PRICE DISPERSION IN THE AIRLINE INDUSTRY: THE EFFECT OF INDUSTRY ELASTICITY AND CROSS-PRICE ELASTICITY

A Dissertation

by

JONG HO KIM

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

August 2006

Major Subject: Economics

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Approved by:

Chair of Committee,	Steven Wiggins
Committee Members,	James Griffin
	Qi Li
	Steven Puller
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ABSTRACT

Price Dispersion in the Airline Industry:

The Effect of Industry Elasticity and Cross-Price Elasticity. (August 2006)

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Chair of Advisory Committee: Dr. Steven Wiggins

This dissertation analyzes the sources of price dispersion due to the price discrimination in the U.S. airline industry. Using the multi-stage budgeting approach with the almost ideal demand system (AIDS) specification, we estimate demand for air travel at the airline level, and empirically decompose an airline's own price elasticity into cross-price elasticity vis-à-vis other airlines and an industry elasticity. Conceptually, cross-price elasticity measures the responsiveness of quantity demanded of airline service offered by an airline to a unilateral change in the firm's own price with total expenditures given, whereas the industry elasticity measures the responsiveness of total quantity of airline travel demanded to a change in the overall price of air travel. Then, we investigate the determinants of price dispersion induced by discriminatory pricing across airline routes. Our results show that cross-price elasticity of demand for air travel, reflecting competitive-type discrimination, is the key factor affecting price dispersion in the airline industry. This result is consistent with the earlier findings of Borenstein and Rose (1994), but is based on a direct test of the underlying theory of Holmes (1989).

DEDICATION

To my parents,

Jae Hoo Kim and Soon Ok Bae,

who made all of this possible,

by their boundless love, devotion, support and encouragement.

ACKNOWLEDGEMENTS

It has been an exceptional journal. I have never dreamed of studying economics in the U.S. as an international graduate student. The work with this dissertation has been extensive and trying, but also exciting, instructive, and fun. Without help, support, encouragement and patience from several persons, I would never have been able to finish this work.

First of all, I would like to gratefully and sincerely thank Dr. Wiggins for his inspiring and encouraging way of guiding me to a deeper understanding of economics, his priceless comments throughout this research, and his patience in letting me cope with all the difficulties with this research. He, as a mentor, also taught me how to deal with problems in life.

I also would like to thank Dr. Griffin for his advice that was essential for the completion of this dissertation. He provided me with invaluable lessons and insights on the workings of academic research in economics. In particular, he has shown me, by his example, what a good economist (and person) should be.

I am very grateful to the members of my dissertation committee, Dr. Qi Li and Dr. Steven Puller, for their support and encouragement on this research. I also express my gratitude to Dr. Hae-Shin Hwang for his invaluable comments on my research and his consistent support during my graduate study.

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Last, but not least, I would like to thank my sister, Ji-Hae, for her love and understanding during my life in College Station, TX. Her support and encouragement was in the end what made this dissertation possible.

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CHAPTER I

INTRODUCTION

This dissertation analyzes the sources of price dispersion induced by price discrimination in the U.S. airline industry. There is a considerable body of work addressing the sources of price dispersion. My work is founded on the theoretical work by Borenstein (1985) and the follow-on work by Holmes (1989). Borenstein shows that price discrimination could exist in a monopolistically competitive market. This important result suggests that traditional models, which prior to his work focused only on price discrimination in monopoly markets, are seriously incomplete.

Holmes (1989) expands on Borenstein's (1985) results by building on the fundamental result that price discrimination is rooted in differences among consumers in their reservation prices and brand preferences. Holmes contribution is to show that one can conceptually separate the price elasticity of demand for an individual firm into an industry elasticity and cross-price elasticity vis-à-vis other firms. When a firm unilaterally raises the price of its good, the industry elasticity measures the tendency of consumers not to buy the good at all, whereas the cross-price elasticity measures the tendency of consumers to buy from a rival firm selling imperfect (or heterogeneous) substitute.

This dissertation follows the style of *The Journal of Law, Economics,& Organization*.

Price discrimination on the basis of consumers' diverse industry elasticities is referred to "monopoly type" price discrimination by Borenstein and Rose (1994), while "competitive type" price discrimination is based on consumers' diverse cross-price elasticities. The most important investigation testing between these types of price discrimination is carried out by Borenstein and Rose (1994). Using a reduced form model of price dispersion in the airline industry, they show that price dispersion is positively correlated with the level of market competitiveness. This empirical finding is suggestive of competitive-type price discrimination, and indirectly shows that heterogeneity in the tendency of consumers to switch airlines is the sole or dominant determinant of price dispersion in the airline industry. On the other hand, Borenstein and Rose's (1994) seminal work can be viewed as incomplete because they only indirectly examine the relationship between price discrimination and the two components of price elasticity. In addition, they are unable to separate the industry elasticity and cross-price elasticity as the sources of price discrimination in their model.

We test a model of price discrimination tied directly to Holmes (1989) which considers both industry and cross-price elasticity as sources of price discrimination. In particular, we attempt to directly test whether the industry or cross-price component of price elasticity is the primary determinant of observed price dispersion in the airline industry.

Using the multi-stage budgeting approach with the almost ideal demand system (AIDS) specification, we first estimate demand for air travel at the airline level. More specifically, we divide the decision to travel into three stages: (1) the decision regarding the travel budget, (2) the decision to travel by auto or plane, and (3) the choice among carriers. This type of multi-stage budgeting has been used by Ellision et al (1997), Hausman (1996), Hausman, Leonard and Zona (1994) and Hausman and Leonard (2002). This methodology permits a theoretically and empirically crisp separation between the industry and cross-price elasticities of demand. We use both airline industry data (for the bottom stage as well) and travel survey micro data for estimation of the choice between modes of travel, and the choice of traveling or staying home.

After estimating demand for air travel, we use the estimated components of price elasticities to investigate the determinants of price dispersion induced by price discrimination across airline routes. Following Borenstein and Rose (1994), we use the Gini coefficient of air fares to measure the degree of price dispersion. Our results show that cross-price elasticity of demand for air travel, reflecting competitive-type discrimination, is the key factor affecting price dispersion in the airline industry. This result is consistent with the earlier findings of Borenstein and Rose, but is based on a direct test of the underlying theory of Holmes.

Chapter II describes the structure of consumers' decision on travel in each of three stages and presents the empirical model and method, data used to estimate consumers choice among carriers conditional on total revenue of air travel at the bottom level. We discuss consumers' decision at the top two levels and describe the empirical model, data used for the estimation of demand model for air travel unconditional on travel revenue in Chapter III. Chapter IV provides the estimated industry elasticities and cross-price elasticities, and then, examines their roles in explaining price dispersion in the U.S. airline industry.

CHAPTER II

DEMAND FOR AIR TRAVEL: FIRM LEVEL

2.1 Introduction: A Multi-Stage Budgeting Model

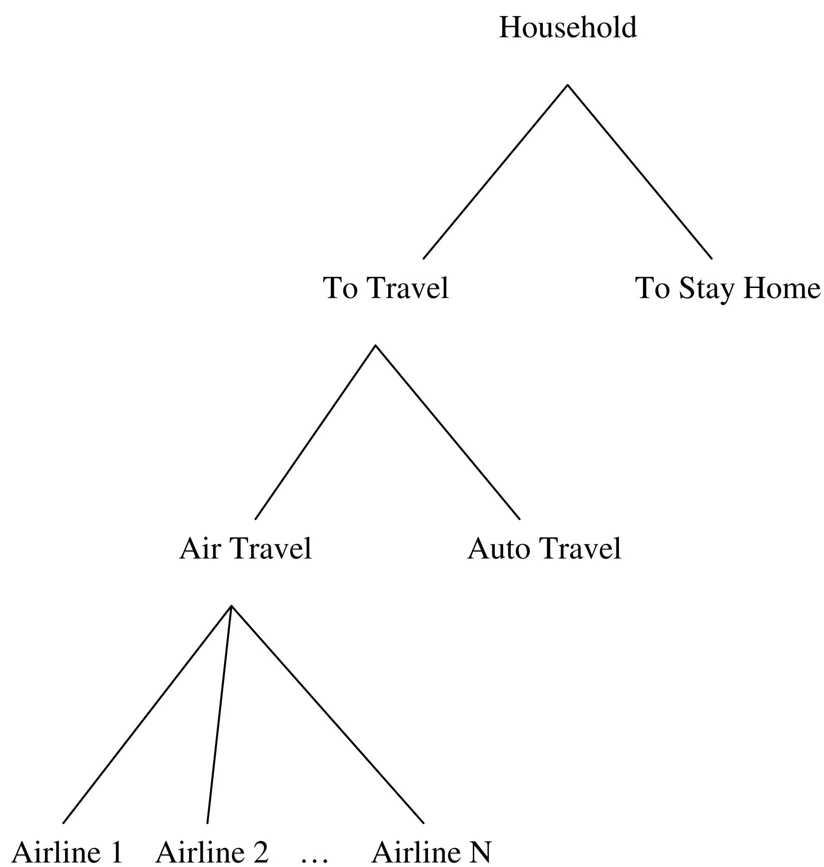

Figure 1. The Consumer Decision Tree Regarding Travel

The model of demand for air travel we use is a three-stage budgeting model based on multi-stage budgeting approach developed by Gorman (1959). We assume that travelers can allocate total expenditure in stages so that their choice in each stage is made conditional only on the expenditures allocated in the upper stage and prices of goods in that stage. The decision tree in Figure 1 illustrates the structure of travelers' choice: (1) at the top stage, travelers decide whether or not to travel and expenditure is allocated to overall travel; (2) at the middle stage, given total travel expenditure, travelers determine modes of transportation; and (3) at the bottom stage, travelers' preference on airlines is revealed conditional on total expenditure on air travel.

The multi-stage budgeting model allows us to empirically decompose an airline's own or firm level price elasticity into cross-price elasticity vis-à-vis other airlines and an industry elasticity. Conceptually, cross-price elasticity measures the responsiveness of quantity demanded of a good to a unilateral change in the firm's own price with total expenditures given, whereas the industry elasticity measures the responsiveness of total quantity of airline travel demanded to a change in the overall price of air travel. Price elasticity measured at the bottom level in Figure 1 represents the cross-price elasticity, whereas at the top two levels, we observe the industry price elasticity of air travel. In this chapter, the focus is on measuring the cross-price elasticity among airlines at the bottom level of Figure 1.

2.2 Specification of the Almost Ideal Demand System Model

As a demand system at the bottom stage, we employ the Almost Ideal Demand System (AIDS) of Deaton and Meullbauer (1980a). The AIDS specification provides a flexible functional form that allows for an unconstrained substitution pattern across products within a group. Further, without requiring homothetic preferences, the AIDS model aggregates perfectly over individuals, which permits aggregation of individual level data over various dimensions.

Let the AIDS expenditure function for air travel on a route where N airlines are competing be defined as

$$\log e(u,p) = a(p) + u \cdot b(p) \tag{1}$$

where u is the utility travelers derive from air travel and p is the air fare. This expenditure function represents the PIGLOG[1] class, which allows exact aggregation over travelers such that demand for an airline can be represented as an outcome of decisions made by a rational representative traveler. We then take the following functional forms for $a(p)$ and $b(p)$:

$$a(p) = \alpha_0 + \sum_{k=1}^{N} \alpha_k \log p_k + \frac{1}{2} \sum_{k=1}^{N} \sum_{l=1}^{k} \gamma_{kl}^{*} \log p_k \log p_l \tag{2}$$

$$b(p) = \beta_0 \Pi p_k^{\beta_k} \tag{3}$$

where p_i is quantity-weighted average fare charged by airline i, and α, β, γ^* are parameters to be estimated. Substituting (2) and (3) into (1) and applying Shepard's Lemma yield the expenditure share equation of AIDS model:

[1] The PIGLOG represents price independent generalized logarithmic preferences

$$s_i = \alpha_i + \sum_{i=1}^{N} \gamma_{ij} \log(p_j) + \beta_i \log\left(\frac{E^{air}}{P}\right) \quad (4)$$

where expenditure share $s_i \equiv \frac{p_i q_i}{\sum_{j=1}^{N} p_j q_j} = \frac{p_i q_i}{E}$, E is total expenditure on air travel,

and P is price index defined by

$$\log P = \alpha_0 + \sum_{k=1}^{N} \alpha_k \log p_k + \frac{1}{2} \sum_{k=1}^{N} \sum_{l=1}^{k} \gamma_{kl} \log p_k \log p_l \quad (5)$$

and

$$\gamma_{ij} = \frac{1}{2}\left(\gamma_{ij}^* + \gamma_{ji}^*\right). \quad (6)$$

If equation (5) is used for the price index, the expenditure share equation is not linear in $\log p_i$. To avoid non-linearity in our estimation equation, we use the Stone price index ($\log P = \sum_{i=1}^{N} s_i \cdot \log p_i$) as an approximation of the price index in equation (5). In order to satisfy the restrictions implied by the theory of utility maximization problem of a representative consumer, we impose the following adding-up, homogeneity, and symmetry restrictions:

Adding-up: $\sum_{i=1}^{N} \alpha_i = 1, \sum_{i=1}^{N} \beta_i = 0, \sum_{i=1}^{N} \gamma_{ij} = 0$

Homogeneity: $\sum_{j=1}^{N} \gamma_{ij} = 0$

Symmetry: $\gamma_{ij} = \gamma_{ji}, \quad \forall i, j$

The adding-up condition ensures $\sum_{i=1}^{N} s_i = 1$ and is imposed by not estimating one firm's share equation to avoid the problem of singularity in the error covariance matrix. In this setup, Southwest Airlines is the omitted share equation. In addition, Southwest's price is used as the numeraire price to satisfy the homogeneity restriction.

Under the AIDS specification, it is relative prices between alternative airlines and total expenditure on air travel that travelers take into account in choosing airlines. Previous studies on the airline industry show, however, that travelers' demand for air travel depends on the quality of service and brand preference as well as relative prices among rival carriers.[2] Accordingly, we include in our estimation equation, airline dummies to control for travelers' preferences for brand, and an indirect service dummy to control for the quality of services offered by airlines on a particular route.[3] Indirect service dummies represent whether an airline only offers indirect service. Table 1 indicates that the percentage of indirect-only routes increases with statutory route distance. Also, the distribution of indirect-only routes varies across airlines. Meanwhile, when airlines offering similar mean fares are compared, the percentage of indirect-only service routes and the mean of revenue share incline to be negatively correlated.

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[2] Refer to Berry, Carnall and Spiller (1996), Borenstein (1989) and Reiss and Spiller (1989).

[3] Berry, Carnall and Spiller (1996), Borenstein (1989) and Reiss and Spiller (1989) suggest that the presence of hub airport should be considered in estimating the demand for air travel. Theses studies examine factors affecting fares charged on travelers and demand for airline service at "industry level," while in this study, we estimate "carrier level" demand for air travel on those routes where Southwest entered. Due to our scope of study, the presence of hub airport seems to be highly correlated with a indirect service dummy and a brand dummy. Hence, we exclude a hub dummy in estimating firm level demand for air travel.

Table 1. Percentage of Indirect-Only Routes, Mean Fare, and Mean Revenue Share

	Statutory Distance Between Origin and Destination City											
	1-749 miles				750-1499 miles				1500- miles			
	Mean Indirect -Only	Mean Fare	Mean Share	Obs	Mean Indirect -Only	Mean Fare	Mean Share	Obs	Mean Indirect -Only	Mean Fare	Mean Share	Obs
American Airlines (AA)	47.9%	102.0	14.6%	572	73.6%	167.7	19.8%	716	75.3%	222.7	25.7%	389
Alaskan Airlines (AS)	21.8%	99.5	17.9%	124	15.8%	141.5	38.8%	76	19.2%	335.5	0.7%	52
Continental Airlines (CO)	24.7%	99.7	10.2%	446	50.6%	144.6	13.0%	722	40.3%	181.7	12.3%	365
Delta Air Lines (DL)	49.3%	118.6	16.1%	594	57.7%	165.0	18.5%	711	53.4%	221.8	23.2%	388
America West Airlines (HP)	25.0%	96.2	21.8%	252	38.0%	136.1	23.8%	387	42.2%	208.3	10.3%	258
Northwest Airlines (NW)	58.3%	115.0	9.3%	314	59.9%	133.4	7.5%	459	73.5%	189.2	10.7%	343
Reno Air (QQ)	9.9%	102.4	26.8%	101	15.7%	124.1	11.1%	83	9.5%	213.7	5.3%	42
Trans World Airlines (TW)	39.5%	107.0	19.6%	306	61.0%	140.4	10.8%	469	66.0%	192.6	10.8%	324
United Air Lines (UA)	45.7%	103.5	10.3%	411	61.1%	161.8	13.0%	627	74.3%	223.7	17.9%	381
US Airways (US)	25.9%	118.7	14.3%	321	31.8%	148.0	14.8%	337	39.1%	202.9	9.4%	302
Southwest Airlines (WN)	28.8%	80.7	53.9%	685	55.0%	130.7	33.5%	780	62.5%	145.3	20.2%	408

Source: *Origin and Destination Survey 1989~1997*;
† Auto represents personal use vehicle such as (rental) car, pick-up truck, van, etc.
* In parentheses is the percentage of each mode of transportation chosen by travelers in a distance band

Finally, the share equation to be estimated for airline i[4] on a route t where N airlines are competing is

$$s_{it} = \alpha_i + \sum_{j=1}^{N-1} \gamma_{ijt} \log\left(\frac{p_{jt}}{p_{swt}}\right) + \beta_i \log\left(\frac{E_t^{air}}{P_t}\right) + \sum_{j=1}^{N-1} \delta_{ij} \cdot D_{ijt}^{firm}$$

$$+ \sum_{a_1=0}^{1} \sum_{a_2=0}^{1} \cdots \sum_{a_N=0}^{1} \varphi_{ia_1a_2\ldots a_N} D_{a_1a_2\ldots a_N t}^{direct} \qquad (7)$$

where an airline brand dummy $D_{ijt}^{firm} = 1$ if airline j is ranked at i^{th} in revenue share, and a direct service dummy $D_{a_1a_2\ldots a_N t}^{direct} = 1$ if $d_1 = a_1, d_2 = a_2, \ldots, d_N = a_N$ where $d_i = 0$ if i^{th} ranked airline offers indirect service only and $d_i = 1$ if i^{th} ranked airline offers both direct and indirect service, or direct service only.[5] For example, on a route t where three carriers are competing, $D_{101t}^{direct} = 1$ implies that the leading airline and Southwest offers direct service (either both direct and direct service or direct service only) and airline 2 only offers indirect-only service.

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[4] If we identify airlines by their names, total number of share equation system will grow faster as more airlines are competing on a route. For example, possible combination of 3 carriers for two-carrier route is 3(= ${}_3C_2$), and that of 10 carriers for two-carrier route is 45(= ${}_{10}C_2$). In order to reduce the number of share equation system to be estimated, we label firms by their revenue share rank one quarter before Southwest (SW)'s entry. Suppose that before SW's entry, airline x, y, and SW serve route A, and y, z, and SW serve route B. Also, the order of revenue share on route A and B is SW>x>y and y>SW>z, respectively. Then, airline x and y are named "1" (first in revenue share except for SW); airline y and z are labeled "2" (second in revenue share except for SW); and "3" (number of airlines on each route) will be given to SW. SW is to be labeled "total number of airlines on a route," and its share equation is not estimated but derived from share equation system of rest airlines. In addition, on routes where the number of airlines remain unchanged after SW's entry, the airline leaving with SW's entry will be given "number of airlines on that route", which will be allocated to SW as well.

[5] $D_{11\ldots11t}^{direct}, D_{00\ldots00t}^{direct}$ are dropped out in that all airlines offer services of same quality.

2.3 Data Description

The data used for estimation of the airline firm price elasticity are the Department of Transportation's *Origin and Destination Survey (DB1A)* for the first quarter of 1989 through the fourth quarter of 1997. The DB1A is a ten percent random sample of all tickets that originate in the U.S. and provides information on the carrier, origin and destination, dollar amount paid by each passenger, fare class and travel distance for each segment that passengers have traveled.

Southwest's entry provides a natural setting for investigating how travelers respond to the changes in air fares. More specifically, we can make full use of variations in the relative prices among airlines and the revenue shares of airlines by focusing on Southwest entry routes. Consequently, we focus on coach class travel in those markets where Southwest entered and has been serving since then. Table 2 breaks DB1A into three distance bands with 750 mile increments and compares average fares and Gini coefficients of fares over time both before and after Southwest's entry.[6] Southwest tries to expand its market by offering much lower fares than its rivals. In response to Southwest's entry, incumbent airlines lower their fares by about $30 regardless of the distance of routes. Interestingly, rival airlines adjust their average fares upon Southwest's entry and remain relatively constant in ensuing quarters. Consequently, in choosing which pre-entry quarter to compare with a post-entry quarter, it makes little difference. In addition, incumbent airlines fare dispersion measured by Gini index seems to not respond to Southwest's entry. Figure 2 and Figure 3 confirm that the distribution

[6] Refer to Appendix A for the definition of Gini coefficient of fares.

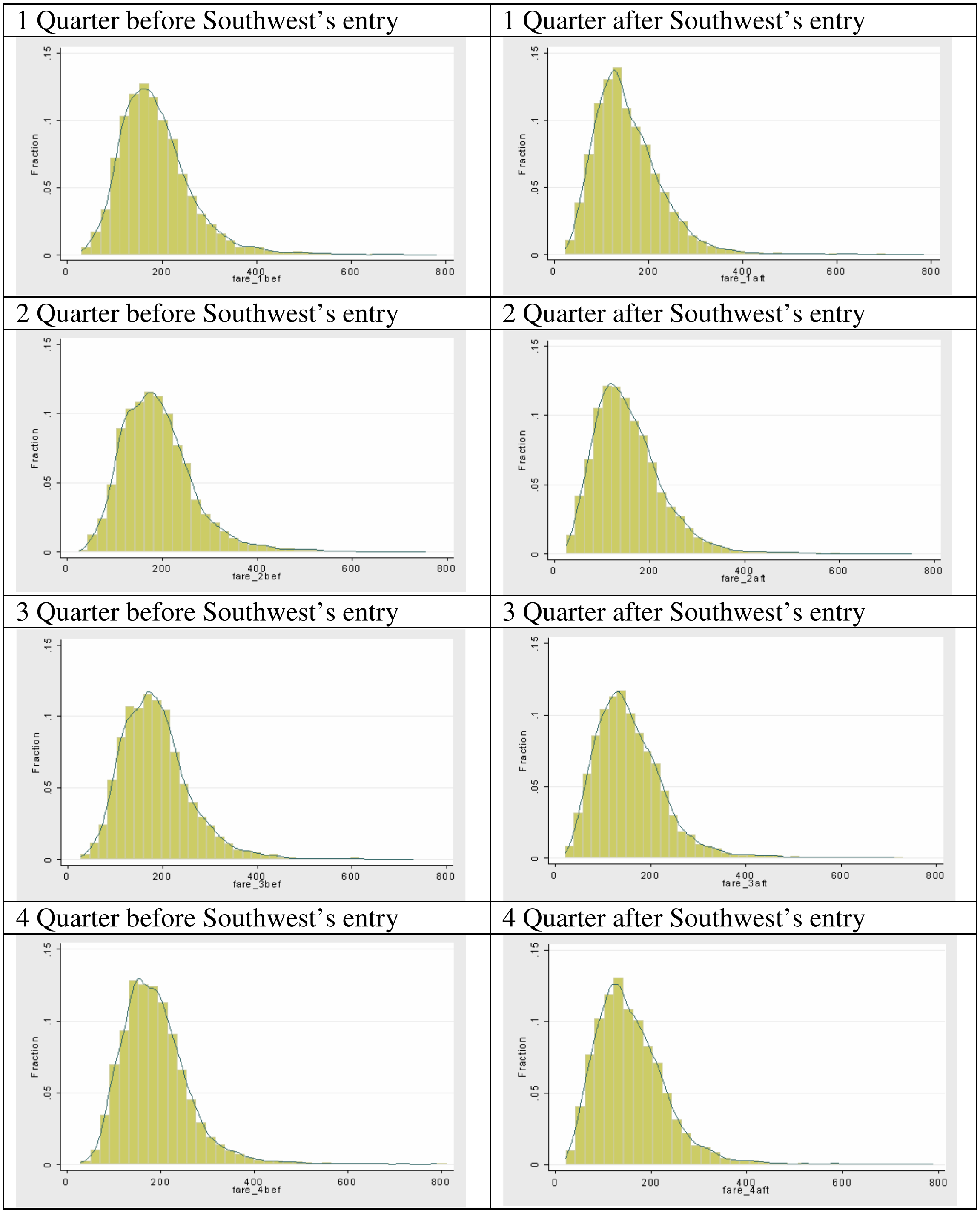
Table 2. Average Fare and Fare Gini Before and After Southwest's Entry

		Statutory Distance Between Origin and Destination City								
		1-749			750-1499 miles			1500- miles		
		Mean Fare	Mean Gini	Obs	Mean Fare	Mean Gini	Obs	Mean Fare	Mean Gini	Obs
Non-Southwest	4 Q before	144.5	0.167	1348	183.2	0.173	2478	228.3	0.196	1723
	3 Q before	141.8	0.166	1386	178.8	0.172	2462	231.5	0.196	1707
	2 Q before	145.8	0.158	1419	184.1	0.167	2518	237.7	0.188	1784
	1 Q before	141.5	0.164	1475	180.0	0.177	2583	232.0	0.194	1820
	1 Q after	108.0	0.170	2195	151.7	0.172	3425	206.7	0.187	2121
	2 Q after	108.2	0.169	2098	152.7	0.169	3355	209.5	0.189	2052
	3 Q after	110.1	0.165	2106	154.7	0.167	3318	210.4	0.187	1963
	4 Q after	109.8	0.169	2033	155.8	0.169	3182	214.8	0.189	1893
Southwest	1 Q after	80.7	0.114	671	130.7	0.068	760	145.3	0.101	365
	2 Q after	67.1	0.118	636	115.5	0.067	747	141.4	0.097	353
	3 Q after	67.8	0.107	636	117.4	0.057	741	142.7	0.096	351
	4 Q after	69.6	0.081	618	119.3	0.056	714	141.4	0.082	344

of average fares and that of share are skewed more to the left after Southwest's entry, but remains unchanged before or after Southwest's entry.

