Demand Analysis for Air Passenger Service in U.S. City-Pair Markets
Author(s): Junwook Chi, Won W. Koo, and Siew H. Lim
Source: *Journal of the Transportation Research Forum*, Vol. 49, No. 1 (Spring 2010), pp. 81-93
Published by: Transportation Research Forum
Stable URL: http://www.trforum.org/journal

Demand Analysis for Air Passenger Service in U.S. City-Pair Markets

by Junwook Chi, Won W. Koo and Siew H. Lim

With single- and multi-segment market data, this paper used a heteroskedasticity-adjusted instrumental variable technique to explore the determinants of air passenger service. The results showed that price played a more prominent role than income in both single- and multi-segment markets. The results further indicated that demand of air passengers is price elastic and rises as distance increases. We found evidence that population, tourism, and business factors were significant predictors of demand. Tourism has a larger impact than the local Professional Scientific Technical (PST) industry earnings on airline demand in single-segment markets, while the inverse relationship is found in multi-segment markets. Based on these results, policymakers should focus on continuation, growth, and improvement of their air transportation infrastructure in metropolitan areas that have a high demand for business travel as well as vacation travel.

INTRODUCTION

Demand analysis is important to regional economic development in a broad sense. Air transportation requires ground facilities, network planning and operating resources to provide an efficient air passenger service. Effective air transportation planning and development help meet the consumers' needs of air passenger service, relieve the effects of air traffic congestion, and develop regional economies. For example, the expansion program of Oakland International Airport enabled policymakers to bring 14.5 million passengers to the airport in 2005, making it one of the fastest-growing airports in the U.S. (OIAPR 2007). From a policymaker's perspective, it is essential to understand what determines demand for air passenger service in order to forecast said demand and develop adequate regional planning. Given that air transportation will continue to play an important role in domestic passenger services in the future, the need for exploring and identifying these determinants is further increased.

From firms' perspectives, airline service demand is an important element of operation enhancement. The International Air Transport Association (IATA 2008) reported that, "For the first time ever, fuel replaced labor as the largest single cost item for the global airline industry in 2006." The rise of fuel cost share was a direct result of skyrocketing fuel prices that have cast substantial financial burdens on airlines to improve operating performance. Much like freight and passenger service counterparts in the transportation sector, airline operating performance is difficult to gauge, because outputs produced by the airlines will not necessarily improve performance if they are not purchased or consumed. Empty miles and low load factors result in waste and misallocation of economically scarce resources, such as fuel and labor. Moreover, since firms have no control over rising input prices, cost efficiency is essential for long-term sustainability and financial viability. Understanding consumption behavior and consumers' sensitivity to price and income changes will enable airlines to improve resource allocation, operations and financial performance.

To better understand consumer behavior, this paper has developed a demand model to examine the determinants of air passenger service in city-pair markets in the U.S. The rest of the paper is organized into five additional sections. The following section provides a review of literature on demand modeling in the airline industry and the objective of the paper. The third section discusses an empirical model based on a conceptual framework of demand for air passenger service; it also describes the variables and data sources. The fourth section explains the study's econometric procedures, and the fifth section discusses the empirical results. The final section concludes the paper.

LITERATURE REVIEW

A group of studies has developed a general demand function for air passenger service in the U.S. city-pair markets. Quandt and Baumol (1966) showed an abstract mode model for specific travel modes, which is a function of population, income, travel times, costs and the industry share of employment in manufacturing and white-collar occupations. Similarly, Liew and Liew (1979) and Kanafani (1983) specified a simple form of air travel demand from origin to destination as a function of city-specific activities and transport supply characteristics.

Additional literature examines specific city and route characteristics in the demand model, highlighting the impacts of quality and quantity of air passenger services. Douglas and Miller (1974) incorporated the expected delay as a factor that inversely represents the travel time by assuming that the delay and inconvenience of air service is a key determinant of service demand. They explained demand for air passenger service using airfare, expected schedule delays and vectors of tangible aspects of service quality. Similarly, De Vany (1975) and Ippolito (1981) focused on the roles of airfare, flight frequency, load factor and other service quality variables in the demand model. Tretheway and Oum (1992) identified the key determinants of airline demand, including price, income, fare of other transportation modes, flight frequency and timing of service, day of the week, season of the year, safety record, demographics, distance, in-flight amenities, customer loyalty and travel time.

Although previous literature has advanced the understanding of determinants of demand for U.S. air passenger service, such studies are not without shortcomings. First, little attention has been paid to explaining the crucial determinants of demand for air passenger service by different types of flights. Domestic air passenger service is operated by direct flights with a single-segment and also by flights with multi-segments. Thus, excluding any segment data may lead to the problem of biased estimates in determining demand for air passenger service if direct flights and flights including multi-segments have different demand behaviors. For this reason, it is important to examine both single- and multi-segment market data and test whether the roles of determinants of demand are consistent across different samples.

