

Market structure and “frequency economics” in air transport in the United States

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Received: July, 2017.

Accepted: October, 2019.

Published: December 2019.

Abstract

This article provides an original theoretical model for air transport companies in the U.S. air travel market. The theoretical model of competition among airlines is empirically tested by estimating two equations of demand and price fixing. This estimate is made for 239 routes and 23 airports.

This research provides estimates of the elasticity of demand in terms of price and income. It also provides the elasticities of demand in relation to the frequencies and elasticities of price fixing with regard to the frequencies that would allow us to introduce the new concept of “*frequency economics*” for the airlines.

Finally, the article presents results that might be useful to the airlines and public authorities, since it also analyzes the effect of the existence or absence of competitive transportation alternatives to air transport, as well as the influence of the hub airports and the population variable. Knowing the results offered here will undoubtedly prove useful to the actors involved in this industry, in terms of how distance, occupancy and the number of frequencies on each route influence costs.

Key words

Frequencies; airports; competition models; elasticities.

How to cite this article

Coto-Millán, P., & Gundelfinger Casar, J. (2019). Market structure and “frequency economics” in air transport in the United States. *Harvard Deusto Business Research*, VIII(3), 253-267.

<https://doi.org/10.3926/hdbr.241>

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The theoretical model of competition among airlines is tested, estimating two equations of demand and price fixing

1. Introduction

The U.S. domestic air transport system is characterized by a hub and spoke system, with several larger hub airports, such as Atlanta, Chicago, Los Angeles and Miami, which distribute domestic passengers to another 23 large airports and more than 100 medium-sized spokes.

The aim of this study is to provide an original theoretical model for air transport companies in the U.S. air travel market, as well as to empirically test this theoretical model of competition among the airlines by estimating two equations of demand and price fixing.

The unique contribution to the existing literature is made by increasing both the sample size (239 routes) and the time horizon (60 quarters), introducing for each of these routes variables such as frequencies, price per mile charged by the airlines, aircraft capacity and the distance between each origin-destination pair, as well as several dummy variables, among other factors.

For this purpose, a theoretical oligopolistic model of competition was applied, with vertical differentiation of products that could be empirically tested by means of two equations (demand and price). The vertical differentiation will be gathered based on the service frequency as a variable of competition.

This work is structured as follows: after the introduction, a review of the existing literature on this field will be undertaken in the second section, with a theoretical discussion of the hypotheses to be tested in the third section. The empirical model is offered in Section 4. The sources of the data are detailed in Section 5. Section 6 shows the results obtained, while Section 7 presents the conclusions that can be drawn from the study that has been conducted. Finally, Section 11 presents the bibliographic references.

2. Review of the existing literature

Rich and varied literature exists on the effect frequencies have on demand in air transport. However, De Vany (1975) is the first author to empirically show how flight frequencies, measured as quality of service, are an important variable that affects the demand for air transport.

Douglas and Miller (1974), Eriksen (1977), Swan (1979) and Ippolito (1981) built demand models based on both airplane capacity and the number of frequencies operated by the airlines.

Years later, Abrahams (1983), Reis and Spiller (1989), Brander and Zhang (1990), Brander and Zhang (1993), Wei and Hansen (2007), Berry and Jia (2010), Yan and Winston (2014), Ko (2016) and Mohammadian, Abareshi, Abbasi and Goh (2019) modeled the demand for air transport using variables such as the number of frequencies, fleet size and ticket price.

Demand models can also be developed from a microeconomic perspective. Norman and Strandenes (1990) modeled the demand for air transport based on the supposition that the flight frequencies have a uniform distribution. Nikulainen (1992) also developed a demand model during a specified period of time, with the main supposition being the fact that said demand is a function of the frequencies that are scheduled by the airlines in a given market.

The study consists of an analysis of 239 routes and 23 airports in the United States

Logit models, in turn, have been extensively used in characterizing the demand for air transport. Kanafani and Ghobrial (1985), Hansen and Kanafani (1989), Hansen (1990), Dobson and Lederer (1993), Pels, Nijkamp and Rietveld (2000), and Adler (2001) developed demand models based on frequencies and prices, among other variables.