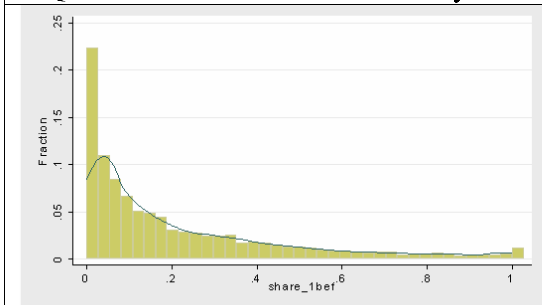
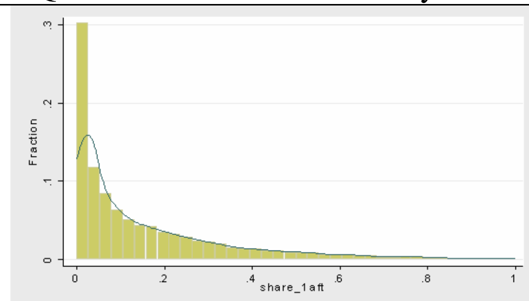
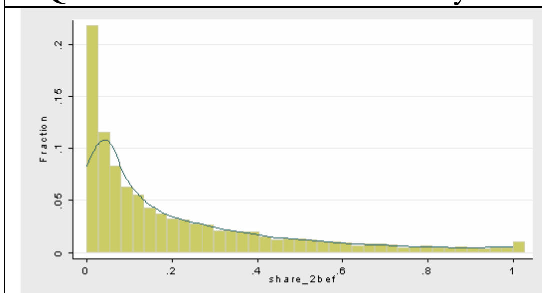
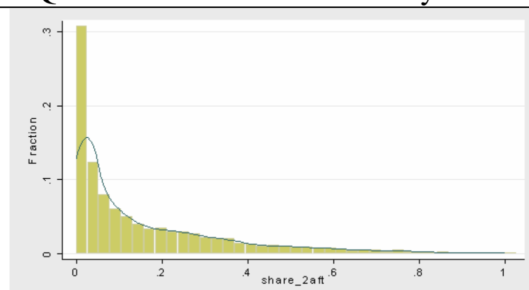
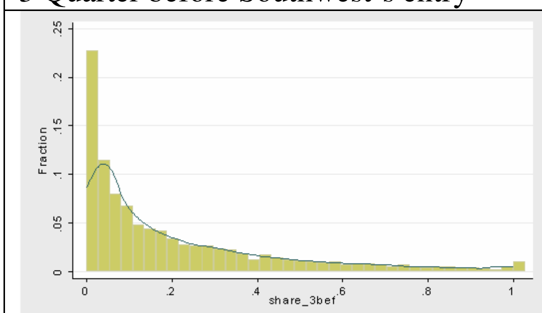
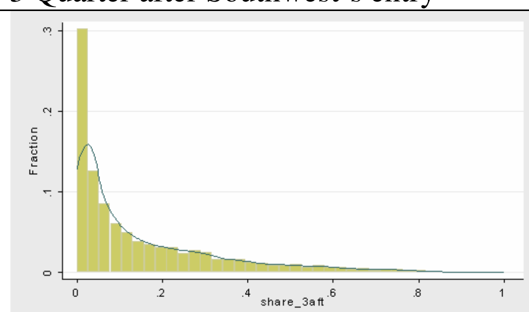
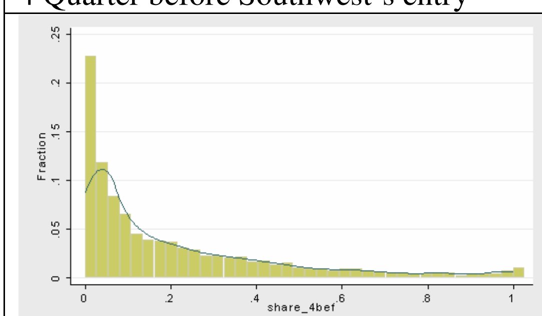
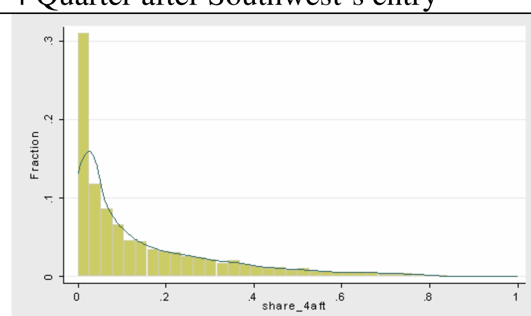
Table 3 shows how many incumbent airlines leave or entrant airlines enter when Southwest enters.[7] In general, when Southwest enters a new route, one or none of the incumbent airlines leaves and one to two airlines enter other than Southwest. Due to the

[7] From DB1A, we define a route is entered by Southwest if travelers start and continue to take Southwest- for example, Southwest is defined to enter Boise, ID to Portland, OR route at the last quarter of 1994 because tickets by Southwest for this route has been observed since then. It should be noted that if no tickets by Southwest are observed, it could be either Southwest does not serve this route, or number of tickets sold by Southwest are so small that 10% random sample of those tickets is not drawn; however, we can not distinguish one from the other.



Source: *Origin and Destination Survey 1989~1997*
For comparison reason, average fares of Southwest is excluded in figures for the quarters after Southwest's entry

Figure 2. Average Fare of Airlines on a Route: Histogram and Kernel Density

1 Quarter before Southwest's entry	1 Quarter after Southwest's entry
	
2 Quarter before Southwest's entry	**2 Quarter after Southwest's entry**
	
3 Quarter before Southwest's entry	**3 Quarter after Southwest's entry**
	
4 Quarter before Southwest's entry	**4 Quarter after Southwest's entry**
	

Source: *Origin and Destination Survey 1989~1997*
For comparison reason, revenue share of Southwest is excluded in figures for the quarters after Southwest's entry

Figure 3. Revenue Share of Airlines on a Route: Histogram and Kernel Density

Table 3. Number of Airlines 1 Quarter Before/After Southwest's Entry

		Number of airlines competing on a route 1 quarter after Southwest's entry												
		1	2	3	4	5	6	7	8	9	10	11	12	13
Number of airlines competing on a route 1 quarter before Southwest's entry	1	5	41	16	5									
	2	1	18	88	26	5								
	3		7	35	71	40	10	1						
	4			9	54	109	45	15						
	5			1	18	41	83	34	3					
	6				2	13	38	72	22	4		1		
	7					1	7	29	72	17	3		1	
	8						1	8	17	32	11			
	9								2	10	14	7	4	
	10									2	3	4	1	1
	11									1	2		1	

Source: *Origin and Destination Survey 1989~1997*

entry or exit of airlines, information on fares and number of travelers is not available for some quarters. The incomplete panel structure of the data makes it challenging to estimate demand using dynamic Almost Ideal Demand System model. Instead, for representing dynamic relationship between fare and revenue share incurred by Southwest's entry, we chose observations one quarter before and after SW's entry. In particular, we limit the number of airlines serving a route to from 1 to 8 airlines before SW's entry and from 2 to 8 airlines after SW's entry, and consider only routes where the number of airlines after SW's entry is equal to or one more than before SW's entry.[8]

---

[8] We first exclude routes where more than 8 carriers are competing after Southwest's entry in that observations of those routes are not large enough to provide statistically meaningful estimation results. Among those routes where 8 or less carriers are competing after Southwest's entry, we focus on two different types of routes. On one type of routes, no incumbent carriers drop out of the route, and therefore, the change in the number of competing carriers results entirely from Southwest entry. On another type of

These restrictions, which are imposed for tractability of the empirical model, account for about 68 percent of the total observations.

2.4 Estimation Results

Using Seemingly Unrelated Regression (SUR) proposed by Zellner (1962), our AIDS model with revenue share equation of (7) is estimated.[9] In implementing our empirical model, we need to first consider the problem of the potential endogeneity of price. First, our expenditure share data across airlines for a particular route are aggregated from micro data, where the prices are exogenous to consumers. Second, airlines seem to determine fare schedule in advance and offers tens of different fares for the same route by imposing restrictions on tickets such as advance-purchase and Saturday night stay-over. Average fares in our estimation, therefore, are unlikely to be correlated with the error term in the demand equation.

A second problem is that Southwest's fare is unobservable before its entry. Yet, it is the period before Southwest's entry and the period after entry that results in a large shift in Southwest's share, which is critical for estimating the price elasticities. Consequently, it is useful to think of Southwest as having a high virtual price prior to entry that resulted in a zero share.[10]

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routes, only one incumbent carrier leaves the route in response to Southwest's entry. Then, the net change in the number of competing carriers induced by Southwest's entry equals zero.

[9] We exclude routes whose daily total passengers are less than 10.

[10] When number of airlines on a route is not changed by Southwest's entry, we assume that Southwest replaces the airline that left with Southwest's entry. For this route, the fare of the airline replaced by Southwest is used as a denominator for relative price before Southwest's entry.

We first estimate the SUR model using observations for all routes after Southwest's entry and observations for routes where one airline leaves with Southwest's entry. Now, from the coefficients estimated, we can calculate Southwest's virtual fare before its entry using information on fares and shares of other airlines. The following virtual fare formula is calculated from equation (7) by solving for the virtual fare that yields a predicted zero Southwest share in the pre-entry period as follows:

$$p_{sw}^{Virtual} = \exp\left[\left\{\left(1-\sum_{i=1}^{N-1}\hat{\alpha}_i\right) - \sum_{i=1}^{N-1}\sum_{j=1}^{N-1}\hat{\gamma}_{ij}\cdot\log p_{jt} - \sum_{i=1}^{N-1}\hat{\beta}_i\cdot\log E_t - \sum_{i=1}^{N-1}\sum_{j=1}^{N-1}\hat{\delta}_{ij}\cdot D_{ijt}^{firm} - \sum_{i=1}^{N-1}\sum_{a=1}^{2}\sum_{b=1}^{2}\cdots\sum_{m=1}^{2}\sum_{n=1}^{2}\hat{\varphi}_{iab\ldots mn}\cdot D_{ab\ldots mnt}^{direct}\right\}\Big/\sum_{i=1}^{N-1}\sum_{j=1}^{N-1}\hat{\gamma}_{ij}\right] \quad (8)$$

Table 4 indicates that the mean of Southwest's estimated virtual fare is always greater than that of incumbent's maximum fare. This high virtual fare supports our assumption of a Southwest zero revenue share before its entry. In effect, Southwest sets its fare too high to have positive share prior to entry. Given Southwest's virtual fare, we then re-estimate the SUR model using all observations both before and after Southwest's entry.

We discuss in detail the estimation results for those routes where three airlines are competing after Southwest enters. The first two columns of Table 5 provide estimates of the AIDS model for observations excluding those routes where no incumbent airlines drop out of in response to Southwest's entry. Coefficients of airline dummies show that, when relative fares are being controlled, Continental, United and Delta will have 23.5 %, 17.5 % and 14.0 % more share than Alaskan or Expressjet. Further, if leading firm only offers direct service and Southwest provides indirect-only service, the incumbent airline will have at least 30.2 % more share than when its service

Table 4. Southwest's Virtual Fare 1 Quarter Before Its Entry[11]

			Obs	Mean	Std. Dev.	Min	Max
number of Airlines After SW's Entry	2	SW's Virtual Fare	10	185	154	3	442
		Max Fare of Other Airlines	10	108	22	85	156
	3	SW's Virtual Fare	26	1602	2537	147	13059
		Max Fare of Other Airlines	26	255	115	97	649
	4	SW's Virtual Fare	34	2260	2352	132	14590
		Max Fare of Other Airlines	34	223	93	94	512
	5	SW's Virtual Fare	67	9036	10656	429	61230
		Max Fare of Other Airlines	67	252	92	111	673
	6	SW's Virtual Fare	69	11700	8865	107	31195
		Max Fare of Other Airlines	69	247	90	98	537
	7	SW's Virtual Fare	59	1.34E+16	5.78E+16	11186	3.57E+17
		Max Fare of Other Airlines	59	277	112	120	674
	8	SW's Virtual Fare	64	3.94E+25	2.54E+26	16	1.96E+27
		Max Fare of Other Airlines	64	285	101	117	695

Source: *Origin and Destination Survey 1989~1997*

is indirect only. Airline 2 will lose 9.0 % of its market share if the leading firm offers direct service and Southwest starts to provide direct service on that route.

The last two columns of Table 5 offer estimates for observations which include Southwest's virtual fare. In this case, the data sets include both pre- and post-entry. Being compared with the coefficients in the first two columns, there is no qualitative difference in coefficients. The estimated coefficient of own relative fare for airline 1 is -0.208 and statistically significant, which implies that if airline 1 lowers its relative fare by 10 %, then its revenue share will increase by 2.08 % points. In addition, the coefficients for the constant, logarithm of expenditure and relative price, becomes

[11] Although Southwest's virtual fare seems to be too large on routes where more than five airlines are competing, the level of virtual fare has little impact on regression results only if virtual fare is greater than maximum fare of other rival airlines.

Table 5. Estimation Results: 3 Airlines After Southwest's Entry

AIDS Model of Determinants of Share

S_i	Without SW's Virtual Fare		With SW's Virtual Fare	
	Airline 1	Airline 2	Airline 1	Airline 2
Constant	0.794 *** (0.135)†	0.474*** (0.101)	0.883 *** (0.093)	0.457 *** (0.073)
$\log(E/P)$	-0.071 *** (0.022)	-0.059 (0.015)	-0.078 *** (0.014)	-0.052 *** (0.011)
$\log(p_1/p_{SW})$	-0.164 * (0.096)	0.041 (0.050)	-0.208 *** (0.049)	0.058 (0.040)
$\log(p_2/p_{SW})$	0.041 (0.050)	-0.049 (0.051)	0.058 (0.040)	-0.052 (0.037)
$D_{110}^{indirect}$	0.305 ** (0.140)	0.007 (0.093)	0.310 *** (0.116)	0.012 (0.086)
$D_{101}^{indirect}$	-0.008 (0.084)	-0.090 (0.059)	0.019 (0.059)	-0.165 *** (0.043)
$D_{100}^{indirect}$	0.429 *** (0.112)	-0.231 *** (0.068)	0.386 *** (0.094)	-0.227 *** (0.063)
$D_{011}^{indirect}$	0.055 (0.183)	0.072 (0.125)	0.024 (0.099)	0.086 (0.072)
$D_{010}^{indirect}$	-0.375 ** (0.185)	-0.260 * (0.145)	-0.338 ** (0.160)	-0.254 ** (0.126)
$D_{001}^{indirect}$	-0.108 (0.075)	-0.048 (0.050)	-0.128 (0.051)	-0.049 (0.036)
D_{AA}^{firm}	0.094 (0.074)	0.094 (0.074)	0.000 (0.000)	
D_{CO}^{firm}	0.235 ** (0.092)	0.235 ** (0.092)	0.210 *** (0.061)	0.210 *** (0.061)
D_{DL}^{firm}	0.140 *** (0.052)	0.140 *** (0.052)	0.105 *** (0.038)	0.105 *** (0.038)
D_{HP}^{firm}	0.078 (0.070)	0.078 (0.070)	0.064 (0.053)	0.064 (0.053)
D_{NW}^{firm}	0.000 (0.000)		0.000 (0.000)	
D_{QX}^{firm}				0.163 * (0.091)
D_{TW}^{firm}		0.000 (0.000)	0.012 (0.062)	0.012 (0.062)
D_{TZ}^{firm}	-0.006 (0.157)		-0.077 (0.116)	
D_{UA}^{firm}	0.175 *** (0.055)	0.175 *** (0.055)	0.151 *** (0.042)	0.151 *** (0.042)
D_{US}^{firm}	0.060 (0.066)	0.060 (0.066)	0.016 (0.050)	0.016 (0.050)
D_{YV}^{firm}	0.248 (0.142)		0.191 (0.112)	
Number of Obs	52	52	78	78
R-square	0.5678	0.5706	0.6667	0.5953

† Standard errors are in parentheses

*=significant at 10% level, **=significant at 5% level, ***=significant at 1% level.

- Airline dummies D_{AS}^{firm} and D_{RU}^{firm} are omitted due to the problem of perfect collinearity.

statistically more important-their level increases and standard deviations decreases-as Southwest's virtual fare is used. The rest of estimation results is reported in Appendix B.

2.5 Price Elasticity and the Almost Ideal Demand System

When N firms are competing in a market, the expenditure share equation of AIDS specification is:

$$s_i = \alpha_i + \sum_{i=1}^{N} \gamma_{ij} \log(p_j) + \beta_i \log\left(\frac{E}{P}\right) \tag{9}$$

where expenditure share $s_i \equiv \frac{p_i q_i}{\sum_{j=1}^{N} p_j q_j} = \frac{p_i q_i}{E}$, E is total expenditure on air travel,

and P is price index defined by

$$\log P = \alpha_0 + \sum_{k=1}^{N} \alpha_k \log p_k + \frac{1}{2} \sum_{k=1}^{N} \sum_{l=1}^{k} \gamma_{kl} \log p_k \log p_l \tag{10}$$

A general definition of price elasticities from the AIDS specification is

$$\varepsilon_{ij} = \frac{d \ln q_i}{d \ln p_j} = -\delta_{ij} + \frac{d \ln s_i}{d \ln p_j} = -\delta_{ij} + \frac{1}{s_i}\left(\gamma_{ij} - \beta_i \frac{d \ln P}{d \ln p_j}\right) \tag{11}$$

where δ_{ij} is the Kronecker delta equal to 1 when $i = j$ and 0 otherwise. Given price index of equation (12), price elasticities derived from non-linear expenditure share equation are

$$\varepsilon_{ij} = -\delta_{ij} + \frac{\gamma_{ij}}{s_i} - \frac{\beta_i}{s_i}\left(\alpha_j + \sum_{k=1}^{N} \gamma_{kj} \ln(p_k)\right) \tag{12}$$

In order to avoid non-linearity in our estimation equation, we use the following Stone price index as an approximation of the price index:

$$\log P = \sum_{i=1}^{N} s_i \cdot \log p_i \tag{13}$$

The linearly approximated AIDS specification proposed first by Deaton and Muellbauer (1980a) raises a question of how to compute price elasticities in that the price index is a function of the expenditure shares which are the dependent variable of the AIDS specification. A common approach[12] of computing formulas for price elasticities with parameters from the linear approximation AIDS model is

$$\varepsilon_{ij} = -\delta_{ij} + \frac{\gamma_{ij}}{s_i} - \frac{\beta_i}{s_i} s_j \tag{14}$$

where expenditure share is assumed to be constant (i.e. $d \ln P / d \ln p_i = s_i$). The price elasticity calculated at the bottom stage represents cross-price elasticity, which measures substitution patterns between airlines "conditional" on the expenditure for air trip.

2.6 Estimates of Price Elasticity

The cross-price elasticities of each airline on routes with two through eight airlines are reported in Table 6.[13] In case when three carriers are competing on a route, the cross-price elasticity of the leading firm is -1.30 and that of Southwest is -1.71. Southwest seems to have the highest cross-price elasticities on all routes regardless of the number of competitors. Also, cross-price elasticities tend to decrease with number of competitors. There are more competing airlines on longer-haul routes, which are

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[12] See Green and Alston (1990), Ellison et al (1997) and Hausman and Leonard (2002).

[13] All the vectors of cross-price on routes with 2 through 8 carriers are reported in Appendix C1 and Appendix C2. The differences in cross-price elasticities in Appendix C1 and in Appendix C2 are whether or not virtual fares of Southwest are used in estimating systems of share equations at the bottom stage.

Table 6. Estimates of Cross-Price Elasticities Conditional on Air Travel Expenditure

		Number of Airlines Competing on A Route After SW's Entry						
		2	3	4	5	6	7	8
Airline	1	-1.16‡ (0.39)†	-1.30 (0.09)	-0.80 (0.15)	-1.11 (0.08)	-0.89 (0.09)	-0.85 (0.12)	-0.87 (0.12)
	2	-2.60 (1.46)	-1.21 (0.18)	-0.99 (0.31)	-1.05 (0.14)	-0.76 (0.14)	-0.94 (0.16)	-0.56 (0.15)
	3		-1.71 (0.08)	-1.16 (0.32)	-1.15 (0.13)	-1.05 (0.13)	-1.18 (0.18)	-0.67 (0.19)
	4			-1.64 (0.25)	-0.91 (0.17)	-0.86 (0.16)	-0.75 (0.17)	-0.68 (0.15)
	5				-1.63 (0.06)	-0.69 (0.22)	-0.86 (0.16)	-0.88 (0.16)
	6					-1.60 (0.06)	-0.01 (0.27)	-0.69 (0.20)
	7						-1.14 (0.02)	-0.81 (0.21)
	8							-1.09 (0.01)

† Standard errors, derived from the Delta method, are in parentheses.
‡ All the cross-price elasticities are calculated using estimates of the AIDS model with Southwest's virtual fare.
- Shaded area represents cross-price elasticities of Southwest.
* Airlines other than Southwest are defined by their revenue ranking and Southwest is defined as the number of airlines competing on a route. For example, if American, Delta and Southwest are serving a route and the ranking of revenue shares is American>Southwest>Delta, then American is named as "1", Delta "2" and Southwest "3." In the estimation of AIDS demand system, Southwest share equation is always omitted to singularity problem. Therefore, it seems natural to name Southwest as "the number of firms in a route" regardless of its rank in revenue share. This is why Southwest is named as "3" instead of "2" in this example.

dominated by major airlines providing hub-and-spoke system. Frequent flyers programs of airlines with hub-and-spoke system are designed to provide consumers with incentives not to switch to rival carriers offering lower fares. Therefore, it is expected that on routes where airlines are competing with rivals in non-price factors, cross-price elasticities will be lower, other things held constant.

Table 7 shows how cross-price elasticities of incumbent airlines respond to Southwest's entry. On those routes where two or three airlines are competing after

Table 7. Estimates of Cross-Price Elasticities Before/After Southwest's Entry

Cross-Price Elasticities[‡] Before SW's Entry								
		Number of Airlines Competing on A Route After SW's Entry						
		2	3	4	5	6	7	8
Airline[*]	1	-1.09[‡] (0.32)[†]	-1.21 (0.07)	-0.99 (0.10)	-1.09 (0.07)	-0.91 (0.08)	-0.88 (0.11)	-0.88 (0.11)
	2		-1.21 (0.18)	-1.14 (0.19)	-1.04 (0.12)	-0.79 (0.13)	-0.95 (0.14)	-0.59 (0.14)
	3			-0.98 (0.23)	-1.14 (0.13)	-1.04 (0.12)	-1.17 (0.17)	-0.68 (0.18)
	4				-0.91 (0.16)	-0.87 (0.16)	-0.77 (0.15)	-0.71 (0.14)
	5					-0.66 (0.23)	-0.86 (0.15)	-0.88 (0.16)
	6						0.05 (0.28)	-0.68 (0.21)
	7							-0.79 (0.24)

Cross-Price Elasticities[‡] After SW's Entry								
		Number of Airlines Competing on A Route After SW's Entry						
		2	3	4	5	6	7	8
Airline[*]	1	-1.26[‡] (0.50)[†]	-1.45 (0.13)	-0.97 (0.17)	-1.13 (0.10)	-0.87 (0.11)	-0.81 (0.14)	-0.85 (0.14)
	2		-1.21 (0.18)	-1.180 (0.24)	-1.06 (0.16)	-0.74 (0.16)	-0.94 (0.17)	-0.51 (0.17)
	3			-0.98 (0.24)	-1.16 (0.14)	-1.05 (0.14)	-1.19 (0.19)	-0.66 (0.20)
	4				-0.90 (0.18)	-0.86 (0.16)	-0.73 (0.18)	-0.62 (0.18)
	5					-0.71 (0.20)	-0.85 (0.17)	-0.88 (0.16)
	6						-0.06 (0.25)	-0.70 (0.20)
	7							-0.83 (0.19)

† Standard errors, derived from the Delta method, are in parentheses.
‡ All the cross-price elasticities are calculated using estimates of the AIDS model with Southwest's virtual fare.
* Airlines are defined by their revenue ranking and Southwest is defined as the number of airlines competing on a route.

Southwest's entry, the entry of Southwest makes the cross-price elasticities of leading airlines in revenue share increase by 16 to 20 percent. Meanwhile, there seems to be little difference between cross-price elasticities of incumbent airlines before and after Southwest's entry on the routes where four or more airlines are competing after Southwest's entry. This results implies that the entry of Southwest makes the consumers of incumbent airlines more responsive to price changes by switching airlines when one or two existing airlines are competing against Southwest's entry.

CHAPTER III

DEMAND FOR AIR TRAVEL: INDUSTRY LEVEL

3.1 Separability and Multi-Stage Budgeting[14]

In Chapter II, consumers' choice of airlines is analyzed conditional on the expenditure allocated to air travel. In this Chapter, we analyze consumers' decision in the upper two stages: in the middle stage, transportation modes are determined given total amount of travel expenditure, which will be determined in the top stage. Specifically, we first determine the demand for air travel at the middle stage and then the demand for travel at the top stage. We assume a weak separability of preferences so that the AIDS model can be used for the following analysis of estimating demand for air travel and then demand for travel.

Separable preferences can be represented by a direct utility function:

$$u = v(q) = f\left(v_{air}(q_{air}), v_{auto}(q_{auto}), \ldots, v_{others}(q_{others})\right) \tag{15}$$

where v is a strictly quasi concave, increasing and differentiable function, v_i is a well-behaved sub-utility function for each mode of transportation, and q is travel quantity (or frequency) vector whose subvector q_i represents quantity (or frequency) of city-pair travels for each non-overlapping mode of transportation. The utility function of the form of equation (15) implies that, at the bottom level, demand for an airline j can be written as

[14] This section is largely from the chapter 5 of Deaton and Muellbauer (1980b).

$$q_j = g_{air,j}(e_{air}, p_{air}) \tag{16}$$

where $g_{air,j}$ is a well-behaved demand function for airline choice, e_i is the expenditure function for air travel and p_{air} is the price vector of city-pair travels by airplane. Share equations of the AIDS model employed in Chapter II is based on the maximization of $v_{air}(q_{air})$ subject to $\sum_{j \in air} p_{air,j} q_{air,j} = e_{air}$.

In the middle stage, a representative consumer will maximize his utility function of the form (1) subject to the budget constraint

$$\sum_i e_i(u_i, p_i) = E_{travel}, i = air, auto, ..., other \tag{17}$$

where $u_i \equiv v_i(q_i)$ is the utility level of each transportation mode, p_i is the price vector of city-pair travels in transportation mode i, and e_i is the expenditure function for transportation mode i which minimizes the amount of expenditure that is required to reach the utility level u_i at price vector p_i, i.e.,

$$e_i(u_i, p_i) = \min_{q_i}\left[\sum_{j \in i} p_{i,j} q_{i,j}; v_i(q_i) = u_i\right], i = air, auto, ..., other \tag{18}$$

In general, if no restrictions are imposed on e_i or u_i, the maximization problem described by equation (15) and (17) requires the knowledge of all individual prices of city-pair travels in each mode of transportation.[15] Empirically implementing empirically a mutli-stage budgeting approach would be more feasible if we are able to use a single price for each mode of transportation. Gorman (1959) proves that we may use a single

[15] This is not feasible due to the lack of sufficient data: The 1995 American Travel Survey (ATS) provides no information about how much consumers spent for city-pair travels in each mode of transportation, though it furnishes information about the share of air travel and auto travel.

price for each transportation mode if and only if the preference of the upper stage[16] is additively separable.[17]

In order to overcome Gorman's highly restrictive condition on preferences, Deaton and Muellbauer (1980b) proposed an approximation solution in which only a single price of each transportation mode is needed under the less restrictive assumption of weakly separable preferences. The approximation solution starts with rewriting the expenditure function e_i in (16):

$$e_i(u_i, p_i) = e_i(u_i, p_i^0) \cdot \frac{e_i(u_i, p_i)}{e_i(u_i, p_i^0)}, \, i = air, auto, ..., other \tag{19}$$

where p_i^0 is a base period price vector of transportation mode i. The term $e_i(u_i, p_i^0)$ is the amount of expenditure that is required to reach the utility level u_i at base period price vector p_i^0. This can be interpreted as a quantity index denoted by Q_i where indirect utility function u_i is given by $u_i = \psi(e_i, p_i^0)$. The other term $\frac{e_i(u_i, p_i)}{e_i(u_i, p_i^0)}$ is a true cost-of-living price index for transportation mode i. This can be written as $P_i(p_i, p_i^0; u_i)$ to emphasize its dependence on u_i. A representative consumer then maximize

$$u = f\left[\psi_{aur}\left(v_{air}, p_{air}^0\right), \psi_{auto}\left(v_{auto}, p_{auto}^0\right), ..., \psi_{aur}\left(v_{air}, p_{air}^0\right)\right] \tag{20}$$

subject to

[16] In our three stage model, the upper stage for the bottom stage and the middle stage is the middle stage and the top stage, respectively. In order for Gorman's condition to hold, therefore, the preference for modes of transportation and for traveling should be additively separable.