In addition, flight frequency, load factor and capacity are questionable as variables in explaining the demand for air passenger service. According to classic economic theory, these variables are irrelevant in the demand for air passenger service since they are mainly supply side variables. However, the past studies justified these service variables by using consumers' time value and service convenience. Ghobrial and Kanafani (1995) argued that a high flight frequency is likely to increase demand for air passenger service, because more convenient and flexible departure and arrival schedules may increase the demand. In addition, Douglas and Miller (1974) suggested that stochastic delay, which was inversely affected by flight frequency, influences the demand for air passenger service. Moreover, Ippolito (1981) and Talley and Eckroade (1984) argued that a high load factor could increase the likelihood that passengers miss their desirable departure time and wait longer for the next available flights. However, the inclusion of the irrelevant variables in the demand model causes econometric estimation of the model to be inefficient (Pindyck and Rubinfeld 1991).

This paper investigates the demand for domestic air passenger service in city-pair markets. To examine the demand for air passenger services of both direct flights and flights with multi-segments, two sets of single-segment data (the T-100 segment and the T-100 market) and one set of multi-segment data (the Airline Origin and Destination Survey, DB1B) are used. In addition, the paper determines whether the roles of key determinants of demand are consistent from 2000 to 2005.This paper distinguishes itself from other studies by excluding flight frequency, capacity and load factor, which have a weak justification in the demand model and tend to be empirically insignificant in the previous literature. In addition, tourism and the market share of Professional Scientific Technical

(PST) industries are used to identify different price elasticity groups of travelers in the demand model. Based on recent empirical evidence of the positive relationship between PST industries and the demand for air passenger service (Alkaabi and Debbage 2007), our intention is to separate the impact of business travel, which tends to be less price elastic, from that of vacation travel. Finally, special attention is also given to diagnostic tests to produce robust and unbiased statistical results.

THE MODEL

This paper develops a theoretical foundation of demand for air passenger service based on passengers' utility maximization, given a budget constraint. Following the demand functions of intercity travel used by Liew and Liew (1979) and Phu (1991), the paper specifies the demand for a specific passenger service as a function of fares, passengers' travel budget and other exogenous travel factors. The other exogenous travel factors include seasons, size of markets, specific regional market characteristics and socio-economic factors, which are related to passengers' travel behaviors. Since surface transportation modes and airlines are not generally substitutable[1], prices of the surface transportation modes are not included as part of the demand model. This paper uses the tourism and distance variables as important determinants of demand for air passenger service and evaluates the impacts of these variables. The tourism variable is included in the model, because tourism areas are likely to have high demand for air travel, especially vacation trips. For the distance variable, an increase in distance tends to lead to a smaller substitution effect between air travel and other surface transportation modes, which results in higher demand for air passenger service. In addition, per-capita income is used as a proxy for travel budget, because data on passengers' travel budgets are not available. Based on the theoretical foundation, the original form of the demand model in this paper is written as follows:

$$(1)\quad D_{ij} = \alpha P_{ij}^{\beta_1} INC_{ij}^{\beta_2} POP_{ij}^{\beta_3} TOUR_{ij}^{\beta_4} PST_{ij}^{\beta_5} DIST_{ij}^{\beta_6} \exp(\beta_7 Q_1 + \beta_8 Q_2 + \beta_9 Q_3) e^{\varepsilon_{ij}}.$$

The linearized form is then specified as:

$$(2)\quad \begin{aligned} \ln D_{ij} &= \alpha + \beta_1 \ln P_{ij} + \beta_2 \ln INC_{ij} + \beta_3 \ln POP_{ij} + \beta_4 TOUR_{ij} + \\ &\beta_5 \ln PST_{ij} + \beta_6 \ln DIST_{ij} + \beta_7 Q_1 + \beta_8 Q_2 + \beta_9 Q_3 + \varepsilon_{ij} \end{aligned},$$

where *i* and *j* represent origin and destination, respectively, and the β_i are the coefficients of independent variables. The variables are defined as follows:

D_{ij}: Number of air transportation passengers from origin *i* to destination *j*. The total number of passengers for all classes (e.g., business and coach) is used in each quarter.

P_{ij}: Average airfare per passenger-mile charged to passengers from origin *i* to destination *j*. It is weighted by the number of passengers.

INC_{ij}: Average per-capita personal income[2] between origin and destination cities. If an airport is located in a metropolitan area, the average metropolitan per-capita income is used. Otherwise, the average state per-capita income is used.

POP_{ij}: Average population between the origin and destination cities. Metropolitan population is used when an airport is located within a metropolitan area. Otherwise, county population is used.[3]

$TOUR_{ij}$: Dummy for origin or destination located in tourism areas, holding a value of either zero or one. A list of tourism areas is selected based on a large tourism market share for overseas visitors.[4] The $TOUR_{ij}$ is used to examine relationships between the tourism areas and airfares, especially for vacation travelers.