3. Methodology

3.1. A theoretical demand model that can be empirically estimated for air transport services

The background provided in the air transport literature reveals different theoretical models that can be empirically estimated. The model presented here is an original model for transport demand inspired by the one presented by Coto-Millán (1999, 2002). Accordingly, it is based on a function of utility expressed as:

$$U_0 = U_0(x_1, x_2, \dots, x_H; x_{H+1}, \dots, x_Z); \quad (1)$$

In which U_0 represents the vector of utility for the consumer; the vector $(x_1, \dots, x_H)$ represents the quantities of transport services demanded by consumers; the vector $(x_{H+1}, \dots, x_Z)$ represents the rest of the non-transport service-related goods and services.

For reasons of simplicity, we will assume that the function of utility is characterized by the additive property, which permits (1) to be expressed as follows:

$$U_0 = U_1(x_1, x_2, \dots, x_H) + U_2(x_{H+1}, \dots, x_Z); \quad (2)$$

From expression (2), of interest is the first summand related to the utility of transport services. This function can be specified for an origin and a destination that we will designate as route k . Furthermore, the transport services are demanded according to their number of frequencies, and thus we will introduce the good f_{ik} , as the number of frequencies demanded by the consumer on route k . This can be expressed as:

$$U_{ik} = U_{ik}(x_{ik}; f_{ik}); \text{ where } i = 1, \dots, H \quad (3)$$

Where U_{ik} represents the utility of the individual on route k to purchase a quantity of transport services x_{ik} , with a frequency f_{ik} .

The budgetary restriction can be expressed as follows:

$$Y_{ik} = \sum P_{ik} x_{ik} - \sum w_{ik} f_{ik}; \quad (4)$$

Where Y_{ik} represents the level of income from consumers demanding transport i on route k ; P_{ik} represents the price of transport i on route k ; w_{ik} represents the time savings for the consumer

De Vany (1975) was the first author to demonstrate how frequencies are an important variable that affects the demand for air transport

of transport i on route k as the result of the existence of a certain frequency; supposedly with more frequencies, individuals can dedicate more time to work and thus this increase generates and increment in income in $\sum w_{ik} f_{ik}$.

The balance of consumers demanding transport services will be determined by solving the following maximization problem:

$$\begin{aligned} \text{Max } U_{ik} &= U(x_{ik}; f_{ik}); \text{ where } i = 1, \dots, H \text{ means of transport} \\ \text{Subject to: } Y_{ik} &= \sum P_{ik} x_{ik} - \sum w_{ik} f_{ik}; \end{aligned} \quad (5)$$

The demand functions for the balance of the consumers demanding transport services that emerge from solving for the optimal value of (4) are:

$$x_{ik} = x_{ik}(P_{ik}; w_{ik}; Y_{ik}); \quad (6)$$

$$f_{ik} = f_{ik}(P_{ik}; w_{ik}; Y_{ik}); \quad (7)$$

Where the optimal demands for transport services, x_{ik} , depend on the prices P_{ik} of the transport service i . In addition, demand also depends on the number of frequencies of the transport service which, when increasing the traveler's time, generates an increase in income.

The reason is that the traveler might spend more time on his or her job, and therefore increase his or her income.

From here, it is possible to estimate the functions of the transport service demand i on route k with frequency f . A recurrent issue is how to assess the existence of frequencies on a route k . Typically, the greater the number of frequencies, the greater the time savings are for the traveler, in such a way that (6) and (7) can be compacted into (8) as follows:

$$x_{ik} = x_{ik}(P_{ik}; f_{ik}; Y_{ik}); \quad (8)$$

The general demand for transport services in expression (8) can now be expanded for air transport as follows:

$$x_{ik} = x_{ik}(P_{ik}; f_{ik}; Y_{ik}; \text{Pop}_k; DV_k^{\text{att}}; D_k^{\text{hub}}); \quad (9)$$

