TITLE Carriers' Price Dispersion in the U.S. Airline Industry

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ABSTRACTS
This paper explores price dispersion in the U.S. airline industry by highlighting individual carriers' price discrimination strategies. Using heteroskedasticity-adjusted instrumental variable technique, we found that individual carriers play crucial roles in determining price dispersion, implying that the carriers' price discrimination strategies may influence variation in airfares. Based on the estimated price dispersion and the estimated average price, we distinguished sources of price dispersion by categorizing individual carriers' pricing strategies. In 2005, for example, monopoly-type price discrimination was likely to result in price dispersion for Northwest, whereas competitive-type price discrimination was likely to lead to price dispersion for Delta. However, most of the carriers showed different types of pricing strategies under the same market conditions in 2000. Therefore, this paper supported evidence that the type of the pricing strategies is not equal across the U.S. air carriers.

INTRODUCTION

Airfares have been an important element in the United States (U.S.) airline industry. Airline pricing research improves our understanding of market structure and competitiveness of the industry, and shed some light on carriers' price discrimination practices. However, the extent of price discrimination practices is not readily assessable due to complicated discrimination factors, such as ticket restriction, days remaining until departure, and passenger group. Without comprehensive information on the carriers' price discrimination strategies, it is difficult to understand pricing behaviors in the domestic airline industry.

Despite the complex nature of price discrimination and the lack of accurate data, previous research attempted to examine price discrimination in the U.S. airline industry. Borenstein and Rose (1994) use an inequality measure (the Gini coefficient) of airfares as a proxy of price discrimination. They find that price dispersion cannot be explained by cost differences[i] alone and greater market competition is associated with a higher level of price dispersion in the domestic airline markets. A one standard deviation reduction in the Herfindahl-Hirschman (Herfindahl) Index from its mean is found to increase the Gini coefficient by 14 percent. Hayes and Ross (1998) modify the approach of Borenstein and Rose (1994) by using more dispersion measures and larger cross-sectional data. They find that most dispersion is associated with "price wars" and peak-load pricing, whereas some discrimination is observed at monopolized endpoints. Accordingly, they conclude that there is an estrangement between price dispersion and price discrimination. In addition, Stavins (2001) focuses on the relationship between market power characteristics and price discrimination by examining the effects of ticket restrictions on airfares. The results show that the level of price discrimination is higher in more competitive markets and lower in less competitive markets. Thus, she concludes that price discrimination increases as the market becomes more competitive. Furthermore, Carbonneau et al. (2004) find that price discrimination and market power are not positively correlated in the U.S. airline industry, and thus price discrimination alone is not evidence of market power. On the contrary, Gerardi and Shapiro (2007) find that market competition is negatively associated with price dispersion, which supports traditional explanation of price discrimination.

While previous studies provided valuable information on price discrimination in the U.S. airline industry, the empirical findings, however, were inconsistent. The inconsistencies may be resulting from mixing the different types of price discrimination, such as monopoly-type and competitive-type price discrimination.[ii] For example, Borenstein and Rose (1994) find that market competition appears to have a positive impact on price dispersion, but Gerardi and Shapiro (2007) provide the inverse influence of market competition on price dispersion. In traditional economic theory, a carrier uses price discrimination to maximize its profit in monopolistic markets, which results in a positive relationship between market power and price dispersion (monopoly-type price discrimination). On the other hand, competitive market forces can increase the number of discounted airfares deviated from the full fares, leading to more price dispersion in the markets. This results in a negative relationship between market power and price dispersion (competitive-type price discrimination). Because market structures in most domestic segment markets ranged between monopoly and perfect competition, the markets are likely to have both monopolistic and competitive market forces. This indicates that markets may have the offsetting impacts between these market forces, and therefore the impact of market power characteristics on price dispersion can be positive or negative, depending on the dominant effect of monopolistic or competitive markets forces. Thus, we attempt to examine different types of price discrimination under different market conditions.

In addition, previous studies controlled for the effect of individual carriers by including carrier fixed-effects in their estimations and neglected the role of individual carriers and their pricing strategies. In this paper, we argue that there are differences across carriers in the relationship between market conditions and price dispersion. Carriers' goals (e.g., profit or market share maximization) and managerial decisions in segment markets may result in carriers' unique pricing strategies in segment markets. According to the data in this paper, price dispersion is found to vary by carriers.[iii] For this reason, we examine the impacts of individual carriers on price dispersion and discuss the carriers' price discrimination strategies.[iv] Categorizing the extent and type of price discrimination enables us to explain carriers' pricing strategies in a stylized manner.

In summary, the objective of the study is to provide comprehensive information on individual carriers' pricing strategies. To do this, we categorize carriers' pricing strategies into four types: rigid monopoly-type prices, monopoly-type price discrimination, competitive-type price discrimination, and rigid competitive-type prices. This may provide better insight on the sources of price dispersion and carriers' price discrimination strategies. The information may help policymakers and carrier managers understand individual carriers' pricing strategies and make their decisions.

The rest of the paper is organized as follows. The next section describes a price dispersion model and the third section provides data description. Discussion on the econometric procedures and the results of price dispersion model are followed. The paper then presents combined findings from the price dispersion and average price models. Finally, concluding remarks are provided in the last section.

THE PRICE DISPERSION MODEL

We model price dispersion as a function of operating cost factors, demand characteristics, market power, and individual carriers. Operating cost factors include capacity at origin and destination ($ORICAP_i$ and $DESCAP_j$), load factor ($ORILOAD_i$ and $DESLOAD_j$), frequency at origin and destination ($ORIFREQ_i$ and $DESFREQ_j$), distance ($DIST_{ij}$), round trip ($ROUND_{ij}$), and ticket restriction ($RESTRICT_{ij}$).[v] In addition, we use population ($AVGPOP_{ij}$), income ($AVGINC_{ij}$), tourism areas ($TOUR_{ij}$), and route variables ($ORIHUB_i$, $ORISLOT_i$, $ORIMULTIPLE_i$, $DESHUB_j$, $DESSLOT_j$, and $DESMULTIPLE_j$) as factors influencing the demand for air service. Market concentration at origin and destination ($ORIHERF_i$ and $DESHERF_j$), market share at origin and destination ($ORISHARE_i$ and $DESSHARE_j$), and Low Cost Carrier competition ($LOWCOST_{ij}$) are used as market power characteristics. We also include dummy variables for major carriers American (AA_{ij}), United (UA_{ij}), Delta (DL_{ij}), Continental (CO_{ij}), Northwest (NW_{ij}), and Southwest (SW_{ij}), and three seasonal dummies (*Q1*, *Q2*, and *Q3*). Specifically, the price dispersion from origin *i* to destination *j* is as follows:[vi]

