The Magnitudes of Economic and Non-Economic Factors on the Demand for U.S. Domestic Air Travel

by Ju Dong Park and Won W. Koo

The primary purpose of this study is to analyze air carriers' behavior in capturing market share by examining the economic factors affecting passenger behavior toward air travel. This study also examines non-economic factors such as seasonality, unexpected events (9/11 attack), mergers, and trends. Because the airlines included in this study compete with each other, seemingly unrelated regression estimation (SURE) is used to estimate the parameters of the demand models which have correlated error terms. The economic and statistical relationship of the factors with air passenger miles provides valuable information to understand the nature of the demand for the U.S. air passenger industry. In examining demand determinants, this study concludes that air fare, income, seasonality, and mergers play significant roles in determining the demand for air passengers.

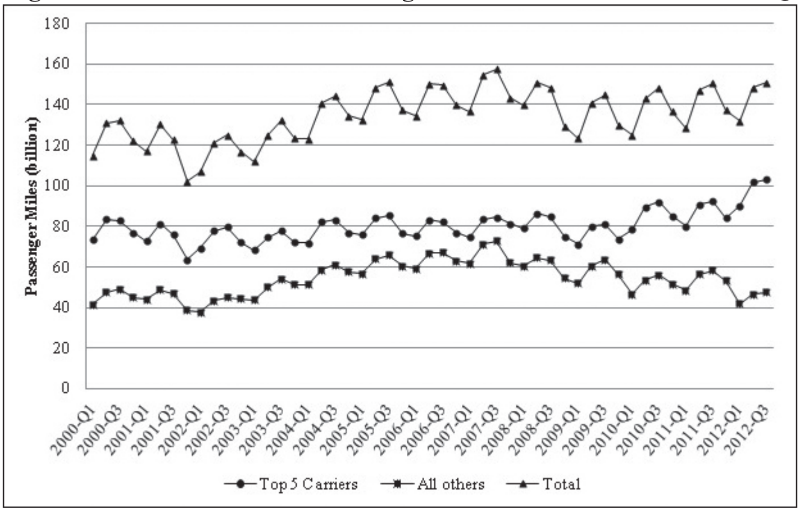
INTRODUCTION

The airline industry plays an important role in transporting people in the United States. U.S. domestic air passenger miles substantially increased from 114 billion in the first quarter of 2000 to 151 billion in the third quarter of 2012 (U.S. Bureau of Transportation Statistics 2012). With the growth of the U.S. airline industry, competition among airlines and its impacts on passenger travel have become the prevailing issue in air transportation economics since the Airline Deregulation Act of 1978,which undoubtedly, was the most important event affecting the airline industry. It partially shifted control for air travel from the political platform to the marketplace. Competition among major airlines under deregulation brought some benefits, such as air fare reductions, and improvements in capacity utilization for the U.S. airline industry. As shown in Figure 1, the total U.S. domestic airline passenger miles increased by 31% while passenger miles for the top five U.S. carriers[1] increased by 41% during the period of 2000:Q1-2012:Q3.

Figure 2 shows the U.S. nominal and real average air fares per passenger mile for the period of 2000:Q1-2012:Q3. The nominal average air fare in the United States increased by three cents (2000 U.S. dollar) for the 12 years; however, the real average air fares per passenger mile decreased by two cents for the same period. In general, U.S. domestic air fares decreased from 2000 to 2012, resulting in an increase in U.S. domestic air travel.

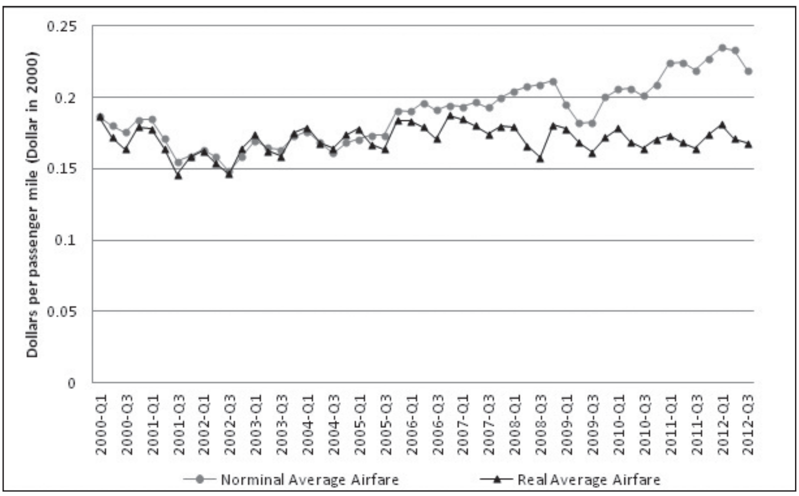
The primary purpose of this study is to analyze air carriers' behavior in capturing market share by examining the economic factors and non-economic factors that affect passenger behavior toward air travel in the United States. Some of the factors are air fare, disposable income, seasonality, the 9/11 attack, and mergers.

Figure 1: U.S. Domestic Air Passenger Miles for the Period of 2000:Q1-2012:Q3



Source: The T-1 tables, Bureau of Transportation Statistics, 2012.

Figure 2: U.S. Nominal and Real Average Air Fares per Passenger Mile for the Period of 2000:Q1-2012:Q3



Source: T-1 tables, Bureau of Transportation Statistics, 2012.