Where x_{ik} now represents the demand for transport services of airline i on route k ; f_{ik} represents the frequencies of air transport of airline i on route k ; Y_{ik} represents the income of the individual who uses airline i on route k ; the variable Pop_k represents the population level on route k ; the variable DV_k^{att} represents the existence of alternative means of transport on route k as a variable that is assigned the value of 1 if there is an alternative means and 0 if there is

Reis and Spiller (1989), Wei and Hansen (2007) and Mohammadian et al. (2019) also used frequencies to model the demand for air transport

not; the variable D_k^{hub} is a “dummy” variable that represents the existence (or lack thereof) of a connection with an airport hub; if the origin or destination is an airport hub, the dummy variable is assigned a value of 1 and 0 if this is not the case.

Once the equilibrium demand functions for the transport services are obtained, the offer side will now be addressed. Transport companies offer their services while attempting to maximize their profits. Thus, the profit equation can be written as:

$$\Pi_{jk} = P_{jk} x_{jk} - C_{jk}; j = 1, \dots, N \text{ companies} \quad (10)$$

Where Π_{jk} are the profits of airline j on route k ; P_{jk} represents the price of airline j on route k ; where x_{jk} is the amount of services offered by airline j on route k ; and where C_{jk} represents the costs of providing transport services by airline j on route k .

The equilibrium of the company requires maximizing Π_{jk} in (10), and finding an equilibrium function for the inverse demand, dependent on the marginal cost.

In the case of air transport, we are referring to the costs of transport on route k , and therefore, the marginal costs function for air transport on route k becomes MC_k , which is defined as:

$$MC_k = MC(X_k; D_k; F_k); \quad (11)$$

The inverse demand function can now be expressed as:

$$P_{jk} = (x_{jk}; f_{jk}; Y_{ik}; D_k; IHH_k); \quad (12)$$

Finally, the system of equations to be estimated will consist of an equation for the demand and an equation for the behavior of the industry, through the price fixing behavior. In other words, the logarithmically linearized functions (11) and (12) that follow.

$$\begin{aligned} \ln x_{ik} &= \beta_0 + \beta_1 \ln P_{ik} + \beta_2 f_{ik} + \beta_3 \ln Y_{ik} + \beta_4 \ln \text{Pop}_k + \beta_5 DV_k^{\text{att}} + \beta_6 D_k^{\text{hub}} + \varepsilon \\ \ln P_{jk} &= \alpha_0 + \alpha_1 \ln x_{jk} + \alpha_2 \ln D_k + \alpha_3 f_{jk} + \alpha_4 \ln (IHH_k) + \alpha_5 DV_k^{\text{No}} + e \end{aligned} \quad (13)$$

4. The empirical model

4.1. Demand equation, by route and airline

Using the system of equations in expression (13), our empirical specification for the demand equation takes on the following logarithmic form:

$$\ln x_{ik} = \beta_0 + \beta_1 \ln P_{ik} + \beta_2 f_{ik} + \beta_3 \ln Y_{ik} + \beta_4 \ln \text{Pop}_k + \beta_5 DV_k^{\text{att}} + \beta_6 D_k^{\text{hub}} + \varepsilon$$

The sample consists of panel data, including 60 quarterly observations between 2001 and 2015

Where the dependent variable is the number of passengers transported on each route, $\text{Ln } x_{ik}$. The explanatory variables included in this equation are the following:

$\text{Ln } P_{ik}$: The prices offered by each of the airlines i on each route k . A negative sign is expected on the coefficient of this variable, assuming a normal demand curve.

$\text{Ln } f_{ik}$: Number of daily frequencies that are offered by each of the airlines i with regard to the market mean on each route k . A positive coefficient for this variable is expected as an indication of the “quality” perceived by the consumer of this type of services.

$\text{Ln } Y_{ik}$: Per capita income of each U.S. state in which every airport is located from which a passenger takes off. A positive coefficient is expected for this variable.

$\text{Ln } \text{Pop}_k$: The population data for each state on each origin-destination route. A positive sign is expected.

DV_k^{att} : Is assigned a value of 1 if the alternative means of transport (bus, train, fast ferry) takes less than 210 minutes. A negative sign is expected.

