Price Dispersion in the U.S. Airline Industry

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This paper explores price dispersion in the U.S. airline industry by highlighting differential individual carriers' pricing strategies. Using instrumental variables (IV) estimation, the results show that individual carriers play crucial roles in determining price dispersion, implying that their price discrimination strategies may influence variation in airfares. Based on observed price dispersion and average price, we distinguished sources of price dispersion and found that the pricing strategies varied across U.S. air carriers. 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.

INTRODUCTION

Airline pricing is dynamic and complicated because it involves multiple supply- and demand-driven conditions that shape the airlines' strategies in different markets. Airline pricing research improves knowledge of market structure and competitiveness of the industry, and sheds 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 groups. Without comprehensive information on the carriers' price discrimination strategies, it is difficult to understand pricing behaviors in the domestic airline industry.

Previous research has 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[1] alone and greater market competition is associated with higher levels of price dispersion in the domestic airline markets.[2] A one standard deviation reduction in the Herfindahl-Hirschman (Herfindahl) Index from its mean is found to increase the Gini coefficient by 14%. 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, the study 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, thus, price discrimination alone is not evidence of market power. On the contrary, Gerardi and Shapiro (2009) find that market competition is negatively associated with price dispersion, which supports the traditional explanation of price discrimination.

While previous studies provided valuable information on price discrimination in the U.S. airline industry, the empirical findings were inconsistent. The inconsistencies may be explained by the different types of price discrimination, such as monopoly-type and competitive-type price discrimination.[3] 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. This results in a negative relationship between market power and price dispersion (competitive-type price discrimination). Because market structures in most domestic segment markets range between monopoly and perfect competition, the markets are likely to have both monopolistic and competitive market forces.[4] This indicates that markets may have offsetting impacts between these market forces, 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.

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 unique carriers' pricing strategies in their segment markets. The data used in this paper show that the extent of price dispersion can vary by carriers.[5]

The objective of the paper is to provide comprehensive information on individual carriers' pricing strategies. It examines the impacts of individual carriers on price dispersion, categorizes the extent and type of price discrimination under different market conditions, and discusses the carriers' pricing strategies in a stylized manner.[6] In particular, carriers' pricing strategies are categorized 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 sources of price dispersion and carriers' pricing strategies. The information may help policymakers and carrier managers understand the domestic carriers' pricing strategies and make their decisions.

The rest of the paper is organized in the following manner: the section that follows describes the extent and type of price discrimination. The third section provides the price dispersion model and data description. Discussion of the econometric procedures and the results of price dispersion model follow. This paper then presents the estimated price dispersion under different market conditions. Based on observed price dispersion and average price, the types of pricing strategies are discussed. Finally, concluding remarks are provided in the last section.

THE EXTENT AND TYPE OF PRICE DISCRIMINATION

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 that due to competitive market forces. To do this we redefine monopoly-type price discrimination and competitive-type price discrimination by considering changes in average price and price dispersion.[7] In this paper, monopoly-type price discrimination is defined as discriminatory pricing that increases variations in markups of price over cost to the travelers who have low own-price, cross-price, and industry elasticities of demand. That is, fare changes of their tickets, other flights, other airlines, and other transportation modes do not affect these travelers' behaviors (e.g., business travelers). Therefore, carriers are likely to use monopoly-type price discrimination based on passengers' elasticities of demand, which leads to *higher average airfares*[8] and *higher price dispersion*. On the other hand, competitive-type price discrimination is defined as discriminatory pricing that increases price variations to the travelers who have high own-price, cross-price, and industry elasticities of demand. The price changes for their tickets, other flights, other airlines, and other transportation modes can largely affect their travel behaviors. For example, vacation travelers are likely to switch their reservations to different airlines for lower fares. Thus, competitive-type price discrimination may be used by airlines for these vacation travelers, which results in *lower average airfares* and *greater price dispersion*. 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.*

Table 1 shows the hypothesized market and carrier characteristics associated with the four types of airfares. For the rigid monopoly-type prices, carriers are likely to show 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 the 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., second and 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 greater dispersion. In such segment markets, the carriers would 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. In the paper, this criterion is used to identify the carriers' pricing strategies for different markets.