[17] A preference is additively separable if its corresponding utility function be written as $u = v(q) = v_{air}(q_{air}) + v_{auto}(q_{auto}) + ... + v_{others}(q_{others})$

$$\sum_i Q_i \cdot P_i(p_i, p_i^0; u_i) = E_{travel},\ i = air, auto, ..., other \tag{21}$$

This standard form with matching indices of price (P_i) and quantity (Q_i) is still difficult to implement empirically because P_i is a function of p_i so that we go back to the initial problem of the attainability of all individual prices. Deaton and Muellbauer (1980b) suggest, however, that the exact price index involved in equation (21) can be approximated by commonly used price indices such as Laspeyres or Paasche indices, provided that consumers' preferences are close to homothetic, that is, changes in price have almost identical impact on patterns of expenditure of households with different income levels.[18] This approximate two-stage budgeting approach justifies the use of the AIDS model at the middle and top stage of our three-stage budgeting approach.

3.2 Specification for the Middle Level: Demand for Different Modes of Transportation

At the middle stage, consumers are to reveal their preferences on modes of transportation, conditional on travel expenditure being held constant. The American Travel Survey (ATS) 1995 conducted by Bureau of Transportation Statistics provides comprehensive information about characteristics of long-distance trip[19] (of persons living in the United States of America), such as origin and destination of trips, principal

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[18] In other words, Laspeyres or Paasche indices can be used for the exact price index involved in equation (5) if $P_i(p_i, p_i^0; u_i)$ is fairly close to p_i^0, $P_i(p_i, p_i^0; u_i)$ is almost proportional to p_i^0, or substitution between transportation modes is limited.

[19] A trip is defined as each time a person goes to a place at least 100 miles away from home and returns. The following types of trips are excluded: (1) travel as part of an operating crew on a train, airplane, truck, bus or ship; (2) regular commuting to work or school; (3) one-way trips to move to a new residence; (4) trips by members of the Armed Forces while on active duty.

Table 8. Modes of Transportation by Distance

One-Way Statutory Distance (miles)	Modes of Transportation						Total
	Auto†	Airplane	Bus	Train	Ship	Others	
0-199	311,024 (95.9%)*	5,567 (1.7%)	6,250 (1.9%)	1,128 (0.3%)	169 (0.1%)	46 (0.0%)	324,184
200-499	101,911 (83.6%)	16,182 (13.3%)	2,664 (2.2%)	1,013 (0.8%)	46 (0.0%)	35 (0.0%)	121,851
500-999	24,538 (52.0%)	21,574 (45.7%)	787 (1.7%)	240 (0.5%)	20 (0.0%)	18 (0.0%)	47,177
1000-1999	7,526 (24.9%)	22,275 (73.7%)	220 (0.7%)	131 (0.4%)	59 (0.2%)	16 (0.1%)	30,227
2000-	1,518 (10.6%)	12,645 (88.3%)	38 (0.3%)	51 (0.4%)	60 (0.4%)	7 (0.0%)	14,319
All Distance	446,517 (83.0%)	78,243 (14.5%)	9,959 (1.9%)	2,563 (0.5%)	354 (0.1%)	122 (0.0%)	537,758

Source: *American Travel Survey* 1995
† Auto represents personal use vehicle such as (rental) car, pick-up truck, van, etc.
* In parentheses is the percentage of each mode of transportation chosen by travelers in a distance band

modes of transportation, reasons for trips, and demographic characteristics of members of household. Table 8 compiled from the ATS 1995 describes how the modes of transportation are distributed over distance. Auto[20] is the mode of choice for shorter trips. Among 324,184 trips whose one-way statutory distance is less than 200 miles, 95.9 percent of trips are made by vehicles such as car, van, pick-up truck and so on. This proportion declines drastically as the distance of travel increases. Auto is used for about 90 percent of the trips with less than 500 mile distance, but it is used only for about 18%

[20] An auto trip is defined as any trip in which the principal means of transportation was car, pickup truck, or van; other truck; rental car, truck, or van; recreational vehicle or motor home.

of the trips of more than 1000 miles. On the other hand, airplane[21] is used for about 80% of the trips of more than 1000 miles. This indicates a substantial substitution between auto and airplane as the distance of travel increases.

Proportions of other transportation modes, such as bus or train, are extremely small, and hence, we will ignore them in the following analysis by assuming that only two alternative modes of transportation, auto and airplane, are available for the consumers to choose. The estimation of consumers' choice between these two modes is based on the following AIDS model:

$$s_{air} = \alpha_{air} + \gamma_{air} \log\left(\frac{p_{air}}{p_{auto}}\right) + \beta_{air} \log\left(\frac{E_{travel}}{P_{travel}}\right) \tag{22}$$

where p_{air} and p_{auto} denote the prices of air travel and auto travel, respectively; expenditure of travel is the sum of air expenditure and auto expenditure, $E_{travel} = E_{air} + E_{auto}$, and expenditure share of air travel $s_{air} = E_{air} / E_{travel}$; and price index for travel $P_{travel} = (p_{air})^{s_{air}} \cdot (p_{auto})^{s_{auto}}$. Share equation (22) implies that determinants of revenue share of air travel are the relative price of air travel, total travel expenditure, and travel price index.

It is important to consider the full prices of auto and air travels in the computation of relative prices because of the significant difference in traveling time between the two transportation modes. The full price consists of two components: the explicit price of travel and the opportunity cost of traveling time. The explicit price

[21] An airplane trip is defined as any trip in which the principal means of transportation was commercial airplane or corporate or personal airplane.

represents all the monetary costs for traveling such as air fares, costs of gas, etc. The opportunity cost of traveling time can be measured by the total amount of forgone wages for the period of traveling time.

The explicit prices of auto and air travel are defined as the total monetary price paid for traveling per mile and per person in the travel party

$$p_{auto}^{explicit} = \left[Dist \times TC_{auto}\right] \cdot \frac{1}{Dist} \cdot \frac{1}{N_{auto\ travel}^{HH}} \tag{23}$$

$$\begin{aligned} p_{air}^{explicit} &= \left[Dist_{to\ airport} \times TC_{auto}\right] \cdot \frac{1}{Dist} \cdot \frac{1}{N_{air\ travel}^{HH}} + \left[Fare \times N_{air\ travel}^{HH}\right] \cdot \frac{1}{Dist} \cdot \frac{1}{N_{air\ travel}^{HH}} \\ &= \left[Dist_{to\ airport} \times TC_{auto} + Fare \times N_{air\ travel}^{HH}\right] \cdot \frac{1}{Dist} \cdot \frac{1}{N_{air\ travel}^{HH}} \end{aligned} \tag{24}$$

where $Dist$ is the statutory distance from the origin to the destination of travel TC_{auto} is the per-mile cost of driving and $N_{auto\ travel}^{HH}$ is the number of household members in the auto travel party. In the explicit price of air travel, $Dist_{to\ airport}$ is the distance to the airport, $N_{air\ travel}^{HH}$ the number of household members in the air travel party, and $Fare$ denotes the air fare per person.

The term in the bracket in (23) is the total cost of traveling for the auto travel party, which is independent of the number in the travel party. Normalization by $Dist$ and $N_{auto\ travel}^{HH}$ gives the cost of travel per person per mile. The total cost of air travel is the sum of the ground travel component, $Dist_{to\ airport} \times TC_{auto}$, which is independent of the number in travel party within the capacity limit of the vehicle, and the variable cost component, $Fare \times N_{air\ travel}^{HH}$, which is proportional to the number in the travel party. To be consistent with the definition of the per-person explicit price of auto travel, the air travel cost is also normalized by the numbers in the travel party and statutory distance. Such normalization of course does not affect the relative price between the two transportation modes for a travel party of given size. It does not affect the comparison of the relative prices faced by travel parties of different sizes, either. The normalization is purely for a convenience in interpretation of our analysis.

The implicit price (opportunity cost of traveling) measure by the foregone wages due to the travel is computed by

$$p_{travel}^{implicit} = \left[Time_{driving} \times Wage_{adult}^{HH} \times N_{travel,adult}^{HH}\right] \cdot \frac{1}{Dist} \cdot \frac{1}{N_{travel}^{HH}} \qquad (25)$$

where $travel$ indicates either auto or airline travel, and $Wage_{adult}^{HH}$ is the wage rate per minute of working persons in the household.[22] Then, the full price is the sum of the two components

$$p_{travel} = p_{travel}^{explicit} + p_{travel}^{implicit} \qquad (26)$$

The inclusion of the implicit price implies that the income level will have a significant effect on the choice of transportation mode. A household of a higher income has a higher implicit price of auto travel and it can outweigh the lower explicit price of slower auto travel compared to a faster airline travel. Therefore, everything else being equal, a higher income household will tend to choose the airline travel more often than a lower income household. This tendency will be more pronounced as income increases. A

[22] Refer to Appendix A for how the wage rate per minute of working persons in the household is constructed.

Table 9. Modes of Transportation by Household Income

Household Income	Modes of Transportation						Total
	Auto†	Airplane	Bus	Train	Ship	Others	
Less than $10,000	15,204 (87.0%)*	1,390 (8.0%)	728 (4.2%)	130 (0.7%)	6 (0.0%)	9 (0.1%)	17,467
$10,000-$14,999	14,725 (83.6%)	1,938 (11.0%)	836 (4.7%)	103 (0.6%)	10 (0.1%)	1 (0.0%)	17,613
$15,000-$24,999	40,008 (88.0%)	4,024 (8.9%)	1,091 (2.4%)	270 (0.6%)	16 (0.0%)	32 (0.1%)	45,441
$25,000-$29,999	31,611 (89.2%)	2,826 (8.0%)	851 (2.4%)	129 (0.4%)	25 (0.1%)	3 (0.0%)	35,445
$30,000-$39,999	70,249 (88.0%)	7,813 (9.8%)	1,422 (1.8%)	284 (0.4%)	32 (0.0%)	4 (0.0%)	79,804
$40,000-$49,999	85,247 (86.9%)	10,867 (11.1%)	1,635 (1.7%)	268 (0.3%)	70 (0.1%)	19 (0.0%)	98,106
$50,000-$59,999	63,538 (83.1%)	11,426 (14.9%)	1,182 (1.5%)	240 (0.3%)	43 (0.1%)	12 (0.0%)	76,441
$60,000-$74,999	56,506 (79.9%)	12,801 (18.1%)	888 (1.3%)	453 (0.6%)	30 (0.0%)	10 (0.0%)	70,688
$75,000-$99,999	39,889 (75.7%)	11,539 (21.9%)	871 (1.7%)	331 (0.6%)	70 (0.1%)	10 (0.0%)	52,710
$100,000-$124,999	16,189 (69.8%)	6,501 (28.0%)	268 (1.2%)	187 (0.8%)	25 (0.1%)	12 (0.1%)	23,182
$125,000-$149,000	5,128 (67.9%)	2,267 (30.0%)	83 (1.1%)	57 (0.8%)	15 (0.2%)	2 (0.0%)	7,552
$150,000 or more	8,223 (61.8%)	4,851 (36.4%)	104 (0.8%)	111 (0.8%)	12 (0.1%)	8 (0.1%)	13,309
All Distance	446,517 (83.0%)	78,243 (14.5%)	9,959 (1.9%)	2,563 (0.5%)	354 (0.1%)	122 (0.0%)	537,758

Source: *American Travel Survey* 1995

† Auto represents personal use vehicle such as (rental) car, pick-up truck, van, etc.

* In parentheses is the percentage of each mode of transportation chosen by travelers in each income band

Table 10. Modes of Transportation by Household Members in the Travel Party

Household Members in the Travel Party	Modes of Transportation						Total
	Auto	Airplane	Bus	Train	Ship	Others	
1	79,285 (68.6%)	33,556 (29.0%)	1428 (1.2%)	1283 (1.1%)	40 (0.0%)	54 (0.0%)	115,646
2	151,793 (85.4%)	23,629 (13.3%)	1566 (0.9%)	669 (0.4%)	122 (0.1%)	26 (0.0%)	177,805
3	71,976 (89.7%)	7,569 (9.4%)	422 (0.5%)	240 (0.3%)	46 (0.1%)	19 (0.0%)	80,272
4	74,882 (91.1%)	6,643 (8.1%)	384 (0.5%)	200 (0.2%)	58 (0.1%)	5 (0.0%)	82,172
5	36,154 (92.3%)	2,750 (7.0%)	132 (0.3%)	91 (0.2%)	33 (0.1%)	6 (0.0%)	39,166
6 or more	32,427 (75.9%)	4,096 (9.6%)	6,027 (14.1%)	80 (0.2%)	55 (0.1%)	12 (0.0%)	42,697
Total	446,517 (83.0%)	78,243 (14.5%)	9,959 (1.9%)	2,563 (0.5%)	354 (0.1%)	122 (0.0%)	537,758

Source: *American Travel Survey* 1995
† Auto represents personal use vehicle such as (rental) car, pick-up truck, van, etc.
* In parentheses is the percentage of each mode of transportation chosen by travelers in an income band

cursory inspection of the 1995 ATS in Table 9 supports this conjecture. Consumers whose household income is less than $50,000 make 11.1 percent or less of their travel by air, while consumers whose household income is greater than $100,000 make at least 28 percent of their travel by air.

It should be also noted that the relative price of auto travel to the airline travel is a decreasing function of the number of household members in the travel party. Therefore, everything else being equal, travel parties with large members prefer auto travel to air travel. This can be seen in Table 10, where the percentage of auto travel is monotonically increasing in the number of traveling party members up to 5 members. On the other hand, the percentage of airplane travel is monotonically decreasing in the number of traveling party members.

3.3 Specification for the Top Level: Demand for Travel

At the top stage, consumers decide how much of their income is to be allocated on travel. Let p_{travel} and $p_{non-travel}$ denote the average travel price per mile of all modes of transportation and the average price of all the goods and services other than travel, respectively. Each household will then face the following form of share equation of the travel:

$$s_{travel} = \alpha_{travel} + \gamma_{travel} \log\left(\frac{p_{travel}}{p_{non-travel}}\right) + \beta_{travel} \log\left(\frac{Income}{P}\right) \tag{27}$$

where $Income$ denotes the income level of households, the expenditure share of travel is

$s_{travel} = \dfrac{E^{travel}}{Income}$, and the general price level P is defined by

$P = \left(p_{travel}\right)^{s_{travel}} \cdot \left(p_{non-travel}\right)^{s_{non-travel}}$ where $p_{travel} = \left(p_{auto}\right)^{s_{auto}} \cdot \left(p_{air}\right)^{s_{air}}$.

Consumers' decision on how much to allocate on travel depends partly on the relative price between travel and non-travel goods (p_{travel} and $p_{non-travel}$). Since p_{travel} is not only a function of explicit costs of transportation but also of implicit costs of time spent traveling, it will vary across households with different income levels as well as with different preferences on modes of transportation. Each household will, however, face almost identical $p_{non-travel}$ because $p_{non-travel}$ represents overall price level P except for the travel and the effect of p_{travel} on P seems to be negligible. Without loss of generality, therefore, we take the non-travel goods as a numeraire good and set its price to one, $p_{non-travel} = 1$. Equation (27) can be then written as

$$s_{travel} = \alpha_{travel} + \gamma_{travel} \log p_{travel} + \beta_{travel} \log\left(\frac{Income}{P}\right) \tag{28}$$

where $\log P = s_{travel} \log p_{travel}$.[23]

3.4 Data Description

We use both airline industry data and travel survey micro data for the estimation of the choice between modes of transportation, and the choice of traveling or staying home. The airline industry data is compiled from the Department of Transportation's Origin and Destination Survey (DB1A) of 1995, and the travel survey micro data is compiled from the 1995 American Travel Survey (ATS).

The 1995 ATS was designed to answer the questions about where, how, why and when Americans travel and who travels. The survey involved interviews with approximately 80,000 randomly selected households nationwide, and gathered information on the origin, destination, volume, characteristics of long-distance travel in the United States, and demographic characteristics of all household members.[24]

At the bottom level, we use each airline's revenue share and its average fare at each directional level-for example, in the first quarter of 1995, Southwest's revenue

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[23] Estimated equation (27) with different normalizations of price of non-travel goods, say $p_{non-travel} = 10 \; or \; 100$ results in little difference in implied elasticities from it.

[24] 85 percent of households eligible for the survey respond to the 1995 survey.

share is 73.5 percent and 45.2% on a route from Los Angeles, CA to Oakland, CA and from Reno, NV to Las Vegas, NV, respectively. In order to match consumers' decision at the bottom level with one at the middle level, we need complete information about number of passengers by air and auto, and the price of each mode at these routes. The 1995 ATS, however, do not provide enough observations for number of travelers by each mode on these routes.

We get around this problem by using the substitution pattern between auto and air travel over distance: auto is the mode of choice for shorter trips, while airplane is the mode most frequently used for longer trips. The statutory distance on a route from Los Angeles, CA to Oakland, CA and from Reno, NV to Las Vegas, NV is 337 miles and 345 miles, respectively. Now that the distance of these two routes is close to each other, we can expect the substitution pattern between air travel and auto travel on these routes to be similar.

We now assume that, on directional city-pair route level, statutory distance between origin and destination city is the only factor that relates consumers' decision on which airline to take to their decision on which mode of transportation to use. Then, we segment the distance of origin and destination city into 20 different distance blocks.[25] Given the distance of travel, consumers' choice on the mode of transportation depends not only on the explicit costs of each mode but also on the opportunity cost of time spent on traveling by each mode which is supposed to be a function of income. To capture the

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[25] We consider travels whose statutory distance is less than 2700 miles, which corresponds to the longest city-pair distance among those routes where Southwest was serving in 1995. Also, the segmentation of distance is designed such a way that each distance band has similar number of travelers.

variation in the opportunity cost of traveling time, as described in Table 11, we divide consumers into 12 different income groups just as reported in the 1995 ATS.[26] Table 11 shows that the percentage of air travel seem to increase monotonically as income level increases or the distance of travel increases. In addition, there seems to be little possibility of endogeneity between consumers' decision on the travel mode and their income in that percentage of travels in each distance band remains constant across households with different income levels. In consequence, 240 different distance-income group observations are used for the estimation of consumers' decision on the modes of transportation.[27]

The price of each mode consists of two exclusive parts: explicit and implicit price. The implicit price of each mode is opportunity cost of time spent per mile per person: the time spent on air travel is derived from T-100 Segment by BTS and the time spent on auto travel is derived on the assumption that people drive at 60 miles per hour. In assessing the opportunity cost of time spent traveling, we extract from the 1995 Panel Study of Income Dynamics (PSID) information on household income, working hours of head and wife. For example, let's suppose a household which consists of a household head, wife, and a daughter. If both the household head and his wife work 3,000 hours a year and their household income is 60,000 dollars, then the opportunity cost of an hour for each of them is 10 dollars per hour. Also, now that their daughter's decision on modes of transportation depends upon her parents income level, if she travels alone, her

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[26] In the 1995 ATS, household income is reported as a category variable with 12 different income groups. We use the 1996 Consumer Expenditure Survey to calculate the average household income of each income group.
[27] The AIDS specification allows us to aggregate individual data over distance and income pair without requiring further assumption on consumer's preferences.

Table 11. Total Number of Air Travel and Its Percentage by Distance and Income

Distance Min	Distance Max	Household Income [0,10)	[10,15)	[15,25)	[25,30)	[30,40)	[40,50)	[50,60)	[60,75)	[75,100)	[100,125)	[125, 150)	[150,)	Total	
100	150	**1.0%** 5,151	**0.8%** 4,705	**1.2%** 12,229	**1.0%** 9,851	**1.4%** 22,401	**1.1%** 25,742	**2.9%** 20,201	**3.2%** 18,183	**2.4%** 12,822	**4.1%** 4,971	**3.8%** 1,545	**4.7%** 2,693	**2.0%** 140,494	32.8%
150	200	**1.1%** 2,724	**2.0%** 2,358	**2.5%** 6,329	**1.5%** 4,967	**2.2%** 10,983	**3.3%** 14,030	**3.6%** 11,177	**6.2%** 9,252	**4.6%** 6,710	**5.6%** 3,077	**5.2%** 1,172	**12.4%** 1,711	**3.7%** 74,490	17.4%
200	250	**3.2%** 1,198	**7.9%** 1,251	**3.6%** 3,758	**2.9%** 2,717	**5.7%** 6,827	**5.2%** 8,087	**6.6%** 6,511	**12.4%** 6,314	**11.6%** 4,672	**19.4%** 2,022	**17.2%** 518	**21.6%** 1,224	**8.1%** 45,099	10.5%
250	300	**6.3%** 863	**7.4%** 746	**6.2%** 2,122	**5.0%** 1,816	**4.8%** 3,652	**8.0%** 4,831	**10.8%** 3,669	**13.0%** 3,579	**16.8%** 2,747	**23.6%** 1,137	**30.4%** 414	**24.6%** 548	**10.5%** 26,124	6.1%
300	350	**13.5%** 579	**17.3%** 619	**7.6%** 1,545	**8.3%** 1,264	**8.4%** 2,706	**12.8%** 3,205	**20.8%** 2,884	**17.8%** 2,325	**22.6%** 1,906	**30.5%** 914	**35.8%** 316	**41.6%** 543	**16.5%** 18,806	4.4%
350	400	**10.1%** 407	**27.9%** 487	**11.8%** 1,121	**8.7%** 974	**15.7%** 1,984	**15.4%** 2,358	**17.6%** 2,024	**21.1%** 2,006	**33.1%** 1,440	**42.9%** 708	**60.7%** 244	**55.4%** 325	**21.0%** 14,078	3.3%
400	450	**17.8%** 303	**23.3%** 330	**11.3%** 887	**10.9%** 662	**15.9%** 1,607	**24.7%** 2,101	**25.8%** 1,600	**28.0%** 1,337	**35.0%** 1,123	**43.5%** 584	**48.6%** 138	**56.9%** 267	**24.9%** 10,939	2.6%
450	500	**13.9%** 274	**16.2%** 302	**20.1%** 758	**18.1%** 537	**23.3%** 1,026	**23.8%** 1,435	**31.4%** 1,351	**31.9%** 1,215	**37.0%** 866	**47.0%** 440	**53.2%** 158	**51.1%** 229	**28.6%** 8,591	2.0%
500	600	**28.8%** 319	**34.3%** 420	**26.2%** 1,129	**25.9%** 881	**26.2%** 1,901	**27.9%** 2,373	**33.9%** 2,126	**41.1%** 1,920	**47.3%** 1,758	**62.8%** 792	**67.9%** 252	**57.6%** 413	**36.2%** 14,284	3.3%
600	700	**33.9%** 333	**36.3%** 355	**34.6%** 891	**27.8%** 722	**37.0%** 1,622	**38.3%** 1,896	**50.7%** 1,672	**52.7%** 1,494	**57.5%** 1,341	**66.6%** 592	**72.5%** 236	**77.0%** 426	**46.4%** 11,580	2.7%
700	800	**34.7%** 196	**40.7%** 241	**38.3%** 624	**35.2%** 463	**40.1%** 1,119	**47.7%** 1,371	**46.8%** 1,166	**54.8%** 1,198	**65.1%** 995	**72.3%** 531	**79.5%** 161	**81.7%** 371	**51.4%** 8,436	2.0%
800	900	**40.0%** 170	**46.9%** 194	**38.3%** 478	**44.7%** 380	**49.5%** 938	**47.8%** 1,307	**54.9%** 989	**64.4%** 1,080	**67.4%** 823	**74.1%** 429	**69.7%** 178	**86.8%** 333	**56.5%** 7,299	1.7%
900	1000	**49.4%** 178	**59.0%** 156	**46.7%** 514	**44.7%** 405	**53.5%** 796	**59.3%** 1,174	**60.6%** 1,068	**66.9%** 1,078	**75.5%** 886	**72.5%** 472	**75.5%** 139	**88.8%** 392	**62.8%** 7,258	1.7%
1000	1200	**61.2%** 227	**60.7%** 336	**57.8%** 725	**54.5%** 552	**63.3%** 1,489	**62.2%** 1,694	**65.8%** 1,793	**73.5%** 1,750	**79.4%** 1,463	**82.1%** 671	**86.5%** 223	**90.3%** 642	**69.3%** 11,565	2.7%
1200	1400	**56.3%** 167	**69.0%** 174	**63.2%** 462	**58.7%** 334	**64.6%** 841	**68.7%** 956	**76.8%** 984	**80.4%** 998	**87.8%** 682	**89.0%** 446	**92.4%** 131	**89.9%** 298	**74.8%** 6,473	1.5%
1400	1600	**76.4%** 110	**82.4%** 142	**71.1%** 401	**72.6%** 266	**71.6%** 627	**86.7%** 858	**88.0%** 723	**84.6%** 877	**86.5%** 783	**89.6%** 365	**94.0%** 150	**94.3%** 280	**83.5%** 5,582	1.3%
1600	1800	**82.7%** 104	**85.0%** 127	**74.8%** 266	**82.3%** 192	**76.9%** 533	**84.1%** 654	**88.6%** 629	**87.9%** 580	**92.2%** 591	**95.2%** 332	**95.2%** 124	**97.8%** 231	**86.7%** 4,363	1.0%
1800	2100	**80.2%** 106	**85.6%** 104	**78.6%** 224	**75.8%** 198	**85.3%** 448	**83.9%** 607	**87.9%** 684	**87.7%** 659	**94.3%** 611	**96.0%** 377	**94.5%** 128	**92.6%** 299	**87.9%** 4,445	1.0%
2100	2400	**72.7%** 66	**89.4%** 104	**92.1%** 178	**89.6%** 154	**87.1%** 319	**89.6%** 481	**90.1%** 527	**88.8%** 649	**92.9%** 621	**97.0%** 300	**94.1%** 102	**95.3%** 258	**90.8%** 3,759	0.9%
2400	2700	**43.2%** 148	**90.4%** 114	**87.4%** 182	**95.8%** 144	**93.1%** 321	**89.5%** 506	**92.0%** 511	**93.7%** 764	**93.4%** 747	**94.3%** 368	**98.4%** 127	**94.5%** 344	**91.1%** 4,276	1.0%
	Total	**10.4%** 13,623 3.2%	**15.1%** 13,265 3.1%	**11.6%** 34,823 8.1%	**10.6%** 27,479 6.4%	**12.7%** 62,140 14.5%	**14.4%** 75,666 17.7%	**18.6%** 62,289 14.6%	**22.5%** 57,258 13.4%	**26.5%** 43,587 10.2%	**33.8%** 19,528 4.6%	**36.6%** 6,456 1.5%	**43.2%** 11,827 2.8%	427,941	

Source: *American Travel Survey* 1995

opportunity cost of an hour spent traveling is assumed to be 10 dollars which is identical to what her father or mother should give up for an hour of traveling.

In order to calculate the explicit price of auto travel, we use AAA's annual driving cost estimates for 1999.[28] Among factors considered for those estimates,[29] we take into account the operating costs such as gas which depends on the distance of travel and other costs factors that do not depend on the distance of travel. The explicit price of air travel is comprised of air fare and costs of driving to airport. The average air fare for each distance band is extracted from the 1995 DB1A, and the average distance to the airport for each distance band is derived from the 1995 ATS.

Table 12 describes how each component of explicit and implicit price of air travel and auto travel varies over distance. The explicit cost of auto travel per person exceeds that of air travel when one-way distance of travel is greater than 1200 miles. Time saved by air travel get larger as the distance travel increases-a consumer can save more than 1200 minutes (or 20 hours) by using airplane if he travels more than 1600 miles. Number of household members in the travel party for auto travel is greater than the number for air travel regardless of travel distance, and the difference between them is greater for short- or mid-haul travel.