PST_{ij}: Earnings of PST service sectors divided by earnings of all industries in the city pair. It is the average of the city pair's shares of total employee earnings in service sectors according to the North American Standard Industrial Classification System (NAICS) 54[5], relative to total industry earnings. The PST_{ij} is used to determine whether these regional business and service factors affect demand for air passenger service for business travelers.

$DIST_{ij}$: Total flight distance from origin i to destination j. For multi-segment flights, the sum of all the segment mileages of the observed route is used.

Q_1; Q_2; Q_3: Dummies for quarters 1, 2 and 3, respectively.

The cross-sectional data from this paper are obtained from various sources. The number of passengers is collected from three sources: the T-100 Domestic Segment, the T-100 Domestic Market and the Airline Origin and Destination Survey (DB1B) from the U.S. Department of Transportation. The T-100 segment data include the number of passengers transported between origin and destination, while the T-100 market data include the number of passengers enplaned at origin and deplaned at destination.[6] Although the T-100 market data capture true passengers' demand from origin to destination, the population market data are currently not available for flights with multiple segments.[7] For this reason, this paper uses the DB1B data to assess the impact of determinants of the demand in multi-segment markets. Unlike the T-100 segment and the T-100 market data, the DB1B data are a 10% sample of total population tickets (USDOT 2007).

The paper collects origin-destination pair airfare data from the DB1B data and calculates average fare per passenger-mile weighted by number of passengers. In addition, population, per-capita personal income and employee earnings data are collected from the U.S. Census Bureau (2008), the U.S. Department of Commerce (2008) and the U.S. Department of Labor (2008), respectively. In this paper, the data for years 2000 and 2005 are used to determine whether the data are consistent in explaining demand for air passenger service for the two time periods. Thus, constant elasticity mode is estimated. The choice of the time period is based on similar market conditions with higher passenger-miles.[8] Table 1 shows the descriptive statistics of the variables, including the mean, median and standard deviation of each variable in the demand model for 2000 and 2005. The sample sizes for the T-100 domestic segment, the T-100 domestic market and the DB1B are 26,366; 24,499; and 58,770, respectively, in 2005, and 20,909; 19,072; and 57,014, respectively, in 2000.

The average number of passengers in city-pair markets decreased between 2000 and 2005. In the T-100 segment data, the average number of passengers for a flight segment was over 30,000 in 2000 and below 25,000 in 2005. In the multi-segment markets (DB1B), the average number of passengers was also lower in 2005. The large standard deviations suggest that the samples were rather dispersed. The average airfare, or dollar per passenger-mile, was \$0.35 in 2000 and \$0.39 in 2005. The average per-capita income was higher in 2000. The average population in the city-pair markets was over three million. Distance traveled averaged 758 and 780 miles in 2000 and 2005, respectively, in single-segment markets. A total of 85% or more of the trips involved a tourism area, while PST service earnings, on average, constituted 6% of total industry earnings in the city pairs.

THE ECONOMETRIC PROCEDURES

Diagnostic tests are used to detect violations of the Ordinary Least Squares (OLS) model assumptions. First, a correlation matrix of variables is used to check for multicollinearity in the demand model. The test results show no significant correlation between explanatory variables in all of the three datasets (the T-100 segment, the T-100 market and the DB1B data).[9] Second, this paper uses the White (White 1980) and the Breusch-Pagan (Breusch and Pagan 1979) tests to check for heteroskedasticity. Third, the Hausman test is employed to check for the null hypothesis of exogeneity of the airfare variable in the demand model. The airfare variable can be endogenous, because an increase in price reduces the number of travelers using air passenger service, which in turn influences the price of air passenger service.

Table 1: Mean, Median and Standard Deviation of Variables in 2000 and 2005

	2000			2005		
Variable	**Mean**	**Median**	**Std. Dev.**[a]	**Mean**	**Median**	**Std. Dev.**[a]
Number of passengers [b] (the T-100 Segment)	30,756	14,411	45,752	24,892	10,235	39,591
Number of passengers [b] (the T-100 Market)	27,616	11,193	44,323	22,875	8,742	38,547
Number of passengers [b] (the DB1B)	719	170	1,666	705	167	1,702
Average airfare ($ per passenger-mile) [c]	0.35	0.23	0.53	0.39	0.24	0.63
Per-capita income ($)	35,832	35,563	4,165	31,410	31,051	3,821
Population	3,119,915	2,336,548	2,794,549	3,064,494	2,259,049	2,824,591
Share of the PST industries	0.06	0.06	0.01	0.06	0.06	0.01
Distance [d] (miles)	758	595	603	780	614	608
Dummy						
Tourism areas	0.85	1	0.35	0.87	1	0.32
Quarter 1	0.24	0	0.43	0.23	0	0.42
Quarter 2	0.24	0	0.43	0.25	0	0.43
Quarter 3	0.25	0	0.43	0.25	0	0.43

[a] Standard deviation is abbreviated as Std. Dev. in the table.
[b] Total number of passengers by origin-destination pair and by quarter. The T-100 segment, the T-100 market, and the DB1B sample sizes are 26,366; 24,499; and 58,770, respectively, in 2005. For 2000, 20,909; 19,072; and 57,014 observations are used.
[c] Average airfare estimated from the T-100 segment data. The average airfares from the T-100 market and DB1B are $0.36 and $0.21, respectively, in 2005. For 2000, the average airfares are $0.39 and $0.24.
[d] Average distance was calculated from the T-100 segment data. For the T-100 market and DB1B in 2005, the average distances are 781 and 1,317 miles, respectively. The average distances are 761 and 1,243 miles in 2000.