$$
\begin{aligned}
PD_{ij} = \alpha + \beta_1 \ln ORICAP_i + \beta_2 \ln ORILOAD_i + \beta_3 \ln ORIFREQ_i + \\
\beta_4 \ln DESCAP_j + \beta_5 \ln DESLOAD_j + \beta_6 \ln DESFREQ_j + \\
\beta_7 \ln DIST_{ij} + \beta_8 \ln AVGDIST_{ij} + \beta_9 ROUND_{ij} + \\
\beta_{10} TOUR_{ij} + \beta_{11} RESTRICT_{ij} + \beta_{12} \ln AVGPOP_{ij} + \beta_{13} \ln AVGINC_{ij} + \\
\beta_{14} ORIHUB_i + \beta_{15} ORISLOT_i + \beta_{16} \ln ORIHERF_i + \beta_{17} \ln ORISHARE_i + \\
\beta_{18} DESHUB_j + \beta_{19} DESSLOT_j + \beta_{20} \ln DESHERF_j + \beta_{21} \ln DESSHARE_j + \\
\beta_{22} LOWCOST_{ij} + \beta_{23} ORIMULTIPLE_i + \beta_{24} DESMULTIPLE_j + \\
\beta_{25} AA_{ij} + \beta_{26} UA_{ij} + \beta_{27} DL_{ij} + \beta_{28} CO_{ij} + \beta_{29} NW_{ij} + \beta_{30} SW_{ij} + \\
\beta_{31} Q1 + \beta_{32} Q2 + \beta_{33} Q3 + \varepsilon_{ij},
\end{aligned}
\qquad (1)
$$

where β_i are the coefficients of independent variables. The data are rearranged by origin, destination, carrier, and quarter. Appendix A provides detailed discussion on the right-hand-side variables and their expected signs.

As discussed in Borenstein and Rose (1994) and Hayes and Ross (1998), price discrimination can be an important source of price dispersion by influencing the differences in markups of price over cost. This paper attempts to distinguish price dispersion due to monopolistic market forces from dispersion due to competitive market forces. To do this, we re-define monopoly-type price discrimination and competitive-type price discrimination by considering changes in average price and price dispersion.[vii] In this paper, monopoly-type price discrimination is defined as discriminatory pricing that increases variation in markups of price over cost to business travelers who have low own-price, cross-price, and industry elasticities of demand. That is, price changes of their tickets, other flight times or other airlines, and other transportation modes (e.g., auto and bus) do not affect these travelers' behaviors. Therefore, carriers are likely to use monopoly-type price discrimination based on passengers' elasticities of demand, which leads to *higher average airfares*[viii] and *higher price dispersion*. On the other hand, competitive-type price discrimination is defined as discriminatory pricing that increases the variation to vacation travelers who have high own-price, cross-price, and industry elasticities of demand. The price changes for their tickets, other flight times, other airlines, and other transportation modes can largely affect the travelers' behaviors. For example, the vacation travelers are likely to switch their airlines to different airlines for lower fares. Thus, competitive-type price discrimination may be used to the vacation travelers, which results in *lower average airfares* and *greater price dispersion*, when the business travelers' behaviors are held constant. Furthermore, carriers may use rigid pricing strategies when they do not have information on the elasticities of demand. Rigid monopoly-type prices lead to *higher average airfares* and *less price dispersion*, while rigid competitive-type prices result in *lower average airfares* and *less price dispersion.*

This paper presents two price dispersion models: the models without carriers' interaction terms (Model 1) and with the interaction terms (Model 2). Model 1 examines operating cost, demand, market power, and individual carrier factors on price dispersion as shown in Eq. (1). On the other hand, Model 2 adds the carriers' interaction terms in addition to variables in Model 1 to determine whether individual carriers and market conditions interact.

THE DATA

This paper uses quarterly data for years 2000 and 2005, collected from the U.S. Department of Transportation, the U.S. Census Bureau, the U.S. Department of Labor, and the U.S. Department of Commerce. These years are selected because they are the years with the largest passenger-miles for domestic air-passenger service recorded before and after the terrorist attacks of 2001.[ix] The sample sizes for 2000 and 2005 data are 647,816 and 772,210 observations, respectively. To measure the Gini coefficient,[x] we use the Origin and Destination Survey (DB1B) sample data from the U.S. Department of Transportation. Because of the nature of sample data, we carefully examined the data and eliminated the top and bottom 1 percents of airfare data to remove outliers.[xi] DBIB contains a 10 percent sample of airline tickets from reporting carriers. It includes items such as the reporting carrier, number of passengers, and other passenger's ticket information. Multiplying the Gini coefficient by two shows the expected price difference as a proportion of the mean for two randomly selected tickets (Borenstein and Rose, 1994). T-100 domestic segment data are used to create capacity, load factor, and frequency variables. T-100 domestic segment data are population data containing items such as departures, aircraft size, and transported passengers in single-segment markets. American Airlines (American), United Airlines (United), Delta Air Lines (Delta), Continental Airlines (Continental), Northwest Airlines (Northwest), and Southwest Airlines (Southwest) are selected as major carriers in this paper because these carriers account for 71% of total domestic passenger-miles in 2005 (Bureau of Transportation Statistics, 2007).[xii]

Table 1 provides variable descriptions and summary statistics. The average Gini coefficients of airfares per passenger-miles from origin *i* to destination *j* (PD_{ij}) in 2000 and 2005 are 0.19 and 0.20, which are slightly more dispersed than the average Gini coefficient (0.18) reported by Borenstein and Rose (1994). The nominal average airfare per passenger-mile (P_{ij}) dropped by 19 percent from $0.26 in 2000 to $0.21 in 2005. The average seat capacity at origin ($ORICAP_i$) and destination ($DESCAP_i$) decreased by 19 percent. The load factors at origin ($ORILOAD_i$) and at destination ($DESLOAD_i$) averaged 66 percent in 2000 and 72 percent in 2005. Upward trends in load factor are also found in the T-1 tables, Bureau of Transportation Statistics (2007). Carriers' frequency of flights at origin ($ORIFREQ_i$) and at destination ($DESFREQ_j$) decreased by 22 percent between 2000 and 2005. Total distance ($DIST_{ij}$) averaged 1320 miles, while the average segment distance ($AVGDIST_{ij}$) was approximately 700 miles in both years. The average population of origin and destination cities was less than 3 million. The nominal average per-capita income of origin and destination cities was about $31,000 in 2000, and rose to $36,000 in 2005. Market concentration measured by Herfindahl indexes at origin and destination were roughly the same at 0.34. Average carrier market share at origin (destination) rose from 0.25 (0.25) in 2000 to 0.29 (0.27) in 2005, possibly due to airline consolidation between the two years.

Fifty-six percent of the tickets were round-trip. Roughly 80 percent of the trips departed from or arrived in a tourism area. The percentage of ticket with restrictions, such as advance purchase, cancellation penalty, and Saturday-night stay, increased from an average of 64 percent in 2000 to 80 percent in 2005. Less than 90 percent of the trips originated from the carriers' own hub airports ($ORIHUB_i$), and 90 percent of the trips arrived in a hub airport ($DESHUB_j$). Only about 5 percent of trips involved a slot-controlled airport. Less than one-third of the trips involved origin or destination cities where multiple airports were present.