Table 1: 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

THE PRICE DISPERSION MODEL

Price dispersion is modeled as a function of operating cost factors, demand characteristics, market power, and individual carrier effects. Operating cost factors include capacity ($ORICAP_i$ and $DESCAP_j$), load factor ($ORILOAD_i$ and $DESLOAD_j$), flight frequency at origin and destination ($ORIFREQ_i$ and $DESFREQ_j$), distance ($DIST_{ij}$), round trip ($ROUND_{ij}$), and ticket restriction ($RESTRICT_{ij}$).[9] In this paper, the capacity is measured as the average size of aircraft (number of seats) and the load factor is calculated by dividing passenger-miles by available seat-miles. The capacity, load factor, and flight frequency variables are created by carrier, quarter, and airport (origin and destination).

In addition, we use population ($AVGPOP_{ij}$), income ($AVGINC_{ij}$), tourism areas ($TOUR_{ij}$), and route variables ($ORIHUB_i$, $DESHUB_j$, $ORISLOT_i$, $DESSLOT_j$, $ORIMULTIPLE_i$, and $DESMULTIPLE_j$) as the factors influencing demand for air-passenger service. Dummy variables are used for hub airports, slot control airports, and multiple airports available in a city. The $ORIHUB_i$ ($DESHUB_j$) is equal to one if an origin (destination) airport is the carrier's major hub airport. The $ORISLOT_i$ ($DESSLOT_j$) is equal to one if an origin (destination) airport is a slot-controlled airport (O'Hare, LaGuardia, JFK, or Ronald Reagan airport). For the $ORIMULTIPLE_i$ ($DESMULTIPLE_j$), it is equal to one if more than one airport is available at origin (destination) city.

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. The Herfindahl-Hirschman Index is employed to measure market concentration at origin and destination. For the market share variables, segment market share of passengers by carrier is used at origin and destination. The dummy for low cost carrier competition is equal to one if the route is served by a low cost carrier (LCC).[10] Table 2 provides a description of these variables, including how to create the variables.

In addition, dummy variables are included for carriers like American (AA_{ij}), United (UA_{ij}), Delta (DL_{ij}), Continental (CO_{ij}), Northwest (NW_{ij}), and Southwest Airlines (SW_{ij}) to capture unobserved firms' effects. The fourth quarter is the base for seasonal comparison (*Q1, Q2,* and *Q3*). Specifically, the price dispersion from origin *i* to destination *j* is estimated as follows:[11]

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

where β_i are the coefficients of independent variables. The data are arranged by route/airport, carrier, quarter, ticket restriction, and round trip.

This paper uses various variables related to market power, operating cost, and demand characteristics as possible sources of price dispersion. First, the Herfindahl index, market share, hub airport, and multiple airport variables are used to explore price dispersion in the segment markets. Market power characteristics can have positive (negative) influences on price dispersion, depending on the dominant impact of monopoly-type (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 the competitive-type price discrimination dominates, the level of price dispersion may decrease with market power. Similarly, the existence of multiple airports may lead to less price dispersion under monopoly-type price discrimination, while it is likely to result in greater price dispersion under competitive-type price discrimination. Therefore, the expected signs of 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 operating costs (Pattison 1973). In this paper, an average load factor is used to examine this effect. 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 dummy for slot-controlled airport ($ORISLOT_i$ and $DESSLOT_j$) and average capacity of flight are used 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 a larger number of passengers during on-peak periods, and this creates high fare spreads (Borenstein and Rose 1994). Therefore, positive signs of the variables are expected. Moreover, total distance, average segment distance, round trip, and ticket restriction variables are included on the basis of operating cost differentials. For instance, an increase in total distance may reduce operating costs per passenger, 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 these variables can be expected.