LITERATURE REVIEW

Many studies have investigated the effects of demand for air passenger services using various methods. Proussaloglou and Koppelman (1995) investigated carrier demand in a competitive context and analyzed air carrier choice to assess the market share and revenue implications of service design, pricing, marketing, and promotional strategies. Later, Proussaloglou and Koppelman (1999) extended the conceptual framework and applied it to the choice of carrier, flight, and fare class as a basis for analyzing air travel demand in a competitive market. Brons, Pels, Nijkamp, and Rietveld (2002) used meta-regression analysis to investigate the determinants of price elasticity for inter-continental and international airline services and to identify both common and contrasting factors that influence price elasticity.

Njegovan (2006) examined outbound demand for leisure air travel in the United Kingdom using a demand system that takes into account the ways in which the expenditure on air fares interacts with both the expenditure on non-fare components[2] of travel abroad and with expenditure on domestic leisure. He used the Almost Ideal Demand System (AIDS) models and found that there are strong interactions between air-travel expenditures, other costs of travel abroad, and expenditures on leisure activities in the United Kingdom.

More recently, Chi and Baek (2012) studied short- and long-term effects of determinants of the demand for U.S. air passengers. The authors used the Johansen co-integration analysis and a vector error-correction (VEC) model. NASDAQ (National Association of Securities Dealers Automated Quotations) was used as a proxy for measuring business travel while U.S. disposable income was used as a proxy for measuring leisure passengers. Chi and Baek (2012) found that air fare, disposable income, and NASDAQ had significant effects on U.S. air passenger demand in the long run while the combined short-run dynamic effects of disposable income, NASDAQ, population, and air fare explained changes in air passenger miles.

Nelson, Dickey, and Smith (2011) analyzed the factors affecting the number of visitors to Hawaii from the U.S. mainland. The authors used a double-log form for the airline-demand model and found that cross sectional (spatial) air fare elasticities, on an annual basis, were high and growing over time, but the results estimated from the time series analysis (temporal) were much lower.

However, studies in this field have paid little attention to the empirical analysis of passenger demand for air travel in the United States. In this study, an econometric model is developed to estimate price elasticity, cross-price elasticity, and income elasticity of the demand for U.S. domestic air passengers. Only the top five U.S. carriers are used for this study because their average market share from 2000 to 2012 is 59.84% of the entire market (U.S. Bureau of Transportation Statistics 2012). Based on our empirical analysis, we evaluate domestic air passengers' behavior among the top five carriers, examining the impact of economic and non-economic variables.

CHARACTERISTICS OF THE U.S. AIRLINE INDUSTRY

In 1978, the Airline Deregulation Act was passed to remove government control over the pricing of airline services, operating service routes, market entry and exit, as well as inter-carrier agreements and mergers. Under the Civil Aeronautics Board (CAB) regulation, air carriers' investments and operating decisions were highly restricted. With the CAB controlling the operating routes, market entry/exit, and air fare, the airlines were limited to competing only on food, cabin crew quality, and flight frequency. As a result, air fares and flight frequency were high while load factors[3] were low. Since the deregulation in 1978, the air-transportation market has changed significantly. Airline companies can now control air fares, operating routes, and flight frequency. Therefore, flight frequency is much lower with higher load factors than before deregulation. Borenstein and Rose (2007) found that the average load factors for domestic scheduled service climbed from lows of under 50% prior to deregulation, to over 60% in the mid-1980s, remaining above 70% since the late 1990s and hitting 83% in 2011. Although the U.S. airline industry was deregulated under the 1978 Airline Deregulation Act, the industry's infrastructure, such as regulation of airport facilities, still remains subject to government control.

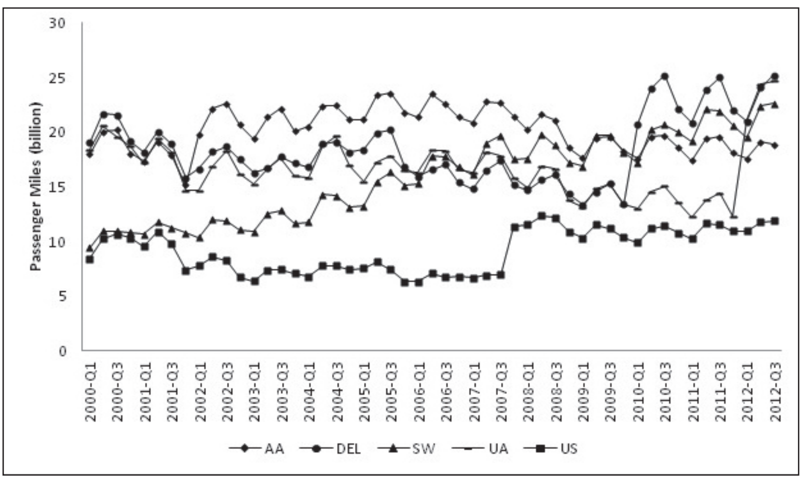
Under deregulation of the airline industry, the number of passengers at major hub airports grew; therefore, airline companies attempted to capture more passengers using various methods. One such alternative is low-fare, no frills,[4] and point-to-point service. For instance, Southwest Airlines began offerings its then unique short haul, no frills, low priced, and interstate service. During the 1990s, Southwest moved into the ranks of the nation's top 10 airlines. Most recently, several major airlines, including Continental, Delta, United, and US Airways, have created subsidiaries that offer low-fare, low-frill, and point-to-point services using economy-sized aircraft.