Table1. Description of variables and summary statistics in the price dispersion and average price models in 2000 and 2005.[a]

Variable	Description	2000		2005	
		Mean	Std. Dev.	Mean	Std. Dev.
PD_{ij}	Gini Coefficient of airfares per passenger-miles from origin *i* to destination *j*	0.19	0.19	0.20	0.21
P_{ij}	Average airfare per passenger-mile ($) from origin *i* to destination *j*	0.26	0.22	0.21	0.19
$ORICAP_i$	Average seat capacity [b] at origin *i*	120	42	98	48
$ORILOAD_i$	Average load factor [c] at origin *i*	0.66	0.11	0.72	0.10
$ORIFREQ_i$	Total frequency of flights by carrier at origin *i*	2,490	5,746	1,930	4,807
$DESCAP_j$	Average seat capacity at destination *j*	119	42	98	48
$DESLOAD_j$	Average load factor at destination *j*	0.66	0.11	0.72	0.11
$DESFREQ_j$	Total frequency of flights by carrier at destination *j*	2,415	5,671	1,879	4,755
$DIST_{ij}$	Total distance (miles) from origin *i* to destination *j*	1,319	866	1,320	850
$AVGDIST_{ij}$	Average segment distance [d] from origin *i* to destination *j*	701	426	700	423
$AVGPOP_{ij}$	Average population of origin and destination cities	2,891,166	2,846,296	2,836,287	2,829,904
$AVGINC_{ij}$	Average per-capita income of origin and destination cities	31,114	3,986	35,669	4,317
$ORIHERF_i$	Herfindahl index [e] at origin *i*	0.35	0.21	0.34	0.20
$ORISHARE_i$	Carrier's market share [f] at origin *i*	0.25	0.26	0.29	0.26
$DESHERF_j$	Herfindahl index at destination *j*	0.35	0.21	0.33	0.19
$DESSHARE_j$	Carrier's market share at destination *j*	0.25	0.26	0.27	0.25
Dummy					
$ROUND_{ij}$	Dummy for a round trip [g]	0.56	0.50	0.56	0.50
$TOUR_{ij}$	Dummy for an origin or destination city that is located in tourism areas [h]	0.81	0.39	0.79	0.41
$RESTRICT_{ij}$	Dummy for ticket restrictions [i]	0.64	0.48	0.80	0.40
$ORIHUB_i$	Dummy for a hub airport [j] at origin *i*	0.89	0.31	0.85	0.35

$DESHUB_j$	Dummy for a hub airport at destination *j*	0.90	0.31	0.90	0.30
$ORISLOT_i$	Dummy for a slot-controlled airport [k] at origin *i*	0.05	0.21	0.04	0.19
$DESSLOT_j$	Dummy for a slot-controlled airport at destination *j*	0.05	0.21	0.05	0.21
$ORIMULTIPLE_i$	Dummy for multiple airports available at origin city [l]	0.30	0.46	0.27	0.45
$DESMULTIPLE_j$	Dummy for multiple airports available at destination city	0.30	0.46	0.30	0.46
$LOWCOST_{ij}$	Dummy for the existence of competition with a low cost carrier (LCC) [m]	0.34	0.47	0.44	0.50
AA_{ij}	Dummy for American Airlines	0.10	0.30	0.06	0.24
UA_{ij}	Dummy for United Airlines	0.11	0.31	0.07	0.25
DL_{ij}	Dummy for Delta Air Lines	0.16	0.37	0.11	0.31
CO_{ij}	Dummy for Continental Airlines	0.05	0.22	0.03	0.18
NW_{ij}	Dummy for Northwest Airlines	0.12	0.33	0.09	0.29
SW_{ij}	Dummy for Southwest Airlines	0.06	0.24	0.06	0.24
$Q1$	Dummy for quarter 1	0.24	0.43	0.24	0.43
$Q2$	Dummy for quarter 2	0.26	0.44	0.25	0.43
$Q3$	Dummy for quarter 3	0.25	0.43	0.25	0.43

(Data sources: U.S. Department of Transportation, U.S. Census Bureau, U.S. Department of Labor, and U.S. Department of Commerce)

[a] The summary statistics are calculated from the regression data used in this paper (647,816 and 772,210 observations for 2000 and 2005 data).

A mean dummy for multiple airports at origin of .3 for 2000 means that 30% of total observations in the regression data have multiple airports available at origin. In addition, standard deviation is abbreviated to Std. Dev. in the table.

[b] Seat capacity is the number of available seats of carrier by quarter. The average capacity is weighted by the number of departures. We used the T-100 Segment data to create airport-specific variables (e.g., $ORICAP_i$, $ORILOAD_i$, $ORIFREQ_i$, $ORIHERF_i$, and $ORISHARE_i$).

[c] Load factor is the number of purchased seats divided by the number of available seats. The average load factor is weighted by the number of departures.

[d] The average segment distance is the total distance divided by the number of stops made to destination. The average segment distance is weighted by the number of passengers from origin to destination.

[e] The Herfindahl index is calculated by summing the squares of individual segment market share of passengers of all ticketing carriers at origin-destination market.
[f] The number of carrier's passengers divided by total passengers at origin.
[g] A dummy for a round trip is equal to one if the flight is a round trip. Otherwise, the dummy is set to zero (e.g., one-way and circle trips).
[h] A list of 50 tourism areas is obtained from the Office of Travel and Tourism Industries (OTTI), U.S. Department of Commerce.
[i] We used the DB1B to create a dummy for ticket restrictions. If the DB1B observations are recorded as ticket restriction, then the $RESTRICT_{ij}$ is equal to one. Otherwise, it is equal to zero.

[j] A dummy for the airport hubs at origin is equal to one if the origin airport is the carrier's own major hub airport. Otherwise, it is equal to zero
[k] The slot-controlled airports are O'Hare International (ORD), Laguardia (LGA), JFK International (JFK), and Ronald Reagan National airports (DCA).
[l] If multiple airports are located in the same city or Metropolitan Statistical Area, then a dummy for multiple airports is equal to one. Otherwise, it is equal to zero.
[m] A list of low-cost carriers (LCCs) is collected from Ito and Lee (2003).
The LCCs include Air South, Access Air, AirTran, American Trans Air, Eastwind, Frontier, JetBlue, Kiwi, Morris Air, National, Pro Air, Reno, Southwest, Spirit, Sun Country, ValuJet, Vanguard, and Western Pacific.

Existence of competition with low-cost carriers (LCC) increased from an average of 34 percent in 2000 to 44 percent in 2005, implying the intensity of competition with LCC rose over time. We also included dummy variables for major carriers like American, United, Delta, Continental, Northwest, and Southwest to capture unobserved firms' characteristics effects in the data. In our sample data, these major airline companies constitute 60 percent of the carriers in 2000, but only 42 percent in 2005. This 18-percent drop reflects an increase in the number of non-major carriers (base group) from 40 percent in 2000 to 58 percent in 2005. Non-major carriers include regional carriers such as JetBlue, Frontier, and Midwest. The fourth quarter (October – December) is the base for seasonal comparison.