Table 2 shows the results of the diagnostic tests for heteroskedasticity and endogeneity in the model. As it appears in the table, the null hypothesis of homoskedasticity is rejected at the 5% level for all three datasets, indicating that heteroskedasticity is present in the model. Similarly, the null hypothesis of exogeneity is rejected at the 5% level for all the datasets. Because heteroskedasticity and endogeneity violate the assumptions for OLS, the OLS estimator is biased, inconsistent and no longer the Best Linear Unbiased Estimator (BLUE). Thus, this paper adopts the Feasible Generalized Least Squares (FGLS) and the Instrumental Variable (IV) techniques to correct the problems of heteroskedasticity and endogeneity. We divide equation (2) by the estimated error to correct for heteroskedasticity and apply the IV technique to estimate the parameters of the demand model.[10]

Table 2: Diagnostic Tests for Heteroskedasticity and Endogeneity in the Demand Model [a]

Year	Data	Heteroskedasticity [b]		Endogeneity [c]
		White Test $\chi^2(47)$	BP Test $\chi^2(9)$	
2005	The T-100 Segment	1,410** [0.001]	304** [0.001]	0.234** [0.001]
	The T-100 Market	665** [0.001]	115** [0.001]	0.208** [0.001]
	The DB1B	5,065** [0.001]	3,015** [0.001]	0.476** [0.001]
2000	The T-100 Segment	965** [0.001]	279** [0.001]	0.405** [0.001]
	The T-100 Market	963** [0.001]	143** [0.001]	0.198** [0.025]
	The DB1B	5,121** [0.001]	2,269** [0.001]	0.382** [0.001]

** Significant at the 1% level.

[a] This paper uses OLS estimation in a double-log form. P-values are presented in parentheses.

[b] The null hypothesis of homoskedasticity is used.

[c] Parameter estimate of residuals is presented. The null hypothesis is exogeneity of the variable.

THE RESULTS

Table 3 shows the results of the heteroskedasticity-adjusted IV estimation of the number of passengers in single- and multi-segment markets in 2005. Overall, almost all explanatory variables are significant predictors of airline service demand. In examining the single-segment markets, all variables have identical signs between the estimations using the T-100 segment and the T-100 market data. Airfare is inversely associated with airline service demand, while per-capita-income, population, tourism and PST industry variables are positively related to the number of passengers. A 1% increase in airfare is found to lead to a 3.30% (2.98%) decrease in the number of passengers using the T-100 segment (market) data.[11] For the income variable, a 1% increase in per-capita income is associated with a 1.43% (0.91%) increase in the number of passengers using the T-100 segment (market) data. These elasticities indicate that both airfare and income are important in determining demand for air passenger service, but airfare is more influential than income.

Demographic and geographic factors, including population, tourism and PST industry variables, are found to increase the number of passengers in the single-segment markets. The impact of tourism appears to be larger than that of the PST service industry in the single-segment markets. This indicates that tourism is a more important factor in explaining demand for air passenger service than regional PST service industries for direct flights. This paper tests the null hypothesis that tourism and the PST service industry have equivalent effects on demand against a one-sided alternative hypothesis that tourism has a greater impact. The null hypothesis is rejected at the 5% level in the single-segment markets. T statistics are 9.66 and 9.82 for the T-100 segment and market data, respectively. In addition, the seasonal dummies are all negative and significant in determining the number of passengers, which reflects the fact that demand for airline service between October and December is significantly higher (Thanksgiving and Christmas travel).

As in the single-segment markets, the price elasticity of demand in the multi-segment markets is consistently larger in magnitude than the income elasticity of demand. A 1% increase in airfare results in a 2.50% decrease in the number of passengers, while a 1% increase in per-capita income leads to a 0.79% increase in the number of passengers. To compare the impacts of price and income on demand, we test the null hypothesis that both price and income have equivalent impacts on demand against a one-sided alternative that price has a greater impact. The null hypothesis is rejected at the 5% significance level,[12] supporting evidence that airfare is a more pronounced determinant of airline passenger service in both single- and multi-segment markets.