D^{hub}_k : This is a dummy variable that reflects the effect of a hub airport. As positive sign is expected, as the presence of a hub airport implies a larger number of passengers attracted by the connection advantages.

4.2. Price equation, by route and airline

In this case, using the second equation from the system (13), the price equation is specified as follows:

$$\text{Ln } P_{jk} = \alpha_0 + \alpha_1 \text{Ln } x_{jk} + \alpha_2 \text{Ln } D_k + \alpha_3 \text{Ln } f_{jk} + \alpha_4 \text{Ln } (HHI_k) + \alpha_5 DV_k^{\text{N}^g} + e$$

Where the dependent variable is the price per mile charged by each airline j on each route k , $\text{Ln } P_{jk}$.

The explanatory variables included in this equation are the following:

$\text{Ln } x_{jk}$: Number of passengers transported on each route by each airline j and on each route k . A negative sign is expected, since the price increases would result in a reduction in the number of passengers.

$\text{Ln } D_k$: The distance between the origin and the destination of route k . A negative sign is expected for the distance variable coefficient, since the costs per mile decrease with the distance, and these reductions are expected to be transferred to the prices.

$\text{Ln } f_{jk}$: Number of daily frequencies offered by each airline i as compared to the market mean on each route k . A positive sign is expected for the coefficient of this variable as a proxy of the relative perceived quality.

$\text{Ln } HHI_k$: Herfindahl index, which is defined as the sum of the square of the market shares of each airline i as compared to the market mean on each route k . A positive sign is expected for

The source of the data is the United States Department of Transportation

the coefficient of this variable, since the greater the market power, the more facility there is to increase ticket prices.

DV_k^{No} : This is a dummy variable that represents the number of operators on each route k . It is assigned a value of 1 on routes with competition from other airlines and 0 on the rest. A negative sign is expected, since the existence of competition implicitly implies less market power to increase prices.

5. Data sources and the sample

The sample used in the analysis is made up of panel data. This technique makes it possible to carry out a more dynamic analysis by incorporating the time dimension of the data, which enriches the study. This panel includes 60 quarterly observations from 2001 to 2015 for the U.S. market for scheduled flights, consisting of 239 routes. The information related to the total number of passengers transported by the airline i on route k , x_{ik} , the prices P_{ik} for each airline on each route and the frequencies of the flights for the airline i as compared to the market mean f_{ik} on route k has also been obtained from the same official source: the United States Department of Transportation.

The distance variable on the route k , D_k , refers to the distance in miles between the origin and destination on each route. The exogenous income variable y_{ik} has been obtained from the per capita income of each U.S. state provided by the United States census bureau, as well as the population of each state on each origin-destination route, Pob_k .

The following three dummy variables have also been included: alternative transport time (DV_k^{att}) which is assigned a value of 1 if the alternative means of transport (bus, train, fast ferry) takes less than 210 minutes, since it is considered that in this case there is a competitive alternative means of transport, and a value of 0 if this is not the case. For this calculation, the websites of each of the operators of each alternative means of transportation were checked.

Number of operators (DV_k^{No}), which is assigned a value of 1 on routes with more than one operator and 0 if there is not more than one, and the existence of a hub airport (D_k^{hub}), which is given a value of 1 in the case of airports that have more than 10 million passengers and 0 if this is not the case.

6. Estimate and results

The estimate was made correcting for heteroscedasticity by means of White robust standard errors. This method is appropriate for large samples such as ours.

Tables 1, 2 and 3 show the results of the main statistics, while Tables 4 and 5 show the results of the estimates for both the demand and price equations, respectively.

In Tables 4 and 5, the explanatory variables are marked with an asterisk when the contrast produces a confidence interval of 90%, 2 asterisks if it is 95%, and 3 asterisks if it is 99%.

Finally, Table 6 shows the airline routes in the U.S. domestic market that were analyzed in this study.

The regressions performed have been calculated using Gretl econometric software.