The explicit, implicit and full price of each mode of transportation by distance band is reported in Table 13. It should be noted that each price means what should be given up for a consumer to travel a mile. Now that consumers in our model are to decide

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[28] AAA's study calculates the average costs of all expenses associated with owning and operating a vehicle over five years and 75,000 miles of driving using a compact, mid-size and large vehicle.
[29] Covered expenses include vehicle depreciation, insurance, fuel, tires, license, registration and taxes, vehicle financing, routine maintenance and repair.

Table 12. Components of Explicit and Implicit Price of Air Travel and Auto Travel

Distance Band			Air						Auto		
			Implicit Cost (Time Spent)				Explicit	People in the travel party[5]	Implicit	Explicit	People in the travel party[5]
Min	Max	Avg.	Flying[1]	At Airport[2]	To Airport[3]	Time Total	Fare[4]		Time Driving[6]	Gas + etc[7]	
100	150	121	50	120	1	171	$66	1.4	121	$18	1.7
150	200	173	60	120	3	184	$96	1.3	173	$24	1.7
200	250	222	70	120	17	207	$65	1.2	222	$31	1.7
250	300	272	78	120	26	225	$62	1.2	272	$38	1.7
300	350	324	86	120	26	232	$82	1.2	324	$44	1.8
350	400	373	96	120	26	243	$78	1.2	373	$51	1.8
400	450	423	95	120	30	244	$84	1.2	423	$55	1.9
450	500	474	104	120	22	246	$106	1.2	474	$64	1.8
500	600	551	114	120	35	269	$113	1.2	551	$71	1.9
600	700	646	122	120	28	270	$118	1.2	646	$88	1.8
700	800	748	139	120	36	294	$138	1.3	748	$100	1.8
800	900	848	149	120	42	311	$138	1.3	848	$112	1.9
900	1000	947	159	120	34	313	$146	1.3	947	$126	1.8
1000	1200	1091	178	120	39	337	$156	1.4	1091	$151	1.8
1200	1400	1289	201	120	64	385	$174	1.4	1289	$179	1.8
1400	1600	1496	225	120	38	383	$179	1.4	1496	$205	1.8
1600	1800	1696	253	120	38	411	$195	1.4	1696	$236	1.8
1800	2100	1943	275	120	38	433	$220	1.4	1943	$286	1.7
2100	2400	2266	307	120	28	455	$234	1.4	2266	$347	1.6
2400	2700	2528	336	120	27	483	$266	1.4	2528	$416	1.5

1. Source: T-100 Segment; time flying = air time + ramp to ramp time
2. Consumers are assumed to spend 120 minutes (or 2 hours) at the airport for check in and transition
3. Source: *American Travel Survey* 1995
4. Source: DB1A 1995
5. Source: *American Travel Survey* 1995; average number of household members in the travel party
6. Consumers are assumed to drive at the speed of 60 miles per hour for long distance travel
7. Source: AAA's annual driving cost estimates for 1995; only depreciation and operating costs are considered.

which mode of transportation to use given the origin and destination of travel, we need to compare the price of air travel and that of auto travel in a distance band. When only explicit price is being considered, auto is cheaper way of transportation unless the distance of travel is greater than 1400 miles; but, when the opportunity cost of time spent

Table 13. Explicit, Implicit and Full Price of Air Travel and Auto Travel

Distance Band			Air Price[1] (cents/mile)			Auto Price[2] (cents/mile)		
Min	Max	Avg.	Explicit	Implicit	Full[3]	Explicit	Implicit	Full[3]
100	150	121	51.59	28.22	79.81	14.62	17.81	32.43
150	200	173	38.40	22.67	61.07	14.19	17.61	31.80
200	250	222	31.66	21.31	52.97	14.31	17.57	31.89
250	300	272	30.76	18.60	49.36	14.22	17.72	31.95
300	350	324	27.20	15.68	42.87	13.89	17.04	30.93
350	400	373	24.30	14.17	38.47	13.94	17.87	31.80
400	450	423	24.24	13.34	37.58	13.33	16.33	29.65
450	500	474	23.69	11.76	35.45	13.84	17.12	30.96
500	600	551	21.74	10.62	32.37	13.34	16.43	29.76
600	700	646	19.32	9.33	28.64	13.93	17.16	31.09
700	800	748	19.39	8.35	27.74	13.62	16.86	30.48
800	900	848	17.23	7.62	24.86	13.44	16.84	30.28
900	1000	947	16.30	7.14	23.44	13.48	17.31	30.79
1000	1200	1091	15.07	6.40	21.47	14.22	18.00	32.22
1200	1400	1289	14.24	5.83	20.07	14.09	18.83	32.92
1400	1600	1496	12.55	5.26	17.81	14.34	17.23	31.57
1600	1800	1696	12.04	5.05	17.09	14.06	17.03	31.09
1800	2100	1943	11.83	4.51	16.34	15.52	18.20	33.72
2100	2400	2266	10.88	4.46	15.33	16.28	20.77	37.05
2400	2700	2528	11.12	4.24	15.36	17.53	21.65	39.18

1. Explicit and implicit price of air travel is derived from equation (8) and (9), respectively.
2. Explicit and implicit price of auto travel is derived from equation (11) and (12), respectively.
3. Full price = explicit price + implicit price

traveling is considered as well, the threshold distance that air travel starts to have cost advantage drops to 600 miles. Unless the number of household members in the travel party is changed over distance, the explicit price of auto travel is supposed to remain constant across different distance bands. The reason that the explicit price of auto travel hits the lowest when travel distance is between 500 and 600 miles is because the number of household members in the travel party is the largest in that distance band. On the other hand, the implicit price of each travel depends not only on the number of household members working but also on total number of household members in the travel party-given total number of hours spent traveling, the implicit price of each travel increases as more household members working or less total household members are in the travel party. The implicit price of auto travel is lower for mid-haul travel in that total number of household members in the travel party is smaller for short-haul travel and number of household members working in the travel party is larger for long-haul travel.

When explicit prices of air travel and auto travel are being compared, airplane is the cheaper way of transportation if one-way statutory distance of travel is greater than 1200 miles. Meanwhile, when both explicit and implicit prices of each mode are being compared, airplane is cheaper way of transportation if one-way statutory distance of travel is greater than 600 miles. The fact that air travel is preferred more when full price of each mode is compared explains why Southwest is more successful in competing with major incumbent airlines on short- or mid-haul distance routes-when compared to hub-and-spoke system of major airlines, Southwest's direct point-to-point service saves more flying time on relatively shorter-haul distance routes.

3.5 Estimation Results

In estimating AIDS revenue share equation of (22) and (28), we treat the prices of air travel and auto travel as exogenous variables. This is based on the following observations. The price of each travel consists of two parts: implicit price and explicit price. First, now that implicit price of each travel is a function of opportunity costs of time spent travel, implicit price is likely to be exogenous to consumers. Second, the explicit price of auto travel is a function of exogenous factors such as gas price and

Table 14. Estimation Results: To Fly or To Drive

AIDS Model of Determinants of Air Travel Revenue Share

S_i	Air Travel
Constant	-0.053 (0.115)†
$\log\left(E^{travel} / P^{travel}\right)$	0.037*** (0.009)
$\log\left(p^{air} / p^{auto}\right)$	-0.471*** (0.014)
Number of Obs	240
R-square	0.8263
F-statistics	563.55

† Standard errors are in parentheses
***=significant at 1% level.

depreciation rate of cars; and air fare, the major component of explicit price of air travel, seems to be determined in advance and to be offered in tens of different types with various restrictions such as advance-purchase and Saturday night stay-over. Hence, the explicit price of each travel seems to exogenous to consumers such that the price of each travel is unlikely to be correlated with error term in demand equation for the choice of mode of transportation.[30]

The OLS estimates from equation (22) are reported in Table 14. The estimated coefficient of relative price of air travel is -.471 and statistically significant, which implies that, if the price of air travel is lowered by 10 percent, then revenue share of air travel will increase by 4.71 percent points. The significantly positive coefficient on

[30] We can also assume that price of each travel is exogenous to consumers for our share equation is derived from utility maximization problem which assumes that prices are given to consumers.

Table 15. Estimation Results: To Travel or To Stay Home

AIDS Model of Determinants of Travel Revenue Share

S_i	Travel
Constant	0.154*** (0.003)†
$\log(Income / P)$	-0.013*** (0.000)
$\log p_{travel}$	-0.003*** (0.001)
Number of Obs	44725
R-square	0.069
F-statistics	1653.87

† Standard errors are in parentheses
***=significant at 1% level.

$\log(E^{travel} / P^{travel})$ indicates that, as the expenditure on travel increases, consumers are more likely to travel by air.

Table 15 reports the OLS estimates from equation (28). The estimated coefficient of relative price of travel is statistically significant and its value of -.003 indicates that revenue share of travel will increase by 0.03 percent in response to 10 percent reduction in the price of travel. The revenue share of travel is expected to fall as household income rises since the estimated coefficient of income is negative and statistically significant.

One of the potential contributions of this work is to combine industry level data with micro survey data in estimating demand for air travel. In our model for consumers' decision regarding travel, we assume that distance between origin and destination city is the only factor that matches consumers' decision on which airline to take with their decision on which mode of transportation to use. Now that demand for each airline is estimated using industry data and the demand for air travel is estimated using micro survey data, it is worthwhile to test how good the estimated demand for air travel is in predicting changes in industry data.

Our data indicates that, one quarter after Southwest entry, the average fare of all airlines falls from $161 to $119 and the average number of passengers on a route rises from 584 to 1119.[31] In other words, total number of air passengers increases by 62.8 percent in response to the drop in air fare by 30.0 percent caused by the Southwest entry. The procedure described below is designed to answer the question-what is the expected change in air passengers from the estimated equation (6) if the price of air travel drops 30 percent:

1. Let's assume the price of auto and overall price level of travel remains the same after Southwest's entry.
2. Air fare of $119 and $161 correspond to $203 and $244 in terms of full price which includes the opportunity cost of time spent traveling as well as air fare. Then, air price elasticity of total travel expenditure derived from the estimated equation is -1.72 such that, using midpoint theorem, the estimated total expenditure on travel increases to $158,520 from $114,799, which is derived from the ATS 1995.
3. Given the estimated total expenditure on travel of $158,520 after fare cut initiated by Southwest's entry, we are now able to calculate expenditure share of

[31] The actual number of passengers would be ten times of these numbers for DB1A is 10 percent random sample of all tickets that originate in the U.S.

air travel after price change-58.94% under the assumption that the price of auto and overall price level of travel remains constant.

4. The estimated revenue share of air travel allows us to let the price level of travel be changed such that the overall price level of travel falls by 3.26 percent. We then recalculate the expected revenue share of air travel after allowing the price of travel to be changed. The expected share of air travel turns out to be about 58.94 percent under the assumption that the price of auto is not affected by the entry of Southwest. This implies that, in assessing predicted change in air passengers from the estimated equation (6), we may use the revenue share of 58.94 percent for air travel.
5. Now that the price of air travel, total expenditure on travel and revenue share of air travel after Southwest's entry are $203, $158,520 and 58.9 percent, respectively, the predicted number of passengers taking airplane after price drop caused by Southwest's entry is 461, while the actual number of air passengers is 250 from the 1995 ATS. When midpoint theorem is used, the actual revenue share of air travel after Southwest's entry derived from the 1995 DB1A increases by 62.8 percent, while the predicted revenue share of air travel after Southwest's entry derived from the 1995 ATS increases 59.4 percent.

Our industry data, which are used in estimating the demand for air carriers, indicates that, one quarter after Southwest's entry, the total number of passengers on a route using airline increases by 62.8 percent in response to the fall in average air fare by 30.0

percent; but, on the other hand, the demand for air travel estimated using micro survey data predicts that, if air fare falls by 30.0 percent, total number of passengers using air travel will rise by 59.4.

Our estimated demand for air travel seems to work well in predicting what is actually observed and, therefore, supports our assumption that distance between origin and destination city is the only factor that matches industry data to micro survey data.

3.6 Conditional and Unconditional Price Elasticity in the Almost Ideal Demand System

In our three-stage budgeting approach, cross-price elasticity is the price elasticity calculated at the bottom stage and measures substitution patterns between airlines “conditional” on the expenditure for air trip. On the other hand, industry elasticity, which is the price elasticity computed at the top two stages, captures substitution patterns between different modes of transportation “unconditional” on travel expenditure-that is, total expenditure on travel as well as relative prices between different modes of transportation are to respond to changes in the price of a mode of transportation.

The formula that is used for the calculation of the price elasticity of demand for air travel and travel is

$$\varepsilon_{air} = -1 + \frac{\gamma_{air}}{s_{air}} - \beta_{air} + \frac{d \ln E_{travel}}{d \ln p_{air}} \tag{29}$$

and

$$\varepsilon_{travel} = -1 + \frac{\gamma_{travel}}{s_{travel}} - \beta_{travel} + \frac{d\ln Income}{d\ln p_{travel}} \tag{30}$$

, which is derived from the AIDS share equation (22) and (28), respectively. At the middle stage, the last term of equation (28) disappears, i.e. $\frac{d\ln E_{travel}}{d\ln p_{air}} = 0$, because the total amount of money allocated to travel is given to consumers. If we consider both the middle stage and top stage together, however, the change in the price of air travel brings about the change in the travel expenditure and the price elasticity of air travel is no longer conditional on the travel expenditure. In order to put the middle and top stage together in computing the industry elasticity, we need to first consider the effect of the change in the price of each mode on total expenditure of travel:

$$\frac{d\ln E_{travel}}{d\ln p_i} = \frac{d\ln p_{travel}}{d\ln p_i} \cdot \frac{d\ln E_{travel}}{d\ln p_{travel}} = s_i \cdot \frac{d\ln E_{travel}}{d\ln Q_{travel}} \cdot \frac{d\ln Q_{travel}}{d\ln p_{travel}} = s_i \cdot \frac{\varepsilon^{price}_{travel}}{\varepsilon^{\exp enditure}_{travel}} \tag{31}$$

where price elasticity of travel $\varepsilon^{price}_{travel} = \frac{d\ln Q_{travel}}{d\ln p_{travel}}$, expenditure elasticity of travel $\varepsilon^{\exp enditure}_{travel} = \frac{d\ln E_{travel}}{d\ln Q_{travel}}$, and $i =$ air, auto.[32] Combining price elasticity of travel expenditure with price elasticity of demand for different modes of transportation, we have the industry elasticity unconditional on travel expenditure:

$$\begin{aligned}\varepsilon_{ij} &= -\delta_{ij} + \frac{\gamma_{ij}}{s_i} - \frac{\beta_i}{s_i} s_j + \frac{d\ln E_{travel}}{d\ln p_i} \\ &= -\delta_{ij} + \frac{\gamma_{ij}}{s_i} - \frac{\beta_i}{s_i} s_j + s_j \cdot \frac{\varepsilon^{price}_{travel}}{\varepsilon^{\exp enditure}_{travel}}, \ i, j = \text{air, auto}\end{aligned} \tag{32}$$

[32] At the middle stage, expenditure on travel is assumed to be constant such that the mode price elasticity of travel expenditure is zero, i.e.. $dE^{travel} / dp_i = 0$

where price elasticity of travel $\varepsilon_{travel}^{price} = \dfrac{d\ln Q_{travel}}{d\ln p_{travel}}$, expenditure elasticity of travel

$\varepsilon_{travel}^{expenditure} = \dfrac{d\ln E_{travel}}{d\ln Q_{travel}}$, and $\delta_{ij} = 1$ if $i = j$ and $\delta_{ij} = 0$ otherwise.

At the top two stages, we introduce full prices of transportation modes and travel to rationalize consumers' choice of transportation modes. The full prices depend not only to the monetary costs spent on traveling but also on the opportunity cost of time spent in traveling. Let $p_i^{explicit}$ and $p_i^{implicit}$ denote the explicit price (monetary cost) of travels by each mode and the implicit price (opportunity cost) of travels by each mode, respectively. The full price of air (or auto) travel, then, is $p_i = p_i^{explicit} + p_i^{implicit}$ such that explicit price elasticity is given by

$$\varepsilon_{ij}^{explicit} = \frac{d\ln q_i}{d\ln p_j^{explicit}} = \frac{p_j^{explicit}}{p_j}\frac{d\ln q_i}{d\ln p_j} = \left(\frac{p_j^{explicit}}{p_j^{explicit} + p_j^{implicit}}\right)\varepsilon_{ij} \qquad (33)$$

where $\varepsilon_{ij} = -\delta_{ij} + \dfrac{\gamma_{ij}}{s_i} - \dfrac{\beta_i}{s_i}s_j$ for $i, j =$ air, auto.[33] The explicit price elasticity of air travel computed in the following section accounts for how sensitive air travel is to the change in air fares.

3.7 Estimates of Conditional and Unconditional Price Elasticity

The price elasticities and expenditure elasticities estimated at the top two stages are reported in Table 16. The second and third column presents price elasticities and

[33] We assume that the opportunity costs of time spent in traveling is independent of the monetary costs of travel- i.e., $dp_i^{implicit} / dp_i^{explicit} = 0$.

Table 16. Price Elasticities and Expenditure Elasticities for the Top Two Stages

The Middle Stage			The Top Stage		
	Price Elasticity	Expenditure Elasticity		Price Elasticity	Expenditure Elasticity
Air Travel	-2.06 (0.27)†	1.08 (0.17)	Travel	-1.13 (4.75)	0.48 (3.24)
Auto Travel	-1.83 (0.24)	0.93 (0.15)	Non-Travel	-1.02 (0.15)	1.01 (0.08)

†Standard errors, derived from the Delta method, are in parentheses.

expenditure elasticites of each mode, whereas the fifth and sixth column describes price elasticities and expenditure elasticities of travel and non-travel goods. The price elasticity of air travel and auto travel turns out to be around -2 and be similar to each other, while the expenditure elasticity of each mode seems to be unit elastic. The price elasticity of air travel measured at the middle stage represents industry elasticity conditional on the travel expenditure given to consumers. Meanwhile, if consumers' decision at the top stage is considered in calculating the price elasticity of air travel, the changes in the price of air travel are allowed to influence the total expenditure on travel by affecting the relative price between travel and non-travel goods. The price elasticity measured at the middle and top stage represents the unconditional industry elasticity.

Table 17 shows how the conditional (and unconditional) industry elasticities of air travel vary across different distance-bands. The fourth and fifth column report industry elasticity of air travel derived from the middle stage of our three-stage budgeting approach, conditional on total expenditure on travel; the sixth column presents

Table 17. Estimates of Conditional and Unconditional Industry Elasticity

distance		revenue share of air travel	conditional industry elasticity		travel expenditure elasticity	travel (full) price elasticity§	unconditional industry elasticity	
min	max		full†	explicit‡			full†	explicit‡
100	150	5.8%	-9.14	-5.91	1.64	-1.16	-9.18	-5.94
150	200	6.0%	-8.86	-5.57	1.61	-1.14	-8.90	-5.60
200	250	15.6%	-4.05	-2.42	1.24	-1.14	-4.20	-2.51
250	300	17.7%	-3.70	-2.30	1.21	-1.13	-3.86	-2.41
300	350	21.4%	-3.23	-2.05	1.17	-1.13	-3.44	-2.18
350	400	31.0%	-2.55	-1.61	1.12	-1.13	-2.87	-1.81
400	450	33.7%	-2.44	-1.57	1.11	-1.13	-2.78	-1.79
450	500	31.6%	-2.52	-1.69	1.12	-1.10	-2.84	-1.90
500	600	37.4%	-2.30	-1.54	1.10	-1.12	-2.68	-1.80
600	700	48.7%	-2.00	-1.35	1.08	-1.11	-2.50	-1.69
700	800	50.9%	-1.96	-1.37	1.07	-1.10	-2.48	-1.74
800	900	52.3%	-1.94	-1.34	1.07	-1.11	-2.48	-1.72
900	1000	56.2%	-1.87	-1.30	1.07	-1.10	-2.46	-1.71
1000	1200	63.1%	-1.78	-1.25	1.06	-1.11	-2.45	-1.72
1200	1400	67.3%	-1.74	-1.23	1.05	-1.10	-2.44	-1.73
1400	1600	70.9%	-1.70	-1.20	1.05	-1.10	-2.44	-1.72
1600	1800	74.1%	-1.67	-1.18	1.05	-1.09	-2.44	-1.72
1800	2100	75.4%	-1.66	-1.20	1.05	-1.08	-2.44	-1.77
2100	2400	76.9%	-1.65	-1.17	1.05	-1.09	-2.45	-1.73
2400	2700	82.4%	-1.61	-1.16	1.04	-1.09	-2.47	-1.79

† The conditional (or unconditional) full industry elasticity measures the sensitivity of demand to the change both in explicit cost of air travel and in opportunity cost of air travel.
‡ The conditional (or unconditional) explicit industry elasticity measures the sensitivity of demand to the change only in explicit cost of air travel.
§ To be comparable with (industry) price elasticities estimated at the middle level, travel price elasticities estimated at the top level is calculated in each distance band.
¶ The unconditional industry elasticities are calculated using

the expenditure elasticity of air travel derived from the middle stage; the seventh column describe price elasticity of travel calculated from the estimates of demand at the top stage; and the last two columns tell industry elasticity of air travel when the effect of changes in the price of air travel on travel revenue is considered by combining the upper two stages. Since price elasticity consists of explicit costs and implicit costs components, industry elasticities for full price and industry (price) elasticities for explicit price are computed separately.

Both full and explicit industry elasticities conditional (or unconditional) on travel expenditure decrease as route distance increases and are relatively high on short-haul routes. In addition, the difference between full industry elasticities explicit industry elasticities tells us consumers are more sensitive to changes in opportunity costs of time when they are traveling short distance. High full industry elasticity on relatively short-haul routes explains why Southwest's entry makes consumers switch from other modes of transportation on relatively short-haul routes. It offers lower fares and direct service on the basis of a point-to-point system such that consumers of Southwest could save on both the explicit cost and implicit cost of traveling.

The indirect impact of price changes via changes travel expenditure gives rise to the difference between conditional and unconditional industry elasticities. On short-haul routes, the revenue share of air travel is so low that conditional and unconditional industry elasticities are almost identical. On the other hand, the difference between conditional and unconditional industry elasticities is relatively large on long-haul routes because the revenue share of air travel is dominant on those routes.

CHAPTER IV

THE EFFECT OF PRICE ELASTICITY ON PRICE DISPERSION

4.1 Price Elasticity and Price Dispersion

In the standard textbook model of market structures, a monopoly firm may charge different prices to consumers with different price elasticities of demand, provided it is able to segment the market into different sub-groups of consumers and to prevent or limit resales by consumers who pay the lower price to those who pay the higher price. In a perfectly competitive market, firms have no market power to price discrimination-there exists only one price. From these two extreme cases, one could infer that in an imperfectly competitive market, the degree of price discrimination of a firm would increase as a market becomes more concentrated. Contrary to our intuition, theoretical works by Borenstein (1985) and Holmes (1989) provide formal models in which price discrimination may increase with market competition.

Using a spatial model of monopolistic competition, Borenstein (1985) shows that the effect of market competition on the level of price discrimination by firms depends on the sources of price discrimination. He allows consumers to differ not only in their utility derived from a good (reservation prices) but also in their preferences between particular brands of that product.[34] Conceptually, he identifies two sources of quantity sold when the price of a brand is lowered: (i) increase in total market sales and (ii) sales that switch from rival brands. In response to a change in the price of a brand, the latter accounts for

[34] In our study, goods represent modes of transportation, while brands represent services offered by different firms in a specific mode of transportation.

how sensitive are consumers who are choosing between different brands, while the former accounts for how sensitive are consumers who are choosing between a specific brand and no purchase.

The distinction between two sources of change in quantity demanded enables us to analyze the effect of market competitiveness on the degree of price discrimination in monopolistically competitive markets. In order to model a monopolistically competitive market, he assumes that a market consists of two exclusive regions-a competitive region and a monopoly region. In the competitive region, all the consumers are responding to a price increase by choosing to buy from a rival brands, while in the monopoly region, all the consumers are responding to a price increase by choosing not to purchase a good. He then defines a market is more competitive if more consumers are in the competitive region. By assumption, consumers in the competitive region differ only in their preferences on brands but have similar reservation prices. Sorting mechanisms designed to distinguish consumers by their reservation prices are of no use in identifying consumers in the competitive region with different brand preferences. Therefore, one could predict that, if consumers are sorted by their preferences on brands, the level of price discrimination is expected to increase as a market becomes more competitive due to increased inter-brand competition.[35]

The distinction between discrimination based on the tendency to switch brands from one based on the tendency to leave the market is first analytically formulated by

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[35] On the other hand, when consumers are being sorted by their brand preferences, the level of price discrimination will be minimized if all consumers are in the monopoly region and be maximized if all consumers are in competitive region.

Table 18. An Example of Monopoly- and Competitive-Type Price Discrimination

		Cross-Price Elasticity	**Industry Elasticity**	**Price Elasticity**
Case 1	Type A	1	1.5	2.5
	Type B	1	0.5	1.5
Case 2	Type A	1.5	1	2.5
	Type B	0.5	1	1.5

Holmes (1989). Using a symmetric duopoly model of differentiated products, he shows that in an oligopoly model, price elasticity (ε^{price}) consists of cross-price elasticity (ε^{cross}) and industry elasticity ($\varepsilon^{industry}$) such that

$$\varepsilon^{price} = \varepsilon^{cross} + \varepsilon^{industry} \tag{34}$$

and the price-cost markup formula is

$$\frac{p-c}{p} = \frac{1}{\varepsilon^{price}} = \frac{1}{\varepsilon^{cross} + \varepsilon^{industry}} \tag{35}$$

When a firm unilaterally increases its price of a good, the cross-price elasticity measures the tendency of consumers to move on to a competing firm or brand, while the industry elasticity captures the tendency of consumers to drop out of the market. By following Borenstein (1985), price discrimination is defined as "monopoly type" if discrimination between consumers is due to their differences in industry elasticity; price discrimination is defined as "competitive type" if discrimination between consumers is due to their differences in cross-price elasticity.

In an example described in Table 18, type A consumers are more sensitive to price changes than type B consumers and therefore, if price discrimination is allowed, they will be charged a lower price in equilibrium. Under the traditional price discrimination model (price discrimination based on the differences in price elasticity), each consumer type will pay identical equilibrium prices in both case 1 and 2. Even though each type of consumers has same aggregate price elasticity in both cases, the source of differences in price elasticity between each type is not alike. For example, consumers' heterogeneity in the industry elasticity in case 1 yields distinction between different types of consumers, while heterogeneity in the cross-price elasticity in case 2 causes distinction between different types of consumers. Under monopoly type price discrimination, consumers are sorted by their industry elasticity such that type B consumers will be charged a higher price only in case 1. Meanwhile, under competitive type price discrimination, price discrimination will only be observed in case 2 in response to differences in the cross-price elasticities.

Borenstein and Rose (1994) carry out an investigation empirically testing which type of price discrimination is practiced in the U.S. airline industry. Using a reduced form model of price dispersion in airline markets, they find price dispersion is correlated with more competitive structures.[36] This result confirms the theoretical prediction of competitive type price discrimination, and indirectly shows that heterogeneity in the tendency of consumers to switch airlines is the sole or dominant determinant of price dispersion in airline markets.

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[36] In their study, price dispersion refers to the variation in prices charged to different passengers by an airline on a route. The dispersion of fares in the airline industry results both from the variation in the costs of serving different types of consumers and from self-selective discriminatory pricing. Due to data limitations and possible correlation between costs of serving different consumers and discriminatory prices charged on heterogeneous consumers, it is difficult to empirically discern discriminatory pricing from cost variation as a source of price dispersion.

