriers exert a downward pressure on fares, their presence is only weakly correlated with price dispersion.

That the pattern of dispersion has changed drastically under deregulation is well illustrated in table 6. The table shows a weak but consistently negative correlation between each 1982 index and the same index in 1975. By both measures, price dispersion has approximately tripled in that time.

The data indicate that multi-tier fare structures are no longer reserved for tourist-oriented routes on which carriers might hope to generate additional traffic without suffering very much revenue dilution. Yields are no lower on routes with more price dispersion. There is some evidence that the presence of one of the upstart new carriers implies more dispersion. Overall, though, the picture is one of widespread dispersion on routes of every size, length and customer type.

The spread of multi-tier fare structures is consistent

TABLE 6  
CORRELATIONS BETWEEN 1975 AND 1982 DISCOUNTING MEASURES  
(1023 routes)

	D18	D1A8	D28	D1A7	D27
D18	1.000				
D1A8	0.842 <sup>+</sup>	1.000			
D28	0.708 <sup>+</sup>	0.589 <sup>+</sup>	1.000		
D1A7	-0.087 <sup>+</sup>	-0.039	-0.049	1.000	
D27	-0.096 <sup>+</sup>	-0.056	-0.060 <sup>+</sup>	0.956 <sup>+</sup>	1.000

\* = Significantly different from 0 at 5% level

+ = Significantly different from 0 at 1% level

#### SUMMARY STATISTICS FOR DISCOUNTING INDICES

	MEAN	STANDARD DEVIATION	MINIMUM	MAXIMUM
D18	0.0929	0.0548	0.0000	0.8480
D1A8	0.1291	0.0656	0.0000	0.8790
D28	0.0957	0.0753	0.0000	0.4510
D1A7	0.0459	0.0414	0.0000	0.1370
D27	0.0315	0.0339	0.0000	0.1610

with the theory of price discrimination presented in chapter 2. With the end of CAB regulation, carriers sophistication in sorting customers has increased, e.g., the 'stay over Saturday' restriction, and they now discriminate on virtually every route. Another explanation, however, is that carriers are now better able to carry out peak-load pricing schemes, particularly with removal of the 35% seating limit on capacity-controlled discounts.

## SECTION 7

As was discussed in section 4, the welfare effects of discounting are ambiguous in theory. In practice, policy is usually determined by examining the effect of price differences on industry output and on the distribution of income. In some cases, such as with the senior citizen discounts that many drugstores now offer, income distribution is the overriding consideration. Since airline travel is not generally thought of as a necessity, however, and since it makes up a very small proportion of poor people's expenditures, distribution issues are seldom raised in setting government policies toward airlines. Thus, I have not attempted to characterize the distributional effects of discounting in the airline industry.

Those who claim that multi-tier fare structures are in the public interest often make arguments that are very similar to the reservation price sorting theory in chapter 2. They assert that passengers who pay discount prices are making some, perhaps small, contribution to joint costs, and that without the low fares, many would not fly at all. Yet, price dispersion was so strongly correlated with lower average fares in the 70's that simple correlations between dispersion and traffic increases are not convincing. Thus, the question of whether price dispersion generates more new traffic than an equivalent coach fare, i.e., resulting in the same average fare, remains unanswered.

The evidence presented here indicates that the price dispersion due to the few discounts available 1975 did in fact increase traffic more than would have occurred with an equivalent drop in coach fares on those routes. On the other hand, the traffic-generating effect apparently does not carry over to the 1982 sample. In fact, there is evidence that price dispersion now reduces output compared to routes with the same average fare, but less dispersion.

These conclusions result from estimation of an air travel demand functions for 1975 and 1982. The form of the estimated demand function is

$$(5) \quad OD = C \cdot A_1^{NR} \cdot DT^{A_2} \cdot FR^{A_3} \cdot (1+D)^{A_4} \cdot PPG^{A_5} \cdot PIA^{A_6} \cdot TRINX^{A_7}$$

where

OD = second quarter 'local' traffic on the route

NR = 0, 1, or 2. Of the two endpoints, the number that were classified as small airports near larger hubs.

DT = route distance

FR = average fare

(1+D) = discounting measure, D1, D1A or D2. (see text)

PPG = geometric mean of the populations at the endpoint SMSA's

PIA = arithmetic mean of the per capita income of the endpoint SMSA's.

TRINX = index of tourism

This multiplicative functional form has been used in previous studies of air travel demand, such as those by Brown & Watkins [4], Devany [7] and Ippolito [14]. It seems sensible because all the factors act interactively in theory.



If the fares are high enough, for instance, demand will be affected only slightly by changes in populations at the endpoints.

All of these works have included variables for fare, population and income. Brown & Watkins employ the number of daily phone calls between cities to capture population and what they call 'community of interest.' This is the likelihood that people or businesses in the endpoint cities would want to communicate with one another.

Devany and Ippolito focus on the importance of quality variables, in particular flight frequency and average load factor. Both studies estimate extremely large elasticities with respect to flight frequency, as discussed earlier. The load factor variables are not significant. Given his focus, it is surprising that Devany does not include a variable for trip time. The distance variable serves that purpose in this study as well as in Ippolito and Brown & Watkins.

Though tourism is recognized as having a significant effect on demand, it has generally not been included in prior studies. Ippolito does recognize it explicitly by estimating dummy variables for Las Vegas, and all routes involving Florida or California. A study of fares and load factors by Graham, Kaplan & Sibley [12] also takes this approach. To my knowledge, these are the only attempts to include tourist attractiveness of cities in a study of airline markets.

No demand study has included a price dispersion variable. This is in part because previous works all used pre-deregulation data, when dispersion was not as pervasive. There were fewer observations of routes with significant price dispersion as well as less interest in its economic impact. In this study, the zero to one range of the dispersion indexes created some difficulty with estimation. Because of the multiplicative functional form and the fact that many of the dispersion measures that were equal to 0 in 1975, the measures were increased by one for the regressions.

This functional form yields parameter estimates that are the estimated demand elasticities with respect to each variable. One drawback, of course, is the imposition of constant elasticities with respect to each variable. This constraint is particularly troublesome with regard to the distance variable. Theory predicts that demand will increase with distance for short hauls because auto or other ground transportation become poorer substitutes as the trip gets longer. However, beyond some distance, this effect would diminish and the elasticity would be more strongly influenced by the travel time costs of longer flights. Therefore, the elasticity would be negative for markets of greater than, say, 300 to 600 miles.

Since the model was estimated in logarithmic form, a  $(\ln(DT))^2$  variable was added to capture the decline in the distance elasticity (LDT2 in the tables). Though the parameter on this variable was usually of the correct sign,

negative, it was not generally significant and the estimated zero-elasticity point was in all cases greater than 20,000 miles. The addition of this term had no significant effect on the other parameters or their standard errors.

The NR variable enters in the appropriate form for a dummy variable in a multiplicative expression. When NR is 0, the term is equal to 1 and therefore has no effect on demand. When NR is 1, the estimated demand is equal to A1 times the otherwise predicted level. We would expect A1 to be less than 1, according to the theory and CAB declarations that secondary airports have been underutilized.

The parameter of TRINX, A7, gives an estimate of the importance of tourist travel on a route. The TRINX term acts to scale up or down the otherwise predicted demand depending on the proportion of demand that is likely to be tourists. We would expect A7 to be positive.

Due to the endogeneity of the average fare level and, perhaps, the dispersion measures, instrumental variable estimation is called for. In this section, IV estimates are presented on the assumption that the FR and the dispersion measure are correlated with the residual. Unfortunately, the fitted values for the dispersion measures were very poorly correlated with the actual indexes, the  $R^2$  in these first stage regressions was between 0.10 and 0.17. The  $R^2$  for the fitted values of FR, on the other hand, was 0.82 for 1982 and 0.99 for 1975, when average fares were very near the exogenous DPFI level.<sup>17</sup> Because of the poor correlations for the dis-

counting measures, the equations were also estimated under the assumption that traffic density did not have a causal effect on discounting.