Nonstop services for U.S. domestic air travel began to increase in the late 1990s. This change corresponded to the widespread introduction of regional jets (RJs), jet aircraft with capacities of fewer than 100 seats that are more efficient than propeller aircraft and/or larger jets. For medium length routes, RJs' low seat-mile costs were capable of supporting airline service in small cities. The ability to serve such markets economically with small jet airliners created the possibility of adding smaller cities and more frequent services to the spokes airports from the hubs, and it also created point-to-point services in the marketplace. Thus, the recent trend in the airline industry is an increase in small jet aircraft service while either maintaining or reducing large jet aircraft service.

Figure 3 shows the passenger miles among the major U.S. air carriers for passenger travel during the period of 2000:Q1-2012:Q3. American Airlines increased its passenger miles by 5%, Delta Airlines by 32%, Southwest Airlines by 140%, United Airlines by 34%, and US Airways by 41%. However, extraordinary decreases in passenger miles for the five major air carriers occurred in the fourth quarter of 2001, immediately after the September 11 attacks.

US Airways increased its market share during the fourth quarter of 2007 through the first quarter of 2008 as the result of a merger with America West at the end of 2005. In the middle of 2008, Delta Airlines and Northwest Airlines agreed to merge, resulting in increased passenger miles for Delta Airlines from the fourth quarter of 2009 to the first quarter of 2010. A merger of United Airlines and Continental Airlines in 2010 brought an improvement in passenger miles from the fourth quarter of 2011 to the first quarter of 2012. These three mergers significantly affected the domestic airline market for passenger services.

Figure 3: Domestic Air Passenger Miles of the Top Five U.S. Carriers for the Period of 2000:Q1-2012:Q3



Source: The T-1 tables, Bureau of Transportation Statistics, 2012.

In addition, alliances between airlines vary from a limited marketing arrangement, such as sharing frequent-flyer programs, to more complex agreements, such as code-sharing. Code-sharing forms the basis of most airline alliances and allows airlines to sell seats on partners' flights as if these flights were their own. Firms use code-sharing agreements for different reasons, such as indirect entry into markets where costs and regulatory barriers would make direct entry impossible, the expansion of networks, and increasing service quality.

Code-sharing agreements operate under either the blocked-space system or the free-sale system. With the blocked-space system, aircraft capacity is shared between marketing carriers[5] and the operating carrier.[5] The marketing carrier buys a block of seats from the operating carrier, sells them to its passengers as its own seats, and keeps all the revenue from those sales. The operating carrier cannot sell any of the seats assigned by the marketing carrier, and both carriers charge fares independently. With the free-sale model, all partners have free, real-time access to the operating carrier's seats, and there is no fixed limit on how many seats the marketing carriers can sell. Moreover, the marketing carrier determines its fares independently from the operating carrier. All revenue from seats that the marketing carrier sells under the free-sale system is kept by the operating carrier.

For example, suppose a passenger buys an indirect ticket from A to C through B from American Airlines, where the flight from A to B is operated by American Airlines and the flight between B and C is operated by US Airways. Under a code-sharing agreement and a free-sale system between them, American Airlines would keep all the revenue generated from the A to B flight and US Airways would keep all the revenue generated from the B to C flight. If there is not a code-sharing agreement between American Airlines and US Airways, a passenger who is looking for a flight from A to C will not buy his/her ticket from American Airlines because it does not offer the service from A to C. As a result, the passenger will buy his/her ticket from another carrier, and American Airlines will lose this passenger. Therefore, it is preferable for American Airlines to accept the code-sharing agreement to earn positive revenue from A to B, rather than losing passengers. Because it is hard to clarify the measurement of revenue passenger miles and the total revenue for air carriers during a certain time period in a given dataset from the U.S. Department of Transportation, concerns about code-sharing effects on air passenger miles and air fares are ignored in this study.

As mentioned previously, there have been four major mergers among U.S. domestic airlines in the last 12 years. Many policy makers are concerned that mergers would substantially reduce competition, increase air fares, and cut service while airline companies say that a merger would reduce their operating costs and allow them to offer lower prices and better service. Airline mergers create advantages and disadvantages for air passengers. On the down side, the merger would lead to a consolidation of routes, giving an airline a monopoly over a particular route, which might cause the fare to increase. However, the merger can open an entry for another airline to operate service in the market and to start charging less. Table 1 shows U.S. airline mergers and acquisitions since 2000. There were a total of 12 mergers among U.S. airline companies in the last 13 years. This study includes the mergers of US Airways with America West Airlines (2005), Delta Airlines with Northwest Airlines (2009), and United Airlines with Continental Airlines (2010). The merger between American Airlines and US Airways is not included in this study mainly because the merger occurred in 2013, which is the last observation included in this study.

Table 1: U.S. Airline Mergers and Acquisitions

Date		Air Carrier	Resulting Entity
Announced	Closed		
01/10/2001	04/09/2001	American Airlines / TWA	American Airlines
04/22/2005	05/09/2011	Republic Airways / Shuttle America	Republic Airways
05/19/2005	09/27/2005	US Airways / America West Airlines	US Airways
08/15/2005	09/08/2005	SkyWest / Atlantic Southeast Airlines	SkyWest / ASA
01/18/2007	01/18/2007	Pinnacle Airlines / Colgan Air	Pinnacle Airlines / Colgan Air
11/19/2008		Southwest Airlines / ATA Airlines	Southwest Airlines
04/14/2008	12/31/2009	Delta Airlines / Northwest Airlines	Delta Airlines
06/23/2009	07/31/2009	Republic Airways / Midwest Airlines	Republic Airways
08/14/2009	10/01/2009	Republic Airways / Frontier Airlines	Republic Airways
05/03/2010	10/01/2010	United Airlines / Continental Airlines	United Airlines
08/04/2010	11/15/2010	SkyWest / Atlantic Southeast Airlines / ExpressJet Airlines	SkyWest / SureJet
09/27/2010	05/02/2011	Southwest Airlines / AirTran Airways	Southwest Airlines
07/01/2010	07/01/2010	Pinnacle Airlines / Mesaba Airlines	Pinnacle Airlines / Mesaba Airlines
02/14/2013	12/09/2013	US Airways / AMR / American Airlines	American Airlines (AAL)

Source: Airlines for America.