Third, demand characteristics are used as possible sources of price dispersion. This paper includes various demand characteristics (population, income, flight frequency, and seasonal effects) because these factors can affect the demand for air-passenger service, 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 discrimination. For example, a high frequency of flights may increase the demand for air-passenger service and reduce industry elasticities, which increase price dispersion. On the other hand, frequent flights reduce the time between flight departures and are likely to increase cross-elasticities among flights, which may affect price dispersion. The expected impacts of the variables are ambiguous. However, for the tourism area variable, a negative sign can be expected because a high concentration of vacation travelers in markets is likely to decrease price dispersion compared with the markets where business and vacation travelers are evenly distributed.

Data used in this paper come from various sources, including the U.S. Department of Transportation, the U.S. Department of Labor, the U.S. Department of Commerce, and the U.S. Census Bureau. The primary data sources are the *Origin and Destination Survey* (DB1B) sample and *T-100 Domestic Segment* data from the U.S. Department of Transportation (Bureau of Transportation Statistics 2007). The DB1B contains a 10% sample of tickets from reporting carriers, which includes items such as operating and ticketing carriers, number of passengers, and airfares. The DB1B is used to measure the Gini coefficient.[12] 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). Because of the nature of sample data, we carefully examined and eliminated the top and bottom 1% of airfare data to remove outliers.[13] The T-100 domestic segment data are used to create capacity, load factor, flight frequency, Herfindahl index, and market share variables. The T-100 domestic segment data contain items such as numbers of departures, seats, and passengers for single-segment markets. American Airlines, United Airlines, Delta Air Lines, Continental Airlines, Northwest Airlines, and Southwest Airlines 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).[14]

This paper uses all U.S. itineraries of economy class (quarterly data) for 2000 and 2005.[15] The sample sizes for 2000 and 2005 data are 647,816 and 772,210 observations, respectively. As found in Table 2, the average Gini coefficients of airfares per passenger-mile 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% from $0.26 in 2000 to $0.21 in 2005. The average seat capacity at origin ($ORICAP_i$) and destination ($DESCAP_i$) decreased by 18%. The load factors at origin ($ORILOAD_i$) and at destination ($DESLOAD_i$) averaged 66% in 2000 and 72% in 2005. Upward trends in load factor are also found in the T-1 tables, Bureau of Transportation Statistics (2007). Carriers' frequency of flights at origin ($ORIFREQ_i$) and at destination ($DESFREQ_j$) decreased by 22% between 2000 and 2005. Total distance ($DIST_{ij}$) averaged 1,320 miles, while the average segment distance ($AVGDIST_{ij}$) was approximately 700 miles in both years. The average population of origin and destination cities was less than three million. The nominal average per-capita income of origin and destination cities was about $31,000 in 2000 and rose to about $36,000 in 2005. Market concentration measured by the Herfindahl indexes at origin and destination were roughly the same at 0.34 in 2005. 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.

A total of 56% of the tickets were round-trip. Roughly 80% of the trips departed from or arrived in a tourism area. The tourism area ($TOUR_{ij}$) includes a list of 50 tourism cities from the *Office of Travel and Tourism Industries,* U.S. Department of Commerce (2007). The dummy is equal to one if the market share for 2001 overseas visitors is equal to 0.5% or greater. Otherwise, it is equal to zero. This paper assumes that overseas and domestic travelers have the same tourist destinations; the tourism areas include New York City, Los Angeles, Miami, Orlando, San Francisco, Oahu/Honolulu, Las Vegas, Washington, D.C., and Chicago.

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

Existence of competition with low-cost carriers (LCC) increased from an average of 34% in 2000 to 44% in 2005, implying the intensity of competition with LCC rose over time. In the sample data, the six carriers constitute 60% of the carriers in 2000, but only 42% in 2005. This 18% drop reflects an increase in the number of other carriers (base group) from 40% in 2000 to 58% in 2005. Non-major carriers include regional carriers such as JetBlue, Frontier, and Midwest.