One variable of some importance has been omitted . The 'frequency delay' that Douglas & Miller [9] discuss can be approximated by a measure of the number of flights on a route. The difficulty in adding such a variable is that demand has a strong causal effect on the number of flights. Though IV estimation alleviates this problem asymptotically, it does not appear to do so in this sample. A number of frequency delay variables were tried and in each case the elasticity was between 0.7 and 1.0 with small standard errors. Loosely speaking, this would imply a 7% to 10% increase in demand from a 10% increase in flights. These estimates are quite similar to those of Ippolito [14] and Devany [7], but the numbers seem far too high. Though none of the the other parameters shifted in sign when the variable was added, the standard errors increased a great deal. The frequency delay variable is derived in appendix A. These regressions are presented in appendix B (Tables B6 and B7).

The results of the estimation for 1975 and 1982 are in table 7 and 8, respectively. The variables that begin with 'L' are the natural logarithm of the actual data and their parameters can be interpreted as elasticities.

Before discussing the dispersion measure, let us consider

TABLE 7

ESTIMATED AIR TRAVEL DEMAND FUNCTION FOR 1975  
 IV ESTIMATION -- FR7, D1A7, D27 ENDOGENOUS  
 (Asymptotic Standard Errors in Parentheses)  
 DEPENDENT VARIABLE: LN(OD7)

	<u>with D1A index</u>	<u>with D2 index</u>
CONSTANT	-19.75 <sup>+</sup> (2.977)	-20.08 <sup>+</sup> (2.978)
NR	-0.533 <sup>+</sup> (0.041)	-0.543 <sup>+</sup> (0.041)
LDT	-0.327 (0.406)	-0.345 (0.406)
LDT2	0.069 <sup>+</sup> (0.032)	0.065 <sup>+</sup> (0.031)
LFR7	-2.062 <sup>+</sup> (0.393)	-1.953 <sup>+</sup> (0.399)
LD1A7	6.621 <sup>+</sup> (1.223)	LD27 8.405 <sup>+</sup> (1.519)
LPPG7	1.059 <sup>+</sup> (0.042)	1.068 <sup>+</sup> (0.041)
LPIA7	3.116 <sup>+</sup> (0.263)	3.117 <sup>+</sup> (0.263)
LTRINX	0.214 <sup>+</sup> (0.023)	0.207 <sup>+</sup> (0.024)
<hr/>		
OBS	1023	1023
CRSQ	0.695	0.694
SSR	343.89	344.14

\* = Significant at the 5% level

+ = Significant at the 1% level

TABLE 8

ESTIMATED AIR TRAVEL DEMAND FUNCTION FOR 1982  
 IV ESTIMATION -- FR8,D18,D1A8,D28 ENDOGENOUS  
 (Asymptotic Standard Errors in Parentheses)  
 DEPENDENT VARIABLE: LN(OD8)

	<u>with D1</u> <u>index</u>	<u>with D1A</u> <u>index</u>	<u>with D2</u> <u>index</u>
CONSTANT	-18.39 <sup>+</sup> (2.705)	-19.79 <sup>+</sup> (2.516)	-22.17 <sup>+</sup> (2.484)
NR	-0.393 <sup>+</sup> (0.047)	-0.414 <sup>+</sup> (0.046)	-0.329 <sup>+</sup> (0.042)
LDT	0.799 (0.421)	0.946 <sup>*</sup> (0.390)	1.289 <sup>+</sup> (0.380)
LDT2	-0.018 (0.031)	-0.021 (0.029)	-0.056 <sup>*</sup> (0.027)
LFR8	-1.962 <sup>+</sup> (0.148)	-2.035 <sup>+</sup> (0.142)	-1.932 <sup>+</sup> (0.141)
LD18	-5.941 <sup>+</sup> (1.383)	LD1A8 -5.434 <sup>+</sup> (1.012)	LD28 -2.136 <sup>*</sup> (0.875)
LPPG8	1.122 <sup>+</sup> (0.041)	1.125 <sup>+</sup> (0.039)	1.161 <sup>+</sup> (0.038)
LP1A8	2.486 <sup>+</sup> (0.237)	2.596 <sup>+</sup> (0.226)	2.660 <sup>+</sup> (0.228)
LTRINX	0.125 <sup>+</sup> (0.026)	0.126 <sup>+</sup> (0.024)	0.162 <sup>+</sup> (0.023)
<hr/>			
OBS	1063	1063	1063
CRSQ	0.541	0.580	0.586
SSR	390.13	358.44	351.42

\* = Significant at the 5% level

+ = Significant at the 1% level

the other parameters. For the most part, they are very reasonable and in line with previous works in the area. The parameters on the NR variable imply that demand is less for flights from small airports that are near larger hubs. This effect, though, has declined. The estimates shown are the natural logs of the A1 parameters. The values translate to approximately 0.6 for the 1975 equations and 0.7 for the 1982 equations. In all of the regressions, this parameter was significantly different from 0.

The distance variable is not very sensible for 1975, but the significant estimates are positive. Likewise, the elasticity implied by all the 1982 estimates is positive for all relevant distances. Another approach, estimating the parameter separately for 0-500 mile routes, 500-1500 mile routes and over 1500 mile routes, yielded similar results. The parameters were always positive, but they were smaller for the long distance flights.

The estimated fare elasticities are around -2.0 in both years and had small standard errors. This number is larger than Devany's -1.07 or Brown & Watkins' -1.30. One possible reason for an overestimate of the fare elasticity (in absolute value) is the correlation between the fare variable and distance. If the distance variable is not correctly specified, then the fare variable might pick up some of the negative influence of distance on demand. This would explain a high fare elasticity and the failure of the distance elasticity to become negative at longer distances.

Misspecification would occur if the LDT2 variable did not properly capture the decline in the distance elasticity as route length increases. This seems to be the case since the estimated distance elasticities are never negative for route of reasonable length.

The population variable should be near 1. After controlling for other factors, it seems reasonable that an increase in population would bring an equal sized increase in demand. In table 7, the population parameter is not significantly different from 1. The 1982 estimates in table 8 are significantly above 1, but numerically still close to 1. In all the regressions, the population parameters were significantly above 0.

Though one would probably expect the income elasticity parameter to be greater than 1, on the assumption that air travel is a luxury good, the estimates are somewhat high for 1982 and very high for 1975. Still, Ippolito [14] estimated a 2.35 income elasticity. Devany's [7] estimates ranged from 0.47 to 3.15, but were never significant.

The tourism index parameter can be interpreted by comparing the values implied by this parameter across routes. The minimum TRINX was 0.0024. With a 0.125 TRINX parameter, this implies a multiplier of 0.47. The median TRINX was 0.0074 implying a 0.54 multiplier. Most routes involving Las Vegas had a TRINX around 0.3, resulting in a multiplier of 0.86. All of the multipliers are less than one, but this is due entirely to the presence of the constant term. Thus, the



values should be interpreted comparatively. If we assume that there is virtually no tourism on the minimum route, then the median route demand is increased by about 15% due to tourism, that is, about 13% of all demand is tourist. With the 0.162 estimate of the TRINX parameter, the latter proportion would be 17%. These are a reasonable figures in light of the results from a study of the air travel industry by Touche-Ross & Co. [32]. They estimated that 48% of all air travel is for 'vacation' purposes and that about 40 of those travelers stay in hotels. From these figures, we would expect about 19% of travel to be accounted for by the TRINX variable. On the Las Vegas routes, the model estimates that 45% and 54% of all demand is tourist.

The most surprising outcome of the analysis is the parameter of primary interest, the dispersion elasticity. The effect of price dispersion in 1975 was as most of the advocates of discounting would have predicted. Both measures show a positive effect of dispersion on demand after controlling for average fare level. But in 1982, when discounting had spread from the high-density tourist routes to virtually all markets, its effect on demand reverses. The 1982 estimates are significant and negative. This result obtained, however, with the poorly correlated fitted values. When the dispersion measure was treated as an exogenous variable, table 9 shows that the result is not as strong. The D1 index is negative, but just barely significant. The D2 index is very near 0. The parameter also become much smaller

in these estimates. Estimated by OLS, the D1 parameter is almost significantly negative and the D2 parameter is, again, very close to 0. The OLS regressions are included in appendix B (Tables B3 and B4).

The parameter estimates of D18 and D28 in table 8 imply decreases in quantity sold of 41% and 18% on the average route due to price dispersion. These numbers are not very believable. When the dispersion measures are assumed to be exogenous, however, the estimated declines are 5.8% and 0.4%. On the other hand, the 1975 estimates imply a demand increase of 34% and 24%. And, when the 1975 discounting measures are taken as exogenous, the estimates change by less than 1% for both indexes (see Appendix B, Table B5).