THE ECONOMETRIC PROCEDURES

Diagnostic tests for multicollinearity, heteroskedacity, and endogeneity were conducted to provide a robust and unbiased model. First, the Breusch-Pagan (1979) and the White (1980) tests are used to detect heteroskedasticity in the model. As shown in Table 2, the null hypothesis of homoskedasticity can be rejected at the 5 percent significance level in both 2000 and 2005, indicating that heteroskedasticity is present in the model. Second, the Hausman test is used to check for the possible endogeneity with load factor, frequency, Herfindahl index, and market share variables.[xiii]

Under competitive-type price discrimination, load factor and frequency variables may be endogenous since increases in the values of these variables decrease unit operating costs and enable the carriers to provide various discounted fares from full fare (more price dispersion), which increase vacation travelers' demand for their service, thereby influencing load factor and frequency of service. Similarly, Herfindahl index and market share variables may be all endogenous because increases in these variables can lead to more monopoly-type discrimination (greater price dispersion), which may induce a new entry to these markets and in turn affect market concentration and market share. Table 2 shows that the null hypothesis of exogeneity can be rejected at the 5 percent level for most of the variables, indicating that these variables are endogenous. Herfindahl index and market share variables at destination are found to be exogenous for the 2000 data and the load factor variable at destination is also exogenous for the 2005 data.

To correct the problems of heteroskedasticity and endogeneity in the model, we use the estimation that combines feasible generalized least squares (FGLS) and instrumental variable (IV) techniques. This heteroskedasticity-corrected IV estimator is more asymptotically consistent than the ordinary least squares (OLS). The estimation procedures are: (1) divide all variables in Eq. (1) by the estimated error; (2) regress each of the endogenous variables on the relevant exogenous variables in Eq. (1) and obtain the estimated endogenous variables; (3) replace the endogenous variables with the estimated endogenous variables; and (4) estimate the model in step (3) with the OLS.

Table 2. Multivariate diagnostic tests for heteroskedasticity and endogeneity in the price dispersion model in 2000 and 2005.[a]

Diagnostic Test		2000	2005
Heteroskedasticity [b]			
Breusch-Pagan Test		F(33, 647,782) = 222** [0.001]	F(33, 772,176) = 804** [0.001]
White Test		F(2, 647,813) = 3,163** [0.001]	F(2, 772,207) = 2,579** [0.001]
Endogeneity [c]			
Load Factor	Origin	0.028** [0.001]	0.011** [0.001]
	Destination	0.017** [0.001]	0.001 [0.235]
Frequency	Origin	-0.009** [0.001]	-0.007** [0.001]
	Destination	-0.027** [0.001]	-0.020** [0.001]
Herfindahl Index	Origin	-0.001** [0.001]	-0.005** [0.001]
	Destination	-0.001 [0.384]	-0.005** [0.001]
Market Share	Origin	-0.002** [0.001]	-0.005** [0.001]
	Destination	-0.001 [0.752]	0.001** [0.001]
* Significant at the 5% level. ** Significant at the 1% level.			

[a] The paper uses the semi-log form of OLS estimation. P-values are presented in parentheses.
[b] The null hypothesis of homoskedasticity is used.
[c] Parameter estimates of residual are presented. The null hypothesis of exogeneity of the variable is used.

RESULTS OF PRICE DISPERSION MODELS

The estimation results

Table 3 shows the results of the heteroskedasticity-corrected IV estimation (Model 1) using the 2000 and 2005 data. Overall, most of the estimated coefficients are found to be statistically significant. The findings are summarized as follows. First, operating cost characteristics are found to be crucial determinants of price dispersion. Capacity, load factor, average segment distance, round trip, and ticket restriction all tend to have positive influences on price dispersion, suggesting that the differences in operation characteristics may affect variation in airfares, if markups of price over costs are held constant. That is, increases in these variables are likely to lower unit average operating costs, which enable the carriers to decrease airfares and utilize more complicated rate structures, thereby resulting in more price dispersion (Hayes and Ross 1998).

Table 3. Instrumental variable (IV) estimation (semi-log form) of price dispersion in 2000 and 2005.

Variable	Parameter Estimate [a]	
	2000	2005
INTERCEPT	-0.5113** (0.0210)	-0.4463** (0.0215)
$ORICAP_i$	0.0253** (0.0002)	0.0299** (0.0002)
$ORILOAD_i$	0.0277** (0.0013)	0.0104** (0.0015)
$ORIFREQ_i$	0.0121** (0.0015)	-0.0158** (0.0010)
$DESCAP_j$	0.0162** (0.0002)	0.0104** (0.0002)
$DESLOAD_j$	0.0254** (0.0012)	0.0069** (0.0014)
$DESFREQ_j$	0.0162** (0.0013)	0.0256** (0.0010)
$DIST_{ij}$	-0.1222** (0.0045)	-0.1737** (0.0025)
$AVGDIST_{ij}$	0.1334** (0.0035)	0.1734** (0.0024)
$ROUND_{ij}$	0.0374** (0.0004)	0.0304** (0.0004)
$TOUR_{ij}$	-0.0118** (0.0016)	0.0096** (0.0008)
$RESTRICT_{ij}$	0.0966** (0.0007)	0.0799** (0.0009)
$AVGPOP_{ij}$	0.0024** (0.0005)	0.0042** (0.0005)
$AVGINC_{ij}$	0.0025 (0.0028)	0.0043* (0.0021)
$ORIHUB_i$	0.0533** (0.0048)	-0.0052** (0.0019)
$ORISLOT_i$	0.0267** (0.0025)	0.0011 (0.0015)
$ORIHERF_i$	0.0936** (0.0081)	0.0075* (0.0037)
$ORISHARE_i$	-0.0051** (0.0002)	-0.0072** (0.0002)
$DESHUB_j$	0.0175** (0.0051)	-0.0130** (0.0019)
$DESSLOT_j$	0.0114** (0.0029)	-0.0221** (0.0015)
$DESHERF_j$	0.0238** (0.0087)	-0.0570** (0.0036)

$DESSHARE_j$	-0.0031** (0.0002)	-0.0007** (0.0002)
$LOWCOST_{ij}$	0.0223** (0.0022)	-0.0051** (0.0012)
$ORIMULTIPLE_i$	-0.0200** (0.0016)	-0.0015* (0.0007)
$DESMULTIPLE_j$	-0.0084** (0.0018)	0.0080** (0.0007)
AA_{ij}	-0.0143** (0.0008)	-0.0046** (0.0001)
UA_{ij}	-0.0305** (0.0007)	0.0095** (0.0009)
DL_{ij}	-0.0209** (0.0007)	0.0293** (0.0008)
CO_{ij}	-0.0194** (0.0010)	-0.0153** (0.0011)
NW_{ij}	-0.0162** (0.0007)	0.0203** (0.0008)
SW_{ij}	0.0075** (0.0011)	0.0688** (0.0013)
$Q1$	-0.0064** (0.0006)	0.0015* (0.0006)
$Q2$	-0.0002 (0.0006)	0.0020** (0.0006)
$Q3$	0.0030** (0.0006)	0.0000 (0.0006)
Adjusted R^2	0.2720	0.2216
F-value	7,335	6,662
* Significant at the 5% level. ** Significant at the 1% level.		