Table 3: Heteroskedasticity-adjusted IV Estimation (Double-log Form) of the Number of Passengers in Single- and Multi-segment Markets in 2005

Variable	Parameter Estimate [a]		
	Single-segment Markets		Multi-segment Markets
	The T-100 Segment	The T-100 Market	The DB1B
Intercept	-10.906** (1.924)	-6.934** (1.852)	-14.242** (1.240)
P_{ij}	-3.303** (0.092)	-2.979** (0.084)	-2.501** (0.059)
INC_{ij}	1.431** (0.170)	0.906** (0.163)	0.790** (0.109)
POP_{ij}	0.290** (0.020)	0.382** (0.019)	0.419** (0.013)
$TOUR_{ij}$	1.909** (0.045)	1.797** (0.048)	0.654** (0.030)
PST_{ij}	0.973** (0.094)	0.856** (0.091)	1.002** (0.061)
$DIST_{ij}$	-0.529** (0.017)	-0.433** (0.016)	0.691** (0.011)
Q1	-0.454** (0.038)	-0.379** (0.036)	-0.332** (0.025)
Q2	-0.115** (0.037)	-0.049 (0.036)	-0.091** (0.024)
Q3	-0.184** (0.037)	-0.019 (0.035)	-0.172** (0.024)
Adjusted R^2	0.314	0.286	0.488
F-value	1,342	1,088	2,798
No. of Obs.	26,366	24,499	58,770

** Significant at the 1% level
[a] Standard errors are presented in parentheses.

In addition, tourism ($TOUR_{ij}$) and PST service industries (PST_{ij}) are found to be significant predictors of the demand for air passenger service. However, the PST service industry has a larger influence than the tourism area in multi-segment markets, and the opposite is true for single-segment markets. This indicates that regional business and service factors that are likely to influence business travel may play a more prominent role in explaining demand in the multi-segment markets, while tourism appears to have a greater impact in the single-segment markets. One possible reason for this is that vacation travelers may prefer direct flights to multi-segment flights to avoid possible delay in connecting flights and loss of their check-in luggage. In addition, travelers who have limited days for their vacations may prefer direct flights to save time.

Distance has a negative effect on the number of passengers in single-segment markets but a positive effect in multi-segment markets. A 1% increase in flight distance is found to lead to a 0.53% (0.43%) decrease in the number of segment passengers in the T-100 segment (market), but a 0.69% increase in demand in the multi-segment market (the DB1B). One explanation for this change is that under the given range of traveling distances in the single-segment market, increases in travel distance may result in higher airfare. This higher airfare decreases the demand for air passenger service due mainly to possible substitutes with other modes of transportation. However, in multi-segment markets, a longer distance can decrease the substitutability of other transportation modes, because the difference in travel time between air and other modes is larger. This may lead to a positive impact of distance on the number of passengers in the multi-segment markets.

Table 4: Heteroskedasticity-adjusted IV Estimation (Double-log Form) of the Number of Passengers in Single- and Multi-segment Markets in 2000

Variable	Parameter Estimate [a]		
	Single-segment Markets		Multi-segment Markets
	The T-100 Segment	The T-100 Market	The DB1B
Intercept	-5.736* (2.554)	-4.494* (2.281)	-10.486** (1.475)
P_{ij}	-1.249** (0.105)	-1.585** (0.095)	-1.221** (0.060)
INC_{ij}	1.312** (0.223)	0.806** (0.200)	0.867** (0.128)
POP_{ij}	0.273** (0.023)	0.369** (0.022)	0.386** (0.014)
$TOUR_{ij}$	2.106** (0.064)	2.103** (0.067)	0.922** (0.039)
PST_{ij}	1.623** (0.127)	1.098** (0.115)	1.405** (0.074)
$DIST_{ij}$	-0.356** (0.020)	-0.192** (0.018)	0.542** (0.012)
Q1	-0.129** (0.045)	-0.011 (0.040)	-0.093** (0.026)
Q2	-0.097* (0.044)	-0.038 (0.040)	-0.041 (0.026)
Q3	-0.016 (0.045)	0.082* (0.040)	-0.027 (0.025)
Adjusted R^2	0.208	0.230	0.442
F-value	611	634	1,842
No. of obs.	20,909	19,072	57,014

* Significant at the 5% level
** Significant at the 1% level
[a] Standard errors are presented in parentheses.

Table 4 shows the results of IV estimation using the DB1B and T-100 segment and market data for the year 2000. In comparison to 2005, the signs of all significant variables are consistent, except the third quarter (Q3) in the estimation using the T-100 market data. The third quarter shows a negative impact on the number of passengers in 2005, but a positive impact in 2000. Furthermore, all variables except some seasonal dummies are statistically significant at the 1% level. For the single-segment markets, the price elasticities of demand are -1.25 and -1.59, while the income elasticities of demand are 1.31 and 0.81 using the T-100 segment and market data, respectively. This indicates that the differences between the price and income elasticities of demand in 2000 are smaller than those in 2005. For the multi-segment markets, the price elasticity of demand is -1.22, whereas the income elasticity of demand is 0.87, implying that the price effect is larger than the income effect. In addition, this paper uses the one-sided test for equivalence of the price and income parameters as before (Ha: $\beta_1 > \beta_2$) and finds that the null hypothesis is rejected at the 5% significance level for the T-100 market and DB1B data. T statistics for the T-100 segment and market, and the DB1B data are 0.26, -3.48, and -2.52, respectively, in 2000. The consistent findings in 2000 and 2005 provide evidence that airfare tends to be a more influential predictor of air passenger service demand than income in both single- and multi-segment markets.