This paper estimates two price dispersion models: the models without carriers' interaction terms (Model 1) and with the interaction terms (Model 2). Model 1 is used to examine the impacts of operating cost, demand, market power, and individual carrier factors on price dispersion as shown in Eq. (1). On the other hand, Model 2 is used to determine whether individual carriers and market conditions interact.

THE ECONOMETRIC PROCEDURES

Diagnostic tests for multicollinearity, heteroskedasticity, and endogeneity are conducted to provide a robust price dispersion model. First, the Breusch-Pagan (1979) and the White (1980) tests are used to detect heteroskedasticity in the model. As shown in Table 3, the null hypothesis of homoskedasticity can be rejected at the 5% level of significance in both 2000 and 2005, indicating that heteroskedasticity is present in the model. Second, the Hausman exogeneity test is used to check

Table 2: Description of Variables Used in the Price Dispersion and Average Price Models in 2000 and 2005 [a]

Variable	2000		2005		Description
	Mean	Std. Dev.	Mean	Std. Dev.	
PD_{ij}	0.19	0.19	0.20	0.21	Gini Coefficient of airfares per passenger-mile from origin *i* to destination *j*
P_{ij}	0.26	0.22	0.21	0.19	Average airfare per passenger-mile ($) from origin *i* to destination *j*
$ORICAP_i$ [b]	120	42	98	48	Average seat capacity at origin *i*
$ORILOAD_i$ [c]	0.66	0.11	0.72	0.10	Average load factor at origin *i*
$ORIFREQ_i$	2,490	5,746	1,930	4,807	Total frequency of flights by carrier at origin *i*
$DESCAP_j$ [b]	119	42	98	48	Average seat capacity at destination *j*
$DESLOAD_j$ [c]	0.66	0.11	0.72	0.11	Average load factor at destination *j*
$DESFREQ_j$	2,415	5,671	1,879	4,755	Total frequency of flights by carrier at destination *j*
$DIST_{ij}$	1,319	866	1,320	850	Total distance (miles) from origin *i* to destination *j*
$AVGDIST_{ij}$ [d]	701	426	700	423	Average stage distance (miles) from origin *i* to destination *j*
$AVGPOP_{ij}$	2,891,166	2,846,296	2,836,287	2,829,904	Average population of origin and destination cities
$AVGINC_{ij}$	31,114	3,986	35,669	4,317	Average per-capita income of origin and destination cities
$ORIHERF_i$ [e]	0.35	0.21	0.34	0.20	Herfindahl-Hirschman Index at origin *i*
$ORISHARE_i$ [f]	0.25	0.26	0.29	0.26	Carrier's market share at origin *i*
$DESHERF_j$ [e]	0.35	0.21	0.33	0.19	Herfindahl-Hirschman Index at destination *j*
$DESSHARE_j$ [f]	0.25	0.26	0.27	0.25	Carrier's market share at destination *j*
Dummy					
$ROUND_{ij}$ [g]	0.56	0.50	0.56	0.50	=1 if a flight is a round trip, =0 otherwise
$TOUR_{ij}$ [h]	0.81	0.39	0.79	0.41	=1 if an origin or destination city is located in tourism areas, =0 otherwise
$RESTRICT_{ij}$ [i]	0.64	0.48	0.80	0.40	=1 if a ticket has a restriction(s) , =0 otherwise

Table 2: Description of Variables Used in the Price Dispersion and Average Price Models in 2000 and 2005 Continued)