Though the sample is quite large and the explanatory power of the equations is very high for cross-section analysis, the parameters of D1 and D2 are sensitive to the instrumentation. Furthermore, an  $R^2$  of 0.55 means that 45% of the movement is not explained by these variables. Certainly, part of this is attributable to specific characteristics of certain markets and/or cities. An alternative estimation procedure allows us to separate out some of these special characteristics.

If the equation (5) demand function holds for 1975 and 1982, then the change in output on routes can also be explained.

$$(6) \frac{OD8}{OD7} = \frac{C \cdot A1^{NR} \cdot DT8^{A2} \cdot FR8^{A3} \cdot D8^{A4} \cdot PPG8^{A5} \cdot PIA8^{A6} \cdot TRINX^{A7}}{C \cdot B1^{NR} \cdot DT7^{B2} \cdot FR7^{B3} \cdot D7^{B4} \cdot PPG7^{B5} \cdot PIA7^{B6} \cdot TRINX^{B7}}$$

TABLE 9  
ESTIMATED AIR TRAVEL DEMAND FUNCTION FOR 1982  
IV ESTIMATION -- FR8 ENDOGENOUS  
(Asymptotic Standard Errors in Parentheses)  
DEPENDENT VARIABLE: LN(OD8)

	<u>with D1</u> <u>index</u>	<u>with D1A</u> <u>index</u>	<u>with D2</u> <u>index</u>
CONSTANT	-21.58 <sup>+</sup> (2.383)	21.05 <sup>+</sup> (2.360)	-22.04 <sup>+</sup> (2.375)
NR	-0.296 <sup>+</sup> (0.038)	-0.335 <sup>+</sup> (0.038)	-0.283 <sup>+</sup> (0.038)
LDT	1.124 <sup>+</sup> (0.362)	1.154 <sup>+</sup> (0.359)	1.178 <sup>+</sup> (0.362)
LDT2	-0.051 (0.027)	-0.045 (0.026)	-0.056 <sup>*</sup> (0.026)
LFR8	-1.756 <sup>+</sup> (0.129)	-1.920 <sup>+</sup> (0.131)	-1.735 <sup>+</sup> (0.129)
LD18	-0.754 <sup>*</sup> (0.378)	LD1A8 -2.036 <sup>+</sup> (0.326)	LD28 -0.046 (0.265)
LPPG8	1.146 <sup>+</sup> (0.036)	1.145 <sup>+</sup> (0.036)	1.150 <sup>+</sup> (0.036)
LPIA8	2.613 <sup>+</sup> (0.215)	2.597 <sup>+</sup> (0.214)	2.630 <sup>+</sup> (0.216)
LTRINX	0.189 <sup>+</sup> (0.020)	0.169 <sup>+</sup> (0.020)	0.197 <sup>+</sup> (0.020)
<hr/>			
OBS	1063	1063	1063
CRSQ	0.617	0.623	0.617
SSR	324.50	319.63	325.13

\* = Significant at the 5% level

+ = Significant at the 1% level

Route or city-specific effects that did not change between 1975 and 1982 would not influence the parameters of this estimation. Clearly, for the NR, DT and TRINX variables only the ratio of the parameters can be estimated. An F-test of the hypothesis that all the A and B parameters are equal except for those of the discounting measure strongly rejected this proposition. Thus, the 1975 and 1982 elasticities with respect to fare, price dispersion, population and income were estimated separately, and the NR, DT and TRINX variables were included. The results are shown in table 10.

The results are not nearly as significant as for either year separately and the magnitudes of the parameters are not as reasonable. Still, all the parameters have the expected sign. The dispersion variables are all insignificant, but their signs are the same as in the single-year regressions. The OLS regressions and those with discounting assumed to be exogenous all result in significantly positive parameters for the 1975 indexes and negative, but insignificant parameters for the 1982 measures. They are presented in appendix B (Tables B8 and B9).

Other regressions with various measures of tourism, frequency delay and the distance elasticity were run, but are not reported. The results were consistent in the signs of all of the parameter estimates. By both measures, 1975 discounting had a positive effect on traffic in every case, and in most cases, the estimates were significantly different from zero. The 1982 measures had negative parameters in nearly all

TABLE 10

ESTIMATED AIR TRAVEL DEMAND FROM 1975 TO 1982 CHANGES  
 IV ESTIMATION -- FR7,FR8,D1A7,D1A8,D27,D28 ENDOGENOUS  
 (Asymptotic Standard Errors in Parentheses)  
 DEPENDENT VARIABLE: LN(OD8/OD7)

	with D1A index		with D2 index
CONSTANT	-2.355 (2.417)		-2.555 (2.458)
NR	0.180+ (0.039)		0.200+ (0.035)
LDT	0.730 (0.381)		0.875* (0.370)
LDT2	-0.019 (0.027)		-0.024 (0.027)
LFR7	-0.339 (0.363)		-0.154 (0.334)
LFR8	-0.916+ (0.167)		-0.893+ (0.167)
LD1A7	1.077 (1.039)	LD27	1.157 (1.288)
LD1A8	-1.622 (1.062)	LD28	-0.755 (0.799)
LPPG7	1.934+ (0.324)		1.899+ (0.340)
LPPG8	1.805+ (0.329)		1.773+ (0.344)
LPIA7	0.198 (0.442)		0.183 (0.437)
LPIA8	0.412 (0.396)		0.407 (0.396)
LTRINX	-0.099+ (0.023)		-0.090+ (0.022)
OBS	1023		1023
CRSQ	0.403		0.411
SSR	221.93		218.80

\* = Significant at the 5% level

+ = Significant at the 1% level

cases and in no case was the estimate positive and significant. Though we certainly cannot conclude that price dispersion has drastically lessened air travel, it seems clear that it has not greatly enhanced traffic either.

## CONCLUSION

To the surprise of many industry observers, deregulation of the airline industry has resulted in expanded use of restricted discount coach fares. Some economists now argue that these fares can be cost justified. Yet, we have seen that differences in 'no-show' rates can explain only a very small percentage of the fare differences. While the peak-load pricing argument is more substantial, it does not explain advance-purchase, minimum-stay or round-trip restrictions that are commonly attached to low fares. Furthermore, the distinction between demand-based allocation of joint costs and price discrimination is somewhat artificial.

Analysis of over 1000 routes shows that price dispersion is not just evident on high-density, tourist-oriented routes as it was prior to deregulation. Multi-tier fare structures are just as common in markets that are frequented by business and 'personal' travelers. In addition, carriers now have much greater flexibility in adjusting the proportion of seats on each flight that will be sold at discount fares. They are no longer constrained by the 35% maximum that the CAB had imposed.

Along with this expanded availability of discount fares, their effect on traffic has apparently also changed. In 1975, price dispersion seems to have increased airlines' sales. The evidence for 1982 indicates that this is no longer the case. In fact, holding constant the average fare on a route, price dispersion appears to have a negative impact on quantity.

This change from the 1975 results can be explained in terms of the model of price discrimination in chapter 2. With deregulation of the airline industry, firms have turned to using discounts to compete with other airlines as much as to expand the market for air travel. Thus, restricted low fares have spread from the tourist routes to markets where there are fewer customers who have reservation prices near the market fare levels. In chapter 2, we saw that a sorting device that attracts many marginal customers in one market can, when applied to a different consumer population, have much stronger 'demand diverting' effects. This is particularly true if reservation price and strength of brand preference are positively correlated. Also, discounts that are clearly 'diversionary', such as the frequent flyer programs, have flourished in the competitive industry. As a result, the traffic enhancing effects of discounting that were so evident in 1975 have, at least, been greatly diminished. Price discrimination that is demand diverting is less likely to raise output in the market and, as was often the case in the simulations, it can cause total sales to decline.

Under regulation, carriers rarely competed by making changes that had to be approved by the CAB. In fact, the Board often required assurance that changes in one airlines' fare structure would not harm the other airlines. Thus, it would be consistent for them to have only requested permission for discount fares that were demand creating. Since deregulation, however, competitive price changes are commonplace.



Airlines no longer have to obtain CAB approval and can implement the changes more quickly, thus maximizing the strategic and promotional advantages of new discounts. This has increased the potential gains to firms from demand diverting price discrimination.