THE MODEL

This study developed a theoretical model of demand for air passenger services through maximizing passengers' utility under a given budget constraint. Following McCarthy (2001), the utility function for the air transportation passengers and their budget constraint are specified as follows:

(1) $Max\ U = f_u(PM^1, PM^2, \dots, PM^i)$

individual's budget constraint is

(2) $\sum_{i=1}^{n} AF^i \cdot PM^i = INC$

where PM^i is total passenger miles of the airline company i (i=1,2,…,n); AF^i is air fare per passenger mile of the air carrier i (i=1,2,…,n); and INC is individual's budget allocated for air travel.

The Lagrangian equation is formed from equations (1) and (2) as follows:

(3) $\mathrm{L} = f_u(PM^1, PM^2, \dots, PM^i) + \lambda\,(INC - \sum_{i=1}^{n} AF^i \cdot PM^i)$

The first differential of equation (3) with respect to PM^i and λ yield

(4) $\frac{\partial L}{\partial PM^i} = f_u^i - \lambda AF^i$ for $i = 1,2, \dots, n$

(5) $\frac{\partial L}{\partial \lambda} = INC - \sum_{i=1}^{n} AF^i \cdot PM^i$

where $f_u^i = \frac{\partial f_U}{\partial PM^i}$ for i = 1,2,…,n

Equating equations (4) and (5) to zero and solving yield demand for air travel as:

(6) $PM^i = f_D(AF^1, AF^2, \ldots, AF^n, INC)$

Based on equation (6), we specified an empirical demand model of each airline. Airlines considered in this study are American Airlines, Delta Airlines, Southwest Airlines, United Airlines, and US Airways. In addition, the demand model includes non-economic variables representing seasonality for passengers' preference of season for their air travel. Another additional non-economic variable included in the model is the September 11 terrorist attacks to examine whether the attack affects air travel. We also added dummy variables representing mergers between US Airways and America West Airlines in 2005, Delta Airlines and Northwest Airlines in 2009, and United Airlines and Continental Airlines in 2010. The empirical model also includes the trend variable to examine whether there is a general trend in passengers' air travel in the U.S. The empirical model is specified as:

(7) $PM_t^i = f(AF_t^1, AF_t^2, AF_t^3, AF_t^4, AF_t^5, INC_t, SE, SEP\_ATT, MER)$

where PM_t^i is the total passenger–miles of U.S. domestic carrier i at time period t; AF_t^i is the air fare per passenger mile of carrier i at time period t; INC_t is the disposable income per capita; SE is a dummy variable representing the seasonal effects; SEP_ATT is a dummy variable representing the impact of the September 11 attack; MER is a dummy variable representing the impact of mergers among airline companies. Equation (7) is re-specified under a double log functional form as:

(8) $$\ln PM_t^i = \alpha_i + \sum_{j=1}^{5} \beta_{ij} \ln AF_t^j + \gamma_i \ln INC_t + \sum_{h=1}^{3} \delta_{ih} D_t^h + \delta_i^{sa} D_t^{sa} + \sum_{k=1}^{3} \delta_k D_t^k + \tau_i lnTRE + \varepsilon_{it}$$

where α is the intercept term and the βs,γs, δs, and τs are coefficients of corresponding variables. $\ln PM_t^i$ is log value of the total air passenger miles (billions) of carrier i in time t, $\ln AF_t^j$ is log value of average air fare per mile (U.S. dollar) of carrier j in time t, $\ln INC_t$ is log value of average per capita disposable income (thousands of U.S. dollars) in time t. In addition, D_t^hs are seasonal dummy variables for Spring (D_t^1), Summer (D_t^2), and Fall (D_t^3), D_t^{sa} is a dummy variable representing the September 11 attack, and D_t^ks are dummy variables for mergers of US Airways (D_t^1), Delta Airlines (D_t^2), and United Airlines (D_t^3). Finally, TRE represents trend variable and ε_{it} is the random error terms.

The estimated coefficient (β_{ij}) represents own and cross price elasticites. It is expected $\beta_{ij} < 0$ for $i=j$ and $\beta_{ij} < 0$ or $\beta_{ij} > 0$ for $i \neq j$, depending upon the relationship between the airlines. If two airlines are substitutes for each other, $\beta_{ij} > 0$ for $i \neq j$ and $\beta_{ij} < 0$ for $i \neq j$ if the airlines are complements. The estimated coefficient (γ_i) represents income elasticity and is expected to be positive. The coefficient (δ_{ih}) represent seasonal effects and the sign is expected to be either positive or negative, depending upon passengers' preference of seasons for their travel. The estimated coefficient (δ_i^{sa}) represents the September 11 terrorist attack and the sign of the coefficient is expected to be negative mainly because of passengers' hesitation to fly for the short period just after the attack. The coefficient (δ_k) represents the effects of the airline merger, and the signs are expected to be positive. Finally, τ_i represents the general trend of passenger travel by air, and the sign is expected to be either positive or negative.