$ORIHUB_i$ [j]	0.89	0.31	0.85	0.35	=1 if an origin airport is carrier's major hub airport, =0 otherwise
$DESHUB_i$ [j]	0.90	0.31	0.90	0.30	=1 if a destination airport is carrier's major hub airport, =0 otherwise
$ORISLOT_i$ [k]	0.05	0.21	0.04	0.19	=1 if an origin airport is a slot-controlled airport, =0 otherwise
$DESSLOT_j$ [k]	0.05	0.21	0.05	0.21	=1 if a destination airport is a slot-controlled airport, =0 otherwise
$ORIMULTIPLE_i$ [l]	0.30	0.46	0.27	0.45	=1 if multiple airports are available at origin city, =0 otherwise
$DESMULTIPLE_j$ [l]	0.30	0.46	0.30	0.46	=1 if multiple airports are available at destination city, =0 otherwise
$LOWCOST_{ij}$ [m]	0.34	0.47	0.44	0.50	=1 if the route is served by a low cost carrier (LCC), =0 otherwise
AA_{ij}	0.10	0.30	0.06	0.24	=1 if American Airlines is an operating carrier, =0 otherwise
UA_{ij}	0.11	0.31	0.07	0.25	=1 if United Airlines is an operating carrier, =0 otherwise
DL_{ij}	0.16	0.37	0.11	0.31	=1 if Delta Air Lines is an operating carrier, =0 otherwise
CO_{ij}	0.05	0.22	0.03	0.18	=1 if Continental Airlines is an operating carrier, =0 otherwise
NW_{ij}	0.12	0.33	0.09	0.29	=1 if Northwest Airlines is an operating carrier, =0 otherwise
SW_{ij}	0.06	0.24	0.06	0.24	=1 if Southwest Airlines is an operating carrier, =0 otherwise
Q1	0.24	0.43	0.24	0.43	=1 if it is the first quarter, =0 otherwise
Q2	0.26	0.44	0.25	0.43	=1 if it is the second quarter, =0 otherwise
Q3	0.25	0.43	0.25	0.43	=1 if it is the third quarter, =0 otherwise

[a] It is noteworthy that the summary statistics are calculated from the regression data used in this paper and they may not be same as the mean values of aggregated data. For example, the mean value of the dummy for multiple airports at origin is .3, indicating that 30% of total observations in the regression data have multiple airports available at origin.

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

[c] Average load factor is the average number of purchased seats divided by the number of available seats. It is weighted by the number of departures (arrivals).

[d] The average stage distance is the total distance divided by the number of segments made to destination. It is weighted by the number of passengers.

[e] The Herfindahl-Hirschman Index is the sum of the squares of individual segment market share of passengers of all ticketing carriers at origin/destination market.

[f] The carrier's market share is the number of carrier's passengers divided by total passengers at origin (destination).

[g] The dummy for a round trip is equal to one if origin and final stop are the same and a ticket is not circle trips, which involve more than one destination.

[h] A list of 50 tourism areas was obtained from the *Office of Travel and Tourism Industries* (OTTI), U.S. Department of Commerce (2007).

[i] The dummy for a restricted ticket is equal to one if the DB1B observations are recorded as a restricted ticket. First classes for Southwest reported in the DB1B were treated as coach classes in this paper.

[j] The dummy for the hub airports at origin (destination) is equal to one if the origin (destination) airport is the carrier's own major hub airport.

[k] The dummy for slot-controlled airports is equal to one if the origin (destination) airport is O'Hare International, Laguardia, JFK International, or Ronald Reagan National airports.

[l] The dummy for multiple airports is equal to one if multiple airports are located in a same city of a Metropolitan Statistical Area (MSA). Because of lack of information on travelers' airport-choice behaviors from a MSA to others, we used the MSA for the variable.

[m] A list of low-cost carriers (LCCs) is obtained from Ito and Lee (2003).