Borenstein and Rose (1994)'s seminal work can be viewed as incomplete because they only indirectly examine the relationship between price discrimination and two components of price elasticity-industry elasticity and cross-price elasticity. They provide little direct evidence to answer the question, whether the "industry" or "cross-price" component of price elasticity is the primary determinant of observed price dispersion in the airline industry. The price-cost markup formula in equation (2) enables us to investigate directly the relationship between price dispersion and the industry and cross-price elasticity without requiring an assumption on consumer sorting mechanism.

We extend Holmes (1989) model to investigate directly the relationship between the degree of price discrimination and distribution of cross-price elasticity and industry elasticity. Suppose two different types of consumers, A and B, and their cross-price elasticity and industry elasticity are $\varepsilon_i^{cross}, \varepsilon_i^{industry}$ (i=A, B) such that $\varepsilon_i^{price} = \varepsilon_i^{cross} + \varepsilon_i^{industry}$ (i=A, B) where $\varepsilon_A^{cross} > \varepsilon_B^{cross>} > 0$, $\varepsilon_A^{industry} > \varepsilon_B^{industry} > 0$, and the proportion of A and B is p and $(1-p)$, respectively. Since prices are monotonically decreasing in price elasticity in markup formula of equation (2), price differential is expected to be positively correlated with difference in the price elasticity of each group:

$$\varepsilon_A^{price} - \varepsilon_B^{price} = \left(\varepsilon_A^{cross} - \varepsilon_B^{cross}\right) + \left(\varepsilon_A^{industry} - \varepsilon_B^{industry}\right) \quad (36)$$

where difference in consumers' preference on brands of a product, $\left(\varepsilon_A^{cross} - \varepsilon_B^{cross}\right)$, is the source of competitive type price discrimination, and monopoly type price discrimination is practiced based on difference in consumers' valuation on the product, $\left(\varepsilon_A^{industry} - \varepsilon_B^{industry}\right)$.

The structure of the DB1A data base, however, prevents us from estimating cross-price elasticities and industry elasticities of consumers in different groups separately in that DB1A provides no information on detailed restrictions imposed on tickets or purposes of air travels. Considering the fact that our estimates of price elasticity accounts for how average consumers of type A and B respond to the change in prices, we need to first look into the effect of mean price elasticity on price dispersion. Let μ and σ denotes mean and standard deviation of price elasticity, respectively. Then, mean of each component of price elasticity is

$$\mu^{j} = \varepsilon_{A}^{j} \cdot p + \varepsilon_{B}^{j} \cdot (1-p),\ j = \text{cross, industry} \tag{37}$$

, and standard deviation of each component of price elasticity is

$$\sigma^{j} = \left[\left(\varepsilon_{A}^{j} - \varepsilon_{B}^{j}\right)^{2} \cdot p \cdot (1-p)\right]^{\frac{1}{2}},\ j = \text{cross, industry.}^{37} \tag{38}$$

Now we consider the coefficient of variation of price as a measure for the variation in price charged to different consumers:

$$CV = \frac{\sigma}{\mu} \tag{39}$$

where

$$\begin{aligned}
\mu &= \mu_{A} \cdot p + \mu_{B} \cdot (1-p) \\
&= \left(\varepsilon_{A}^{cross} + \varepsilon_{A}^{industry}\right)p + \left(\varepsilon_{B}^{cross} + \varepsilon_{B}^{industry}\right)(1-p) \\
&= \left(\varepsilon_{A}^{cross} p + \varepsilon_{B}^{cross}(1-p)\right) + \left(\varepsilon_{A}^{industry} p + \varepsilon_{B}^{industry}(1-p)\right) \\
&= \mu^{cross} + \mu^{industry}
\end{aligned} \tag{40}$$

and

[37] We assume that total revenue from type A consumers is equal to that from type B consumers.

$$\sigma = \left[\left((\varepsilon_A^{cross} + \varepsilon_A^{industry}) - \mu \right)^2 p + \left((\varepsilon_B^{cross} + \varepsilon_B^{industry}) - \mu \right)^2 (1-p) \right]^{\frac{1}{2}}$$

$$= \left[\left(\sigma^{cross} \right)^2 + \left(\sigma^{industry} \right)^2 + 2\,\mathrm{cov}\left(\varepsilon^{cross}, \varepsilon^{industry} \right) \right]^{\frac{1}{2}} \quad (41)$$

The coefficient of variation of price and mean price elasticity are comprised of industry elasticity, cross-price elasticity and percentage of each type. In order to examine the relationship between price dispersion and mean of industry and cross-price elasticity, we need to first analyze partial effect of each component on mean price elasticity and the coefficient of variation of price. From equation (4) and (8), $j =$ cross, industry

$$\frac{\partial \mu}{\partial \varepsilon_A^j} = p; \frac{\partial \mu}{\partial \varepsilon_B^j} = 1 - p; \frac{\partial \mu}{\partial p} = \varepsilon_A^{price} - \varepsilon_B^{price},$$

and

$$\frac{\partial \sigma}{\partial \varepsilon_A^j} = \sqrt{p(1-p)}; \frac{\partial \sigma}{\partial \varepsilon_B^j} = -\sqrt{p(1-p)}; \frac{\partial \sigma}{\partial p} = \frac{\left(\varepsilon_A^{price} - \varepsilon_B^{price} \right)(1-2p)}{2\sqrt{p(1-p)}}, \quad (42)$$

such that

$$\frac{\partial CV}{\partial \varepsilon_A^{cross}} = \frac{\partial CV}{\partial \varepsilon_A^{industry}} = \frac{\varepsilon_B^{price} \sqrt{p(1-p)}}{\mu^2} > 0 \quad (43)$$

$$\frac{\partial CV}{\partial \varepsilon_B^{cross}} = \frac{\partial CV}{\partial \varepsilon_B^{industry}} = \frac{-\varepsilon_A^{price} \sqrt{p(1-p)}}{\mu^2} < 0 \quad (44)$$

$$\frac{\partial CV}{\partial p} = \frac{-\left(\varepsilon_A^{price} - \varepsilon_B^{price} \right)\left(\varepsilon_A^{price} p^2 - \varepsilon_B^{price} (1-p)^2 \right)}{2\mu^2 \sqrt{p(1-p)}}$$

$$= \begin{cases} > 0 \quad if \;\; p < \dfrac{\sqrt{\varepsilon_B^{price}}}{\sqrt{\varepsilon_A^{price}} + \sqrt{\varepsilon_B^{price}}} \\ < 0 \quad if \;\; p > \dfrac{\sqrt{\varepsilon_B^{price}}}{\sqrt{\varepsilon_A^{price}} + \sqrt{\varepsilon_B^{price}}} \end{cases} \quad (45)$$

We now can analyze the effect of mean cross-price elasticity and mean industry elasticity on price dispersion by inspecting the sign of following partial derivatives: for $i = A, B$ and $j = cross, industry$,

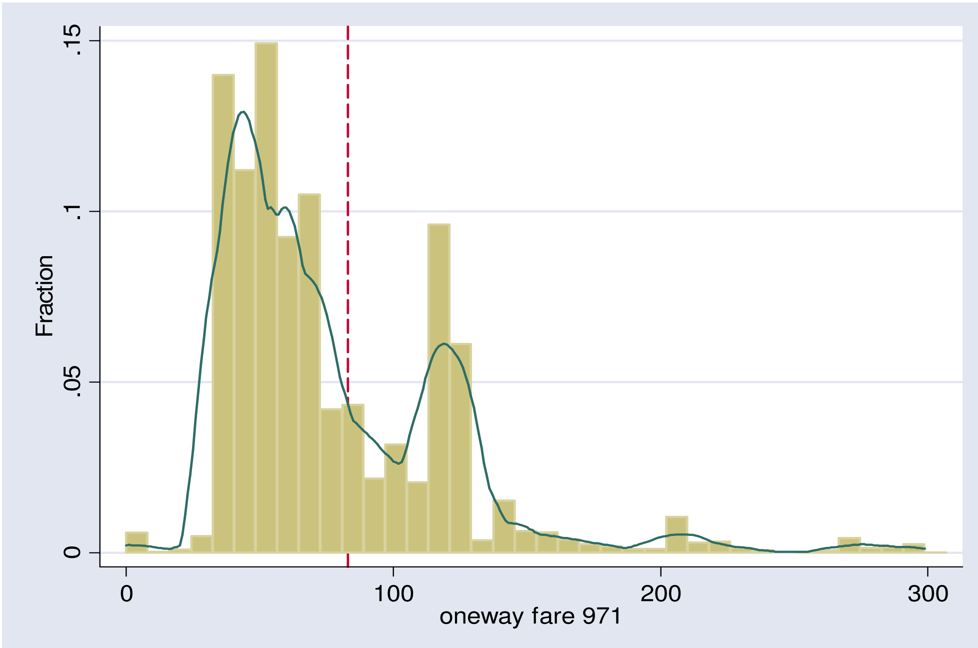
$$\frac{\partial CV}{\partial \mu^j} = \frac{\partial CV / \partial \varepsilon_i^j}{\partial \mu^j / \partial \varepsilon_i^j}; \frac{\partial CV}{\partial \mu^j} = \frac{\partial CV / \partial \varepsilon_i^j}{\partial \mu^j / \partial \varepsilon_i^j}; \frac{\partial CV}{\partial p} = \frac{\partial CV / \partial p}{\partial \mu^j / \partial p} \tag{46}$$

Equation (9) through (13) implies that as the mean of cross-price (or industry) elasticity falls, price dispersion will be expanded if price dispersion is caused by the variation in cross-price (or industry) elasticity of less price-sensitive consumers (type B) or the proportion of more price-sensitive consumers is relatively high, i.e.

$p > \frac{\sqrt{\varepsilon_B^{price}}}{\sqrt{\varepsilon_A^{price}} + \sqrt{\varepsilon_B^{price}}}$. On the other hand, price dispersion will be compressed as the mean of cross-price (or industry) elasticity falls if price dispersion is caused by the variation in cross-price (or industry) elasticity of more price-sensitive consumers (type A) or the proportion of more price-sensitive consumers is relatively low, i.e.

$p < \frac{\sqrt{\varepsilon_B^{price}}}{\sqrt{\varepsilon_A^{price}} + \sqrt{\varepsilon_B^{price}}} \left(< \frac{1}{2} \right)$.

Figure 4 shows how one-way fares of Delta airline from Los Angeles, LA to Salt Lake City, UT in the first quarter of 1997. The dashed line and the solid line represent mean fare and kernel density of one-way fares, respectively. Also, fares around first peak on the left are believed to account for fares charged on price-sensitive consumers, while fares around the second peak on the right are believed to account for fares charged



Source: DB1A 1997
Dashed line represents mean one-way fare of Delta airline from Los Angeles, CA (LAX) to Salt Lake City, UT (SLC) in the first quarter of year 1997, while solid line represents kernel density of one-way fares of Delta airline in that directional route.

Figure 4. Fare Distribution of Delta Airline: From LAX to SLC; 1st Quarter of `97

to price-insensitive consumers. In general, similar patterns in the distribution of fares are observed on our sample routes. There are two peaks-one for price-sensitive consumers and the other for price-insensitive consumers. Furthermore, the percentage of price-sensitive consumers is greater than that of price-insensitive consumers. The distance between the peak for price-sensitive consumers and mean fare is about the half of mean fare, while the distance between the peak for price-insensitive consumers and mean fare varies across routes. In the following analysis, we assume that the portion of price-sensitive consumers (type A) is greater than that of price-insensitive consumers and the level of price dispersion of an airline on a route relies on how far the peak for price-insensitive consumers is from mean fare. Based upon these assumptions, we expect that price dispersion is negatively correlated with the mean of industry elasticity or cross-price elasticity.[38]

4.2 The Effect of Price Elasticity on Price Dispersion: Empirical Results

In order to measure the level of fare dispersion by an airline, we use a Gini fare index, which is highly correlated with the coefficient of variation of fares. On those routes where Southwest started to serve, the average of fare Gini index is 0.174, which implies that when two tickets of an airline on a route are randomly picked up, the expected absolute difference in fares of those two tickets is 34.8 percent of the mean fare. The largest Gini fare index of 0.525 means that the expected fare difference is 105 percent of the mean of fare, while the smallest fare Gini index of 0 indicates that only one type of fare is offered.[39]

We test whether the "industry" or "cross-price" component of price elasticity is the primary determinant of observed price dispersion in the airline industry by estimating the following equation:

$$Gini_{fare} = \alpha + \beta_1 \varepsilon^{cross} + \beta_2 \varepsilon^{industry} \tag{47}$$

where $Gini_{fare}$ denotes Gini fare index, $\varepsilon^{cross} (> 0)$ the (conditional) cross-price elasticity and $\varepsilon^{industry} (> 0)$ the (unconditional) industry elasticity. If we assume that the percentage

[38] In addition, it is implicitly assumed that both industry elasticity and cross-price elasticity of price-sensitive consumers are greater than those of price-insensitive consumers.
[39] Among 6140 observations, 7.6% of Gini indices is zero which implies that an airline offers only type of fare on a route.

Table 19. Estimation Results: Cross-Price, Industry Elasticity and Fare Gini

$Gini_{fare}$	
Constant	0.220*** (0.013) †
ε^{cross}	0.049*** (0.003)
$\varepsilon^{industry}$	-0.008 (0.007)
Number of Obs	5526
R-square	0.0529
F-statistics	154.13

†Standard errors are in parentheses
***=significant at 1% level.

of price-sensitive consumers is greater than that of price-insensitive consumers and the heterogeneity in price-insensitive consumers is the primary source of variation in fare dispersion across routes, both industry elasticity and cross-price elasticity are expected to be negatively correlated with Gini fare index.

Table 19 shows that cross-price elasticity of demand is the key factor affecting price dispersion of airlines. This result is consistent with the earlier findings of Borenstein and Rose (1994), but is considerably more rigorously rooted in the underlying theory. Statistically significant positive relationship between price dispersion and cross-price elasticity also indicates that in the airline industry, price discrimination is practiced to compete with rival carriers, not to compete with rival modes of transportation. Meanwhile, estimation results predict that if cross-price elasticity decreases by one, the expected absolute difference in fares between two randomly selected air tickets increases by 9.6 percent of the mean fare.

Table 20. Estimation Results: Cross-Price Elasticity, Distance and Fare Gini

$Gini_{fare}$	
Constant	0.225*** (0.004) †
ε^{cross}	0.048*** (0.003)
$dist$	6.41E-06*** (2E-06)
Number of Obs	5526
R-square	0.0542
F-statistics	1598.29

†Standard errors are in parentheses
***=significant at 1% level.

The estimated industry elasticities reported in Table 17 show little variation across mid- to long-haul routes, which could cause statistical insignificance of the industry elasticity. In order to compensate for possible incompleteness in estimating the unconditional demand for air travel, we substitute the distance of routes for the industry elasticity in that considerable substitution between airplane and auto is observed as the distance of travel varies. Now we estimate the following estimation equation:

$$Gini_{fare} = \alpha + \beta_1 \varepsilon^{cross} + \beta_2 dist$$

where $dist$ denotes the statutory distance of routes. We expect the distance of routes to be positively correlated with fare dispersion because as the distance of travel increase, there exist less substitutes for air travel so that industry elasticity is likely to decrease. Table 20 indicates that the distance of travel has significantly positive effect on price dispersion, while the coefficient of cross-price elasticity remains significant and unchanged.[40] When the cross-price elasticity increases by one standard deviation, the Gini index increases by 0.019 which means that the expected difference of fares between two randomly chosen tickets increases by 3.8 percent of the average fare. On the other hand, one standard deviation of distance increases the Gini index by 0.004. This suggests that the cross-price elasticity is the dominant determinant of observed price dispersion due to discriminatory pricing in the airline industry.

[40] This result suggests that another way of estimating demand for air travel should be studied in the future work.

CHAPTER V

CONCLUSION

This dissertation has examined the sources of price dispersion induced by price discrimination in the U.S. airline industry. There is a considerable body of work addressing the sources of price dispersion in an imperfectly competitive market. Specifically, Borenstein (1985) distinguishes price discrimination rooted in differences among consumers in their reservation prices of a good from that rooted in differences in consumers' brand preferences. The follow-on work by Holmes (1989) decomposes a firm's price elasticity of demand into industry elasticity and cross-price elasticity. When a firm unilaterally raises the price of its good, the industry elasticity captures consumers' tendency to drop out of the market, while the cross-price elasticity measures consumers' tendency to switch to rival brands. These two sources of price discrimination become known as "monopoly-type" price discrimination and "competitive-type" price discrimination.

The most important investigation testing between these types of price discrimination is carried out by Borenstein and Rose (1994). Using a reduced form model of price dispersion in the airline industry, they show that price dispersion is positively correlated with the level of market competitiveness. This empirical finding is suggestive of competitive-type price discrimination, and indirectly shows that heterogeneity in the tendency of consumers to switch airlines is the sole or dominant determinant of price dispersion in the airline industry. On the other hand, Borenstein and

Rose's (1994) seminal work can be viewed as incomplete because they only indirectly examine the relationship between price discrimination and the two components of price elasticity. In addition, they are unable to separate the industry elasticity and cross-price elasticity as the sources of price discrimination in their model.

We test a model of price discrimination tied directly to Holmes (1989) which considers both industry and cross-price elasticity as sources of price discrimination. In particular, we attempt to directly test whether the industry or cross-price component of price elasticity is the primary determinant of observed price dispersion in the airline industry.

Using the multi-stage budgeting approach with the almost ideal demand system (AIDS) specification, we first estimate demand for air travel at the airline level. More specifically, we divide the decision to travel into three stages: (1) the decision regarding the travel budget, (2) the decision to travel by auto or plane, and (3) the choice among carriers. This methodology permits a theoretically and empirically crisp separation between the industry and cross-price elasticities of demand. We use both airline industry data (for the bottom stage as well) and travel survey micro data for estimation of the choice between modes of travel, and the choice of traveling or staying home. In addition, to make full use of variations in relative prices and revenue shares, we focus on the routes where the Southwest airline entered.

Southwest seems to have the highest cross-price elasticities on all routes regardless of the number of competitors. Also, the entry of Southwest makes the consumers of incumbent airlines more responsive to price changes by switching airlines when one or two existing airlines are competing against Southwest's entry. On the other hand, the cross-price elasticities tend to decrease with number of competitors. There are more competing airlines on longer-haul routes, which are dominated by major airlines providing hub-and-spoke system. Frequent flyers programs of airlines with hub-and-spoke system are designed to provide consumers with incentives not to switch to rival carriers offering lower fares. Therefore, it is expected that on routes where airlines are competing with rivals in non-price factors, cross-price elasticities will be lower, other things held constant.

To capture the role of the opportunity cost of time spent travel in consumers' choice of transportation mode, we introduce a concept of the full prices of each mode of transportation. The full price consists of two components: the explicit price of travel and the opportunity cost of traveling time. The explicit price represents all the monetary costs for traveling such as air fares, costs of gas, etc. The opportunity cost of traveling time can be measured by the total amount of forgone wages for the period of traveling time.

Both full and explicit industry elasticities conditional (or unconditional) on travel expenditure decrease as route distance increases and are relatively high on short-haul routes. In addition, the difference between full industry elasticities explicit industry elasticities tells us consumers are more sensitive to changes in opportunity costs of time when they are traveling short distance. High full industry elasticity on relatively short-haul routes explains why Southwest's entry makes consumers switch from other modes of transportation on relatively short-haul routes. It offers lower fares and direct service on the basis of a point-to-point system such that consumers of Southwest could save on both the explicit cost and implicit cost of traveling.

The indirect impact of price changes via changes travel expenditure gives rise to the difference between conditional and unconditional industry elasticities. On short-haul routes, the revenue share of air travel is so low that conditional and unconditional industry elasticities are almost identical. On the other hand, the difference between conditional and unconditional industry elasticities is relatively large on long-haul routes because the revenue share of air travel is dominant on those routes.

We use the estimated components of price elasticities to investigate the determinants of price dispersion induced by price discrimination across airline routes. Following Borenstein and Rose (1994), we use the Gini coefficient of air fares to measure the degree of price dispersion. Our results show that cross-price elasticity of demand for air travel, reflecting competitive-type discrimination, is the key factor affecting price dispersion in the airline industry. This result is consistent with the earlier findings of Borenstein and Rose, but is based on a direct test of the underlying theory of Holmes.

In order to compensate for possible incompleteness in estimating the unconditional demand for air travel, we substitute the distance of routes for the industry elasticity in that considerable substitution between airplane and auto is observed as the distance of travel varies. The distance of travel turns out to be significantly and positively correlated with price dispersion, while the coefficient of cross-price elasticity remains significant and unchanged. This result suggests that another way of estimating demand for air travel should be studied in the future work.

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APPENDIX A

VARIABLE DESCRIPTIONS

Gini coefficient of fares ($Gini_{fare}$): $Gini_{fare}$ is computed using the following formula

$$Gini_{fare} = 1 - 2 \cdot \left[\sum_{i=1}^{N} \left(\frac{fare_i \cdot pax_i}{total\ revenue} \left\langle \frac{1}{2} \frac{pax_i}{total\ pax} + \left(1 - \sum_{j=1}^{i} \frac{pax_i}{total\ pax} \right) \right\rangle \right) \right]$$

where N is total number of different fare level tickets issued by an airline on a route, pax_i is number of tickets sold at the fare level $fare_i$ and total revenue is

$$total\ revenue = \sum_{i=1}^{N} fare_i \cdot pax_i \ .$$

Wage rate per minute of working persons in the household ($Wage_{adult}^{HH}$): $Wage_{adult}^{HH}$ is

defined as $Wage_{adult}^{HH} = \dfrac{Income^{HH}}{N_{working}^{HH} \cdot Minute_{working}^{total}}$. We extract from the 1995 Panel Study of Income Dynamics (PSID) information on household income ($Income^{HH}$), number of working persons in a household such as a household head and his wife ($N_{working}^{HH}$) and their total working minutes a year ($Minute_{working}^{total}$) which is the sum of working minutes of each working person in a household. Each working person in a household is assumed to have the same opportunity cost of time spent traveling, which can be measured by the total amount of forgone wages for the period of traveling time. In addition, childre

APPENDIX B

ESTIMATION RESULTS: AIDS MODEL OF DETERMINANTS OF SHARE FOR THE CHOICE OF CARRIERS

Table B1. Two Carriers on a Route After Southwest's Entry

AIDS Model of Determinants of Share

S_i	Without SW's Virtual Fare	With SW's Virtual Fare
	Airline 1	Airline 1
Constant	2.040 (0.424)	2.040 (0.424)
$\log(E/P)$	-0.229 (0.079)	-0.229 (0.079)
$\log(p_1/p_{SW})$	-0.300 (0.116)	-0.300 (0.116)
$D_{10}^{indirect}$	-0.174 (0.091)	-0.174 (0.091)
$D_{01}^{indirect}$	-0.304 (0.092)	-0.304 (0.092)
D_{DL}^{firm}	0.300 (0.139)	0.300 (0.139)
D_{QX}^{firm}	0.631 (0.172)	0.631 (0.172)
D_{TW}^{firm}	0.443 (0.182)	0.443 (0.182)
Number of Obs	16	26
R-square	0.9424	0.5468
F-Statistic	18.69	3.1

† Standard errors are in parentheses.

- Airline dummies D_{AA}^{firm}, D_{CO}^{firm}, D_{HP}^{firm}, D_{NW}^{firm}, D_{RU}^{firm}, D_{UA}^{firm} and D_{KN}^{firm} are omitted due to perfect collinearity.

Table B2. Four Carriers on a Route After Southwest's Entry

AIDS Model of Determinants of Share

S_i	Without SW's Virtual Fare			With SW's Virtual Fare		
	Airline 1	Airline 2	Airline 3	Airline 1	Airline 2	Airline 3
Constant	0.106 (0.118)	0.483 (0.090)	0.354 (0.071)	0.177 (0.095)	0.399 (0.070)	0.251 (0.057)
$\log(E/P)$	0.062 (0.020)	-0.035 (0.014)	-0.043 (0.011)	0.047 (0.016)	-0.026 (0.012)	-0.030 (0.009)
$\log(p_1/p_{SW})$	0.135 (0.077)	-0.117 (0.056)	-0.055 (0.033)	0.036 (0.059)	-0.068 (0.046)	-0.063 (0.027)
$\log(p_2/p_{SW})$	-0.117 (0.056)	-0.005 (0.059)	0.050 (0.027)	-0.068 (0.046)	-0.040 (0.046)	0.068 (0.022)
$\log(p_3/p_{SW})$	-0.055 (0.033)	0.050 (0.027)	-0.016 (0.027)	-0.063 (0.027)	0.068 (0.022)	-0.001 (0.021)
$D_{1101}^{indirect}$	0.219 (0.067)	-0.096 (0.047)	-0.031 (0.035)	0.213 (0.059)	-0.095 (0.042)	-0.059 (0.032)
$D_{1100}^{indirect}$	0.125 (0.086)	-0.003 (0.062)	0.002 (0.044)	0.125 (0.083)	-0.019 (0.060)	-0.016 (0.044)
$D_{1011}^{indirect}$	-0.383 (0.178)	-0.161 (0.131)	0.096 (0.126)	-0.154 (0.127)	-0.301 (0.095)	0.011 (0.066)
$D_{1010}^{indirect}$	0.262 (0.099)	-0.094 (0.072)	0.019 (0.059)	0.293 (0.098)	-0.103 (0.071)	0.007 (0.052)
$D_{1001}^{indirect}$	0.008 (0.060)	-0.140 (0.043)	-0.018 (0.031)	0.072 (0.052)	-0.174 (0.037)	-0.046 (0.028)
$D_{1000}^{indirect}$	0.143 (0.056)	-0.122 (0.040)	-0.005 (0.029)	0.141 (0.056)	-0.126 (0.040)	-0.015 (0.030)
$D_{0101}^{indirect}$	-0.138 (0.084)	-0.111 (0.061)	-0.010 (0.044)	-0.105 (0.071)	-0.132 (0.052)	-0.024 (0.037)
$D_{0100}^{indirect}$	0.007 (0.076)	0.036 (0.068)	0.000 (0.039)	0.015 (0.077)	0.013 (0.066)	-0.005 (0.040)
$D_{0011}^{indirect}$	-0.132 (0.115)	0.032 (0.082)	0.097 (0.059)	-0.132 (0.097)	0.032 (0.069)	0.106 (0.051)
$D_{0001}^{indirect}$	-0.056 (0.072)	-0.115 (0.053)	-0.029 (0.037)	-0.109 (0.056)	-0.075 (0.041)	-0.009 (0.029)
D_{AA}^{firm}	0.006 (0.043)	0.006 (0.043)	0.006 (0.043)	0.038 (0.029)	0.038 (0.029)	0.038 (0.029)
D_{AS}^{firm}	0.018 (0.047)	0.018 (0.047)	0.018 (0.047)	0.040 (0.035)	0.040 (0.035)	0.040 (0.035)
D_{CO}^{firm}		-0.009 (0.052)	-0.009 (0.052)		0.012 (0.036)	0.012 (0.036)
D_{DL}^{firm}	0.020 (0.040)	0.020 (0.040)	0.020 (0.040)	0.045 (0.026)	0.045 (0.026)	0.045 (0.026)
D_{HP}^{firm}	0.019 (0.043)	0.019 (0.043)	0.019 (0.043)	0.037 (0.029)	0.037 (0.029)	0.037 (0.029)
D_{NW}^{firm}	-0.019 (0.043)	-0.019 (0.043)	-0.019 (0.043)	0.015 (0.027)	0.015 (0.027)	0.015 (0.027)
D_{QX}^{firm}	-0.035 (0.046)	-0.035 (0.046)	-0.035 (0.046)	0.000 (0.000)		0.000 (0.000)
D_{QQ}^{firm}	-0.048 (0.057)	-0.048 (0.057)	-0.048 (0.057)	0.015 (0.043)	0.015 (0.043)	0.015 (0.043)

Table B2. Continued.