DATA

To analyze the effects of economic factors and non-economic factors on major air carriers' passenger miles in U.S. domestic air transportation service, time-series data for passenger miles and air fare per passenger mile are collected for the following major U.S. carriers: American Airlines (AA), Delta Airlines (DEL), Southwest Airlines (SW), United Airlines (UA), and US Airways (US). Quarterly data for 2000:Q1 through 2012:Q3 were used for this study.

The total air passenger miles are used as a proxy for air passenger demand and are collected from T-1 tables published by the Bureau of Transportation Statistics (BTS) in the U.S. Department of Transportation (USDOT). The tables (T-1) summarize the T-100 traffic data reported by air carriers. The monthly data compiled by U.S. air carriers include available seat miles (ASMs), available ton miles (ATMs), revenue passenger miles (RPMs), revenue ton miles (RTMs), revenue air hours (RAHs), revenue miles flown (MILES), and revenue departure performed (FLIGHTS). Because quarterly data were used for this study, quarterly RPMs are calculated by summing monthly data.

The average air fare per passenger mile is used as a proxy for air fare and is obtained from F41 tables published by the BTS in the USDOT. The F41 tables contain financial information on large certified U.S. air carriers and include balance sheets, cash flow, employment, income statements, fuel cost and consumption, and aircraft operating expenses. Large certified carrier means the air carrier that holds the Certificate of Public Convenience and Necessity issued by the USDOT with annual operating revenues of $20 million or more. Since F41 tables provide quarterly data for operating revenues by airlines, an average air fare per passenger mile for U.S. domestic air passenger service of each air carrier was calculated by dividing total operating revenues by total RPMs as a proxy of average air fares by each airline. Since this study focuses on aggregate demand for air travel in the United States, the price variables (average air fare per passenger mile) by airlines are the most appropriate in estimating the price effect on aggregate demand for air travel by airlines.[7] Stratifying the data by flight length will provide the relationship between air fare and distance; however, this study is not focused on this issue.

The U.S. personal disposable income per capita is from the B-30 table, U.S. Government Printing Office (2012). Table B-30 provides quarterly data for disposable personal income. The Consumer Price Index (CPI) for air fare and the general CPI were used separately to calculate the real value for air fare and disposable personal income. Both the general CPI and CPI for air fare were obtained from the Bureau of Labor Statistics (BLS), United States Department of Labor (2012). The data used for empirical analysis contain 51 quarterly observations.

Summary statistics for the dataset are presented in Table 2. This study includes only the top five airline companies in the United States for the period of 2000:Q1 to 2012:Q3 mainly because more than 50% of total market share is accounted for those five airline companies (Bureau of Transportation Statistics 2012). In Table 2, average air fare per mile is measured in U.S. dollars adjusted by the CPI for air fare and average per capita income is measured in thousands of U.S. dollars and adjusted by CPI.

Table 2: Summary Statistics

Airlines		Variable		
		PM_t^i	AF_t^i	INC_t
American Airlines	Max	236	0.167	Max: 37.925 Min: 25.094 Mean: 31.094 s.d: 4.234
	Min	150	0.122	
	Mean	202	0.145	
	s.d	19.26	0.022	
Delta Airlines	Max	252	0.204	
	Min	134	0.123	
	Mean	185	0.173	
	s.d	31.44	0.031	
Southwest Airlines	Max	226	0.149	
	Min	95	0.112	
	Mean	158	0.125	
	s.d	39.02	0.024	
United Airlines	Max	246	0.191	
	Min	123	0.125	
	Mean	167	0.164	
	s.d	26.37	0.027	
US Airways	Max	124	0.230	
	Min	63	0.158	
	Mean	92	0.191	
	s.d	19.84	0.033	

Data sources: U.S. Department of Transportation, U.S. Government Printing Office, and U.S. Department of Labor.
Standard Deviation is abbreviated as s.d. in the table.
Total air passenger miles (billions) of carrier *i* in time period *t* is abbreviated as PM_t^i in the table.
Average air fare per mile (US dollars) of carrier *i* in time period *t* is abbreviated as AF_t^i in the table.
Average per capita disposable income (thousands of US dollars) in time period *t* is abbreviated as INC_t in the table.

ECONOMETRIC PROCEDURE AND EMPIRICAL RESULTS

Autocorrelation was tested by using the Durbin-Watson (DW) statistics. If autocorrelation is present, the Ordinary Least Squares (OLS) is no longer the Best Linear Unbiased Estimator (BLUE) (Stock and Watson 2010). The DW tests for AA, DEL, and SW under the double-log model indicates that the test is inconclusive because the values of the DW test were between 1.039 (critical value of lower bound) and 1.748 (critical value of upper bound) at the 1% significant level. The DW statistics for UA and US are close to 2, which accepts the null hypothesis of no serial correlation. To correct for the presence of first-order serial correlation for AA, DEL, and SW, the Yule-Walker (YW) method was applied. After serial correlation correction, all variables of the DW test were close to 2, indicating that the null hypothesis of no serial correlation is accepted.

The *F-test* is used to test a joint hypothesis for seasonality. For the test, we developed two models: an unrestricted model including seasonal dummy variables and a restricted model excluding seasonal dummy variables. The null hypothesis is $H_0 : \delta_{i1} = \delta_{i2} = \delta_{i3} = 0$ and the alternative hypothesis is $H_a : \delta_{i1} \neq \delta_{i2} \neq \delta_{i3} \neq 0$. If H_0 is rejected, there is seasonality in the industry. The test statistics are calculated as follows:

(9) $$F_{q,n-k} \sim \frac{(SSE_R - SSE_{UR})/q}{SSE_{UR}/n-k}$$

where *SSE* is the sum of squared errors. The subscript represents type of model; *UR* represents unrestricted model and *R* represents restricted model.