Does this mean that discounting in the airline industry is harming society? Probably not. First of all, the evidence that price dispersion has caused large decreases in output is not robust. Second, the effect of discounting on income distribution may be favorable. The Touche-Ross study of airline passengers shows that many non-business travelers are from middle-class and lower-middle-class households. ([32], p.129) The median household income of vacation flyers in 1978 was about \$20,000 when the national median was \$19,626.

Finally, though the price discrimination explanation is consistent with the results, there is also an interpretation that ties the apparent negative output effect of dispersion to peak-load pricing. This interpretation suggests that the estimated causal effect of price dispersion on output is spurious. If less dense routes have more variable demand, then we would expect to see greater price dispersion on those routes due to peak-load pricing. Carriers would allocate joint costs (among flights, such as aircraft depreciation) less evenly on thin routes in order for fares on each flight to reflect the shadow value of additional capacity on that flight. Thus, demand variability would be correlated with thin routes and a cause of price dispersion. This would

produce the apparent effect of dispersion on output. The effect would be much weaker in 1975, however, both because of the 35% limit on seats that could be made available for discounts and because airlines were less sophisticated in their use of capacity controls for peak-load pricing.

It remains for future study whether demand variability on a route is, in fact, correlated with total passengers. There is good reason, however, to think that it would be. First, the law of large numbers suggests that as there are more independent decisions of whether or not to take a certain trip, the ratio of the variance of passengers to the mean will decline. Second, if dense routes are generally made up of the normal business and personal travel between two cities augmented by a significant amount of tourist travel, then these markets have a greater variety of types of passengers. Less homogeneous consumers imply less homogeneous preferred travel times. Thin routes, on the other hand, might have more homogeneous flyers and, thus, greater demand peaking problems. Finally, demand variability itself might cause there to be fewer passengers. If peak-load pricing is imperfect in smoothing demand, then on routes with variable demand, a greater proportion of potential customers will be turned away due to full flights. If some choose not to take the trip rather than take an alternative flight, output declines.

It does not appear that the complex fare structures that

airlines now maintain are expanding the air travel market. The demand diversion explanation for this result prompts some concern that price dispersion in airline fares may not be in the public interest. Yet, the peak-load pricing interpretation, as well as the possibility of positive income redistribution effects, imply that price dispersion could very well benefit society. Certainly, a great deal of further study is necessary before government intervention would be justified.

## APPENDIX A

This appendix explains in detail the source of each data series used in the statistical analysis and the criteria used for constructing each series. Each series is classified as either route-specific, airport-specific, or city-specific (SMSA-specific). All dollar figures have been inflated to 1982 dollars using the Consumer Price Index. Statistical summaries of the series are at the end of the appendix.

### Route-Specific Data Series:

1. OD7,OD8 -- 10% sample of 'local' traffic between endpoints.

Source: CAB, Origin and Destination Survey, Table 8

Construction: None, the numbers were taken exactly as printed in Table 8 for the second quarter of each year. They were not multiplied by 10 to account for the sampling. For details of the O&D Survey sampling methods see the introduction to CAB, Origin and Destination Survey, Tables 1-8 publication.

2. DT -- Route distance

Source: CAB, DB1 Summary Computer Tape

Construction: For routes with endpoints that aggregate multiple airports, the distance is the passenger-weighted average of the airport-to-airport distances.

3. CR8 -- Number of Carriers

Source: CAB, DB1 Summary Computer Tape

Construction: Number of carriers with more than 0.5% of total traffic in the 5 fare categories used according to the DB1 sample. 'Unknown' (Carrier Code 99) was counted as a carrier if more than 0.5% of traffic was assigned to this category (which was the case on about half of all routes).

4. HF8 -- Herfindahl Index

Source: CAB, DB1 Summary Computer Tape

Construction: Sum of squared values of carrier market shares calculated in the sum of the 5 fare categories included. 'Unknown' was included as well as (1 - share of all carriers included) which was non-zero occasionally due to the 0.5% market share cutoff.

5. FR8 -- Average fare in 5 included fare categories, 1982

Source: CAB, DB1 Summary Computer Tape

Sum of all revenues from the 5 included fare categories divided by (one-way trips + 2\*roundtrips)

6. FR7 -- Average fare in 5 included fare categories, 1975

Source: O&D Survey, Table 13 and Official Airline Guide, North American Edition June 1, 1975

Construction:

1. Passengers in each fare category came from Table 13.

All fares for which the number of passengers was less than 1% of route total were counted as 0.

2. Y-fare was that listed in the OAG. When no Y-fare was

available, but there was direct service, an S-fare ('economy' service) was always listed and was used as the standard coach fare. When there was no direct service, coach fares were calculated from the DPFI formula in effect on June 1, 1975. For Alaska and Hawaii routes, the fares were calculated from the tables in the OAG.

3. Though it was not true in all cases, the same percentage discounts were assumed for each fare category on all routes.

- 1) K-fare -- 10% discount
- 2) YN-fare -- 20% discount
- 3) YD,YE-fares -- 24% discount

The 24% figure comes from the 25% discount most of these fares carried until June 15 which declined to 20% after June 15. Fares listed in the YG, group, category were included in YE. (By 1982, YG fares had virtually ceased to exist on scheduled airlines.)

7. S08,S18 -- Nonstop and One-stop flights per week, 1982

Source: OAG, North American Edition, May 1, 1982

Construction:

1. Flights not operating both before and after May 15 were not included.
2. Included flights were added to the appropriate total according to the number of days of the week they operated.
3. 'NO LOCAL TRAFFIC' flights were not included.

8. S07,S17 -- Nonstop and one-stop flights per week, 1975.

Source: OAG, North American Edition, June 1, 1975

Construction: Same as for S08,S18.

9. FQD7,FQD8 -- Frequency delay variables

Source: S07,S17,S08,S18

Construction: The variables are the average time between flights, assuming as 18 hour flight day. The variables are bounded below at 1 hour and above at 9 hours, on the assumption that increase and decreases beyond these levels have little effect on demand (As frequency delay gets large, multi-stop and change-of-plane flights become good substitutes)

$$X8 = 18/((S08+S18)/7)$$

$$FQD8 = \begin{cases} 1 & \text{if } X8 \leq 1 \\ X8 & \text{if } 1 < X8 < 9 \\ 9 & \text{if } X8 \geq 9 \end{cases}$$

and likewise for FQD7.

10. NEWSH -- share of traffic carried by a newly certificated carrier.

Source: DB1, Summary Computer Tape

Construction: Share of traffic in the 5 included fare categories attributed to one of the carriers certificated for interstate service after passage of the ADA(see footnote 1 for a list of these airlines).

11. TRINX -- measure of tourism proportion of total demand

Source: TRPCT and DB1, Summary Computer Tape

Construction: Weighted average of endpoint TRPCT's. The weights were the ratios of 2 times the roundtrips originating at each endpoint plus 1/2 of the total one-way trips.

$$\text{TRINX} = \frac{(2*RT1+OW/2)*TRPCT2 + (2*RT2+OW/2)*TRPCT1}{2*(RT1+RT2)+OW}$$

where RT1 and RT2 are the roundtrips originating at each endpoint and TRPCT1 and TRPCT2 are the TRPCT's for those endpoints.

12. TRISX -- measure of total tourist demand

Source: TRISM and DB1, Summary Computer Tape

Construction: Weighted average of endpoint TRISM's.

Weighting was the same as for TRINX.

13. PPG7, PPG8 -- Geometric mean of endpoint populations (see POP)

14. PIA7, PIA8 -- Arithmetic mean of endpoint per capita income (see PCI)

15. D18, D1A8, D1A7 -- Dispersion Index - spread of fares

Source: Other data series as described in text, section 5.

16. D28, D27 -- Dispersion Index - Average discount from Standard Coach Fare

Source: Other data series as described in text, section 5.



### Airport-Specific Data Series:

1. NR -- Airport near larger hub airport

Source: FAA, Airport Activity Statistics

Construction: If according to the map in this publication, page iv, an airport was within 100 miles of an airport that was larger in hub-size classification (the classifications are large, medium, small and non-hub), it was labeled as near a larger airport, NR=1.