S_i	Without SW's Virtual Fare			With SW's Virtual Fare		
	Airline 1	Airline 2	Airline 3	Airline 1	Airline 2	Airline 3
D_{RU}^{firm}			-0.041 (0.103)			
D_{TW}^{firm}	0.000 (0.000)			0.122 (0.053)		0.122 (0.053)
D_{UA}^{firm}	0.002 (0.041)	0.002 (0.041)	0.002 (0.041)	0.021 (0.027)	0.021 (0.027)	0.021 (0.027)
D_{US}^{firm}			0.000 (0.000)		-0.062 (0.040)	-0.062 (0.040)
D_{YV}^{firm}		0.127 (0.104)			0.174 (0.092)	
Obs.	86	86	86	120	120	120
R-square	0.4438	0.4995	0.4348	0.4429	0.5001	0.4025

† Standard errors are in parentheses.

- Quality dummies $D_{0010}^{indirect}$ is omitted due to perfect collinearity.

Table B3. Five Carriers on a Route After Southwest's Entry

AIDS Model of Determinants of Share

S_i	Without Virtual Fare				With Virtual Fare			
	Airline 1	Airline 2	Airline 3	Airline 4	Airline 1	Airline 2	Airline 3	Airline 4
Constant	0.376 (0.121)	0.489 (0.074)	0.273 (0.057)	0.099 (0.040)	0.403 (0.080)	0.529 (0.050)	0.277 (0.036)	0.137 (0.025)
$\log(E/P)$	0.009 (0.022)	-0.053 (0.014)	-0.037 (0.010)	-0.013 (0.007)	0.008 (0.015)	-0.057 (0.009)	-0.030 (0.007)	-0.014 (0.004)
$\log(p_1/p_{SW})$	-0.056 (0.059)	-0.016 (0.034)	0.011 (0.025)	-0.013 (0.017)	-0.048 (0.040)	-0.003 (0.027)	-0.003 (0.019)	-0.006 (0.013)
$\log(p_2/p_{SW})$	-0.016 (0.034)	-0.050 (0.035)	0.018 (0.020)	-0.002 (0.014)	-0.003 (0.027)	-0.022 (0.028)	0.018 (0.015)	-0.004 (0.011)
$\log(p_3/p_{SW})$	0.011 (0.025)	0.018 (0.020)	-0.007 (0.021)	0.012 (0.011)	-0.003 (0.019)	0.018 (0.015)	-0.021 (0.015)	0.003 (0.008)
$\log(p_4/p_{SW})$	-0.013 (0.017)	-0.002 (0.014)	0.012 (0.011)	0.012 (0.011)	-0.006 (0.013)	-0.004 (0.011)	0.003 (0.008)	0.004 (0.008)
$D_{11101}^{indirect}$	0.075 (0.105)	-0.040 (0.065)	0.045 (0.048)	-0.013 (0.032)	0.076 (0.093)	0.012 (0.059)	0.025 (0.042)	-0.011 (0.027)
$D_{11011}^{indirect}$	0.024 (0.122)	0.019 (0.074)	0.097 (0.056)	0.016 (0.036)	0.023 (0.118)	0.021 (0.073)	0.084 (0.053)	0.013 (0.034)
$D_{11010}^{indirect}$	-0.019 (0.169)	0.124 (0.101)	-0.009 (0.077)	-0.007 (0.049)	-0.009 (0.163)	0.128 (0.101)	-0.017 (0.073)	-0.016 (0.047)
$D_{11001}^{indirect}$	0.002 (0.094)	0.022 (0.057)	-0.015 (0.044)	-0.028 (0.028)	-0.007 (0.065)	0.037 (0.040)	-0.011 (0.029)	-0.007 (0.019)
$D_{11000}^{indirect}$	0.241 (0.104)	-0.002 (0.063)	-0.014 (0.048)	-0.005 (0.030)	0.246 (0.098)	0.021 (0.061)	-0.013 (0.044)	-0.001 (0.029)
$D_{10101}^{indirect}$	0.161 (0.127)	-0.100 (0.076)	-0.047 (0.058)	-0.007 (0.037)	0.198 (0.088)	-0.110 (0.055)	-0.072 (0.040)	-0.027 (0.026)
$D_{10100}^{indirect}$	-0.074 (0.117)	0.139 (0.060)	0.072 (0.047)	-0.085 (0.035)	-0.056 (0.103)	0.134 (0.060)	0.029 (0.048)	-0.038 (0.028)
$D_{10001}^{indirect}$	0.059 (0.074)	-0.088 (0.044)	-0.021 (0.034)	-0.011 (0.021)	0.066 (0.047)	-0.081 (0.029)	-0.033 (0.021)	-0.025 (0.014)
$D_{10000}^{indirect}$	0.104 (0.055)	-0.035 (0.033)	0.027 (0.025)	-0.036 (0.016)	0.100 (0.051)	-0.047 (0.032)	0.036 (0.023)	-0.033 (0.015)
$D_{01110}^{indirect}$	-0.036 (0.168)	0.079 (0.101)	-0.010 (0.077)	0.071 (0.049)	-0.035 (0.163)	0.074 (0.101)	-0.009 (0.073)	0.069 (0.047)
$D_{01101}^{indirect}$	-0.136 (0.126)	0.109 (0.075)	0.051 (0.057)	0.023 (0.036)	-0.184 (0.099)	0.097 (0.061)	0.087 (0.044)	0.039 (0.029)
$D_{01100}^{indirect}$	0.074 (0.101)	-0.008 (0.060)	0.017 (0.046)	0.006 (0.029)	0.075 (0.097)	-0.011 (0.060)	0.011 (0.043)	0.005 (0.028)
$D_{01011}^{indirect}$					0.087 (0.165)	-0.120 (0.103)	0.007 (0.074)	0.012 (0.048)
$D_{01010}^{indirect}$	0.031 (0.171)	0.279 (0.102)	-0.034 (0.078)	0.004 (0.049)	0.025 (0.164)	0.259 (0.101)	-0.020 (0.073)	0.001 (0.047)
$D_{01001}^{indirect}$	-0.252 (0.106)	0.099 (0.064)	0.032 (0.049)	-0.026 (0.031)	-0.174 (0.068)	0.052 (0.043)	0.015 (0.031)	-0.022 (0.020)
$D_{01000}^{indirect}$	-0.100 (0.087)	0.010 (0.052)	0.065 (0.040)	0.015 (0.025)	-0.100 (0.084)	0.005 (0.052)	0.066 (0.038)	0.015 (0.025)
$D_{00101}^{indirect}$	0.036 (0.171)	-0.164 (0.103)	-0.002 (0.078)	-0.047 (0.050)	-0.093 (0.099)	-0.106 (0.061)	0.007 (0.044)	0.010 (0.029)

Table B3. Continued.

S_i	Without Virtual Fare				With Virtual Fare			
	Airline 1	Airline 2	Airline 3	Airline 4	Airline 1	Airline 2	Airline 3	Airline 4
$D_{00100}^{indirect}$	-0.088 (0.072)	0.018 (0.043)	0.097 (0.034)	0.024 (0.021)	-0.088 (0.070)	0.013 (0.044)	0.097 (0.032)	0.023 (0.020)
$D_{00010}^{indirect}$	0.075 (0.088)	0.039 (0.054)	0.046 (0.040)	-0.024 (0.025)	0.069 (0.085)	0.021 (0.053)	0.053 (0.038)	-0.021 (0.024)
$D_{00001}^{indirect}$	-0.126 (0.049)	-0.062 (0.030)	-0.021 (0.023)	-0.012 (0.014)	-0.125 (0.040)	-0.055 (0.025)	-0.021 (0.018)	-0.016 (0.012)
D_{AA}^{firm}	0.032 (0.017)	0.032 (0.017)	0.032 (0.017)	0.032 (0.017)	0.005 (0.010)	0.005 (0.010)	0.005 (0.010)	0.005 (0.010)
D_{AS}^{firm}	0.098 (0.034)	0.098 (0.034)	0.098 (0.034)	0.098 (0.034)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	
D_{CO}^{firm}	0.022 (0.017)	0.022 (0.017)	0.022 (0.017)	0.022 (0.017)	-0.001 (0.010)	-0.001 (0.010)	-0.001 (0.010)	-0.001 (0.010)
D_{DL}^{firm}	0.043 (0.017)	0.043 (0.017)	0.043 (0.017)	0.043 (0.017)	0.015 (0.010)	0.015 (0.010)	0.015 (0.010)	0.015 (0.010)
D_{HP}^{firm}	0.023 (0.021)	0.023 (0.021)	0.023 (0.021)	0.023 (0.021)	0.000 (0.000)	0.000 (0.000)		0.000 (0.000)
D_{NW}^{firm}	0.018 (0.017)	0.018 (0.017)	0.018 (0.017)	0.018 (0.017)		0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
D_{QX}^{firm}	0.000 (0.000)			0.000 (0.000)	0.032 (0.030)		0.032 (0.030)	0.032 (0.030)
D_{QQ}^{firm}		0.073 (0.031)	0.073 (0.031)	0.073 (0.031)			0.000 (0.000)	0.000 (0.000)
D_{RU}^{firm}			0.000 (0.000)	0.000 (0.000)		-0.021 (0.014)	-0.021 (0.014)	-0.021 (0.014)
D_{TW}^{firm}	0.021 (0.017)	0.021 (0.017)	0.021 (0.017)	0.021 (0.017)	-0.010 (0.009)	-0.010 (0.009)	-0.010 (0.009)	-0.010 (0.009)
D_{UA}^{firm}	0.034 (0.016)	0.034 (0.016)	0.034 (0.016)	0.034 (0.016)	0.006 (0.009)	0.006 (0.009)	0.006 (0.009)	0.006 (0.009)
D_{US}^{firm}	0.005 (0.020)	0.005 (0.020)	0.005 (0.020)	0.005 (0.020)	-0.018 (0.013)	-0.018 (0.013)	-0.018 (0.013)	-0.018 (0.013)
D_{YV}^{firm}	0.041 (0.188)				-0.041 (0.104)			
D_{KN}^{firm}				0.000 (0.000)	-0.036 (0.030)			-0.036 (0.030)
D_{EV}^{firm}		0.000 (0.000)				-0.044 (0.026)		-0.044 (0.026)
Obs.	129	129	129	129	196	196	196	196
R-square	0.2449	0.4475	0.3222	0.267	0.3388	0.3749	0.2863	0.2703

† Standard errors are in parentheses.

- Quality dummies $D_{00011}^{indirect}$ is omitted due to perfect collinearity.

Table B4. Six Carriers on a Route After Southwest's Entry: Without SW's Virtual Fare

AIDS Model of Determinants of Share

S_i	Without Virtual Fare				
	Airline 1	Airline 2	Airline 3	Airline 4	Airline 5
Constant		0.270 (0.076)	0.096 (0.053)	0.249 (0.044)	0.057 (0.041)
$\log(E/P)$	0.063 (0.005)	-0.010 (0.013)	0.005 (0.009)	-0.033 (0.007)	-0.003 (0.006)
$\log(p_1/p_{SW})$	0.151 (0.051)	-0.127 (0.033)	0.028 (0.023)	-0.056 (0.017)	-0.015 (0.015)
$\log(p_2/p_{SW})$	-0.127 (0.033)	0.098 (0.038)	0.018 (0.020)	0.028 (0.017)	-0.027 (0.014)
$\log(p_3/p_{SW})$	0.028 (0.023)	0.018 (0.020)	-0.013 (0.021)	-0.015 (0.012)	-0.011 (0.010)
$\log(p_4/p_{SW})$	-0.056 (0.017)	0.028 (0.017)	-0.015 (0.012)	0.010 (0.015)	0.017 (0.009)
$\log(p_5/p_{SW})$	-0.015 (0.015)	-0.027 (0.014)	-0.011 (0.010)	0.017 (0.009)	0.010 (0.010)
$D_{111110}^{indirect}$	-0.092 (0.099)	0.089 (0.070)	-0.006 (0.048)	0.010 (0.035)	0.016 (0.031)
$D_{111011}^{indirect}$	0.505 (0.145)	-0.241 (0.099)	-0.144 (0.068)	-0.010 (0.049)	-0.021 (0.050)
$D_{111000}^{indirect}$	0.154 (0.139)	-0.071 (0.097)	-0.050 (0.066)	-0.021 (0.048)	-0.043 (0.042)
$D_{110111}^{indirect}$	0.289 (0.082)	-0.133 (0.058)	-0.057 (0.040)	-0.030 (0.029)	-0.019 (0.025)
$D_{110101}^{indirect}$	-0.214 (0.140)	0.061 (0.101)	-0.126 (0.070)	0.003 (0.050)	-0.072 (0.046)
$D_{110100}^{indirect}$	0.310 (0.101)	-0.048 (0.070)	-0.132 (0.049)	-0.022 (0.035)	-0.062 (0.032)
$D_{110011}^{indirect}$	0.305 (0.136)	-0.209 (0.093)	-0.133 (0.064)	-0.036 (0.046)	-0.016 (0.042)
$D_{110010}^{indirect}$	0.183 (0.139)	0.128 (0.096)	-0.105 (0.066)	-0.029 (0.048)	-0.046 (0.042)
$D_{110001}^{indirect}$	0.183 (0.083)	-0.211 (0.061)	-0.106 (0.042)	0.001 (0.030)	-0.034 (0.027)
$D_{110000}^{indirect}$	0.151 (0.100)	-0.075 (0.071)	-0.092 (0.049)	0.018 (0.036)	-0.047 (0.032)
$D_{101111}^{indirect}$	0.271 (0.137)	-0.094 (0.095)	-0.109 (0.065)	0.024 (0.047)	-0.033 (0.042)
$D_{101110}^{indirect}$	0.264 (0.137)	-0.066 (0.095)	-0.107 (0.065)	0.011 (0.047)	-0.038 (0.042)
$D_{101010}^{indirect}$	0.078 (0.136)	-0.074 (0.093)	0.099 (0.064)	-0.061 (0.046)	0.013 (0.041)
$D_{101001}^{indirect}$	0.092 (0.142)	-0.304 (0.104)	-0.144 (0.070)	-0.013 (0.051)	-0.038 (0.045)
$D_{101000}^{indirect}$	0.342 (0.139)	-0.180 (0.094)	-0.007 (0.065)	-0.078 (0.047)	-0.043 (0.042)
$D_{100011}^{indirect}$		-0.209 (0.095)	-0.120 (0.064)	0.004 (0.051)	-0.012 (0.050)

Table B4. Continued.

S_i	Without Virtual Fare				
	Airline 1	Airline 2	Airline 3	Airline 4	Airline 5
$D_{100001}^{indirect}$	0.142 (0.050)	-0.086 (0.035)	-0.094 (0.024)	-0.025 (0.018)	-0.033 (0.016)
$D_{100000}^{indirect}$	0.166 (0.058)	-0.009 (0.040)	-0.067 (0.028)	-0.038 (0.020)	-0.043 (0.018)
$D_{010011}^{indirect}$	-0.170 (0.138)	-0.005 (0.093)	-0.028 (0.065)	0.049 (0.046)	0.013 (0.041)
$D_{010001}^{indirect}$	-0.051 (0.080)	-0.037 (0.055)	-0.016 (0.040)	0.051 (0.027)	0.009 (0.026)
$D_{010000}^{indirect}$	0.023 (0.047)	0.006 (0.032)	-0.037 (0.023)	0.030 (0.016)	-0.019 (0.014)
$D_{001001}^{indirect}$	-0.107 (0.098)	-0.014 (0.068)	0.058 (0.047)	0.069 (0.034)	-0.004 (0.030)
$D_{001000}^{indirect}$	-0.036 (0.070)	0.010 (0.049)	0.053 (0.034)	-0.012 (0.024)	-0.025 (0.021)
$D_{000010}^{indirect}$	0.168 (0.080)	-0.061 (0.054)	0.029 (0.037)	-0.052 (0.027)	-0.026 (0.024)
$D_{000001}^{indirect}$	-0.070 (0.036)	-0.055 (0.025)	-0.040 (0.017)	0.013 (0.012)	-0.003 (0.011)
D_{AA}^{firm}	0.014 (0.022)	0.014 (0.022)	0.014 (0.022)	0.014 (0.022)	0.014 (0.022)
D_{AS}^{firm}	-0.019 (0.035)		-0.019 (0.035)		-0.019 (0.035)
D_{CO}^{firm}	0.023 (0.022)	0.023 (0.022)	0.023 (0.022)	0.023 (0.022)	0.023 (0.022)
D_{DL}^{firm}	0.021 (0.023)	0.021 (0.023)	0.021 (0.023)	0.021 (0.023)	0.021 (0.023)
D_{HP}^{firm}	0.033 (0.025)	0.033 (0.025)	0.033 (0.025)	0.033 (0.025)	0.033 (0.025)
D_{NW}^{firm}	0.018 (0.022)	0.018 (0.022)	0.018 (0.022)	0.018 (0.022)	0.018 (0.022)
D_{QQ}^{firm}	-0.010 (0.050)		-0.010 (0.050)		
D_{RU}^{firm}			0.000 (0.000)		
D_{TW}^{firm}	0.017 (0.022)	0.017 (0.022)	0.017 (0.022)	0.017 (0.022)	0.017 (0.022)
D_{UA}^{firm}	0.019 (0.022)	0.019 (0.022)	0.019 (0.022)	0.019 (0.022)	0.019 (0.022)
D_{US}^{firm}	0.006 (0.024)	0.006 (0.024)	0.006 (0.024)	0.006 (0.024)	0.006 (0.024)
D_{9N}^{firm}				0.066 (0.050)	
D_{EV}^{firm}		-0.006 (0.027)	-0.006 (0.027)		-0.006 (0.027)
Obs	133	133	133	133	133
R-square	0.5082	0.3243	0.3961	0.4097	0.21

† Standard errors are in parentheses.

- Airline dummies D_{ZW}^{firm}, D_{J7}^{firm} and quality dummies $D_{111121}^{indirect}$, $D_{112112}^{indirect}$, $D_{121121}^{indirect}$, $D_{121211}^{indirect}$, $D_{122121}^{indirect}$, $D_{122211}^{indirect}$, $D_{211221}^{indirect}$, $D_{212121}^{indirect}$, $D_{222121}^{indirect}$, $D_{222122}^{indirect}$, $D_{222211}^{indirect}$ are omitted due to perfect collinearity.

Table B5. Six Carriers on a Route After Southwest's Entry: With SW's Virtual Fare

AIDS Model of Determinants of Share

S_i	With Virtual Fare				
	Airline 1	Airline 2	Airline 3	Airline 4	Airline 5
Constant	0.002 (0.091)	0.306 (0.059)	0.118 (0.043)	0.184 (0.028)	
$\log(E/P)$	0.062 (0.016)	-0.020 (0.010)	-0.001 (0.007)	-0.025 (0.005)	0.003 (0.002)
$\log(p_1/p_{SW})$	0.079 (0.044)	-0.091 (0.027)	0.012 (0.020)	-0.033 (0.014)	-0.007 (0.011)
$\log(p_2/p_{SW})$	-0.091 (0.027)	0.044 (0.028)	0.008 (0.016)	0.030 (0.013)	-0.008 (0.010)
$\log(p_3/p_{SW})$	0.012 (0.020)	0.008 (0.016)	-0.006 (0.016)	-0.014 (0.009)	-0.010 (0.008)
$\log(p_4/p_{SW})$	-0.033 (0.014)	0.030 (0.013)	-0.014 (0.009)	0.008 (0.011)	0.012 (0.006)
$\log(p_5/p_{SW})$	-0.007 (0.011)	-0.008 (0.010)	-0.010 (0.008)	0.012 (0.006)	0.011 (0.008)
$D_{111110}^{indirect}$	-0.109 (0.105)	0.110 (0.067)	-0.001 (0.047)	0.002 (0.032)	0.011 (0.027)
$D_{111101}^{indirect}$	-0.078 (0.104)	0.003 (0.067)	-0.024 (0.047)	0.071 (0.032)	0.024 (0.027)
$D_{111011}^{indirect}$	0.227 (0.105)	-0.071 (0.067)	-0.059 (0.047)	0.013 (0.033)	-0.011 (0.028)
$D_{111000}^{indirect}$	0.180 (0.107)	-0.050 (0.069)	-0.059 (0.048)	-0.027 (0.033)	-0.063 (0.027)
$D_{110111}^{indirect}$	0.291 (0.085)	-0.102 (0.055)	-0.047 (0.039)	-0.045 (0.026)	-0.038 (0.022)
$D_{110110}^{indirect}$	0.015 (0.148)	0.199 (0.095)	-0.137 (0.067)	-0.014 (0.045)	-0.071 (0.038)
$D_{110101}^{indirect}$	-0.239 (0.150)	0.081 (0.096)	-0.118 (0.068)	-0.016 (0.046)	-0.081 (0.039)
$D_{110100}^{indirect}$	0.300 (0.105)	-0.041 (0.067)	-0.137 (0.048)	-0.025 (0.032)	-0.057 (0.027)
$D_{110011}^{indirect}$	0.305 (0.142)	-0.198 (0.090)	-0.127 (0.064)	-0.045 (0.043)	-0.025 (0.037)
$D_{110010}^{indirect}$	0.175 (0.145)	0.144 (0.093)	-0.087 (0.065)	-0.045 (0.044)	-0.066 (0.037)
$D_{110001}^{indirect}$	0.131 (0.059)	-0.130 (0.038)	-0.091 (0.027)	-0.026 (0.018)	-0.052 (0.015)
$D_{110000}^{indirect}$	0.161 (0.105)	-0.047 (0.068)	-0.078 (0.048)	-0.002 (0.033)	-0.053 (0.027)
$D_{101111}^{indirect}$	0.307 (0.103)	-0.079 (0.066)	-0.104 (0.046)	-0.008 (0.031)	-0.043 (0.027)
$D_{101110}^{indirect}$	0.291 (0.143)	-0.051 (0.092)	-0.095 (0.065)	-0.011 (0.043)	-0.049 (0.037)
$D_{101101}^{indirect}$	0.281 (0.144)	-0.106 (0.092)	-0.090 (0.065)	-0.018 (0.044)	-0.054 (0.037)
$D_{101011}^{indirect}$	0.538 (0.148)	-0.272 (0.096)	-0.152 (0.067)	-0.058 (0.045)	-0.052 (0.038)

Table B5. Continued.

S_i	With Virtual Fare				
	Airline 1	Airline 2	Airline 3	Airline 4	Airline 5
$D^{indirect}_{101010}$	0.066 (0.142)	-0.057 (0.091)	0.094 (0.064)	-0.063 (0.043)	0.009 (0.037)
$D^{indirect}_{101001}$	0.040 (0.151)	-0.233 (0.097)	-0.122 (0.068)	-0.037 (0.046)	-0.067 (0.038)
$D^{indirect}_{101000}$	0.303 (0.144)	-0.147 (0.092)	-0.016 (0.065)	-0.074 (0.044)	-0.045 (0.038)
$D^{indirect}_{100101}$	0.376 (0.144)	-0.176 (0.092)	-0.130 (0.065)	-0.012 (0.044)	-0.049 (0.037)
$D^{indirect}_{100011}$	0.085 (0.150)	-0.197 (0.096)	-0.127 (0.068)	-0.020 (0.046)	-0.036 (0.040)
$D^{indirect}_{100001}$	0.107 (0.043)	-0.071 (0.028)	-0.077 (0.020)	-0.027 (0.013)	-0.035 (0.011)
$D^{indirect}_{100000}$	0.165 (0.060)	-0.012 (0.039)	-0.071 (0.027)	-0.037 (0.018)	-0.038 (0.016)
$D^{indirect}_{211221}$	-0.081 (0.143)	0.039 (0.091)	0.036 (0.065)	0.026 (0.043)	-0.015 (0.038)
$D^{indirect}_{212121}$	0.285 (0.142)	-0.096 (0.091)	-0.103 (0.064)	-0.060 (0.043)	-0.017 (0.037)
$D^{indirect}_{010011}$	-0.078 (0.102)	-0.044 (0.066)	-0.034 (0.046)	0.043 (0.031)	-0.017 (0.027)
$D^{indirect}_{010001}$	-0.011 (0.062)	-0.037 (0.040)	-0.027 (0.028)	0.028 (0.019)	-0.005 (0.016)
$D^{indirect}_{010000}$	0.019 (0.049)	0.012 (0.031)	-0.034 (0.022)	0.026 (0.015)	-0.020 (0.013)
$D^{indirect}_{001001}$	-0.051 (0.073)	0.036 (0.047)	0.029 (0.033)	0.007 (0.022)	-0.019 (0.019)
$D^{indirect}_{001000}$	-0.041 (0.074)	0.021 (0.047)	0.058 (0.033)	-0.021 (0.023)	-0.031 (0.019)
$D^{indirect}_{000101}$	-0.014 (0.143)	0.030 (0.092)	0.040 (0.065)	-0.019 (0.044)	-0.021 (0.038)
$D^{indirect}_{000011}$	0.096 (0.142)	-0.125 (0.091)	-0.038 (0.064)	0.020 (0.043)	0.031 (0.038)
$D^{indirect}_{000010}$	0.169 (0.083)	-0.063 (0.053)	0.028 (0.037)	-0.055 (0.025)	-0.023 (0.022)
$D^{indirect}_{000001}$	-0.051 (0.034)	-0.067 (0.022)	-0.040 (0.015)	0.008 (0.010)	-0.010 (0.009)
D^{firm}_{AA}	0.034 (0.012)	0.034 (0.012)	0.034 (0.012)	0.034 (0.012)	0.034 (0.012)
D^{firm}_{AS}	0.000 (0.000)				0.000 (0.000)
D^{firm}_{CO}	0.036 (0.012)	0.036 (0.012)	0.036 (0.012)	0.036 (0.012)	0.036 (0.012)
D^{firm}_{DL}	0.041 (0.012)	0.041 (0.012)	0.041 (0.012)	0.041 (0.012)	0.041 (0.012)
D^{firm}_{HP}	0.046 (0.015)	0.046 (0.015)	0.046 (0.015)	0.046 (0.015)	0.046 (0.015)
D^{firm}_{NW}	0.034 (0.011)	0.034 (0.011)	0.034 (0.011)	0.034 (0.011)	0.034 (0.011)

Table B5. Continued.

S_i	With Virtual Fare				
	Airline 1	Airline 2	Airline 3	Airline 4	Airline 5
D_{QQ}^{firm}				-0.003 (0.031)	
D_{RU}^{firm}			0.000 (0.000)		
D_{TW}^{firm}			0.041 (0.021)		0.041 (0.021)
D_{UA}^{firm}	0.037 (0.011)	0.037 (0.011)	0.037 (0.011)	0.037 (0.011)	0.037 (0.011)
D_{US}^{firm}	0.034 (0.011)	0.034 (0.011)	0.034 (0.011)	0.034 (0.011)	0.034 (0.011)
D_{9N}^{firm}	0.027 (0.013)	0.027 (0.013)	0.027 (0.013)	0.027 (0.013)	0.027 (0.013)
D_{J7}^{firm}			-0.058 (0.039)		
D_{EV}^{firm}		0.009 (0.017)	0.009 (0.017)		0.009 (0.017)
Obs	202	202	202	202	202
R-square	0.4799	0.3126	0.338	0.3733	0.231

† Standard errors are in parentheses.