Table 3: The Results of Heteroskedasticity and Endogeneity Tests in the Price Dispersion Model in 2000 and 2005 [a]

		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]	$ORILOAD_i$	0.028** [0.001]	0.011** [0.001]
	$DESLOAD_j$	0.017** [0.001]	0.001 [0.235]
	$ORIFREQ_i$	-0.009** [0.001]	-0.007** [0.001]
	$DESFREQ_j$	-0.027** [0.001]	-0.020** [0.001]
	$ORIHERF_i$	-0.001** [0.001]	-0.005** [0.001]
	$DESHERF_j$	-0.001 [0.384]	-0.005** [0.001]
	$ORISHARE_i$	-0.002** [0.001]	-0.005** [0.001]
	$DESSHARE_j$	-0.001 [0.752]	0.001** [0.001]

* Significant at the 5% level.
** Significant at the 1% level.

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

for the possible endogeneity of load factor, flight frequency, Herfindahl index, and market share variables.[16] Under competitive-type price discrimination, load factor and flight 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 services, thereby influencing load factor and frequency of service. Similarly, the Herfindahl index and market share variables may all be 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 3 shows that the null hypothesis of exogeneity can be rejected at the 5% significance level for most of the variables, indicating that these variables are endogenous. The 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 remedy the problems of heteroskedasticity and endogeneity, this paper uses 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 as follows: the FGLS is performed by dividing all variables in Eq. (1) by the estimated errors. Each of the endogenous variables is then regressed on the exogenous variables in Eq. (1) and instruments to obtain the fitted values of the endogenous variables.[17] Finally, the model is estimated with the exogenous variables and the fitted values of the endogenous variables.

RESULTS OF PRICE DISPERSION MODELS

The Estimation Results

Table 4 shows the results of the heteroskedasticity-corrected IV estimation (Model 1) using the 2000 and 2005 data. As is apparent from the table, most of the estimated coefficients are significant at the 5% level. 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 average unit operating costs, which enable the carriers to decrease airfares and utilize more complicated rate structures, thereby resulting in greater price dispersion (Hayes and Ross 1998). 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 demand 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.[18] 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. Carrier's market share is shown to have a negative effect on price dispersion, indicating that competitive-type price discrimination dominates as the market becomes more competitive. Similarly, market concentration, measured by the Herfindahl index at origin, appears to have a positive impact on price dispersion. This implies that competitive-type price discrimination dominates when a carrier's market share is kept constant and the market becomes more concentrated around the carrier. That is, if a carrier's market power shrinks, this is likely to increase competitive-type price discrimination. Positive impacts of market concentration at origin are found in both 2000 and 2005.

Some variables have mixed impacts on price dispersion between 2000 and 2005. The mixed effects may be explained by the carriers' price discrimination strategies for business and vacation travelers, which may produce the offsetting impacts on variations in their airfares. For example, market concentration at destination ($DESHERF_j$) is found to be positively associated with price dispersion in 2005. A higher market concentration around the carrier may increase various discounted fares to vacation travelers, leading to *greater price dispersion* for *lower airfares* (competitive-type price discrimination). On the other hand, a high market concentration around the carrier may decrease the number of high mark-up fares to business travelers, thereby resulting in *less price dispersion* for *lower airfares*. If this effect is larger than the impact of competitive-type discrimination on price dispersion for total airfares, a higher market concentration may reduce price dispersion. These mixed effects indicate that a decrease in market power may have a 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% 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 greater 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

Table 4: Instrumental Variable (IV) Estimation 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)

Table 4: Instrumental Variable (IV) Estimation of Price Dispersion in 2000 and 2005 (cont.)

$LOWCOST_{ij}$	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.

save billions of dollars by skillfully hedging against rising oil prices, while many of its competitors paid substantially more for oil on the spot market.[19] 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 favorably as hedging worked 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.

Model 2 is employed to determine whether individual carriers and market conditions interact in the price dispersion model.[20] Market condition variables (hub airport, tourism areas, market share, and market competition) are assumed to be beyond carriers' control. However, these factors could 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% level.[21] Based on the results of the interaction models, the effects of individual carriers on price dispersion depend on the value (or 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 under different market conditions. To obtain estimated price dispersion, we use the parameter estimates from Model 2 and mean values of our sample.