2. ENP7,ENP8 -- Enplanements at the airports

Source: FAA, Airport Activity Statistics, 1975 and Airport Activity Statistics, 1982

Construction: Total passenger enplanements at an airport during 1975 and 1982. City listings that are aggregates of more than one airports included all such airports.

### City-Specific Data Series

All data were for the SMSA's in which the airport was located with the following exceptions:

1. If an airport was in a larger Standard Consolidated Statistical Area (SCSA), and was the only airport (or aggregate of airports) in the SCSA, then the SCSA data were used.
2. If more than one airport was in an SMSA, the totals were divided among the airports according to their ratios of enplanements.

3. If an airport name included cities in more than one SMSA and no other airports were in any of those SMSA's then all such SMSA's were included.

1. POP7,POP8 -- Population of statistical areas (thousands)

Source: U.S. Census, State, City and County Data Book, 1975 and State and Metropolitan Area Data Book, 1982

Construction: As stated above for all city-specific data series. 1982 populations were extrapolated from 1975 to 1980 growth rates assuming constant geometric growth.

2. PCI7,PCI8 -- Per Capita Income (1982 dollars)

Source: U.S. Census, State and Metropolitan Area Data Book, 1982

Construction: As stated above for all city-specific data series. 1982 PCI's were extrapolated from 1975 to 1979 growth rates assuming constant linear income growth.

3. HTL -- Hotel Revenues, 1977 (\$millions)

Source: U.S. Census, State and Metropolitan Area Data Book, 1982

Construction: As stated above for all city-specific data series.

4. FI -- Financial Sector Revenues, 1977 (\$millions)

Source: U.S. Census, State and Metropolitan Area Data Book, 1982

Construction: As stated above for all city-specific data series.

5. TI -- Total Business Revenues, 1977 (\$millions)

Source: U.S. Census, State and Metropolitan Area Data Book, 1982

Construction: As stated above for all city-specific data series.

6. TGR -- Proportion of state hotel revenues from Tourist or Group/Convention, 1977

Source: U.S. Census of Service Industries, 1977

Construction: For statistical areas that lay entirely in one state, TGR was calculated directly from the revenue figures of the state as shown in Table 10 of the 'Hotels, Motor Hotels and Motels' section of the census. For areas including more than one state, the TGR was the weighted average of each state's TGR, where the weights were the proportion of the statistical area's population that resided in each state.

7. TRISM = HTL \* TGR

Source and Construction: See above.

8. TRPCT = (HTL \* TGR)/TI

Source and Construction: See above.

SUMMARY STATISTICS  
OF ROUTE-SPECIFIC VARIABLES

	MEAN	STANDARD DEVIATION	MINIMUM	MAXIMUM	OBS
OD8	3417.5	5859.8	389.00	68962.	1063
FR8	128.13	54.553	25.690	356.43	1063
CR8	4.9162	1.8850	1.0000	12.000	1063
HF8	0.4245	0.1982	0.1470	1.0000	1063
FQD8	5.2613	2.9611	1.0000	9.0000	1063
PPG8	1936.0	1219.4	94.869	11296.	1063
PIA8	13941.	1191.6	9725.5	18235.	1063
D18	0.0929	0.0548	0.0000	0.8480	1063
D1A8	0.1291	0.0656	0.0000	0.8790	1063
D28	0.0957	0.0753	0.0000	0.4510	1063
OD7	2035.3	3610.5	2.0000	45662.	1023
FR7	150.36	73.827	41.607	502.91	1023
FQD7	5.9675	2.9892	1.0000	9.0000	1023
PPG7	1772.9	1211.3	90.266	11183.	1023
PIA7	11380.	900.53	8551.1	16079.	1023
D1A7	0.0459	0.0414	0.0000	0.1370	1023
D27	0.0315	0.0339	0.0000	0.1610	1023
NR	0.2832	0.4927	0.0000	2.0000	1063
DT	964.77	710.89	85.000	5095.0	1063
TRINX	0.0244	0.0611	0.0024	0.3529	1063
TRISX	167.07	191.35	9.0478	1151.9	1063

# STRATIFICATION OF SELECTED VARIABLES

OD8						
0- 1000	1000- 2000	2000- 3000	3000- 4000	5000- 10000	10000- 20000	OVER 20000
269	355	143	123	107	47	19

S8 (=S08+S18)						
0- 10	10- 20	20- 30	30- 40	50- 100	100- 200	OVER 200
194	183	218	206	187	61	14

D18						
0- 0.02	0.02- 0.04	0.04- 0.07	0.07- 0.10	0.10- 0.20	0.20- 0.40	OVER 0.40
27	89	303	232	369	42	1

D1A8						
0- 0.02	0.02- 0.04	0.04- 0.07	0.07- 0.10	0.10- 0.20	0.20- 0.40	OVER 0.40
12	21	162	194	527	146	1

D28						
0- 0.02	0.02- 0.04	0.04- 0.07	0.07- 0.10	0.10- 0.20	0.20- 0.40	OVER 0.40
138	160	179	164	308	112	2

OD7						
0- 1000	1000- 2000	2000- 3000	3000- 4000	5000- 10000	10000- 20000	OVER 20000
478	272	106	89	55	15	7

S7 (=S07+S17)						
0- 10	10- 20	20- 30	30- 40	50- 100	100- 200	OVER 200
304	158	212	162	132	43	12

D1A7						
0- 0.02	0.02- 0.04	0.04- 0.07	0.07- 0.10	0.10- 0.20	0.20- 0.40	OVER 0.40
380	159	205	118	161	0	0

D37						
0- 0.02	0.02- 0.04	0.04- 0.07	0.07- 0.10	0.10- 0.20	0.20- 0.40	OVER 0.40
512	205	151	97	58	0	0

DT						
0- 300	300- 500	500- 750	750- 1000	1000- 1500	1500- 2500	OVER 2500
141	190	170	169	189	170	34

TRINX						
0- .0025	.0025- .005	.005- .0075	.0075- 0.010	0.010- 0.020	0.020- 0.030	OVER 0.030
3	326	212	196	164	38	124

## APPENDIX B

### SUPPLEMENTARY REGRESSIONS

TABLE B1

REGRESSIONS OF DISPERSION INDEXES FOR 1975  
 IV ESTIMATION -- FQD7,OD7,FR7 ENDOGENOUS  
 (Asymptotic Standard Errors in Parentheses)

	DEPENDENT VARIABLE	
	D1A	D2
CONSTANT	0.084 <sup>+</sup> (0.023)	0.059 <sup>+</sup> (0.019)
NR	0.013 <sup>+</sup> (0.003)	0.011 <sup>+</sup> (0.003)
DT/10000	-0.368 <sup>+</sup> (0.104)	-0.220 <sup>+</sup> (0.085)
FQD7/100	-0.743 <sup>+</sup> (0.135)	-0.497 <sup>+</sup> (0.109)
FR7/1000	0.669 <sup>+</sup> (0.113)	0.433 <sup>+</sup> (0.092)
OD7/100000	-0.085 (0.110)	-0.034 (0.089)
PPG7/100000	0.056 (0.262)	0.058 (0.212)
PIA7/100000	-0.552 <sup>+</sup> (0.189)	-0.414 <sup>+</sup> (0.153)
TRINX	0.089 <sup>+</sup> (0.023)	0.096 <sup>+</sup> (0.019)
<hr/>		
OBS	1023	1023
CRSQ	0.010	0.031
SSR	1.7161	1.1289

\* = Significant at the 5% level

+ = Significant at the 1% level



TABLE B2

REGRESSIONS OF DISPERSION INDEXES FOR 1982  
 IV ESTIMATION -- FQD8, OD8, FR8, HF8 ENDOGENOUS  
 (Asymptotic Standard Errors in Parentheses)