This paper also looked at the demand effects of tourism and vacation travel versus business travel, two segments of air passengers with two very distinct motivations. Tourism and business service factors have a positive influence on the number of passengers in the single-segment markets. The impact of tourism is larger than that of the PST service industry in the single-segment markets; however, in the multi-segment markets, the PST service industry has a relatively greater impact. The coefficients of tourism and the PST service industry are 0.92 and 1.41 respectively, suggesting that the impact of business travel (e.g., PST industry share) may be more important than that of vacation travel in the multi-segment markets. In testing the null hypothesis of equality of these coefficients (Ho: $\beta_4 = \beta_5$) against the alternative hypothesis (Ha: $\beta_4 < \beta_5$), the null hypothesis is rejected at the 5% level,[13] indicating that, as in 2005, factors affecting business travel can be more important than vacation factors in multi-segment markets.

Similarly, the impact of distance is consistent between 2000 and 2005. As previously discussed, competition among transportation modes could increase, as longer distances result in higher airfare in a "moderate range," leading to a negative value in the single-segment markets. On the other hand, substitutions for air passenger service lessen as distance becomes longer, resulting in a positive sign in the multi-segment markets.

Despite identical signs, the magnitudes of the coefficient estimates in Tables 3 and 4 differ. Thus, the Chow test is performed to test for possible structural change in the models between 2000 and 2005. The results show that the null hypothesis of no structural change for the period of 2000–2005 is rejected at the 5% level in both the single- and multi-segment markets. The F-statistics for the model using the T-100 segment, T-100 market and DB1B data are 50.79, 63.85 and 87.24, respectively, suggesting that the size of the impact of each explanatory variable differs significantly between 2000 and 2005. Nevertheless, consistent findings emerged from this paper.

This paper finds that the demand for airline service in city-pair markets is price elastic, and airfare plays a more prominent role than income does in predicting demand. According to an IATA estimate (2008), the price elasticity at the route level was 1.4. Our estimates for city-pair markets range from 1.2% to 1.5% for 2000 and from 2.5% to 3.3% for 2005. Given that airline service demand is price elastic in city-pair markets in the U.S., firms' strategies to increase airfare or airports' policies to raise airport charges and fees will decrease both the number of passengers and the demand for airline service. In light of rising input costs, airlines' profits are squeezed and they face pressure to raise airfare. The IATA (2008) also pointed out that price elasticity decreased with "long-haul routes," due to less opportunity for inter-model substitution, and that it differed by geographical market. Studies by Jung and Fujii (1976) and Verleger (1972) also found that demand tends to be more price inelastic as distance increases. This paper shows that distance negatively affects airline demand in single-segment markets, but its impact on demand is positive in multi-segment markets. This suggests that as distance increases, alternatives to airline transportation lessen, and thereby the demand for airline service rises.

CONCLUSION

It is well known from the existing literature that price and income effects are important factors for airline service. What is less understood is the magnitude of the price and income effects in single- and multi-segment markets. This paper explores the crucial determinants for airline service demand in the U.S. city-pair markets using single- and multi-segment data in two time periods. In addition, this paper points out other important determinants, including factors reflecting the difference between vacation and business travel.

Most of the variables tend to have consistent impacts on the demand for air passenger service in the single- and multi-segment markets. First, aside from the T-100 Segment data in 2000, airfare is a more influential driver of changes in demand than income. The price elasticity of demand is consistently larger than the income elasticity of demand in absolute terms, and the difference between the income and price elasticities appears to be substantial in 2005.

Second, socio-economic characteristics at origin and destination, including income, population, tourism and business factors, also play crucial roles in determining the demand for air passenger service. For example, population size in the cities of origin and destination positively affects airline service demand. The impact of a 1% increase in population could create a 0.27% to 0.41% increase in airline demand. This implies that the growth of regional economies in origin and destination cities is essential in determining the demand for air passenger service in the city-pair markets. For this reason, cities with high incomes and large populations could prioritize plans for airport infrastructure expansion.

Lastly, the importance of business travel factors, as well as vacation travel factors, is addressed. While Quandt and Baumol (1966) did not show a significant effect on business factors, this paper provides evidence of a significant impact of business factors on the demand for air passenger service.

Following Alkaabi and Debbage (2007), this paper reports a significant and positive relationship between the market share of PST industries and the number of air passengers in both years 2000 and 2005. Tourism has a larger impact than the local PST industry earnings on airline demand in single-segment markets, while the inverse relationship is found in multi-segment markets. Based on these results, policymakers should focus on continuation, growth and improvement of their air transportation infrastructure in metropolitan areas that have a high demand for both business travel and vacation travel.