It is estimated through heterocedasticity correction, using White robust standard errors, which is very appropriate for large samples

Table 1
Descriptive statistics

	Mean	Median	Minimum	Maximum
$\ln P_{ik}$	5.2855	5.3137	4.2838	6.1882
DV_{ik}^{att}	0.083333	0.0000	0.0000	1.0000
$\ln Pob_k$	16.239	16.139	14.100	17.483
$\ln y_{ik}$	4.8961	4.9229	4.6052	5.3152
$\ln f_{ik}$	1.1400	1.1571	-1.6040	4.2720
D_k^{hub}	0.36250	0.0000	0.0000	1.0000
$\ln x_{ik}$	7.1990	7.1983	4.9924	10.041
$\ln D_k$	6.9970	7.0591	4.8598	7.9099
DV_k^{NP}	0.15090	0.0000	0.0000	1.0000
$\ln HHI_k$	8.4881	8.3504	8.1117	9.4752

Table 2
Descriptive statistics (continued)

	Standard Dev.	V.C.	Asymmetry	Exc. Kurt.
$\ln P_{ik}$	0.30676	0.058038	-0.36787	-0.33244
DV_{ik}^{att}	0.27639	3.3167	3.0151	7.0909
$\ln Pob_k$	0.76525	0.047124	-0.30230	-0.28421
$\ln y_{ik}$	0.17715	0.036181	0.016583	-0.73943
$\ln f_{ik}$	0.88482	0.77614	-0.014890	0.098906
D_k^{hub}	0.48074	1.3262	0.57206	-1.6728
$\ln x_{ik}$	0.86284	0.11986	0.17381	-0.24133
$\ln D_k$	0.64878	0.092723	-0.74752	0.041829
DV_k^{NP}	0.35797	2.3722	1.9505	1.8045
$\ln HHI_k$	0.34666	0.040841	1.2405	0.16556

Table 3
Descriptive statistics (continued)

	5% Perc.	95% Perc.	IQR	Miss. Obs.
$\ln P_{ik}$	4.7435	5.7411	0.44711	0
DV_{ik}^{att}	0.0000	1.0000	0.0000	0
$\ln Pob_k$	14.877	17.483	1.0931	0
$\ln y_{ik}$	4.6052	5.1722	0.27778	0
$\ln f_{ik}$	-0.35664	2.5937	1.2088	20
D_k^{hub}	0.0000	1.0000	1.0000	0
$\ln x_{ik}$	5.8102	8.6126	1.2461	0
$\ln D_k$	5.6498	7.8318	0.94497	0
DV_k^{NP}	0.0000	1.0000	0.0000	0
$\ln HHI_k$	8.1479	9.2103	0.31790	0

Prices, the existence of alternative means of transportation, the population, the income, the frequencies and the existence of a hub airport all affect the air transport demand

Table 4
Results of the estimate for the demand equation

Dependent variable: $\ln x_{ik}$

Explanatory variables	Coefficient	Standard Dev.	Z	P Value
Constant	4.07149	0.154231	26.40	5.21e-150 ***
$\ln P_{ik}$	-0.623426	0.0163412	-38.15	1.95e-303 ***
$\ln f_{ik}$	0.661679	0.00553928	119.5	0.0000***
$\ln y_{ik}$	0.817748	0.0250232	32.68	5.14e-226***
$\ln \text{Pop}_k$	0.100006	0.00570539	17.53	4.44e-068 ***
DV_k^{att}	-0.229193	0.0222333	-10.31	7.87e-025 ***
D_{hub_k}	0.167571	0.00867923	19.31	5.10e-082***

Adjusted R²: 0.62

P Value (from F): 0.0000

Table 5
Results of the estimate for the price equation

Dependent variable: $\ln P_{jk}$

Explanatory variables	Coefficient	Standard Dev.	Z	P Value
Constant	2.20075	0.120543	18.26	1.24e-073 ***
$\ln x_{jk}$	-0.0734962	0.00298870	-24.59	7.77e-131 ***
$\ln D_k$	0.289717	0.00322225	89.91	0.0000 ***
$\ln f_{jk}$	0.0149730	0.00296448	5.051	4.45e-07***
$\ln \text{HHI}_k$	0.189193	0.0129974	14.56	1.16e-047***
DV_k^{NP}	-0.241251	0.0125118	19.28	8.22e-082 ***

Adjusted R²: 0.44

P Value (from F): 0.0000

Analyzing the data in Table 4, we can see that the explanatory variables have the expected sign and are significant at 1%. In this manner, it is shown that prices, the existence (or lack thereof) of alternative transport, population, income, frequencies and the existence (or lack thereof) of a hub airport are important determining factors in the air transport demand in the United States of America.