[a] Standard errors are presented in parentheses.

Second, demand characteristics tend to be important determinants of price dispersion. Load factor is found to have a positive effect on price dispersion, indicating that higher airfares for on-peak and congested periods influence price dispersion. For example, when a flight has a low load factor, airfares are likely to have less price dispersion. However, if most seats in an aircraft are reserved and few seats are available, the carriers are likely to increase airfares, which result in high airfare spreads.[xiv] Furthermore, slot-controlled airports are likely to be more frequently congested than other airports, which may result in greater price dispersion. Slot-controlled airports at origin are found to have a higher level of price dispersion for the 2000 and 2005 data. Third, market power and market competition are prominent factors in determining price dispersion. Market concentration, measured by Herfindahl index at origin, appears to have a positive impact on price dispersion, indicating that monopoly-type price discrimination dominates as market concentration increases. That is, higher market concentration is likely to increase price discrimination to business travelers, leading to greater price dispersion. Positive impacts of market concentration at origin are found in both 2000 and 2005. This finding is consistent with the previous literature by Gerardi and Shapiro (2007). Market competition, measured by the existence of a low cost carrier (LCC) in the markets, is found to have a positive effect on price dispersion in 2000. This indicates that the existence of LCC competition is likely to increase various discounted airfares to vacation travelers (competitive-type price discrimination), resulting in greater price dispersion in such markets. However, the variable is found to have an inverse effect on price dispersion in 2005. This opposite sign could be due to the fact that, with rising LCC competition between 2000 and 2005 (Table 1), carriers might have engaged in price wars that results in rigid low airfares.

In sum, many of the variables associated with market power and market competition characteristics have mixed impacts on price dispersion. The mixed effects may be explained by the carriers' price discrimination strategies for business and vacation travelers, which may produce the offsetting impacts on variation in their airfares. For example, carrier's market share is found to be negatively associated with price dispersion. A higher market share is likely to increase price discrimination to business travelers, leading to *greater price dispersion* for *higher airfares* (monopoly-type price discrimination). On the other hand, a high market share enables the carrier to have high pricing power that may decrease the number of discounted fares to vacation travelers, thereby resulting in *less price dispersion* for *lower airfares*. If this effect is larger than the impact of monopoly-type discrimination on price dispersion for total airfares, a higher market share may reduce price dispersion. These mixed effects indicate that an increase in market power may have positive or negative influence on price dispersion, depending on the carrier's price discrimination strategies for business and vacation travelers.

The carrier dummies are all statistically significant at the 5 percent level in 2000 and 2005, indicating that the individual carriers are pronounced determinants of price dispersion. Among the six carriers, American, United, Delta, Continental, and Northwest are associated with less price dispersion, while Southwest has greater price dispersion in 2000. This indicates that, relative to non-major carriers, all major carriers but Southwest may have adopted price discrimination strategies that lead to less dispersion for that year. Nevertheless, we observe a shift of pricing strategies for United, Delta, and Northwest that result in more price dispersion in 2005. These dummy variables appear to show that unobserved factors such as firms' management styles and strategies may result in the adoption of different pricing strategies over time. Since 2000, Southwest Airlines has been able to save billions of dollars by skillfully hedging against rising oil prices, while many of its competitors pay substantially more for oil on the spot market.[xv] This low fuel price translates into cost savings for Southwest, which in turn enables it to charge lower airfares and raise market share. Firms that pay higher fuel prices need to pass the higher cost to consumers or absorb the cost and incur a loss. However, as favorable as hedging may work for Southwest, fuel-price hedging does require large initial cash outlays. Many carriers either cannot afford or do not plan to adopt the hedging strategies. On the other hand, instead of hedging against rising oil prices or slashing airfares to compete with discount carriers, Continental and American Airlines target business travelers who are less price-sensitive (Farzad 2006). This may help explain the consistently less dispersed prices charged by the two companies in both 2000 and 2005.

We now use the estimated results of Model 2 to determine whether individual carriers and market conditions interact in the price dispersion model.[xvi] Market condition variables (hub airport, competition with an LCC, tourism areas, market share, and market competition) are assumed to be exogenous and beyond carriers' control. These exogenous factors could, however, affect individual carriers' strategic and pricing decisions. Hence, interactions between firm and market condition variables are essential and could shed some light on firms' pricing strategies under various market conditions. Overall, many of the estimated coefficients appear to be statistically significant at the 5 percent level.[xvii] Based on the results of the interaction models, the effects of individual carriers on price dispersion depend on the value (or the existence) of market conditions, suggesting that Model 2 is more appropriate than Model 1 for predicting price dispersion.

Estimated carriers' price dispersion

This section presents the magnitude of differences in price dispersion among carriers, given the market conditions. This can give information regarding the carriers' price discrimination strategies for different markets. To obtain estimated price dispersion, we use the parameter estimates from Model 2 and mean values of our sample.

Table 4 provides the results of estimated price dispersion of the carriers for the different market conditions in 2000 and 2005. The table includes the percentage dispersion differences of the six major carriers to non-major carriers to compare their price discrimination strategies. In 2005, for flights originating from a hub airport ($ORIHUB_i$), estimated Gini coefficients are higher for United (.21), Delta (.23), and Northwest (.22) than non-major carriers (.20), indicating that these carriers are likely to increase price discrimination and therefore lead to greater dispersion.

On the other hand, Continental (.19) is found to have less price dispersion than non-major carriers. Flights designating to a hub airport ($DESHUB_j$) are shown to have similar differences in the estimated Gini coefficients among the carriers. For the markets with the presence of an LCC ($LOWCOST_{ij}$) and tourism areas ($TOUR_{ij}$), the same patterns of estimated price dispersion are found. The estimated Gini coefficients are higher for United, Delta, Northwest, and Southwest than for non-major carriers, whereas the estimated Gini coefficient is lower for Continental in the same comparison. In particular, Southwest is found to have a much higher level of price dispersion than any other carriers, suggesting that Southwest increases competitive-type price discrimination. Using the mean characteristics of market concentration at the origin ($ORIHERF_i$),[xviii] estimated Gini coefficients are higher for United, Delta, Northwest, and Southwest than for the non-major carriers. On the other hand, estimated Gini coefficients are lower for American and Continental in the same comparison. Most of the carriers have similar differences using the mean value of market concentration at destination ($DESHERF_j$). In addition, for the mean market share at origin ($ORISHARE_i$) and destination ($DESSHARE_j$), United, Delta, Northwest, and Southwest have greater price dispersion than the other non-major carriers, whereas American and Continental have lower dispersion in the same comparison.