## DEPENDENT VARIABLE

	<u>D1</u>	<u>D1A</u>	<u>D2</u>
CONSTANT	-0.011 (0.035)	-0.013 (0.042)	-0.164* (0.052)
NR	-0.030* (0.005)	-0.031* (0.006)	-0.033* (0.007)
DT/10000	0.194 (0.118)	-0.302* (0.141)	-0.534* (0.172)
FQD8/100	0.634* (0.184)	0.984* (0.220)	1.056* (0.268)
FR8/1000	0.111 (0.175)	0.304* (0.209)	0.513* (0.254)
OD8/100000	-0.059 (0.109)	-0.076* (0.130)	-0.006 (0.158)
PPG8/100000	0.991* (0.349)	0.797 (0.417)	1.874* (0.508)
PIA8/100000	0.313 (0.180)	0.554* (0.215)	0.935* (0.261)
TRINX	-0.063 (0.032)	-0.032 (0.039)	-0.013 (0.047)
HF8	0.057* (0.025)	-0.011 (0.029)	0.080* (0.036)
<hr/>			
OBS	1063	1063	1063
CRSQ	-0.042	-0.039	-0.168
SSR	3.2988	4.3290	6.9846

\* = Significant at the 5% level

+ = Significant at the 1% level

TABLE B3

## ESTIMATED AIR TRAVEL DEMAND FUNCTION FOR 1975

## OLS ESTIMATION

(Standard Errors in Parentheses)

DEPENDENT VARIABLE: LN(OD7)

	<u>with D1A</u> <u>index</u>		<u>with D2</u> <u>index</u>
CONSTANT	-19.97 <sup>+</sup> (2.958)		-20.76 <sup>+</sup> (2.967)
NR	-0.534 <sup>+</sup> (0.041)		-0.543 <sup>+</sup> (0.041)
LDT	-0.373 (0.397)		-0.409 (0.398)
LDT2	0.065* (0.031)		0.055 (0.032)
LFR7	-1.934 <sup>+</sup> (0.377)		-1.652 <sup>+</sup> (0.392)
LD1A7	6.899 <sup>+</sup> (0.640)	LD27	8.482 <sup>+</sup> (0.787)
LPPG7	1.057 <sup>+</sup> (0.038)		1.072 <sup>+</sup> (0.038)
LPIA7	3.122 <sup>+</sup> (0.262)		3.126 <sup>+</sup> (0.263)
LTRINX	0.213 <sup>+</sup> (0.022)		0.210 <sup>+</sup> (0.021)
<hr/>			
OBS	1023		1023
CRSQ	0.695		0.695
SSR	343.82		343.88

\* = Significant at the 5% level

+ = Significant at the 1% level

TABLE B4  
ESTIMATED AIR TRAVEL DEMAND FUNCTION FOR 1982  
OLS ESTIMATION  
(Standard Errors in Parentheses)  
DEPENDENT VARIABLE: LN(OD8)

	<u>with D1 index</u>	<u>with D1A index</u>	<u>with D2 index</u>
CONSTANT	-22.14 <sup>+</sup> (2.359)	-21.87 <sup>+</sup> (2.320)	-22.53 <sup>+</sup> (2.354)
NR	-0.282 <sup>+</sup> (0.038)	-0.313 <sup>+</sup> (0.037)	-0.270 <sup>+</sup> (0.037)
LDT	0.903 <sup>+</sup> (0.349)	0.847 <sup>+</sup> (0.344)	0.964 <sup>+</sup> (0.348)
LDT2	-0.045 (0.026)	-0.037 (0.026)	-0.050 (0.026)
LFR8	-1.493 <sup>+</sup> (0.074)	-1.542 <sup>+</sup> (0.074)	-1.486 <sup>+</sup> (0.074)
LD18	-0.687 (0.374)	LD1A8 -1.823 <sup>+</sup> (0.317)	LD28 -0.005 (0.263)
LPPG8	1.129 <sup>+</sup> (0.035)	1.122 <sup>+</sup> (0.035)	1.133 <sup>+</sup> (0.035)
LP1A8	2.683 <sup>+</sup> (0.212)	2.695 <sup>+</sup> (0.209)	2.694 <sup>+</sup> (0.213)
LTRINX	0.198 <sup>+</sup> (0.019)	0.183 <sup>+</sup> (0.019)	0.206 <sup>+</sup> (0.019)
<hr/>			
OBS	1063	1063	1063
CRSQ	0.622	0.632	0.620
SSR	320.70	311.91	321.72

\* = Significant at the 5% level  
+ = Significant at the 1% level

TABLE B5

ESTIMATED AIR TRAVEL DEMAND FUNCTION FOR 1975  
 IV ESTIMATION -- FR7 ENDOGENOUS  
 (Asymptotic Standard Errors in Parentheses)  
 DEPENDENT VARIABLE: LN(OD7)

	<u>with D1A</u> <u>index</u>	<u>with D2</u> <u>index</u>
CONSTANT	-19.38 <sup>+</sup> (2.961)	-20.15 <sup>+</sup> (2.971)
NR	-0.533 <sup>+</sup> (0.041)	-0.542 <sup>+</sup> (0.041)
LDT	-0.298 (0.397)	-0.331 (0.398)
LDT2	0.074* (0.032)	0.064* (0.032)
LFR7	-2.214 <sup>+</sup> (0.382)	-1.947 <sup>+</sup> (0.398)
LD1A7	6.644 <sup>+</sup> (0.642)	LD27 8.135 <sup>+</sup> (0.791)
LPPG7	1.057 <sup>+</sup> (0.038)	1.072 <sup>+</sup> (0.038)
LP1A7	3.112 <sup>+</sup> (0.263)	3.116 <sup>+</sup> (0.263)
LTRINX	0.212 <sup>+</sup> (0.021)	0.209 <sup>+</sup> (0.021)
<hr/>		
OBS	1023	1023
CRSQ	0.695	0.694
SSR	344.01	344.07

\* = Significant at the 5% level

+ = Significant at the 1% level

TABLE B6  
ESTIMATED AIR TRAVEL DEMAND FUNCTION FOR 1975  
IV ESTIMATION -- FR7, FQD7, D1A7, D27 ENDOGENOUS  
(Asymptotic Standard Errors in Parentheses)  
DEPENDENT VARIABLE LN(OD7)

	<u>with D1A index</u>	<u>with D2 index</u>
CONSTANT	-9.805* (2.749)	-9.894* (2.745)
NR	-0.296* (0.040)	-0.299* (0.041)
LDT	0.955* (0.373)	0.939* (0.372)
LDT2	-0.029 (0.029)	-0.030 (0.029)
LFQD7	-0.835* (0.061)	-0.832* (0.061)
LFR7	-1.197* (0.356)	-1.169* (0.359)
LD1A7	1.105 (1.161)	LD27 1.541 (1.438)
LPPG7	0.708* (0.045)	0.709* (0.045)
LP1A7	1.572* (0.260)	1.577* (0.259)
LTRINX	0.175* (0.021)	0.173* (0.021)
OBS	1023	1023
CRSQ	0.758	0.760
SSR	272.63	270.74

\* = Significant at the 5% level

+ = Significant at the 1% level

TABLE B7  
ESTIMATED AIR TRAVEL DEMAND FUNCTION FOR 1982  
IV ESTIMATION -- FR8, FQD8, D18, D1A8, D28 ENDOGENOUS  
(Asymptotic Standard Errors in Parentheses)  
DEPENDENT VARIABLE: LN(OD8)

	<u>with D1 index</u>	<u>with D1A index</u>	<u>with D2 index</u>
CONSTANT	-5.842 <sup>+</sup> (2.086)	-5.419 <sup>+</sup> (2.129)	-6.154 <sup>+</sup> (2.075)
NR	-0.030 (0.039)	-0.097 <sup>*</sup> (0.040)	-0.003 (0.036)
LDT	1.830 <sup>+</sup> (0.315)	1.631 <sup>+</sup> (0.314)	1.961 <sup>+</sup> (0.298)
LDT2	-0.080 <sup>+</sup> (0.230)	-0.060 <sup>+</sup> (0.023)	-0.090 <sup>+</sup> (0.022)
LFQD8	-0.967 <sup>+</sup> (0.046)	-0.955 <sup>+</sup> (0.047)	-0.980 <sup>+</sup> (0.046)
LFR8	-1.266 <sup>+</sup> (0.114)	-1.315 <sup>+</sup> (0.119)	-1.265 <sup>+</sup> (0.115)
LD18	-1.121 (1.048)	LD1A8 -3.713 <sup>+</sup> (0.812)	LD28 -0.250 (0.691)
LPPG8	0.541 <sup>+</sup> (0.041)	0.528 <sup>+</sup> (0.043)	0.541 <sup>+</sup> (0.041)
LP1A8	0.929 <sup>+</sup> (0.190)	0.985 <sup>+</sup> (0.197)	0.910 <sup>+</sup> (0.195)
LTRINX	0.095 <sup>+</sup> (0.019)	0.065 <sup>+</sup> (0.019)	0.110 <sup>+</sup> (0.018)
<hr/>			
OBS	1063	1063	1063
CRSQ	0.749	0.731	0.748
SSR	212.72	228.24	213.37