- Airline dummy D_{ZW}^{firm} and quality dummy $D_{000100}^{indirect}$ is omitted due to perfect collinearity.

Table B6. Seven Carriers on a Route After Southwest's Entry: Without SW's Virtual Fare

AIDS Model of Determinants of Share

S_i	Without Virtual Fare					
	Airline 1	Airline 2	Airline 3	Airline 4	Airline 5	Airline 6
Constant	0.002 (0.130)			0.242 (0.053)		0.059 (0.038)
$\log(E/P)$	0.052 (0.021)	0.020 (0.004)	0.006 (0.004)	-0.045 (0.009)	-0.009 (0.004)	-0.020 (0.006)
$\log(p_1/p_{SW})$	0.087 (0.066)	-0.029 (0.041)	-0.008 (0.032)	-0.038 (0.023)	-0.019 (0.017)	-0.045 (0.016)
$\log(p_2/p_{SW})$	-0.029 (0.041)	0.022 (0.048)	0.029 (0.028)	0.007 (0.021)	-0.004 (0.016)	-0.016 (0.015)
$\log(p_3/p_{SW})$	-0.008 (0.032)	0.029 (0.028)	-0.026 (0.031)	-0.005 (0.018)	0.010 (0.013)	0.015 (0.012)
$\log(p_4/p_{SW})$	-0.038 (0.023)	0.007 (0.021)	-0.005 (0.018)	0.031 (0.020)	0.001 (0.010)	0.013 (0.010)
$\log(p_5/p_{SW})$	-0.019 (0.017)	-0.004 (0.016)	0.010 (0.013)	0.001 (0.010)	0.018 (0.011)	0.000 (0.007)
$\log(p_6/p_{SW})$	-0.045 (0.016)	-0.016 (0.015)	0.015 (0.012)	0.013 (0.010)	0.000 (0.007)	0.029 (0.010)
$D_{1111101}^{indirect}$	-0.099 (0.130)	0.052 (0.117)	-0.124 (0.068)	0.004 (0.049)	0.004 (0.059)	0.084 (0.039)
$D_{1111001}^{indirect}$	-0.020 (0.131)		-0.040 (0.068)	0.054 (0.050)	-0.018 (0.036)	0.000 (0.034)
$D_{1110001}^{indirect}$	0.189 (0.138)	-0.164 (0.159)	-0.139 (0.069)	0.049 (0.053)	-0.010 (0.035)	0.017 (0.036)
$D_{1110000}^{indirect}$	0.106 (0.098)	-0.041 (0.115)	-0.071 (0.051)	0.025 (0.038)	-0.004 (0.037)	0.051 (0.028)
$D_{1100011}^{indirect}$	0.088 (0.134)	-0.245 (0.089)	-0.166 (0.070)	-0.032 (0.051)	-0.025 (0.036)	-0.020 (0.035)
$D_{1100001}^{indirect}$	-0.023 (0.081)	-0.120 (0.056)	-0.140 (0.041)	0.022 (0.032)	-0.019 (0.021)	0.010 (0.021)
$D_{1100000}^{indirect}$	0.024 (0.075)	0.079 (0.051)	-0.063 (0.040)	0.018 (0.028)	-0.001 (0.020)	0.001 (0.019)
$D_{1001000}^{indirect}$	0.086 (0.091)	0.032 (0.063)	-0.030 (0.049)	0.012 (0.034)	-0.039 (0.025)	-0.008 (0.023)
$D_{1000001}^{indirect}$	-0.010 (0.055)	-0.098 (0.037)	-0.082 (0.029)	0.023 (0.020)	0.002 (0.015)	0.011 (0.014)
$D_{1000000}^{indirect}$	0.136 (0.038)	-0.066 (0.026)	-0.025 (0.020)	-0.020 (0.014)	0.013 (0.010)	-0.007 (0.010)
$D_{0110000}^{indirect}$	-0.008 (0.075)	0.005 (0.051)	0.028 (0.040)	0.005 (0.028)	0.008 (0.020)	-0.016 (0.019)
$D_{0100101}^{indirect}$	-0.297 (0.127)	-0.111 (0.086)	-0.074 (0.068)	-0.003 (0.048)	-0.016 (0.034)	-0.021 (0.032)
$D_{0100100}^{indirect}$	-0.036 (0.126)	0.015 (0.084)	0.045 (0.067)	0.016 (0.047)	0.030 (0.034)	-0.030 (0.032)
$D_{0100011}^{indirect}$	-0.121 (0.126)	0.000 (0.085)	0.005 (0.067)	0.041 (0.047)	0.050 (0.034)	-0.015 (0.032)

Table B6. Continued.

S_i	Without Virtual Fare					
	Airline 1	Airline 2	Airline 3	Airline 4	Airline 5	Airline 6
$D^{indirect}_{0100001}$	0.051 (0.141)	-0.157 (0.099)	-0.154 (0.076)	-0.085 (0.055)	-0.040 (0.039)	-0.054 (0.037)
$D^{indirect}_{0100000}$	0.151 (0.066)	-0.012 (0.047)	-0.033 (0.035)	0.030 (0.025)	-0.009 (0.018)	-0.013 (0.017)
$D^{indirect}_{0010100}$	-0.170 (0.127)	-0.008 (0.085)	0.147 (0.067)	-0.007 (0.047)	0.042 (0.034)	-0.017 (0.032)
$D^{indirect}_{0010000}$	-0.155 (0.075)	-0.025 (0.051)	0.114 (0.040)	0.021 (0.028)	0.065 (0.020)	0.026 (0.019)
$D^{indirect}_{0001101}$	-0.425 (0.093)	-0.151 (0.062)	0.109 (0.049)	0.069 (0.035)	0.041 (0.025)	0.024 (0.023)
$D^{indirect}_{0001100}$	-0.097 (0.127)	-0.028 (0.087)	-0.139 (0.070)	-0.066 (0.049)	-0.001 (0.035)	0.035 (0.033)
$D^{indirect}_{0001000}$	0.039 (0.075)	-0.036 (0.050)	-0.019 (0.040)	0.087 (0.028)	0.012 (0.020)	-0.016 (0.019)
$D^{indirect}_{0000101}$	-0.151 (0.126)	0.064 (0.085)	0.003 (0.067)	0.109 (0.047)	0.007 (0.034)	-0.011 (0.032)
$D^{indirect}_{0000100}$	-0.003 (0.127)	-0.011 (0.085)	-0.002 (0.067)	0.077 (0.047)	0.006 (0.034)	-0.009 (0.032)
$D^{indirect}_{0000001}$	-0.152 (0.040)	-0.033 (0.027)	0.011 (0.021)	-0.016 (0.015)	-0.007 (0.011)	0.001 (0.010)
D^{firm}_{AA}	0.091 (0.021)	0.091 (0.021)	0.091 (0.021)	0.091 (0.021)	0.091 (0.021)	0.091 (0.021)
D^{firm}_{CO}	0.101 (0.021)	0.101 (0.021)	0.101 (0.021)	0.101 (0.021)	0.101 (0.021)	0.101 (0.021)
D^{firm}_{DL}	0.097 (0.021)	0.097 (0.021)	0.097 (0.021)	0.097 (0.021)	0.097 (0.021)	0.097 (0.021)
D^{firm}_{HP}	0.092 (0.023)	0.092 (0.023)	0.092 (0.023)	0.092 (0.023)	0.092 (0.023)	0.092 (0.023)
D^{firm}_{NW}	0.096 (0.021)	0.096 (0.021)	0.096 (0.021)	0.096 (0.021)	0.096 (0.021)	0.096 (0.021)
D^{firm}_{KP}		0.193 (0.144)				
D^{firm}_{QQ}		0.218 (0.089)				
D^{firm}_{RU}			0.077 (0.027)		0.080 (0.037)	0.077 (0.027)
D^{firm}_{TW}	0.099 (0.021)	0.099 (0.021)	0.099 (0.021)	0.099 (0.021)	0.099 (0.021)	0.099 (0.021)
D^{firm}_{UA}	0.108 (0.021)	0.108 (0.021)	0.108 (0.021)	0.108 (0.021)	0.108 (0.021)	0.108 (0.021)
D^{firm}_{US}	0.082 (0.021)	0.082 (0.021)	0.082 (0.021)	0.082 (0.021)	0.082 (0.021)	0.082 (0.021)
D^{firm}_{YX}						0.077 (0.036)
D^{firm}_{J7}			0.000 (0.000)			

Table B6. Continued.

S_i	Without Virtual Fare					
	Airline 1	Airline 2	Airline 3	Airline 4	Airline 5	Airline 6
D_{EV}^{firm}		0.057 (0.030)		0.057 (0.030)		0.057 (0.030)
D_{YV}^{firm}		0.032 (0.067)				
Obs	109	109	109	109	109	109
R-square	0.5178	0.2954	0.368	0.479	0.3601	0.2997

† Standard errors are in parentheses.

- Airline dummies D_{AS}^{firm}, D_{TZ}^{firm} and quality dummies $D_{1010001}^{indirect}$, $D_{1001101}^{indirect}$, $D_{1001001}^{indirect}$, $D_{0110101}^{indirect}$, $D_{0110001}^{indirect}$, $D_{0010101}^{indirect}$, $D_{0010001}^{indirect}$, $D_{0001001}^{indirect}$, $D_{0000011}^{indirect}$ are omitted due to perfect collinearity.

Table B7. Seven Carriers on a Route After Southwest's Entry: With SW's Virtual Fare

AIDS Model of Determinants of Share

S_i	With Virtual Fare					
	Airline 1	Airline 2	Airline 3	Airline 4	Airline 5	Airline 6
Constant	-0.187 (0.112)	(dropped) (0.000)	(dropped) (0.000)	(dropped) (0.000)	(dropped) (0.000)	-0.052 (0.027)
$\log(E/P)$	0.072 (0.017)	0.006 (0.004)	-0.008 (0.004)	-0.017 (0.003)	-0.022 (0.003)	-0.014 (0.005)
$\log(p_1/p_{SW})$	0.094 (0.049)	-0.042 (0.030)	-0.006 (0.024)	-0.018 (0.016)	-0.010 (0.013)	-0.030 (0.011)
$\log(p_2/p_{SW})$	-0.042 (0.030)	0.012 (0.032)	0.027 (0.019)	0.008 (0.014)	0.004 (0.011)	-0.012 (0.010)
$\log(p_3/p_{SW})$	-0.006 (0.024)	0.027 (0.019)	-0.023 (0.022)	-0.006 (0.012)	-0.003 (0.009)	0.010 (0.009)
$\log(p_4/p_{SW})$	-0.018 (0.016)	0.008 (0.014)	-0.006 (0.012)	0.018 (0.013)	-0.002 (0.007)	-0.001 (0.007)
$\log(p_5/p_{SW})$	-0.010 (0.013)	0.004 (0.011)	-0.003 (0.009)	-0.002 (0.007)	0.006 (0.008)	0.006 (0.005)
$\log(p_6/p_{SW})$	-0.030 (0.011)	-0.012 (0.010)	0.010 (0.009)	-0.001 (0.007)	0.006 (0.005)	0.027 (0.007)
$D_{1111101}^{indirect}$	-0.156 (0.127)	0.376 (0.137)	-0.091 (0.063)	-0.023 (0.045)	0.081 (0.052)	0.156 (0.036)
$D_{1111001}^{indirect}$	0.017 (0.094)	0.332 (0.126)	0.006 (0.046)	-0.001 (0.033)	-0.004 (0.025)	-0.010 (0.023)
$D_{1110001}^{indirect}$	0.206 (0.132)	0.146 (0.088)	-0.098 (0.064)	-0.024 (0.046)	0.026 (0.033)	0.005 (0.032)
$D_{1110000}^{indirect}$	0.106 (0.094)	0.265 (0.086)	-0.041 (0.047)	-0.017 (0.034)	0.044 (0.033)	0.084 (0.025)
$D_{1100011}^{indirect}$	0.022 (0.130)	-0.216 (0.084)	-0.123 (0.064)	-0.049 (0.046)	-0.004 (0.033)	-0.034 (0.031)
$D_{1100001}^{indirect}$	-0.177 (0.059)	-0.032 (0.038)	-0.053 (0.028)	-0.026 (0.021)	0.000 (0.014)	-0.001 (0.014)
$D_{1100000}^{indirect}$	0.008 (0.075)	0.092 (0.049)	-0.053 (0.037)	0.008 (0.027)	0.007 (0.019)	0.000 (0.018)
$D_{1010001}^{indirect}$	0.320 (0.094)	-0.167 (0.061)	-0.094 (0.047)	-0.054 (0.033)	-0.011 (0.024)	-0.009 (0.023)
$D_{1001101}^{indirect}$	-0.165 (0.126)	0.033 (0.083)	0.032 (0.063)	0.062 (0.045)	0.077 (0.032)	-0.024 (0.030)
$D_{1001001}^{indirect}$	0.014 (0.125)	-0.051 (0.082)	-0.001 (0.063)	0.044 (0.045)	0.013 (0.031)	-0.014 (0.029)
$D_{1001000}^{indirect}$	0.074 (0.090)	0.041 (0.060)	-0.020 (0.045)	0.017 (0.032)	-0.041 (0.023)	-0.010 (0.021)
$D_{1000001}^{indirect}$	0.020 (0.042)	-0.100 (0.028)	-0.071 (0.021)	-0.006 (0.015)	0.000 (0.011)	-0.001 (0.010)
$D_{1000000}^{indirect}$	0.123 (0.037)	-0.056 (0.024)	-0.018 (0.019)	-0.017 (0.013)	0.015 (0.009)	-0.005 (0.009)
$D_{0110101}^{indirect}$	-0.120 (0.126)	0.005 (0.083)	0.041 (0.063)	0.069 (0.045)	0.072 (0.032)	-0.037 (0.030)
$D_{0110001}^{indirect}$	-0.022 (0.125)	-0.013 (0.083)	0.055 (0.062)	0.016 (0.045)	-0.015 (0.031)	-0.009 (0.029)

Table B7. Continued.

S_i	With Virtual Fare					
	Airline 1	Airline 2	Airline 3	Airline 4	Airline 5	Airline 6
$D_{0110000}^{indirect}$	0.002 (0.074)	0.005 (0.049)	0.021 (0.037)	0.009 (0.026)	0.007 (0.019)	-0.011 (0.017)
$D_{0100101}^{indirect}$	-0.333 (0.126)	-0.102 (0.083)	-0.047 (0.063)	-0.015 (0.045)	-0.002 (0.032)	-0.019 (0.030)
$D_{0100100}^{indirect}$	-0.038 (0.125)	0.018 (0.082)	0.047 (0.062)	0.030 (0.044)	0.024 (0.031)	-0.027 (0.029)
$D_{0100011}^{indirect}$	-0.130 (0.125)	0.004 (0.082)	0.011 (0.062)	0.052 (0.044)	0.045 (0.031)	-0.014 (0.029)
$D_{0100001}^{indirect}$	-0.263 (0.074)	-0.095 (0.049)	-0.047 (0.037)	-0.004 (0.027)	-0.013 (0.019)	-0.013 (0.018)
$D_{0100000}^{indirect}$	0.145 (0.065)	-0.001 (0.045)	-0.027 (0.033)	0.016 (0.024)	-0.007 (0.016)	-0.016 (0.015)
$D_{0010101}^{indirect}$	-0.158 (0.126)	0.050 (0.083)	0.129 (0.063)	-0.021 (0.045)	0.015 (0.032)	0.004 (0.030)
$D_{0010100}^{indirect}$	-0.186 (0.126)	0.003 (0.083)	0.162 (0.063)	-0.015 (0.044)	0.055 (0.031)	-0.020 (0.029)
$D_{0010001}^{indirect}$	-0.018 (0.075)	0.002 (0.049)	0.002 (0.037)	0.011 (0.026)	0.010 (0.019)	0.014 (0.018)
$D_{0010000}^{indirect}$	-0.166 (0.074)	-0.020 (0.049)	0.123 (0.037)	0.031 (0.026)	0.064 (0.018)	0.023 (0.017)
$D_{0001101}^{indirect}$	-0.455 (0.091)	-0.132 (0.060)	0.122 (0.045)	0.054 (0.032)	0.049 (0.023)	0.021 (0.021)
$D_{0001100}^{indirect}$	-0.104 (0.126)	-0.021 (0.083)	-0.137 (0.064)	-0.050 (0.045)	-0.017 (0.032)	0.036 (0.030)
$D_{0001001}^{indirect}$	-0.123 (0.066)	0.018 (0.043)	0.042 (0.033)	0.048 (0.023)	0.026 (0.016)	0.008 (0.016)
$D_{0001000}^{indirect}$	0.024 (0.074)	-0.033 (0.049)	-0.013 (0.037)	0.105 (0.026)	0.008 (0.019)	-0.013 (0.017)
$D_{0000101}^{indirect}$	-0.179 (0.125)	0.077 (0.082)	0.017 (0.062)	0.104 (0.044)	0.009 (0.031)	-0.011 (0.029)
$D_{0000100}^{indirect}$	-0.026 (0.126)	0.005 (0.082)	0.012 (0.063)	0.058 (0.044)	0.021 (0.031)	-0.012 (0.029)
$D_{0000011}^{indirect}$	-0.13291 (0.125)	0.081312 (0.082)	-0.01757 (0.062)	0.01445 (0.044)	0.031927 (0.031)	0.026992 (0.029)
$D_{0000001}^{indirect}$	-0.153 (0.034)	-0.032 (0.022)	0.005 (0.017)	-0.008 (0.012)	-0.004 (0.009)	-0.002 (0.008)
D_{AA}^{firm}	0.171 (0.020)	0.171 (0.020)	0.171 (0.020)	0.171 (0.020)	0.171 (0.020)	0.171 (0.020)
D_{AS}^{firm}	(dropped) (0.000)	(dropped) (0.000)	(dropped) (0.000)	(dropped) (0.000)	0.099631 (0.041)	(dropped) (0.000)
D_{CO}^{firm}	0.176 (0.020)	0.176 (0.020)	0.176 (0.020)	0.176 (0.020)	0.176 (0.020)	0.176 (0.020)
D_{DL}^{firm}	0.176 (0.020)	0.176 (0.020)	0.176 (0.020)	0.176 (0.020)	0.176 (0.020)	0.176 (0.020)
D_{HP}^{firm}	0.171 (0.021)	0.171 (0.021)	0.171 (0.021)	0.171 (0.021)	0.171 (0.021)	0.171 (0.021)

Table B7. Continued.

S_i	With Virtual Fare					
	Airline 1	Airline 2	Airline 3	Airline 4	Airline 5	Airline 6
D_{NW}^{firm}	0.171 (0.020)	0.171 (0.020)	0.171 (0.020)	0.171 (0.020)	0.171 (0.020)	0.171 (0.020)
D_{QQ}^{firm}		-0.006 (0.105)				
D_{RU}^{firm}			0.166 (0.022)		0.166 (0.022)	0.166 (0.022)
D_{TW}^{firm}	0.173 (0.020)	0.173 (0.020)	0.173 (0.020)	0.173 (0.020)	0.173 (0.020)	0.173 (0.020)
D_{UA}^{firm}	0.181 (0.020)	0.181 (0.020)	0.181 (0.020)	0.181 (0.020)	0.181 (0.020)	0.181 (0.020)
D_{US}^{firm}	0.160 (0.020)	0.160 (0.020)	0.160 (0.020)	0.160 (0.020)	0.160 (0.020)	0.160 (0.020)
D_{J7}^{firm}			0.139 (0.031)	0.139 (0.031)		
D_{EV}^{firm}		0.148 (0.024)		0.148 (0.024)		0.148 (0.024)
D_{TZ}^{firm}						
D_{YV}^{firm}		0.075 (0.059)				
Obs	168	168	168	168	168	168
R-square	0.5336	0.3265	0.3736	0.4526	0.3652	0.1966

† Standard errors are in parentheses.

- Airline dummies D_{AS}^{firm}, D_{KP}^{firm}, D_{YX}^{firm} are omitted due to perfect collinearity.

Table B8. Eight Carriers on a Route After Southwest's Entry: Without SW's Virtual Fare

AIDS Model of Determinants of Share

S_i	Without Virtual Fare						
	Airline 1	Airline 2	Airline 3	Airline 4	Airline 5	Airline 6	Airline 7
Constant	0.101 (0.115)	0.135 (0.079)	0.289 (0.069)		0.129 (0.033)		0.048 (0.024)
$\log(E/P)$	0.041 (0.017)	0.005 (0.012)	-0.023 (0.011)	0.011 (0.002)	-0.012 (0.005)	0.004 (0.002)	-0.007 (0.004)
$\log(p_1/p_{SW})$	0.118 (0.068)	-0.115 (0.037)	0.005 (0.035)	-0.016 (0.021)	-0.037 (0.018)	-0.026 (0.016)	-0.011 (0.011)
$\log(p_2/p_{SW})$	-0.115 (0.037)	0.148 (0.043)	-0.004 (0.032)	-0.031 (0.021)	0.020 (0.019)	-0.030 (0.017)	0.007 (0.012)
$\log(p_3/p_{SW})$	0.005 (0.035)	-0.004 (0.032)	0.061 (0.043)	-0.014 (0.020)	0.001 (0.018)	0.008 (0.017)	-0.009 (0.012)
$\log(p_4/p_{SW})$	-0.016 (0.021)	-0.031 (0.021)	-0.014 (0.020)	0.037 (0.019)	0.009 (0.013)	0.018 (0.012)	0.009 (0.009)
$\log(p_5/p_{SW})$	-0.037 (0.018)	0.020 (0.019)	0.001 (0.018)	0.009 (0.013)	0.014 (0.017)	0.000 (0.012)	-0.004 (0.009)
$\log(p_6/p_{SW})$	-0.026 (0.016)	-0.030 (0.017)	0.008 (0.017)	0.018 (0.012)	0.000 (0.012)	0.030 (0.016)	0.016 (0.008)
$\log(p_7/p_{SW})$	-0.011 (0.011)	0.007 (0.012)	-0.009 (0.012)	0.009 (0.009)	-0.004 (0.009)	0.016 (0.008)	-0.008 (0.009)
$D^{indirect}_{11111000}$		0.044 (0.065)	0.060 (0.060)	-0.030 (0.033)	-0.021 (0.030)	-0.016 (0.036)	0.009 (0.020)
$D^{indirect}_{11100100}$	-0.031 (0.109)	0.102 (0.066)	-0.045 (0.058)	-0.034 (0.034)	0.013 (0.029)	0.011 (0.025)	-0.004 (0.019)
$D^{indirect}_{11100001}$	0.216 (0.110)	-0.078 (0.067)	-0.073 (0.059)	-0.063 (0.034)	-0.043 (0.029)	0.013 (0.025)	0.020 (0.019)
$D^{indirect}_{11100000}$	0.009 (0.060)	0.077 (0.037)	0.036 (0.033)	-0.048 (0.019)	-0.020 (0.016)	-0.023 (0.014)	-0.007 (0.010)
$D^{indirect}_{11010101}$	0.018 (0.110)	-0.110 (0.066)	-0.003 (0.059)	-0.065 (0.035)	0.043 (0.029)	-0.012 (0.026)	0.005 (0.019)
$D^{indirect}_{11010001}$	0.003 (0.114)	0.050 (0.070)	-0.048 (0.062)	-0.033 (0.035)	-0.007 (0.031)	-0.032 (0.035)	0.005 (0.020)
$D^{indirect}_{11001101}$	0.134 (0.111)	0.072 (0.067)	-0.136 (0.059)	-0.084 (0.034)	-0.004 (0.030)	-0.053 (0.026)	-0.013 (0.019)
$D^{indirect}_{11001000}$	0.262 (0.111)	-0.120 (0.067)	-0.049 (0.060)	-0.082 (0.035)	-0.054 (0.030)	-0.058 (0.026)	0.002 (0.019)
$D^{indirect}_{11000101}$	0.229 (0.109)	-0.011 (0.066)	-0.132 (0.059)	-0.077 (0.034)	-0.045 (0.029)	-0.035 (0.026)	-0.032 (0.019)
$D^{indirect}_{11000001}$	0.131 (0.063)	-0.091 (0.043)	-0.129 (0.035)	-0.071 (0.020)	-0.017 (0.018)	-0.042 (0.017)	-0.015 (0.012)
$D^{indirect}_{11000000}$	0.155 (0.056)	-0.014 (0.035)	-0.039 (0.031)	-0.035 (0.018)	-0.007 (0.015)	-0.008 (0.014)	-0.010 (0.010)
$D^{indirect}_{10100101}$	0.117 (0.112)	-0.099 (0.069)	-0.160 (0.062)	-0.086 (0.036)	-0.032 (0.031)	-0.059 (0.027)	0.007 (0.021)
$D^{indirect}_{10100010}$	0.127 (0.109)	-0.044 (0.066)	-0.054 (0.059)	-0.012 (0.034)	-0.024 (0.029)	-0.003 (0.025)	0.028 (0.019)
$D^{indirect}_{10100001}$	-0.152 (0.069)	0.102 (0.042)	-0.018 (0.037)	-0.023 (0.022)	-0.024 (0.018)	-0.022 (0.016)	-0.003 (0.012)

Table B8. Continued.