Overall, the results indicate that United, Delta, Northwest, and Southwest may have price discrimination strategies that lead to greater price dispersion than the non-major carriers, regardless of market conditions in 2005. In particular, Southwest is found to have much greater price dispersion, ranging from 32% to 43% higher than the non-major carriers. By contrast, American and Continental appear to have consistent price discrimination strategies, which lead to less price dispersion than the non-major carriers for all market conditions.

Table 4. Estimated price dispersion (Gini coefficient) and percentage price dispersion difference by carrier in 2000 and 2005.[a]

Year	Interaction	Estimated Price Dispersion (Gini Coefficient)						
		AA	UA	DL	CO	NW	SW	Others
2005	$ORIHUB_i$	0.20 (-0%)	0.21 (+5%)	0.23 (+15%)	0.19 (-5%)	0.22 (+10%)	N/A [b]	0.20 (0%)
	$DESHUB_j$	0.19 (-5%)	0.21 (+5%)	0.23 (+15%)	0.18 (-10%)	0.21 (+5%)	N/A [b]	0.20 (0%)
	$LOWCOST_{ij}$	0.20 (-0%)	0.22 (+10%)	0.24 (+20%)	0.19 (-5%)	0.21 (+5%)	N/A [b]	0.20 (0%)
	$TOUR_{ij}$	0.21 (-5%)	0.23 (+5%)	0.25 (+14%)	0.20 (-9%)	0.24 (+9%)	0.29 (+32%)	0.22 (0%)
	$ORIHERF_i$	0.20 (-5%)	0.24 (+14%)	0.26 (+24%)	0.20 (-5%)	0.22 (+5%)	0.28 (+33%)	0.21 (0%)
	$DESHERF_j$	0.21 (-0%)	0.24 (+14%)	0.25 (+19%)	0.21 (-0%)	0.26 (+24%)	0.28 (+33%)	0.21 (0%)
	$ORISHARE_i$	0.20 (-5%)	0.22 (+5%)	0.24 (+14%)	0.19 (-10%)	0.21 (+0%)	0.30 (+43%)	0.21 (0%)
	$DESSHARE_j$	0.20 (-5%)	0.22 (+5%)	0.24 (+14%)	0.19 (-10%)	0.24 (+14%)	0.28 (+33%)	0.21 (0%)
2000	$ORIHUB_i$	0.23 (-4%)	0.21 (-13%)	0.22 (-8%)	0.22 (-8%)	0.23 (-4%)	N/A[b]	0.24 (0%)
	$DESHUB_j$	0.18 (-5%)	0.17 (-11%)	0.18 (-5%)	0.16 (-16%)	0.17 (-11%)	N/A[b]	0.19 (0%)
	$LOWCOST_{ij}$	0.19 (-14%)	0.19 (-14%)	0.19 (-14%)	0.19 (-14%)	0.18 (-18%)	N/A[b]	0.22 (0%)
	$TOUR_{ij}$	0.16 (-11%)	0.15 (-17%)	0.16 (-11%)	0.16 (-11%)	0.16 (-11%)	0.19 (+6%)	0.18 (0%)
	$ORIHERF_i$	0.20 (+5%)	0.18 (-5%)	0.17 (-11%)	0.20 (+5%)	0.19 (-0%)	0.20 (+5%)	0.19 (0%)
	$DESHERF_j$	0.20 (+5%)	0.18 (-5%)	0.17 (-11%)	0.21 (+11%)	0.20 (+5%)	0.20 (+5%)	0.19 (0%)
	$ORISHARE_i$	0.17 (-11%)	0.16 (-16%)	0.17 (-11%)	0.17 (-11%)	0.18 (-5%)	0.20 (+5%)	0.19 (0%)
	$DESSHARE_j$	0.18 (-5%)	0.16 (-16%)	0.18 (-5%)	0.19 (-0%)	0.20 (+5%)	0.20 (+5%)	0.19 (0%)

[a] The percentage price dispersion differences to the non-major carriers (Others) are shown in parentheses.
[b] Not applicable because of the non-hub and LCC characteristics of Southwest.

As apparent from the table, the patterns of the carriers' price dispersion change for the period of 2000-2005. For example, United and Delta have a higher level of price dispersion than the non-major carriers for all the market conditions in 2005, but these carriers have a lower level of dispersion in the same comparison for all of the market conditions in 2000. Similarly, Northwest has more price dispersion for all market conditions in 2005. It is found to have more or less dispersion, depending on the market conditions, in 2000. The most distinct changes in estimated price dispersion for the 2000-2005 period are for Southwest. Although the carrier is still found to have more price dispersion than other carriers in 2000, the differences in its price dispersion to the non-major carriers is much smaller than those in 2005. The dispersion differences of Southwest to non-major carriers range from +5% to +6% in 2000, whereas they are between +32% to +43% in 2005. The results support that the carriers' price discrimination strategies may change over the period, thereby affecting price dispersion.

THE COMBINED RESULTS OF ESTIMATION OF PRICE DISPERSION AND AVERAGE PRICE

In addition to a price dispersion model, we examine an average price model using the same set of independent variables and the same observations. The average price model uses the average airfares weighted by the number of passengers (P_{ij} in Table 1) as the dependent variable. The combined results may provide a better explanation for each of the variables associated with one of the four types of pricing strategies: rigid monopoly-type prices, monopoly-type price discrimination, competitive-type price discrimination, and rigid competitive-type prices. For example, if a carrier has a positive impact on industry average price and a negative impact on price dispersion, the carrier's airfares are categorized as rigid monopoly-type prices. On the other hand, if a carrier has a positive impact on both average price and price dispersion, the carrier's airfares are categorized as monopoly-type price discrimination. Similar explanation is used for competitive-type prices. Thus, this approach can distinguish price dispersion due to monopoly-type discrimination from price dispersion due to competitive-type discrimination.

Table 5 shows the hypothesized market and carrier characteristics associated with the four types of airfares. For rigid monopoly-type prices, carriers are likely to have a very high level of monopolistic behaviors. The markets are highly concentrated, and the carriers' airfares are not influenced by fluctuations of cost and demand, which lead to rigid high airfares. For monopoly-type price discrimination, carriers are likely to have a moderate or high level of monopolistic behaviors. To maximize profits, carriers utilize various types of price discrimination (e.g., the second and the third degree price discrimination), which result in high airfares with more dispersion. For competitive-type price discrimination, on the other hand, markets are likely to be highly competitive and carriers may have low airfares with more dispersion. In such segment markets, the carriers should provide various discounted airfares deviated from full airfares. Finally, rigid competitive-type prices are associated with a very high level of competitive market behaviors, which are close to those in the perfect competition or highly competitive market. Given the estimated average airfare and price dispersion, major carriers' pricing strategies are categorized in a stylized manner to improve our understanding of the types of pricing strategies the carriers use under different market conditions.