Table 3 shows the result of the *F-tests* for seasonality for each airline. The null hypothesis of no seasonality for all five air carriers are rejected since the values of the *F-test* for seasonality are 13.219 (AA), 9.742 (DEL), 98.420 (SW), 26.132 (UA), and 6.928 (US), respectively. Since all values of *F-test* for seasonality are greater than the critical value of $F_{(3,40)}$(=4.31) at the 1% significant level, it is concluded that there is seasonality of demand for domestic air passengers, especially for those five major airlines in the United States.

Table 3: Result of F-test for Seasonality

Air Carrier	*Sum of Square Error (SSE)*		*F-test*
	Unrestricted Model	Restricted Model	
American Airlines (AA)	0.0416	0.0839	13.219***
Delta Airlines (DEL)	0.1901	0.3363	9.742***
Southwest Airlines (SW)	0.0226	0.1937	98.420***
United Airlines (UA)	0.2014	0.6169	26.132***
US Airways (US)	0.1929	0.2984	6.928***

***, **, * denote significance at the 1%, 5%, and 10% levels, respectively.

The *t-test* was used to examine the effects of the terrorist attack on September 11 and each merger. To test effect of the September 11 attack, the null hypothesis is $H_0: \delta_i^{sa} = 0$; and the alternative hypothesis is $H_a: \delta_i^{sa} \neq 0$. If H_0 is rejected, there is an impact of the attack on the industry; otherwise, there is no impact of the attack on the industry. Likewise, the *t-test* was used to test the effect of each merger on the U.S. domestic airline industry. The null hypothesis is $H_0:\delta_1 = 0$ for US Airways's merger and the alternative hypothesis is $H_a:\delta_1 \neq 0$. For the Delta Airlines's merger, the null hypothesis is $H_0:\delta_2 = 0$ and the alternative hypothesis is $H_a:\delta_2 \neq 0$. Lastly, for the United Airlines's merger, the null hypothesis is $H_0:\delta_3 = 0$ and the alternative hypothesis is $H_a:\delta_3 \neq 0$. If H_0 is rejected, there is an impact of mergers on the industry; otherwise, there is no impact of mergers on the industry.

Since the airlines included in this study compete with each other, Seemingly Unrelated Regression Estimation (SURE) by Zellner (1962) is used to estimate the parameters of the demand models under an assumption that individual demand models are correlated through error terms. In other words, if the residuals of individual demand equations are correlated with one another, SURE is more efficient than single equation estimation (Pindyck and Rubinfeld 1998).

Table 4 shows the results of SURE of the demand for U.S. domestic air travel. The *system* R^2 is 0.9746, indicating that the independent variables in the model explains 97% of the variation of the dependent variables.

In the demand model for air passengers of American Airlines, own price elasticity of demand is -0.909 and statistically significant at the 1% significant level, indicating that AA's passenger miles increases by 0.909% when its air fare per passenger mile decreases by 1%. Its cross price elasticity with Delta Airlines, Southwest Airlines, and United Airlines are 0.149, -0.009, and 0.057 and they are not statistically significant; however, its cross price elasticity of demand for US Airways is 0.543 and statistically significant at the 1% significant level. This indicates that these two airlines

Table 4: Result of Seemingly Unrelated Regression Estimation (SURE)

Variable	AA	DEL	SW	UA	US
Intercept	5.531 (1.27)	14.42 (1.65)	3.954 (1.43)	2.074 (0.30)	11.923* (1.76)
LNAFAA	-0.909*** (-2.77)	0.770 (1.28)	0.414* (1.99)	0.684 (1.29)	1.406*** (2.77)
LNAFDEL	0.149 (0.66)	-1.06** (-2.51)	-0.146 (-1.01)	-0.415 (-1.14)	-0.444 (-1.27)
LNAFSW	-0.009 (-0.04)	0.264 (0.72)	-0.45*** (-3.53)	1.089*** (3.33)	0.3996 (1.29)
LNAFUA	0.057 (0.39)	0.127 (0.46)	0.215** (2.28)	-0.298 (-1.23)	0.210 (0.91)
LNAFUS	0.543*** (3.47)	0.558** (1.95)	0.273** (2.75)	0.640** (2.56)	-1.893*** (-6.63)
LNINC	1.294** (2.51)	0.404 (0.39)	1.505*** (4.60)	2.131** (2.59)	0.495 (0.62)
D1	0.012 (0.58)	0.009 (0.25)	-0.09*** (-6.32)	0.394 (1.16)	-0.036 (-1.08)
D2	0.083*** (3.96)	0.142*** (3.62)	0.089*** (6.67)	0.232*** (6.98)	0.088*** (2.69)
D3	0.100*** (4.27)	0.182*** (4.11)	0.098*** (6.61)	0.312*** (8.35)	-0.027 (-0.72)
D4	-0.209*** (-4.99)	-0.068 (-0.87)	-0.002 (-0.09)	0.054 (0.81)	-0.086 (-1.32)
D5					0.241*** (4.98)
D6		0.320*** (5.80)			
D7				0.262*** (5.19)	
TRE	-0.029*** (-2.77)	0.008 (0.38)	0.041*** (7.21)	-0.04*** (-2.49)	-0.030** (-2.15)
System R^2	0.9746				
df[a]	192				

Degree of Freedom is abbreviated as *df* in the table.
***, **, * denote significance at the 1%, 5%, and 10% levels, respectively.

compete with each other in most routes. Income elasticity of demand for American Airlines is 1.294 and is statistically significant at the 5% significant level. If per capita income increases by 1%, AA's passenger miles increase 1.294%. Since the estimated coefficients of seasonal dummy variables for summer and fall are 0.083 and 0.100 and statistically significant at the 1% significant level, AA's passenger miles increase by 0.083% and 0.100% during summer and fall, respectively. However, the estimated coefficient of seasonal dummy variable for spring is 0.012 and insignificant. The estimated coefficient of the dummy variable for the September 11 attack is -0.209 and statistically significant at the 1% significant level, indicating AA's passenger miles decreased by 0.209% as a result of the September 11 attack. Lastly, the estimated coefficient of trend variable is -0.029 and is statistically significant at the 1% significant level.