The findings of this paper may help policymakers and carriers in making investment decisions for regional air transportation infrastructure to correctly reflect the demand for air passenger service. The research can be extended in several directions. Future research can analyze the return on investments for construction or expansion of ground facilities, route structures and schedules. More specifically, it can investigate how to efficiently allocate funds of the Airport Improvement Program (AIP) to increase the return on investment.

Endnotes

1. Since surface transportation modes, such as bus, auto and passenger-rail, are much slower than air transportation, they are not generally competing with each other for the average distance of air travel. In addition, some ground transportation modes (e.g., bus and rail) are often unavailable for air-service routes. According to Hagler and Todorovich (2010), auto is mostly used for travelling fewer than 100 miles and high-speed rail is best suited for travel between 100-500 miles. Air is efficiently used for travel in excess of 500 miles. In this paper, the average distance for air passenger service is 1,243 (1,317) miles for the year 2000 (2005) from the DB1B samples. Because most observations cover distances of more than 500 miles, a substitution effect between air and ground transportation modes would be small.

2. Note that this paper uses per-capita income, because per-capita disposable income is not available at a city level from the Bureau of Economic Analysis (BEA), U.S. Department of Commerce. The paper uses a real term in 2000 dollars for per-capita income, because the demand model is performed for 2000 and 2005.

3. For example, in 2005 the average population between Fargo, ND, and Minneapolis, MN, is 1,658,656. Fargo-Moorhead MSA population is 185,680 and Minneapolis-St. Paul MSA population is 3,131,632.

4. If the market share for overseas visitors is equal to 0.5% or greater, then the $TOUR_{ij}$ is equal to one, otherwise it is equal to zero. A list of 50 tourism areas in 2000 was collected from the Office of Travel and Tourism Industries (USDOC 2007).

5. NAICS 54 represents the professional, scientific and technical (PST) services sector. Activities included legal advice and representation; accounting, bookkeeping and payroll services; architectural, engineering and specialized design services; computer services; consulting services; research services; advertising services; photographic services; translation and interpretation services; and veterinary services.

6. For example, 100 passengers board a plane from Fargo, ND (origin) and stop at Minneapolis/St. Paul, MN, where 40 passengers deplane (hub airport) and the other 60 passengers continue on to Washington, DC (destination). The number of passengers on the Fargo-Minneapolis segment is counted as 100 passengers in the segment data and 40 passengers in the market data. The T-100 domestic segment and the T-100 market data are population data from reporting carriers in single-segment markets.

7. Based on the example in Footnote 6, the number of passengers on the route of Fargo, ND-Washington DC, which combines multiple segments, is not available in the market data.

8. Years 2000 and 2005 are collected, since these years do not include a negative impact of the terrorist attacks of 9/11 in terms of passenger-miles for air service. The year 2005 was also the latest annual data available in February 2006.

9. The correlation matrix tables are available upon request.

10. The IV technique is performed as follows: endogenous airfare variable is regressed with the lagged values of airfares and the relevant exogenous variables

$$P_t = \beta_0 + \beta_1 P_{t-1} + \beta_2 \ln INC_t + \beta_3 \ln POP_t + \beta_4 TOUR_t + \beta_5 \ln PST_t + \beta_6 \ln DIST_t + \beta_7 Q_1 + \beta_8 Q_2 + \beta_9 Q_3 + \varepsilon_t$$

to obtain predicted airfare variable ($\hat{P}_t$). The endogenous airfare variable in the demand model is then replaced with the $\hat{P}_t$. Since the $\hat{P}_t$ is uncorrelated with the error in the equation, this method is asymptotically consistent to estimate the model.

11. Our estimated price elasticities range from -3.30 to -1.22, which seem higher than those in previous studies but not out of the acceptable range. Based on 254 price elasticity estimates taken from 21 studies, Gillen et al. (2003) find that the minimum estimated elasticity of -3.2 and the median of all estimates is -1.22. In a survey of passenger transport demand studies, Oum et al. (1990) show that price elasticities range from -4.60 to -0.40 for vacation travel, -4.18 to -0.08 for non-vacation travel and -4.51 to -0.44 for mixed travel. This paper uses route level data instead of aggregate data, which can produce greater price elasticities of demand. In addition, as shown in Table 1, many routes used in this paper contain tourism at the origin or destination, which lead to higher price elasticities of demand (e.g., vacation travel).

12. T statistics for the T-100 segment and market, and the DB1B data are -9.27, -10.91 and -13.20, respectively, in 2005.

13. T statistics for the DB1B in 2000 and 2005 are 6.75 and 5.44, respectively.

References

Alkaabi, K.A. and K.G. Debbage. "Air Passenger Demand and Skilled Labor Markets by U.S. Metropolitan Area." *Journal of Air Transport Management* 13, (2007): 121-130.

Breusch, T. and A. Pagan. "A Simple Test for Heteroscedasticity and Random Coefficient Variation." *Econometrica* 47, (1979): 1287-1294.

De Vany, A.S. "The Effect of Price and Entry Regulation on Airline Output, Capacity, and Efficiency." *The Bell Journal of Economics* 6, (1975): 327-345.