\* = Significant at the 5% level  
+ = Significant at the 1% level

TABLE B8

## ESTIMATED AIR TRAVEL DEMAND FROM 1975 TO 1982 CHANGES

## OLS ESTIMATION

(Standard Errors in Parentheses)

DEPENDENT VARIABLE: LN(OD8/OD7)

	with D1A index		with D2 index
CONSTANT	-2.394 (2.301)		-2.235 (2.321)
NR	0.212 <sup>+</sup> (0.032)		0.216 <sup>+</sup> (0.032)
LDT	1.155 <sup>+</sup> (0.317)		1.155 <sup>+</sup> (0.318)
LDT2	-0.023 (0.025)		-0.020 (0.025)
LFR7	-0.201 (0.297)		-0.289 (0.308)
LFR8	-0.860 <sup>+</sup> (0.064)		-0.866 <sup>+</sup> (0.068)
LD1A7	4.558 <sup>+</sup> (0.501)	LD27	5.258 <sup>+</sup> (0.620)
LD1A8	-0.185 (0.273)	LD28	-0.288 (0.222)
LPPG7	1.786 <sup>+</sup> (0.260)		1.824 <sup>+</sup> (0.262)
LPPG8	1.720 <sup>+</sup> (0.269)		1.748 <sup>+</sup> (0.271)
LPIA7	0.571 (0.414)		0.506 (0.415)
LPIA8	0.726 <sup>+</sup> (0.367)		0.680 (0.368)
LTRINX	-0.052 <sup>+</sup> (0.018)		-0.054 <sup>+</sup> (0.018)
OBS	1023		1023
CRSQ	0.446		0.441
SSR	204.80		206.63

\* = Significant at the 5% level

+ = Significant at the 1% level

TABLE B9

ESTIMATED AIR TRAVEL DEMAND FROM 1975 TO 1982 CHANGES  
 IV ESTIMATION -- FR7,FR8 ENDOGENOUS  
 (Asymptotic Standard Errors in Parentheses)  
 DEPENDENT VARIABLE: LN(OD8/OD7)

	with D1A index		with D2 index
CONSTANT	-2.833 (2.977)		-2.723 (2.326)
NR	0.214+ (0.033)		0.218+ (0.033)
LDT	1.006+ (0.342)		1.016+ (0.345)
LDT2	-0.027 (0.025)		-0.025 (0.026)
LFR7	-0.245 (0.303)		0.037 (0.312)
LFR8	-0.770+ (0.150)		-0.794+ (0.147)
LD1A7	4.283+ (0.510)	LD27	4.889+ (0.634)
LD1A8	-0.165 (0.284)	LD28	-0.281 (0.225)
LPPG7	1.873+ (0.299)		1.889+ (0.300)
LPPG8	1.804+ (0.306)		1.810+ (0.307)
LPIA7	0.558 (0.414)		0.491 (0.415)
LPIA8	0.722* (0.367)		0.673 (0.369)
LTRINX	-0.052+ (0.019)		-0.053+ (0.018)
OBS	1023		1023
CRSQ	0.445		0.440
SSR	205.28		207.00

\* = Significant at the 5% level

+ = Significant at the 1% level



## FOOTNOTES

- 1 Braniff declared bankruptcy in 1981. National Airlines was merged into Pan Am in 1978. The same year, Republic Airlines was formed by the merger of North Central Airlines and Southern Airways, both local service carriers. The company later acquired Hughes Airwest. The new scheduled airlines are World, Capitol, People Express, New York Air, Midway, Muse, Jet America, Northeastern, Pacific East, Hawaii Express, and Emerald. In addition, three former intrastate carriers, Air Florida, Southwest and PSA, now operate in interstate markets.
- 2 All the traffic and financial data presented in the study are for domestic operations only.
- 3 For an in-depth comparison of intrastate carriers with trunk and local service airlines before deregulation, see Jordan [16].
- 4 During the DPFI, United Airlines testified that the price elasticity of demand was -0.3. The Board settled on -0.7. Econometric studies have generally estimated a much more elastic demand. See Brown & Watkins [4], Devany [7], Ippolito [14], and section 7 of this study.
- 5 Calculations from Graham & Kaplan [34], Appendices A and B and CAB, Air Carrier Traffic Statistics.
- 6 Virtually every study of airlines has accepted this correlation. See, for instance, Salop [25], Graham & Kaplan [34], Touche-Ross & Co. [32], and Douglas & Miller [9].
- 7 See Salop [25], Graham & Kaplan [34], Douglas & Miller [9], Ippolito [14], or Devany [7].
- 8 The Touche-Ross & Co. study of airline passengers [32], indicates that the vast majority of frequent flyers (defined as 6 or more trips in the 12 months prior to the survey)) are business travelers.
- 9 See Kahn [17], chapters 3 and 5.
- 10 This is probably for marketing reasons. For carriers to impose a 'no-show' penalty, they would have to require payment well in advance of the flight. Collecting the penalty otherwise would be costly and difficult. Payment in advance, however, would be very inconvenient for many business travelers who make reservations within just a few days of the flight. Without a penalty, though, people flying standby have an incentive to make fraudulent reservations (see footnote 12). This is part of the reason for the absence of standby fares on virtually all domestic

flights.

- 11 If the load factor averages 50%, then an absolute upper bound on the proportion of full flights is 0.5. In that case, the other 0.5 proportion of all flights would have to be completely empty. Since very few flights are near 0% load factors, the assumption in the text seems reasonable.
- 12 This number is probably much too high. In 1968, Braniff reported that youth standby fares had inspired fraudulent reservations that had raised their 'no-show' rate from 1.8% to 4.8%. (Kahn [17], p.76f) Assuming that the 'no-show' rate is now 5%, that full-fare passengers make up 40% of all sales (including unrestricted low coach fares), and that all 'no-shows' are full-fare passengers, the correct figure would be 0.125.
- 13 See CAB, Oakland Service Case, Docket 36699.
- 14 All coach class fares that were not Y-fares were at least 5% below the Y-fare.
- 15 Business revenue has a 0.96 correlation with population, so there does not appear to be a reasonable way to separate these demand sources. Another possible indication of business demand, revenues from the financial sector (e.g., insurance, stock brokers, accountants) has a 0.93 correlation.
- 16 The t-test of the hypothesis that a correlation is equal to 0 is roughly equivalent to a test of the significance of the regressor in a single-variable regression with a constant term.
- 17 The instruments used were the levels and natural logarithms of NR, DT, DT2, YF7 (the 1975 DPFI fare level), PPG7, PPG8, PIA7, PIA8, TRINX, TRISX, and for each endpoint, ENP7, ENP8, hotel revenues (HTL), financial sector revenues (FI), and total business revenues (TI).

## Chapter Four: Conclusion

The power to earn economic profits is not necessary for a firm to maintain discriminatory prices. It is clear now that in free-entry markets for differentiated goods, competition does not present a barrier to discrimination. Furthermore, models of monopolistic pricing behavior are not adequate for analyzing discrimination in these markets.

Inherent in theories of monopoly price discrimination is the notion that pricing strategy is not used to compete with other firms. Yet, this may be the principle motivation for some of the discriminatory pricing that we observe. Rather than trying to draw new customers into the market, competitive firms may single out for discounts those customers who buy the product from another firm, but who can easily be persuaded to switch brands. The output and welfare effects of this strength-of-brand-preference sorting tend to be less favorable than the effects of the more widely recognized reservation-price sorting.

In the recently deregulated airline industry, it is likely that both types of sorting occur. As is probably the case in many markets, these consumer characteristics are strongly correlated. People with high reservation prices tend to be less flexible in their choice of flights or airlines. It is also likely that the dispersion we observe in airline fares is partially attributable to peak-load pricing.

In an attempt to shed light on whether fare dispersion is benefitting society, I have analyzed its effects on traffic in city-pair markets. The results do not support those who claim that airline discounting practices have expanded the air travel market. Other things equal, fare dispersion appears to have a negative, though perhaps small, impact on output. This is a reversal of its apparent influence prior to deregulation.