Table 5. Hypothesized market and carrier characteristics associated with the four types of pricing strategies.

Type	Average Price	Level of Price Dispersion	Market and Carrier Characteristics
Type 1	High	Low	Rigid monopoly-type prices - High level of monopolistic market behaviors - High market share - Highly concentrated markets are likely to increase the level of price rigidity (airfares do not depend on fluctuations in cost and demand) - Carriers increase full fares to business travelers and decrease the number of discounted airfares to vacation travelers
Type 2	High	High	Monopoly-type price discrimination - Carriers use various types of price discrimination to maximize their profits including the first degree price discrimination (e.g., airfare auction), the second degree price discrimination (e.g., block pricing for bulk buy), and the third degree price discrimination (e.g., airline websites setting fares that vary by class, group, the date of booking, and the time of the flight)
Type 3	Low	High	Competitive-type price discrimination - High level of competitive market behaviors - Passengers have choices in the flight time and airlines (high cross-elasticity of demand among brands) - Airfares may be rapidly adjusted by cost changes
Type 4	Low	Low	Rigid competitive-type prices - High level of competitive market behaviors - Market structure is close to the perfect competition market or highly competitive market - Large number of consumers and carriers - Potential new entry if markets are profitable - Carriers provide low-markup airfares to business and vacation travelers

Table 6 shows the four types of pricing strategies for the major carriers given the market conditions in 2000 and 2005. American and Continental tend to have rigid prices under various market conditions in 2005. While American has both rigid monopoly-type and rigid competitive-type prices depending on market conditions, Continental has rigid monopoly-type prices for all of the market conditions. On the other hand, Northwest appears to use monopoly-type price discrimination for all of the market conditions. In addition, United uses both monopoly-type and competitive-type price discriminations, based on market conditions. Delta and Southwest have competitive-type price discrimination. These carriers have the same type of price discrimination for all market conditions. Overall, the results enable us to distinguish the sources of carriers' price dispersion. For example, Northwest and Delta have greater price dispersion than non-major carriers, but sources accounted for their price dispersions are different. The price dispersion of

Northwest may result from monopoly-type price discrimination strategies, whereas that of Delta may result from competitive-type price discrimination strategies.

In contrast to 2005, most of the carriers have different types of pricing strategies under the market conditions in 2000. American, United, Delta, Continental, and Northwest all have rigid monopoly-type prices for the markets with the existences of hub airports, LCC, and tourism areas in 2000. At the mean of the Herfindahl indexes, American, Continental, Northwest, and Southwest have competitive-type price discrimination. In addition, United, Delta, and Continental have rigid competitive-type prices at the mean of market shares. Overall, all carriers, except Southwest, adopt different types of pricing strategies depending on the market conditions. Only Southwest uses competitive-type price discrimination under all market conditions. Thus, this paper provides evidence that the carriers' pricing strategies may vary, depending on the market conditions and the time-periods.

Table 6. The four types of pricing strategies by carrier given the market conditions in 2000 and 2005.[a]

Year	Type	Origin Hub	Destination Hub	LCC	Tourism	Origin Herfindahl index	Destination Herfindahl index	Origin Share	Destination Share
2005	Type 1	*AA* *CO*	*AA* *CO*	*AA* *CO*	*AA* *CO*	*CO**	*CO**	*CO**	*CO**
	Type 2	*UA** *NW**	*UA** *NW**	*UA** *NW**	*UA** *NW**	*NW**	*NW**	*NW**	*NW*
	Type 3	*DL**	*DL**	*DL**	*DL** *SW*	*UA** *DL** *SW*	*UA** *DL** *SW*	*UA** *DL** *SW*	*UA** *DL** *SW*
	Type 4					*AA**	*AA**	*AA*	*AA**
2000	Type 1	*AA* *UA** *DL** *CO* *NW**	*AA* *UA** *DL** *CO* *NW**	*AA* *UA** *DL** *CO* *NW**	*AA* *UA** *DL** *CO* *NW**	*UA**	*UA** *DL**	*NW**	
	Type 2								*NW*
	Type 3				*SW*	*AA** *CO** *NW** *SW*	*AA** *CO** *NW** *SW*	*SW*	*AA** *SW*
	Type 4					*DL**		*AA* *UA** *DL** *CO**	*UA** *DL** *CO**

[a] The types of pricing strategies are determined by the estimated average airfare and the estimated price dispersion, in comparison to the non-major carriers.

* A change in the types of pricing strategies between 2000 and 2005.

CONCLUSIONS

This paper explores price dispersion in the U.S. airline industry and discusses the domestic carriers' price discrimination strategies. With quarterly observations for 2000 and 2005, we combined empirical results of price dispersion and average price to provide information on the sources of carriers' price dispersion.

The findings are summarized as follows. First, operating cost, demand, and market power characteristics are important determinants of price dispersion. For example, price dispersion increases with capacity, load factor, and average segment distance, implying that these operating cost factors affect price dispersion when price markups over costs are held constant. Similarly, price dispersion increases with market power, indicating that carriers' dominant power influence variation of markups if operating costs are fixed. Special attention is given to individual carriers' price discrimination strategies. American, United, Delta, Continental, and Northwest have less price dispersion, while Southwest has greater price dispersion in 2000. Regarding the impacts of individual carriers on price dispersion between 2000 and 2005, United, Delta, and Northwest are found to have less price dispersion for the periods of 2000 and 2005. This implies that these two carriers changed their price discrimination strategies for the period.

Second, this paper examines interaction between the carriers and market conditions. In examining variables of hub airport, existence of LCC, tourism areas, market share, and market competition, we find that the effect of individual carriers on price dispersion depends on these market conditions. This indicates that the carriers may use different pricing strategies depending on conditions of segment markets. For example, the threat of higher competition or characteristics of segment markets may affect individual carriers' pricing decision in such markets.

Third, we classify the carriers' pricing strategies based on the estimated average price and the estimated price dispersion. This provides important pieces of information on the sources of carriers' price dispersion. For instance, in 2005, both Northwest and Delta have a higher level of price dispersion than non-major carriers. However, sources for the price dispersion are found to be different. Monopoly-type price discrimination is likely to result in price dispersion for Northwest, while competitive-type price discrimination is likely to lead to price dispersion for Delta. Therefore, this paper provides evidence that the type of the pricing strategies is not equal across carriers.