Table 5 provides the results of estimated price dispersion of the carriers for the different market conditions in 2000 and 2005. The table includes the dispersion differences of the six major carriers to non-major carriers to discuss their price discrimination strategies. In 2005, for flights originating from a hub airport ($ORIHUB_i$), estimated Gini coefficients are higher for United (0.21), Delta (0.23), and Northwest (0.22) than non-major carriers (0.20), indicating that these carriers are likely to increase price discrimination and, therefore, lead to greater dispersion. On the other hand, Continental (0.19) is found to have less price dispersion than non-major carriers. Flights with destinations of hub airports ($DESHUB_j$) are shown to have similar differences in the estimated Gini coefficients among the carriers. For the tourism area markets ($TOUR_{ij}$) in 2005, the estimated Gini coefficients are higher for United, Delta, Northwest, and Southwest than for non-major carriers, whereas they are lower for American and 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 2005 mean characteristics of market concentration at the origin ($ORIHERF_i$),[22] 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 differences similar to $ORIHERF_i$ using the mean value of market concentration at destination ($DESHERF_j$). In addition, for the average market shares 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 less price 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 has much greater price dispersion, ranging from 32% to 43% higher than the non-major carriers. In 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.

As shown in the table, the patterns of the carriers' price dispersion change for the period 2000-2005. For example, United and Delta have a higher level of price dispersion than the non-major carriers for all of 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 greater 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 greater 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. This supports evidence that the carriers' price discrimination strategies may change over the period, thereby affecting price dispersion.

Table 5: Estimated Price Dispersion (Gini Coefficient) and 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%)
	$TOUR_{ij}$	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%)
	$TOUR_{ij}$	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 price dispersion differences relative to the non-major carriers (Others) are presented in parentheses.
[b] Not applicable because Southwest does not use major hub airports.

THE COMBINED RESULTS OF ESTIMATION OF PRICE DISPERSION AND AVERAGE PRICE

In addition to a price dispersion model, we examine the average price 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 2) 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. A 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. We answer the question of how high is high and how low is low by comparing major carriers' price dispersion with the non-major carriers.

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, and 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 the sources that 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 hub airports and tourism areas in 2000. At the mean value 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 value of origin and destination 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.

CONCLUSIONS

This paper explores price dispersion in the U.S. airline industry and discusses the domestic carriers' pricing 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 influences 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 2000-2005 period.

Second, this paper examines the interactions between carriers and market conditions. In examining hub airport, 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.

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	Tourism	Origin Herfindahl index	Destination Herfindahl index	Origin Share	Destination Share
2005	Type 1	*AA* *CO*	*AA* *CO*	*AA* *CO*	*CO**	*CO**	*CO**	*CO**
	Type 2	*UA** *NW**	*UA** *NW**	*UA** *NW**	*NW**	*NW**	*NW**	*NW*
	Type 3	*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**	*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 carrier's estimated price dispersion and average airfare relative to the non-major carriers.
* A change in the types of pricing strategies between 2000 and 2005.

Third, given the estimated price dispersion and average airfare, 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. 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 the same across carriers.

Endnotes

1. Stigler (1987) and Varian (1989) provide the explanations for discriminatory prices based on differences in price markups and cost.

2. Price dispersion can be defined as variation in airfares charged for the same ticket across carriers, holding all other characteristics constant. There are two major sources of price dispersion: 1) heterogeneities in costs or service levels and 2) pricing strategies by carriers.

3. 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.

4. It should be noted that U.S. airline industry is not a contestable market based on theoretical and empirical findings. A contestable market is a market structure in which entry into an industry is free and exit is costless, which makes the potential new entrants affect the price decisions of incumbent firms (Griffiths and Ison 2001). Theoretically, the requirements of contestable markets do not apply in most of the city-pair markets because carriers need capital resources to enter new markets. In addition, many empirical studies found that perfect contestability is not applicable in the U.S. airline industry (Graham et al. 1983; Bailey et al. 1985; Morrison and Winston 1987). This implies that the threat of entry is not constraining airfares to competitive levels on city-pair markets.