Douglas, G.W. and J.C. Miller. "Quality Competition, Industry Equilibrium, and Efficiency in the Price-Constrained Airline Market." *American Economic Review* 64, (1974): 657-669.

Ghobrial, A. and A. Kanafani. "Quality of Service Model of Intercity Air-travel Demand." *Journal of Transportation Engineering* 121, (1995): 135-140.

Gillen, D.W., W.G. Morrison, and S. Christopher. "Air Travel Demand Elasticities: Concepts, Issues and Measurement." *Department of Finance Canada Report*. Department of Finance, Canada, 2003.

Hagler, Y. and P. Todorovich. "Where High-Speed Rail Works Best." *America 2050*. www.america2050.org. Accessed on February 1, 2010.

International Air Transport Association (IATA). *Air Travel Demand Summary Report*. May, 2008. http://www.iata.org. Accessed July 15, 2008.

Ippolito, R.A. "Estimating Airline Demand with Quality of Service Variables." *Journal of Transport Economics and Policy* 15, (1981): 7-16.

Jung, J.M. and E.T. Fujii. "The Price Elasticity of Demand for Air Travel." *Journal of Transport Economics and Policy* 10, (1976): 257-262.

Kanafani, A. *Transportation Demand Analysis*. McGraw-Hill, New York, 1983.

Liew, C.K. and C.J. Liew. "Empirical Comparison of Various Forms of Economic Travel Demand Models." *Transportation Research Record* 728, (1979): 72-76.

Oakland International Airport Press Releases (OIAPR). "Seventh Consecutive Year of Record Passenger Traffic Growth at OAK in 2004." Oakland International Airport Press Releases, 2005. http://www.oaklandairport.com. Accessed March 15, 2007.

Oum, T.H., W.G. Waters, and J.S. Yong. "A Survey of Recent Estimates of Price Elasticities of Demand for Transport." *Policy, Planning, and Research Working Papers.* Infrastructure and Urban Development Department, The World Bank, 1990.

Phu, S.H. "The Effects of U.S. Airline Deregulation on Public Intercity Passenger Travel Demand an Econometrics Analysis." Dissertation (Ph.D). University of Oklahoma, 1991.

Pindyck, R.S. and D.L. Rubinfeld. *Econometric Models and Economic Forecasts*, 3rd Edition. McGraw-Hill, Inc., New York, 1991.

Quandt, R.E. and W.J. Baumol. "The Demand for Abstract Transport Modes: Theory and Measurement." *Journal of Regional Science* 6, (1966): 13-26.

Talley, W.K. and W.R. Eckroade. "Airline Passenger Demand in Monopoly Flight Segments of a Single Airline." *Transportation Journal* 24, (1984): 73-79.

Tretheway, M. and T. Oum. "Airline Economics: Foundations for Strategy and Policy." Centre for Transportation Studies, University of British Columbia, Vancouver, 1992.

U.S. Census Bureau. *Population Estimates Files.* www.census.gov. Accessed January 15, 2008.

U.S. Department of Commerce (USDOC). *Domestic Product and Income Tables*. National Economic Accounts, Bureau of Economic Analysis. www.bea.gov. Accessed January 15, 2008.

U.S. Department of Commerce (USDOC). *Overseas Visitors to Select U.S. Cities/Hawaiian Islands - 2000-1999*. Office of Travel and Tourism Industries (OTTI). http://tinet.ita.doc.gov. Accessed March 15, 2007.

U.S. Department of Labor (USDOL). *NAICS 54 Tables.* Bureau of Labor Statistics. www.bls.gov. Accessed January 15, 2008.

U.S. Department of Transportation (USDOT). *T-100 Segment, T-100 Market, and Origin and Destination Survey (DB1B)*. Bureau of Transportation Statistics. http://www.bts.gov. Accessed March 15, 2007.

Verleger, P.K. "Models of the Demand for Air Transportation." *Bell Journal of Economics and Management Science* 3, (1972): 437-457.

White, H. "A Heteroscedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroscedasticity." *Econometrica* 48, (1980): 817-838.

Junwook Chi *is a transportation economist at the Nick J. Rahall, II Appalachian Transportation Institute and Center for Business and Economic Research at Marshall University. He received his Ph.D. in transportation and logistics from North Dakota State University. His specialty area of research is transportation economics and regional economic development. He currently manages the multi-year transportation research and economic development projects for the U.S. Army Corps of Engineers and West Virginia Department of Transportation.*

Won W. Koo *is Chamber of Commerce Distinguished Professor and director of the Center for Agricultural Policy and Trade Studies at North Dakota State University. Koo received a Ph.D. in economics from Iowa State University in 1974. He has been an educator and researcher in international trade and transportation area related to international trade.*

Siew Hoon Lim *is an assistant professor in the Department of Agribusiness and Applied Economics at North Dakota State University. She received her Ph.D. in economics from the University of Georgia. Her research areas include transportation economics, industrial organization, and productivity and efficiency analysis.*