In column (3), Delta Airlines's own price elasticity of demand is -1.06 and statistically significant at the 5% significant level. This implies that passenger miles of DEL decrease by 1.06% for every 1% increase in its air fare per passenger mile. Its cross price elasticity with US Airways is 0.558 and statistically significant at the 5% significant level, indicating that they compete with each other in most routes. The cross price elasticities of American Airlines, Southwest Airlines, and United Airlines are 0.770, 0.264, and 0.127, respectively, but are not statistically significant. Income elasticity of demand is 0.404 but insignificant for Delta Airlines. This might be interpreted that Delta Airlines is likely to have more business travel passengers than leisure travel passengers. In general, leisure travel passengers are more sensitive to air fare than business travel passengers. The estimated coefficient of seasonal dummy variable for summer and fall are 0.142 and 0.182 and statistically significant at the 1% significant level while spring is 0.009 but insignificant. DEL's passenger miles increase by 0.142% and 0.182% during summer and fall, respectively, and are significant at the 1% level. The estimated coefficient of the dummy variable for the September 11 attack is -0.068, but insignificant, which means DEL's passenger miles may not have been affected by the September 11 attack. The estimated coefficient for mergers between Delta Airlines and Northwest Airlines is 0.320 and statistically significant at the 1% significant level, indicating that passenger miles of Delta Airlines increased after the merger with Northwest Airlines in the middle of 2008. The estimated coefficient of the trend variable is 0.008 but insignificant.

In column (4), the price elasticity of demand for Southwest Airlines is -0.45 and statistically significant at the 1% significant level. When air fare per passenger mile decreases by 1%, passenger miles increase by 0.45%. Its cross price elasticity of demand for American Airlines, United Airlines, and US Airways are 0.414, 0.215, and 0.273 and statistically significant at the 10%, 5% and 5% significant levels, respectively, indicating that they compete with each other. SW's cross price elasticity with Delta Airlines is -0.146 but is not significant. Income elasticity of demand is 1.505 and statistically significant at the 1% significant level, indicating an increase in passenger miles by 1.505% for every 1% increase in per capita income. The estimated coefficient of seasonal dummy variables for spring, summer, and fall are -0.09, 0.089, and 0.098 and statistically significant at the 1% significant level, indicating seasonality in passenger demand for airline service. The estimated coefficient of dummy variable for the September 11 attack is -0.002 but statistically insignificant. This means that SW's passenger miles were not affected by the September 11 attack. The estimated coefficient of trend is 0.041 and statistically significant at the 1% significant level.

In column (5), United Airlines's own price elasticity of demand is -0.298 and not significant. UA's cross price elasticity of demand with Southwest Airlines and US Airways are 1.089 and 0.640 and are statistically significant at the 1% and 5% levels, respectively. This means that they compete with each other in most routes. On the other hand, the cross price elasticity with DEL is -0.415 but not significant, indicating limited competition between them. Income elasticity of demand for UA is 2.131 and statistically significant at the 5% significant level. This means passenger miles increased by 2.131% for every 1% increase in per capita income. The estimated coefficients of summer and fall seasonal dummy variables are statistically significant at the 1% level, implying that passenger demand for UA's air service is seasonal. The estimated coefficient of dummy variable for the

September 11 attack is 0.054 but statistically insignificant, which means UA's passenger miles were not affected by the September 11 attack. The estimated coefficient for the merger of United Airlines is 0.262 and statistically significant at the 1% significant level. This indicates that passenger miles of United Airlines increased by 0.262% as a result of the merger with Continental Airlines in 2010. The estimated coefficient of trend is -0.04 and statistically significant at the 1% significant level.

In column (6), the price elasticity of demand for US Airways is -1.893 and statistically significant at the 1% significant level; therefore, US Airways passenger miles increase by 1.893% for every 1% decrease in its air fare per passenger mile. Its cross price elasticity of demand with American Airlines is 1.406 and statistically significant at the 1% significant level, meaning that they compete with each other. The cross price elasticity with Delta Airlines, Southwest Airlines, and United Airlines are not significant. This implies that these airlines have limited competition with one another. Income elasticity of demand is 0.495 and is not statistically significant. The estimated coefficient of seasonal dummy variable is 0.088 and statistically significant at the 1% significant level for summer; and are -0.036 and -0.027 and not significant for spring and fall, respectively, indicating weak seasonality. The estimated coefficient of dummy variable for the September 11 attack is -0.086 but not significant. The estimated coefficient for the merger between US Airways and America West is 0.241 and statistically significant at the 1% significant level. This indicates that the merger increased passenger miles of US Airways. The estimated coefficient of trend is -0.030 and statistically significant at the 5% significant level.