ENDNOTES

[i] Stigler (1987) and Varian (1989) provide explanations for discriminatory prices based on differences in price markups and cost.
[ii] The terms "monopoly-type price discrimination" and "competitive-type price discrimination" were first coined by Borenstein and Rose (1994). They used both group's "industry" elasticity of demand (e.g., air travel on a given route) and group's cross-elasticity of demand among specific brands (e.g., flight time and airlines) to define these types of price discrimination. If a market is more competitive, the segment passengers based on their cross-elasticity of demand are likely to produce a higher level of price dispersion (competitive-type price discrimination). On the other hand, monopoly-type discrimination, in which passengers are sorted by their industry elasticities of demand, is likely to create a higher level of price dispersion when a market is closer to monopoly.
[iii] For example, Southwest Airlines has a Gini coefficient of 0.38, while Northwest Airlines 0.22 in 2005.
[iv] Hayes and Ross (1998) include carrier effects (e.g., Southwest Airlines) in a price dispersion model, but provide inconclusive findings because of mixed signs of coefficients.
[v] Operating cost characteristics may also influence demand characteristics.
[vi] The semi-log form provides a better model fit than other forms examined. We used one-way route data, which included both direct and non-direct flights but did not combine the city-pair data for AB and BA routes. In addition, we built route-specific variables by itinerary, carrier, quarter and other flight characteristics (e.g., $AVGPOP_{ij}$) and airport-specific variables by airport, carrier, quarter and other flight characteristics (e.g., $ORICAP_i$). Airport-specific variables are used for capacity, load factor, frequency, Herfindahl index, carrier's market share, and multiple airports because route data are unavailable for these variables.
[vii] This paper modifies the definitions of the two types of price discrimination given by Borenstein and Rose (1994) by considering empirically changes in average prices and price dispersion. This slight modification enables us to clearly show different types of pricing strategies based on empirical results.
[viii] Given constant cost, higher average airfares imply larger markups over cost. By contrast, lower average airfares mean the smaller markups over cost.
[ix] 2005 is also the most recent annual data available in February, 2006.
[x] The Gini coefficient is calculated as follows:
$PD_{ij} = 1 - 2 \times \left(\sum_{i=1,N} P_i \times \frac{PAX_i}{total \quad revenues} \right) \times \left(\frac{PAX_i}{total \quad PAX} + \left(1 - \sum_{j=1,i} \frac{PAX_j}{total \quad PAX} \right) \right)$, where N is the number of different airfare tickets from origin i to destination j, P_i is the reported airfare for the i^{th} ticket, and PAX_i is the number of passengers traveling at that rate (Borenstein and Rose 1994).
[xi] We adopt the method used by Bitzan and Chi (2006), which results in removing any fares higher than $1.22 and $1.20 per passenger-mile for 2000 and 2005 data in this paper.
[xii] It should note that major carriers used in this paper are not official major carriers with more than $1 billion in revenue during a fiscal year. Non-major carriers defined in this paper have only 29% of total passenger-miles.
[xiii] Borenstein and Rose (1994) treat frequency, market share, and Herfindahl index variables as possible endogenous variables and find that there is some evidence of endogeneity for frequency and market share, but none for Herfindahl index.
[xiv] Pattison (2001) also argues that the peak-load prices should bear all the capacity costs, when the total capacity is fully utilized at on-peak times.
[xv] For example, in 2008, 70 percent of Southwest's fuel needs are hedged at a price of $51 per barrel, while its rivals are paying over or about $120 per barrel (Herbst 2008).
[xvi] This paper used each of the market factors separately and estimated it with all of the carrier's dummies. This produces a simple model with the least number of highly correlated variables and the fewest independent variables. If all of the interaction terms are added to the base model, it generates large number of highly correlated variables and the number of explanatory variables increases.
[xvii] The results show that 34 and 36 interaction terms are significant out of total 45 interactions in 2000 and 2005, respectively. The results of the interaction model (Model 2) are not included due to a large quantity of tables, but they are available upon request.
[xviii] This paper uses 0.34 and 0.33 of the Herfindahl index at origin ($ORIHERF_i$) and destination ($DESHERF_j$) and 29% and 27% of carrier's market share at origin ($ORISHARE_i$) and destination ($DESSHARE_j$) in 2005, respectively.

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APPENDIX A. SOURCES OF PRICE DISPERSION AND EXPECTED SIGNS OF VARIABLES

This paper uses various variables related to market power, operating cost, and demand characteristics as possible sources of price dispersion. First, Herfindahl index, market share, dummies for hub airport and LCC, and multiple airport variables are used to explore price dispersion in the segment markets. Market power characteristics can have positive or negative influences on price dispersion, depending on the dominant impact of monopoly-type or competitive-type price discrimination in segment markets. If monopoly-type price discrimination dominates, the level of price dispersion is likely to increase with market power. In other words, increases in market concentration and market share can be associated with more price dispersion under monopoly-type price discrimination. However, if competitive-type price discrimination dominates, the level of price dispersion may decrease with market power. Similarly, the existence of LCC competition and multiple airports may lead to less price dispersion under monopoly-type price discrimination, while they are likely to result in greater price dispersion under competitive-type price discrimination. Therefore, the expected signs on the variables are ambiguous.

Second, this paper addresses a cost-based explanation as well as a discrimination-based explanation for price dispersion. If markups of price over cost are held constant, the differences in operating costs may influence price dispersion. Borenstein and Rose (1994) and Hayes and Ross (1998) discuss peak-load and congestion pricing for the cost-based explanation. Peak-period demands should bear all the capital costs of the capacity, whereas off-peak demands should bear only running costs (Pattison 1973). In this paper, an average load factor is used to explore price dispersion as well.[xviii]. That is, when a flight has a low load factor, airfares are likely to have less dispersion. However, when the number of reserved seats reaches the maximum available seats and few seats are left, the carrier is likely to charge airfares that lead to high airfare spreads. Similarly, the paper uses a dummy for slot-controlled airports and average capacity of flight for the same reason. The slot-controlled airports are likely to be more frequently congested than other airports, resulting in greater price dispersion. In addition, a high capacity may increase price dispersion because flights with a high capacity generally serve larger number of passengers and the flights will not have fewer discount seats during on-peak periods, leading to greater price dispersion (Borenstein and Rose 1994). Therefore, positive signs of coefficient for the variables are expected. Moreover, total distance, average segment distance, and dummies for round trip and ticket restriction are included on the basis of operating cost differentials. For instance, an increase in total distance may create more differences in operating costs, which may lead to more complicated rate structures and more price dispersion (Hayes and Ross 1998). Similarly, an increase in average distance and existence of round trip and ticket restrictions are likely to increase the carrier’s ability in utilizing complicated rate structures. Thus, positive signs of coefficient for these variables are expected.

Third, demand characteristics are used as possible sources of price dispersion. This paper includes various demand characteristics (population, income, frequency, and seasonal effects) because these factors can affect air passenger-miles, which may in turn influence price dispersion. Borenstein and Rose (1994) argue that greater population and flight density is likely to produce greater equilibrium product variety, which may affect both monopoly-type and competitive-type discriminations. For example, more frequent flights may increase the demand for air-passenger service and reduce industry elasticities, which increase price dispersion. On the other hand, more frequent flights are likely to reduce the time between flights and increase cross-elasticities among flight times, which may affect price dispersion. The expected signs of coefficient for the variables are ambiguous. For the tourism area variable, a negative sign of coefficient is expected because a high concentration of vacation travelers in markets is likely to decrease price dispersion in comparison to the markets where business and vacation travelers are evenly distributed.