5. For example, Gini coefficients are 0.38 for Southwest Airlines and 0.22 for Northwest Airlines in 2005.

6. Hayes and Ross (1998) also included carrier effects (e.g., Southwest Airlines) in a price dispersion model, but did not provide conclusive findings because of mixed signs of coefficients.

7. This paper modifies the definitions of the two types of price discrimination given by Borenstein and Rose (1994) by using average prices and price dispersion. This slight modification enables one to clearly identify different types of pricing strategies based on empirical results.

8. Given constant cost, higher (lower) average airfares imply larger (smaller) markups over the cost.

9. Some operating cost characteristics may also influence demand characteristics.

10. 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.

11. The semi-log form showed better model performance in terms of a better fit and the number of significant variables. This paper used one-way route data, which included both direct and non-direct flights and did not combine the city-pair data for A to B and B to A routes (e.g., LAX-ORD and ORD-LAX)." 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., $ORICAP_i$ and $DESCAP_j$). Because route data were not available for capacity, load factor, flight frequency, Herfindahl index, carrier's market share, and multiple airports, we used airport-specific variables in this paper.

12. The Gini coefficient is calculated as follows:

$$PD_{ij} = 1 - 2 \times \left(\sum_{i=1,N} P_i \times \frac{PAX_i}{total\ revenues} \right) \times \left(\frac{PAX_i}{total\ PAX} + \left(1 - \sum_{j=1,i} \frac{PAX_j}{total\ PAX} \right) \right),$$

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). This paper uses the Gini coefficient because it is the most widely used inequality index and has a major advantage of the simple relationship to the Lorenz curve (Sheret 1991). It is simply equal to twice the area between the line of equality and the Lorenz curve, and therefore it is more intuitive than other indices.

13. 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.

14. It should be noted that major carriers used in this paper are not the "official" use of the term denoting carriers with more than \$1 billion in revenue during a fiscal year. They are the top six carriers that accounted for 71% of total domestic passenger-miles in 2005. The remainder defined as non-major carriers in this paper have only 29% of total passenger-miles.

15. Years 2000 and 2005 are selected because they do not appear to have a negative impact of the terrorist attacks of 2001. These years have the upward trend in passenger-miles for domestic air-service before and after the September 11, 2001. In addition, the year 2005 is also the most recent annual data available in February, 2006.

16. Borenstein and Rose (1994) treat flight frequency, market share, and Herfindahl index variables as possible endogenous variables and find that there is some evidence of endogeneity for flight frequency and market share, but none for the Herfindahl index. It is worth noting that entry and exit by LCCs may be also endogenous. However, it is impossible to determine whether LCCs decide to enter (exit) under what specific conditions and the authors do not have privileged firm information of economic or financial reasons for entry (exit). Furthermore, the Hausman test results showed that exogeneity of the $LOWCOST_{ij}$ cannot be rejected at the 5% significance level.

17. We carefully control for the endogeneity problem by using adequate instruments. The instruments used in this paper include lagged values of load factor, flight frequency, Herfindahl index and market share variables. In the first stage, we found that the R^2 are high, indicating that the instruments explain variations in the endogenous variables well.

18. Pattison (1973) also argues that the peak-load prices should bear all the capacity costs, when the total capacity is fully utilized at on-peak times.

19. For example, in 2008, 70% 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).

20. 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 a large number of highly correlated variables and the number of explanatory variables increases.

21. The results show that 30 and 32 interaction terms are significant out of 40 total 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.

22. This paper uses 0.34 and 0.33 of the Herfindahl index at origin ($ORIHERF_i$) and destination ($DESHERF_j$) for 2000 and 29% and 27% of carrier's market share at origin ($ORISHARE_i$) and destination ($DESSHARE_j$) for 2005, respectively.

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