These results were discussed in the terms of the earlier model of competitive price discrimination. Though there are surely other interpretations, the airline study demonstrates that this theory of free-entry price discrimination can be helpful in studying pricing behavior and its effects.

This theory might also have been useful in 1979 when Alfred Kahn, then director of the Council on Wage and Price Stability, discussed the desirability of prohibiting grocery producers and supermarkets from issuing discount coupons. He asserted that most of these coupons are simple attempts to price discriminate, which is almost surely true. The idea was quickly crushed under the weight of consumer protests. Yet, it is not clear that all consumers as a group benefit from coupons. It would be useful to ask whether discount coupons are intended primarily to attract new customers to a product or persuade them to switch brands of a product they already buy. In the case of coupons issued by supermarkets, particularly for inelastically demanded goods such as milk, the 'demand diversion' argument is quite strong.

A simple, yet revealing guide to distinguishing between 'demand diverting' and 'demand creating' discrimination is to ask 'Would a monopolist in this market offer this sort of discount?' Obviously monopolists have no incentive to engage in diversionary price discrimination. For frequent flyer programs, and supermarket coupons, the answer to this question is almost surely 'no.' On the other hand, the answer is less clear in the case of grocery producers' coupons, indicating that the practice may be demand 'creating' in some markets.

Comparison with monopolistic discrimination brings to light a potentially valuable extension of the theory. It would be useful to contrast the results from free-entry markets with the profit-maximizing behavior of a multi-brand monopolist. In which case is price discrimination more likely to be detrimental to social welfare? If the U.S. government chooses to enforce laws against price discrimination, though it is certainly not clear that it should, this comparison of monopoly and competitive markets could be a guide to where the greatest social gains are likely to be made.

Another interesting question remains unanswered in the theory due to the assumption of exogenous sorting devices. How do firms choose the criteria they use to segment the market? Clearly, concerns with resale and the costs of imposing certain tests have a great deal to do with the choice. These factors are traded off against the potential profit gains from discrimination. One goal of this research should be to determine whether the government could discourage

sorting criteria that have the greatest social costs without stifling price structures that benefit society.

No simple guidelines would accomplish such a task, particularly since income distribution is as great an issue in setting policy on price discrimination as is economic efficiency. Thus, it is as important to determine who wins and loses from an instance of price discrimination as it is to calculate the net gain or loss. Though many economists avoid these considerations, it has become increasingly clear that they must play a role in all government policy, not just issues of taxation and social programs. 'Supply-side' advocates may have overestimated the gains from tax cuts, but they have succeeded in reminding the public that income taxes have costly distortionary effects. Price discrimination, on the other hand, often has favorable effects on distribution and has been shown here to have neutral or positive efficiency effects in some cases. Though the tradeoff between economic efficiency and equitable income distribution is always difficult, it is hoped that this thesis has helped to clarify the efficiency issues that should be considered.

## REFERENCES

- [1] Bailey, E.E. and J.C. Panzar, Jr. "The Contestability of Airline Markets During the Transition to Deregulation." Law and Contemporary Problems (Winter, 1981).
- [2] Baumol, W.J. "Contestable Markets: An Uprising in the Theory of Industry Structure." American Economic Review (March, 1982).
- [3] Borenstein, S. "Price Discrimination in Imperfectly Competitive Markets." May, 1982 (mimeo).
- [4] Brown, S.R. and W.S. Watkins. "Measuring Elasticities of Air Travel Demand from New Cross-Sectional Data." (paper delivered at the annual meeting of the American Statistical Association, 1971).
- [5] Chamberlin, E.H. The Theory of Monopolistic Competition. Cambridge, Mass.: Harvard University Press, 1931.
- [6] Chamberlin, E.H. Towards a More General Theory of Value. New York: Oxford University Press, 1957.
- [7] Devany, A.S. "The Effect of Price and Entry Regulation on Airline Output, Capacity and Efficiency." Bell Journal of Economics (Spring, 1975).
- [8] Dixit, A.K. and J.E. Stiglitz "Monopolistic Competition and Optimum Product Diversity." American Economic Review (June, 1977).
- [9] Douglas, G.W. and J.C. Miller III. Economic Regulation of Domestic Air Transport: Theory and Policy. Washington D.C.: The Brookings Institute, 1974.
- [10] Frank, R.H. "When are Price Differentials Discriminatory?", CAB memo, 1980 (mimeo).
- [11] Fruhan, W.E. Jr. the Fight for Competitive Advantage: A Study of the United States Domestic Trunk Carriers. Boston, MA: Harvard University Graduate School of Business Administration, 1972.
- [12] Graham, D.R., D.P. Kaplan, and D.S. Sibley. "Efficiency and Competition in the Airline Industry." Bell Journal of Economics (forthcoming).
- [13] Greenhut, M.L. and H. Ohta Theory of Spatial Pricing and Market Areas. Durham, N.C.: Duke University Press, 1975.

- [14] Ippolito, R.A. "Estimating Arline Demand with Quality of Service Variables." Journal of Transport Economics and Policy (January, 1981).
- [15] Johnston, J. Econometric Methods, 2nd ed. New York: McGraw-Hill Book Co. (1972).
- [16] Jordan, W.A. Airline Regulation in America: Effects and Imperfections. Baltimore: The Johns Hopkins Press, 1970.
- [17] Kahn, A.E. The Economics of Regulation: Principles and Institutions. New York: John Wiley & Sons, Inc., 1970.
- [18] Kendall M.G. and A. Stuart. The Advanced Theory of Statistics, Volume II. New York: Hafner Press (1973).
- [19] Lerner, A.P. and H.W. Singer "Some Notes on Duopoly and Spatial Competition." Journal of Political Economy (April, 1937).
- [20] Maddala, G.S. Econometrics. New York: McGraw-Hill Book Co. (1981).
- [21] Pigou, A.C. The Economics of Welfare. London: Macmillan, 1932.
- [22] Pindyck, R.S. and D.L. Rubinfeld. Econometric Models and Economic Forecasts, 2nd ed. New York: McGraw-Hill Book Co. (1981).
- [23] Robinson, J. The Economics of Imperfect Competition. London: Macmillan, 1933.
- [24] Salop, S.C. "The Noisy Monopolist: Imperfect Information, Price Dispersion and Price Discrimination." The Review of Economic Studies (October, 1977).
- [25] Salop, S.C. "Alternative Reservation Contracts." CAB memo, 1978 (mimeo).
- [26] Salop, S.C. "Monopolistic Competition with Outside Goods." Bell Journal of Economics (Spring, 1979).
- [27] Salop, S.C. and J.E. Stiglitz "Bargains and Ripoffs: A Model of Monopolistically Competitive Price Dispersion." The Review of Economic Studies (October, 1977).
- [28] Scherer, F.M. Industrial Market Structure and Economic Performance. Chicago: Rand McNally College Publishing Company, 1980.



- [29] Schmalensee, R.L. "Comparative Static Properties of Regulated Airline Oligopolies." Bell Journal of Economics (Autumn, 1977).
- [30] Schmalensee, R.L. "Output and Welfare Implications of Monopolistic Third-Degree Price Discrimination." American Economic Review (March, 1981).
- [31] Spence, A.M. "Job Market Signalling." Quarterly Journal of Economics (August, 1973).
- [32] Touche-Ross & Co. Joint Travel Agent/Airline Economic and Value Study. (report before the CAB, 1978) (mimeo).
- [33] U.S. Civil Aeronautics Board. Deregulating the Airlines: An Economic Analysis. Washington D.C.: Civil Aeronautics Board, 1983.
- [34] U.S. Civil Aeronautics Board. Competition and the Airlines: An Evaluation of Deregulation. Washington, D.C.: Civil Aeronautics Board, 1982.
- [35] U.S. Civil Aeronautics Board. Antitrust Policy for the Aviation Industry. Washington D.C.: Civil Aeronautics Board, 1982.
- [36] U.S. Civil Aeronautics Board. Domestic Passenger Fare Investigation: January 1970 to December 1974. Washington D.C.: U.S. Government Printing Office, 1976.
- [37] Yamey, B. "Monopolistic Price Discrimination and Economic Welfare." Journal of Law and Economics (October, 1974).