CONCLUSIONS

This study discussed the impact of economic and non-economic factors on demand of air passengers in the United States. The economic and statistical relationship of the factors on air passenger miles provides valuable information to understand the nature of the demand for U.S. air travel. In examining demand determinants, this study concludes that air fare, income, seasonality, and mergers among air carriers play significant roles in determining the demand for air passenger service. The study reveals that the major airlines in the United States compete with each other. However, the degree of competition differs on routes served by the airlines. This study found that demand of U.S. domestic air passengers is seasonal. Unexpected events such as the September 11 attack had a limited impact on passenger demand. Mergers among airline companies affected passengers' demand for U.S. domestic air travel significantly.

Acknowledgements

We would like to express our very great appreciation to the general editor of the Journal of the Transportation Research Forum, Dr. Michael W. Babcock, for his valuable and constructive suggestions to revise this research paper. We would also like to thank anonymous referees of the Journal of the Transportation Research Forum for their insightful and helpful comments on an earlier draft of this paper.

Endnotes

1. American Airlines (AA), Delta Airlines (DEL), Southwest Airlines (SW), United Airlines (UA), and US Airways (US).

2. Non fare component means the fare charged is not based on between two consecutive fare construction points. The point of origin and the point of destination of a fare component are fare construction points.

3. The percentage of the seats that were filled.

4. A no frills airline is an airline that offers low fares but eliminate all non-essential services, such as complimentary drinks and snacks, no free check-in baggage, in-flight entertainment systems, business-class seating, and so on.

5. The airline that sells seats to its customers, sets its fares independently, and does not use its own aircraft to operate the flight; it uses its partners' aircraft (the operating carriers) under the code-sharing agreement.

6. The airline with the aircraft whose passengers board under the code-sharing agreement.

7. Air fares vary over distances between origins and destinations. However, we use average air fare by airlines in the U.S. since the purpose of this study is to evaluate aggregate demand for air travel in the U.S. without considering segments between origins and destinations.

References

Airlines for America. "U.S. Airline Mergers and Acquisitions." 2014. Available online at: http://www.airlines.org/Pages/Data/USAirlineMergersAcquisitions.aspx. Accessed August 2, 2014.

Borenstein, S. and N. Rose. "How Airline Markets Work… Or Do They? Regulatory Reform in the Airline Industry." *The National Bureau of Economic Research* Working Paper 13452, 2007.

Brons, M., E. Pels, P. Nijkamp, and P. Rietveld. "Price Elasticities of Demand for Passenger Air Travel: A Meta-Analysis." *Journal of Air Transportation Management* 8, (2002):165-175.

Chi, J. and J. Baek. "A Dynamic Demand Analysis of the United States Air Passenger Service." *Transportation Research Part E* 48, (2012):755-761.

McCarthy. P. *Transportation Economics Theory and Practice: A Case Study Approach.* Blackwell, 2001.

Nelson, L., D. Dickey, and J. Smith. "Estimating Time Series and Cross Section Tourism Demand Models: Mainland United States to Hawaii Data." *Tourism Management 32*, (2011):28-38.

Njegovan, N. "Elasticities of Demand for Leisure Air Travel: A System Modeling Approach." *Journal of Air Transportation Management 12*, (2006):33-39.

Pindyck, R. and D. Rubinfeld. *Econometric Models and Economic Forecasts.* 4th ed, Irwin McGraw-Hill, 1998: 335-371.

Proussaloglou, K. and F. Koppelman. "Air Carrier Demand." *Transportation* 22, (1995):371-388.

Proussaloglou, K. and F. Koppelman. "The Choice of Air Carrier, Flight, and Fare Class." *Journal of Air Transportation Management* 5, (1999):193-201.

Stock, J. and M. Watson. *Introduction to Econometrics.* 3rd ed, Addison Wesley, 2010.

U.S. Bureau of Labor Statistics (BLS). *Consumer Price Index (CPI) for Airlines and General 2012*. Department of Labor. http://www.bls.gov/cpi/. Accessed February 15, 2013.

U.S. Department of Transportation (U.S.DOT). T-1 Tables and F41 Tables. Bureau of Transportation Statistics 2012. http://www.bls.gov. Accessed February 11, 2013.

U.S. Government Printing Office (GPO). B-30 Table, *Economic Report of the President 2012*. http://www.gpo.gov. Accessed February 15, 2013.

Zellner A. "An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests for Aggregation Bias." *Journal of the American Statistical Association* 57, (1962):500-509.

Ju Dong Park *is a research assistant and PhD candidate in the Upper Great Plains Transportation Institute at North Dakota State University in Fargo, North Dakota. Park obtained his MS degree in international transportation management at State University of New York Maritime College in Bronx, New York and he recently was awarded the Best Paper Award from the Transportation Research Forum at its 55th Annual Forum.*

Won W. Koo *is a Chamber of Commerce Distinguished Professor and director of the Center for Agricultural Policy and Trade Studies at North Dakota State University in Fargo, North Dakota. Koo received his PhD in economics from Iowa State University in 1974. His areas in research and teaching are international trade, economic development, demand analysis, econometrics, and quantitative method (optimization). He received an outstanding research award (Quality in Research Discovery) from the American Agricultural Economics Association in 1981 and received the outstanding published research award from the Western Agricultural Economics Association in 1983. Koo received the Eugene R. Dahl Excellence in Research Award from the College of Agriculture, Food System, and Natural Resources from North Dakota State University in 2000 and 2008. He also is the recipient of the 2003 45th Faculty Lectureship Award from North Dakota State University in 2003. Koo received the Fulbright Scholar from Korea University in Seoul, South Korea in 2006 and received the Fred Waldron Award in Outstanding Research from North Dakota State University in 2009.*