S_i	Without Virtual Fare						
	Airline 1	Airline 2	Airline 3	Airline 4	Airline 5	Airline 6	Airline 7
$D_{10100000}^{indirect}$	0.234 (0.054)	-0.097 (0.034)	-0.060 (0.030)	-0.062 (0.018)	-0.007 (0.015)	-0.008 (0.013)	-0.003 (0.010)
$D_{10010100}^{indirect}$	-0.007 (0.109)	-0.116 (0.067)	-0.041 (0.059)	0.061 (0.035)	0.058 (0.030)	0.004 (0.027)	0.000 (0.019)
$D_{10010010}^{indirect}$	0.031 (0.113)	-0.051 (0.069)	0.012 (0.062)	-0.035 (0.036)	0.009 (0.031)	0.017 (0.027)	0.035 (0.020)
$D_{10010000}^{indirect}$	0.144 (0.082)	-0.073 (0.050)	-0.049 (0.044)	-0.020 (0.025)	-0.018 (0.022)	0.009 (0.019)	0.016 (0.014)
$D_{10001001}^{indirect}$	0.019 (0.070)	-0.027 (0.044)	-0.097 (0.039)	-0.069 (0.022)	0.016 (0.020)	-0.026 (0.017)	0.010 (0.013)
$D_{10000101}^{indirect}$	0.155 (0.110)	-0.027 (0.067)	-0.119 (0.059)	-0.063 (0.034)	-0.018 (0.029)	0.003 (0.025)	0.015 (0.019)
$D_{10000100}^{indirect}$	-0.010 (0.108)	-0.043 (0.065)	0.061 (0.058)	-0.046 (0.034)	-0.026 (0.029)	0.033 (0.025)	0.024 (0.018)
$D_{10000011}^{indirect}$	0.256 (0.110)	-0.234 (0.069)	-0.132 (0.061)	-0.048 (0.035)	-0.051 (0.031)	-0.003 (0.027)	-0.018 (0.020)
$D_{10000001}^{indirect}$	0.102 (0.050)	-0.122 (0.032)	-0.091 (0.028)	-0.056 (0.016)	0.002 (0.014)	-0.018 (0.013)	0.000 (0.009)
$D_{10000000}^{indirect}$	0.116 (0.048)	-0.044 (0.030)	-0.048 (0.026)	-0.014 (0.015)	-0.015 (0.013)	-0.015 (0.012)	0.013 (0.009)
$D_{01011000}^{indirect}$	-0.169 (0.109)	0.026 (0.066)	0.027 (0.059)	0.052 (0.034)	0.002 (0.029)	0.049 (0.026)	0.023 (0.019)
$D_{01010000}^{indirect}$	-0.093 (0.080)	0.041 (0.048)	-0.009 (0.042)	0.007 (0.024)	-0.006 (0.021)	0.005 (0.018)	0.040 (0.013)
$D_{01000010}^{indirect}$	0.022 (0.083)	0.021 (0.051)	-0.021 (0.045)	0.010 (0.026)	0.004 (0.022)	-0.001 (0.019)	0.012 (0.014)
$D_{01000001}^{indirect}$	-0.058 (0.081)	-0.013 (0.050)	-0.019 (0.044)	0.021 (0.026)	0.029 (0.022)	0.022 (0.019)	0.007 (0.014)
$D_{00110001}^{indirect}$	-0.325 (0.110)	0.058 (0.066)	-0.037 (0.059)	0.119 (0.034)	-0.011 (0.031)	-0.006 (0.026)	-0.026 (0.019)
$D_{00100000}^{indirect}$	-0.164 (0.109)	0.035 (0.066)	0.026 (0.058)	-0.036 (0.034)	-0.051 (0.029)	-0.022 (0.025)	-0.006 (0.019)
$D_{00011000}^{indirect}$	-0.137 (0.108)	0.043 (0.065)	-0.019 (0.058)	0.042 (0.034)	0.080 (0.029)	-0.032 (0.025)	0.006 (0.018)
$D_{00010000}^{indirect}$	-0.042 (0.068)	0.033 (0.041)	-0.029 (0.036)	0.053 (0.022)	-0.015 (0.019)	0.020 (0.016)	0.011 (0.012)
$D_{00001000}^{indirect}$	-0.148 (0.110)	-0.044 (0.066)	-0.126 (0.059)	0.028 (0.034)	0.018 (0.030)	0.000 (0.026)	0.002 (0.019)
$D_{00000100}^{indirect}$	-0.226 (0.110)	-0.062 (0.066)	-0.076 (0.059)	-0.009 (0.035)	0.020 (0.030)	0.016 (0.026)	0.015 (0.020)
$D_{00000010}^{indirect}$	0.078 (0.080)	-0.016 (0.048)	-0.031 (0.043)	-0.041 (0.032)	0.034 (0.021)	0.048 (0.019)	-0.001 (0.014)
$D_{00000001}^{indirect}$	-0.097 (0.053)	0.047 (0.033)	-0.077 (0.029)	-0.027 (0.017)	-0.010 (0.015)	-0.003 (0.013)	0.006 (0.009)

Table B8. Continued.

S_i	Without Virtual Fare						
	Airline 1	Airline 2	Airline 3	Airline 4	Airline 5	Airline 6	Airline 7
D_{AA}^{firm}	0.005 (0.009)	0.005 (0.009)	0.005 (0.009)	0.005 (0.009)	0.005 (0.009)	0.005 (0.009)	
D_{AS}^{firm}		0.113 (0.062)					
D_{CO}^{firm}	0.013 (0.008)	0.013 (0.008)	0.013 (0.008)	0.013 (0.008)	0.013 (0.008)	0.013 (0.008)	0.013 (0.008)
D_{DL}^{firm}	0.030 (0.009)	0.030 (0.009)	0.030 (0.009)	0.030 (0.009)	0.030 (0.009)	0.030 (0.009)	0.030 (0.009)
D_{HP}^{firm}	0.012 (0.009)	0.012 (0.009)	0.012 (0.009)	0.012 (0.009)	0.012 (0.009)	0.012 (0.009)	0.012 (0.009)
D_{NW}^{firm}	0.021 (0.008)	0.021 (0.008)	0.021 (0.008)	0.021 (0.008)	0.021 (0.008)	0.021 (0.008)	0.021 (0.008)
D_{KN}^{firm}						0.025 (0.027)	
D_{QQ}^{firm}				-0.030 (0.043)			
D_{RU}^{firm}				0.000 (0.000)		0.000 (0.000)	0.000 (0.000)
D_{TW}^{firm}	0.030 (0.008)	0.030 (0.008)	0.030 (0.008)	0.030 (0.008)	0.030 (0.008)	0.030 (0.008)	0.030 (0.008)
D_{UA}^{firm}	0.019 (0.008)	0.019 (0.008)	0.019 (0.008)	0.019 (0.008)	0.019 (0.008)	0.019 (0.008)	0.019 (0.008)
D_{US}^{firm}	0.019 (0.008)	0.019 (0.008)	0.019 (0.008)	0.019 (0.008)	0.019 (0.008)	0.019 (0.008)	0.019 (0.008)
D_{J7}^{firm}		-0.168 (0.039)	-0.168 (0.039)				
D_{EV}^{firm}						0.007 (0.024)	
D_{FL}^{firm}	0.000 (0.000)						
Obs	92	92	92	92	92	92	92
R-square	0.623	0.5501	0.5059	0.5334	0.5976	0.5062	0.4589

† Standard errors are in parentheses.

- Airline dummy D_{YX}^{firm} and quality dummies $D_{11110001}^{indirect}$, $D_{11100101}^{indirect}$, $D_{11100011}^{indirect}$, $D_{11011001}^{indirect}$, $D_{10101101}^{indirect}$, $D_{10100011}^{indirect}$, $D_{01100001}^{indirect}$, $D_{01010001}^{indirect}$, $D_{00010001}^{indirect}$, $D_{00001001}^{indirect}$ are omitted due to perfect collinearity.

Table B9. Eight Carriers on a Route After Southwest's Entry: With SW's Virtual Fare

AIDS Model of Determinants of Share

S_i	With Virtual Fare						
	Airline 1	Airline 2	Airline 3	Airline 4	Airline 5	Airline 6	Airline 7
Constant			0.261 (0.040)	0.088 (0.025)			
$\log(E/P)$	0.049 (0.006)	0.016 (0.003)	-0.023 (0.006)	-0.010 (0.004)	-0.011 (0.003)	-0.004 (0.002)	-0.007 (0.001)
$\log(p_1/p_{SW})$	0.084 (0.056)	-0.045 (0.029)	0.007 (0.024)	-0.020 (0.015)	-0.023 (0.014)	-0.005 (0.011)	-0.002 (0.007)
$\log(p_2/p_{SW})$	-0.045 (0.029)	0.078 (0.026)	-0.023 (0.018)	-0.004 (0.012)	0.006 (0.010)	-0.006 (0.009)	-0.006 (0.006)
$\log(p_3/p_{SW})$	0.007 (0.024)	-0.023 (0.018)	0.037 (0.023)	-0.015 (0.011)	0.003 (0.010)	-0.008 (0.009)	-0.001 (0.006)
$\log(p_4/p_{SW})$	-0.020 (0.015)	-0.004 (0.012)	-0.015 (0.011)	0.023 (0.011)	0.009 (0.007)	0.007 (0.006)	-0.001 (0.005)
$\log(p_5/p_{SW})$	-0.023 (0.014)	0.006 (0.010)	0.003 (0.010)	0.009 (0.007)	0.006 (0.009)	-0.003 (0.006)	0.002 (0.004)
$\log(p_6/p_{SW})$	-0.005 (0.011)	-0.006 (0.009)	-0.008 (0.009)	0.007 (0.006)	-0.003 (0.006)	0.011 (0.007)	0.004 (0.004)
$\log(p_7/p_{SW})$	-0.002 (0.007)	-0.006 (0.006)	-0.001 (0.006)	-0.001 (0.005)	0.002 (0.004)	0.004 (0.004)	0.004 (0.004)
$D_{11111000}^{indirect}$	0.079 (0.155)	0.067 (0.070)	-0.020 (0.067)	0.017 (0.034)	-0.015 (0.030)	0.010 (0.031)	0.004 (0.016)
$D_{11110001}^{indirect}$	-0.039 (0.118)	0.023 (0.068)	-0.052 (0.053)	0.013 (0.033)	0.052 (0.028)	-0.001 (0.024)	0.015 (0.015)
$D_{11100101}^{indirect}$	0.045 (0.089)	0.103 (0.051)	-0.075 (0.039)	-0.020 (0.024)	-0.020 (0.021)	-0.013 (0.018)	0.000 (0.011)
$D_{11100100}^{indirect}$	-0.064 (0.119)	0.131 (0.068)	-0.046 (0.053)	-0.024 (0.032)	0.018 (0.028)	0.021 (0.024)	0.004 (0.015)
$D_{11100011}^{indirect}$	0.280 (0.119)	0.013 (0.068)	-0.130 (0.053)	-0.044 (0.033)	-0.051 (0.029)	-0.027 (0.024)	-0.017 (0.015)
$D_{11100001}^{indirect}$	0.044 (0.088)	0.012 (0.051)	-0.026 (0.039)	-0.030 (0.024)	-0.017 (0.021)	0.012 (0.018)	0.016 (0.011)
$D_{11100000}^{indirect}$	0.003 (0.067)	0.090 (0.038)	0.028 (0.029)	-0.041 (0.018)	-0.018 (0.016)	-0.018 (0.014)	-0.007 (0.009)
$D_{11011001}^{indirect}$	0.101 (0.120)	-0.010 (0.089)	-0.067 (0.065)	-0.028 (0.033)	-0.015 (0.029)	-0.010 (0.030)	-0.004 (0.015)
$D_{11010101}^{indirect}$	0.001 (0.120)	-0.091 (0.069)	-0.019 (0.053)	-0.044 (0.033)	0.048 (0.029)	-0.002 (0.025)	0.007 (0.015)
$D_{11010001}^{indirect}$	0.160 (0.102)	0.010 (0.052)	-0.106 (0.044)	-0.032 (0.025)	-0.016 (0.022)	-0.024 (0.021)	-0.006 (0.012)
$D_{11001101}^{indirect}$	0.200 (0.089)	-0.009 (0.051)	-0.133 (0.039)	-0.072 (0.024)	-0.018 (0.021)	-0.024 (0.018)	-0.008 (0.012)
$D_{11001000}^{indirect}$	0.216 (0.120)	-0.065 (0.069)	-0.048 (0.053)	-0.073 (0.033)	-0.052 (0.029)	-0.040 (0.025)	0.000 (0.015)
$D_{11000101}^{indirect}$	-0.016 (0.076)	0.023 (0.044)	-0.062 (0.034)	-0.029 (0.021)	-0.002 (0.018)	0.003 (0.016)	0.009 (0.010)
$D_{11000001}^{indirect}$	0.127 (0.062)	-0.100 (0.037)	-0.141 (0.029)	-0.047 (0.017)	-0.018 (0.015)	-0.021 (0.014)	-0.011 (0.008)

Table B9. Continued.

S_i	With Virtual Fare						
	Airline 1	Airline 2	Airline 3	Airline 4	Airline 5	Airline 6	Airline 7
$D^{indirect}_{11000000}$	0.150 (0.062)	0.000 (0.035)	-0.052 (0.027)	-0.028 (0.017)	-0.007 (0.015)	-0.004 (0.013)	-0.007 (0.008)
$D^{indirect}_{10100101}$	0.062 (0.120)	-0.070 (0.069)	-0.141 (0.053)	-0.059 (0.033)	-0.037 (0.029)	-0.023 (0.025)	0.002 (0.016)
$D^{indirect}_{10100011}$	0.155 (0.119)	-0.066 (0.068)	-0.075 (0.053)	-0.018 (0.033)	0.002 (0.029)	0.003 (0.024)	0.018 (0.015)
$D^{indirect}_{10100010}$	0.112 (0.119)	-0.017 (0.068)	-0.074 (0.053)	-0.003 (0.033)	-0.019 (0.029)	0.000 (0.024)	0.030 (0.015)
$D^{indirect}_{10100001}$	-0.033 (0.064)	0.037 (0.036)	-0.056 (0.028)	-0.030 (0.017)	-0.024 (0.015)	-0.022 (0.013)	-0.002 (0.008)
$D^{indirect}_{10100000}$	0.229 (0.059)	-0.080 (0.034)	-0.071 (0.026)	-0.049 (0.016)	-0.008 (0.014)	-0.001 (0.012)	0.002 (0.008)
$D^{indirect}_{10010100}$	-0.022 (0.118)	-0.061 (0.068)	-0.043 (0.053)	0.039 (0.033)	0.069 (0.029)	-0.013 (0.025)	-0.008 (0.015)
$D^{indirect}_{10010010}$	0.087 (0.120)	-0.043 (0.069)	-0.049 (0.053)	-0.015 (0.033)	0.008 (0.029)	0.015 (0.024)	0.037 (0.015)
$D^{indirect}_{10010000}$	0.104 (0.089)	-0.064 (0.051)	-0.046 (0.039)	0.006 (0.024)	-0.011 (0.021)	0.021 (0.018)	0.017 (0.011)
$D^{indirect}_{10001001}$	0.057 (0.069)	-0.061 (0.040)	-0.107 (0.031)	-0.045 (0.019)	0.009 (0.017)	-0.007 (0.014)	0.004 (0.009)
$D^{indirect}_{10000101}$	-0.024 (0.076)	0.028 (0.043)	-0.074 (0.033)	-0.013 (0.021)	0.014 (0.018)	0.016 (0.016)	0.025 (0.010)
$D^{indirect}_{10000100}$	-0.031 (0.118)	-0.013 (0.068)	0.047 (0.052)	-0.042 (0.032)	-0.018 (0.028)	0.036 (0.024)	0.026 (0.015)
$D^{indirect}_{10000011}$	0.179 (0.120)	-0.189 (0.069)	-0.121 (0.054)	-0.043 (0.033)	-0.034 (0.029)	-0.004 (0.025)	-0.010 (0.016)
$D^{indirect}_{10000001}$	0.096 (0.047)	-0.073 (0.027)	-0.129 (0.021)	-0.046 (0.013)	-0.007 (0.011)	-0.010 (0.010)	-0.002 (0.006)
$D^{indirect}_{10000000}$	0.109 (0.053)	-0.027 (0.030)	-0.054 (0.024)	-0.010 (0.015)	-0.011 (0.013)	-0.014 (0.011)	0.015 (0.007)
$D^{indirect}_{01100001}$	0.109 (0.118)	0.003 (0.068)	-0.056 (0.052)	-0.023 (0.033)	-0.014 (0.029)	-0.007 (0.024)	-0.005 (0.015)
$D^{indirect}_{01011000}$	-0.158 (0.118)	0.062 (0.068)	0.008 (0.052)	0.042 (0.032)	0.004 (0.028)	0.040 (0.024)	0.021 (0.015)
$D^{indirect}_{01010001}$	-0.123 (0.125)	-0.012 (0.082)	0.015 (0.056)	0.057 (0.035)	0.070 (0.031)	0.009 (0.026)	0.025 (0.016)
$D^{indirect}_{01010000}$	-0.116 (0.086)	0.071 (0.049)	-0.003 (0.038)	0.001 (0.024)	-0.001 (0.021)	0.007 (0.018)	0.036 (0.011)
$D^{indirect}_{01000010}$	0.065 (0.086)	0.034 (0.050)	-0.058 (0.038)	0.008 (0.024)	-0.002 (0.021)	0.002 (0.018)	0.008 (0.011)
$D^{indirect}_{01000001}$	-0.013 (0.074)	0.037 (0.044)	-0.055 (0.033)	0.012 (0.021)	0.010 (0.018)	0.011 (0.015)	-0.001 (0.010)
$D^{indirect}_{00110001}$	-0.330 (0.118)	0.093 (0.068)	-0.052 (0.053)	0.119 (0.033)	-0.024 (0.036)	-0.006 (0.024)	-0.028 (0.015)
$D^{indirect}_{00100000}$	-0.178 (0.118)	0.062 (0.068)	0.017 (0.052)	-0.032 (0.033)	-0.054 (0.028)	-0.005 (0.024)	-0.008 (0.016)
$D^{indirect}_{00011000}$	-0.131 (0.118)	0.067 (0.067)	-0.031 (0.052)	0.027 (0.032)	0.086 (0.028)	-0.032 (0.024)	0.001 (0.015)

Table B9. Continued.

S_i	With Virtual Fare						
	Airline 1	Airline 2	Airline 3	Airline 4	Airline 5	Airline 6	Airline 7
$D_{00010001}^{indirect}$	-0.031 (0.072)	0.052 (0.042)	-0.074 (0.033)	0.014 (0.021)	0.018 (0.018)	0.022 (0.015)	-0.002 (0.010)
$D_{00010000}^{indirect}$	-0.067 (0.074)	0.059 (0.042)	-0.029 (0.033)	0.062 (0.020)	0.016 (0.019)	0.027 (0.015)	0.012 (0.010)
$D_{00001001}^{indirect}$	-0.001 (0.118)	0.010 (0.068)	-0.030 (0.052)	-0.004 (0.032)	0.001 (0.028)	0.003 (0.024)	0.035 (0.016)
$D_{00001000}^{indirect}$	-0.156 (0.118)	-0.016 (0.068)	-0.141 (0.053)	0.028 (0.033)	0.028 (0.029)	-0.006 (0.025)	0.000 (0.015)
$D_{00000100}^{indirect}$	-0.253 (0.118)	-0.008 (0.068)	-0.093 (0.053)	-0.007 (0.033)	0.020 (0.029)	0.035 (0.025)	0.008 (0.016)
$D_{00000010}^{indirect}$	0.048 (0.086)	0.004 (0.049)	-0.023 (0.038)	-0.037 (0.024)	0.038 (0.021)	0.054 (0.018)	-0.003 (0.011)
$D_{00000001}^{indirect}$	-0.110 (0.047)	0.047 (0.027)	-0.086 (0.021)	-0.015 (0.013)	0.003 (0.011)	0.000 (0.010)	-0.003 (0.006)
D_{AA}^{firm}	0.056 (0.009)	0.056 (0.009)	0.056 (0.009)	0.056 (0.009)	0.056 (0.009)	0.056 (0.009)	0.057 (0.014)
D_{AS}^{firm}	-0.067 (0.096)	0.146 (0.058)					
D_{CO}^{firm}	0.061 (0.009)	0.061 (0.009)	0.061 (0.009)	0.061 (0.009)	0.061 (0.009)	0.061 (0.009)	0.061 (0.009)
D_{DL}^{firm}	0.071 (0.009)	0.071 (0.009)	0.071 (0.009)	0.071 (0.009)	0.071 (0.009)	0.071 (0.009)	0.071 (0.009)
D_{HP}^{firm}	0.055 (0.009)	0.055 (0.009)	0.055 (0.009)	0.055 (0.009)	0.055 (0.009)	0.055 (0.009)	0.055 (0.009)
D_{NW}^{firm}	0.066 (0.009)	0.066 (0.009)	0.066 (0.009)	0.066 (0.009)	0.066 (0.009)	0.066 (0.009)	0.066 (0.009)
D_{KN}^{firm}						0.052 (0.021)	
D_{QQ}^{firm}			0.100 (0.040)				
D_{RU}^{firm}				0.055 (0.010)		0.055 (0.010)	0.055 (0.010)
D_{TW}^{firm}	0.071 (0.009)	0.071 (0.009)	0.071 (0.009)	0.071 (0.009)	0.071 (0.009)	0.071 (0.009)	0.071 (0.009)
D_{UA}^{firm}	0.064 (0.009)	0.064 (0.009)	0.064 (0.009)	0.064 (0.009)	0.064 (0.009)	0.064 (0.009)	0.064 (0.009)
D_{US}^{firm}	0.061 (0.009)	0.061 (0.009)	0.061 (0.009)	0.061 (0.009)	0.061 (0.009)	0.061 (0.009)	0.061 (0.009)
D_{YX}^{firm}					0.064 (0.024)		
D_{J7}^{firm}		0.000 (0.000)					

Table B9. Continued.

S_i	With Virtual Fare						
	Airline 1	Airline 2	Airline 3	Airline 4	Airline 5	Airline 6	Airline 7
D_{EV}^{firm}						0.064 (0.018)	
D_{FL}^{firm}		0.039 (0.040)					
Obs	156	156	156	156	156	156	156
R-square	0.5634	0.3928	0.4978	0.543	0.5233	0.5221	0.4725

† Standard errors are in parentheses.

- Quality dummy $D_{10101101}^{indirect}$ is omitted due to perfect collinearity.

APPENDIX C

CROSS-PRICE ELASTICITY VECTORS

Appendix C1. Cross-Price Elasticity Vectors without Southwest's Virtual Fare
: Data one quarter after Southwest's entry are used in the estimation of demand

1) Two carriers are competing one quarter after Southwest's entry

		With Respect to the Price of	
		1	SW
Price Elasticity of Demand for	1	-1.237	0.429
	SW	0.592	-2.075

2) Three carriers are competing one quarter after Southwest's entry

		With Respect to the Price of		
		1	2	SW
Price Elasticity of Demand for	1	-1.290	0.389	0.173
	2	0.118	-1.220	-0.041
	SW	0.329	0.169	-1.483

3) Four carriers are competing one quarter after Southwest's entry

		With Respect to the Price of			
		1	2	3	SW
Price Elasticity of Demand for	1	-0.799	-0.516	-0.402	0.137
	2	-0.251	-0.989	0.707	0.326
	3	-0.118	0.276	-1.156	0.097
	SW	0.047	0.412	0.373	-1.638

4) Five carriers are competing one quarter after Southwest's entry

		With Respect to the Price of				
		1	2	3	4	SW
Price Elasticity of Demand for	1	-1.138	0.033	0.244	-0.162	0.148
	2	-0.042	-1.205	0.222	0.008	0.148
	3	0.024	0.122	-1.025	0.324	-0.206
	4	-0.030	0.000	0.124	-0.698	-0.064
	SW	0.166	0.322	-0.235	-0.169	-1.455

5) Six carriers are competing one quarter after Southwest's entry

		With Respect to the Price of					
		1	2	3	4	5	SW
Price Elasticity of Demand for	1	-0.713	-0.642	0.214	-0.629	-0.387	0.185
	2	-0.322	-0.473	0.146	0.514	-0.737	0.087
	3	0.047	0.103	-1.112	-0.167	-0.294	-0.030
	4	-0.140	0.151	-0.130	-0.811	0.478	0.109
	5	-0.041	-0.142	-0.095	0.277	-0.716	0.174
	SW	0.021	0.057	-0.070	0.308	0.732	-1.379

6) Seven carriers are competing one quarter after Southwest's entry

		With Respect to the Price of						
		1	2	3	4	5	6	SW
Price Elasticity of Demand for	1	-0.830	-0.192	-0.088	-0.287	-0.356	-1.368	0.344
	2	-0.100	-0.903	0.237	0.226	-0.056	-0.428	-0.062
	3	-0.037	0.141	-1.224	0.006	0.250	0.633	-0.093
	4	-0.106	0.031	-0.045	-0.521	0.048	0.533	-0.062
	5	-0.054	-0.026	0.080	0.049	-0.588	0.029	-0.035
	6	-0.119	-0.084	0.123	0.203	0.003	0.069	0.028
	SW	0.113	-0.070	-0.133	-0.041	-0.095	0.271	-1.098

7) Eight carriers are competing one quarter after Southwest's entry

		With Respect to the Price of							
		1	2	3	4	5	6	7	SW
Price Elasticity of Demand for	1	-0.762	-0.736	0.121	-0.317	-0.555	-0.710	-0.342	0.793
	2	-0.286	-0.075	-0.003	-0.502	0.390	-0.804	0.354	0.070
	3	0.000	-0.029	-0.461	-0.240	0.047	0.200	-0.347	-0.399
	4	-0.044	-0.199	-0.110	-0.446	0.175	0.448	0.400	-0.086
	5	-0.093	0.127	0.022	0.130	-0.736	-0.001	-0.151	-0.030
	6	-0.064	-0.193	0.077	0.260	0.012	-0.221	0.708	-0.137
	7	-0.028	0.044	-0.071	0.130	-0.063	0.417	-1.344	0.001
	SW	0.182	0.027	-0.382	-0.187	-0.053	-0.433	0.022	-1.041

Appendix C2. Cross-Price Elasticity Vectors with Southwest's Virtual Fare
: Data one quarter after and before Southwest's entry are used in the estimation

1) Two carriers are competing one quarter after Southwest's entry

		With Respect to the Price of	
		1	SW
Price Elasticity of Demand for	1	-1.155	0.555
	SW	0.448	-2.603

2) Three carriers are competing one quarter after Southwest's entry

		With Respect to the Price of		
		1	2	SW
Price Elasticity of Demand for	1	-1.299	0.435	0.316
	2	0.134	-1.207	-0.132
	SW	0.305	0.030	-1.706

3) Four carriers are competing one quarter after Southwest's entry

		With Respect to the Price of			
		1	2	3	SW
Price Elasticity of Demand for	1	-0.980	-0.246	-0.534	0.600
	2	-0.145	-1.157	0.853	0.256
	3	-0.124	0.318	-0.983	-0.030
	SW	0.163	0.202	0.010	-1.887

4) Five carriers are competing one quarter after Southwest's entry

		With Respect to the Price of				
		1	2	3	4	SW
Price Elasticity of Demand for	1	-1.107	0.117	0.099	0.013	0.105
	2	-0.010	-1.048	0.205	-0.011	-0.059
	3	-0.009	0.116	-1.153	0.104	-0.050
	4	-0.014	-0.004	0.041	-0.905	-0.012
	SW	0.123	0.092	0.070	0.102	-1.631

5) Six carriers are competing one quarter after Southwest's entry

		With Respect to the Price of					
		1	2	3	4	5	SW
Price Elasticity of Demand for	1	-0.894	-0.403	0.102	-0.316	-0.228	0.474
	2	-0.221	-0.765	0.067	0.518	-0.234	0.200
	3	0.010	0.052	-1.047	-0.155	-0.297	0.112
	4	-0.080	0.155	-0.110	-0.864	0.338	-0.018
	5	-0.019	-0.034	-0.082	0.193	-0.688	0.017
	SW	0.071	0.092	0.075	-0.009	0.020	-1.598

6) Seven carriers are competing one quarter after Southwest's entry

		With Respect to the Price of						
		1	2	3	4	5	6	SW
Price Elasticity of Demand for	1	-0.850	-0.224	-0.020	-0.136	-0.010	-0.863	0.185
	2	-0.135	-0.945	0.228	0.151	0.182	-0.329	0.062
	3	-0.035	0.129	-1.176	-0.054	-0.006	0.439	0.030
	4	-0.055	0.038	-0.045	-0.748	-0.014	0.014	0.021
	5	-0.031	0.018	-0.022	-0.020	-0.857	0.234	0.006
	6	-0.075	-0.060	0.083	-0.004	0.137	-0.006	0.002
	SW	0.011	0.012	0.014	0.033	0.046	0.043	-1.143

7) Eight carriers are competing one quarter after Southwest's entry

		With Respect to the Price of							
		1	2	3	4	5	6	7	SW
Price Elasticity of Demand for	1	-0.865	-0.304	0.142	-0.215	-0.324	-0.090	0.053	0.146
	2	-0.117	-0.557	-0.162	-0.034	0.131	-0.152	-0.251	0.044
	3	0.002	-0.149	-0.672	-0.193	0.081	-0.200	-0.028	0.038
	4	-0.053	-0.031	-0.113	-0.675	0.181	0.198	-0.001	0.024
	5	-0.057	0.028	0.038	0.137	-0.880	-0.088	0.132	0.004
	6	-0.015	-0.040	-0.057	0.100	-0.053	-0.688	0.213	0.004
	7	-0.006	-0.039	-0.007	-0.004	0.045	0.115	-0.808	0.000
	SW	0.003	-0.001	0.022	0.019	0.006	0.003	0.009	-1.088

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