Given that the variables in both equations have been estimated by logarithmic transformations, we can make an interpretation in the form of elasticities.

By first analyzing the effect of prices (P_{ik}) on the estimate for the demand equation, a 1% increase would result in a 0.62% decrease in the volume of transported passengers (x_{ik}), which is entirely reasonable. Furthermore, the existence of competitive alternative transportation, DV_k^{att} , triggers a 22% decrease in the number of passengers transported by air.

Table 6

U.S. domestic market routes that form the sample used

Origin	Destination	Origin	Destination	Origin	Destination
Atlanta	Boston	Boston	Seattle	Dallas	Los Angeles, CA
Atlanta	Charlotte	Boston	Tampa, FL	Dallas	Miami, FL
Atlanta	Chicago	Boston	Washington	Dallas	Minneapolis
Atlanta	Dallas	Charlotte	Chicago	Dallas	New York City
Atlanta	Denver	Charlotte	Dallas	Dallas	Orlando, FL
Atlanta	Detroit, MI	Charlotte	Denver	Dallas	Philadelphia, PA
Atlanta	Houston, TX	Charlotte	Detroit, MI	Dallas	Phoenix
Atlanta	Las Vegas, NV	Charlotte	Houston, TX	Dallas	Portland, OR
Atlanta	Los Angeles, CA	Charlotte	Las Vegas, NV	Dallas	Salt Lake City, UT
Atlanta	Miami, FL	Charlotte	Los Angeles, CA	Dallas	San Diego, CA
Atlanta	Minneapolis	Charlotte	Miami, FL	Dallas	San Francisco, CA
Atlanta	New York City	Charlotte	Minneapolis	Dallas	Seattle
Atlanta	Orlando, FL	Charlotte	New York City	Dallas	Tampa, FL
Atlanta	Philadelphia, PA	Charlotte	Orlando, FL	Dallas	Washington
Atlanta	Phoenix	Charlotte	Philadelphia, PA	Denver	Detroit, MI
Atlanta	Portland, OR	Charlotte	San Francisco, CA	Denver	Houston, TX
Atlanta	Salt Lake City, UT	Charlotte	Tampa, FL	Denver	Las Vegas, NV
Atlanta	San Diego, CA	Charlotte	Washington	Denver	Los Angeles, CA
Atlanta	San Francisco, CA	Chicago	Dallas	Denver	Miami, FL
Atlanta	Seattle	Chicago	Denver	Denver	Minneapolis
Atlanta	Tampa, FL	Chicago	Detroit, MI	Denver	New York City
Atlanta	Washington	Chicago	Houston, TX	Denver	Orlando, FL
Boston	Charlotte	Chicago	Las Vegas, NV	Denver	Philadelphia, PA
Boston	Chicago	Chicago	Los Angeles, CA	Denver	Phoenix
Boston	Dallas	Chicago	Miami, FL	Denver	Portland, OR
Boston	Denver	Chicago	Minneapolis	Denver	Salt Lake City, UT
Boston	Detroit, MI	Chicago	New York City	Denver	San Diego, CA
Boston	Houston, TX	Chicago	Orlando, FL	Denver	San Francisco, CA
Boston	Las Vegas, NV	Chicago	Philadelphia, PA	Denver	Seattle
Boston	Los Angeles, CA	Chicago	Phoenix	Denver	Tampa, FL
Boston	Miami, FL	Chicago	Portland, OR	Denver	Washington
Boston	Minneapolis	Chicago	Salt Lake City, UT	Detroit, MI	Houston, TX
Boston	New York City	Chicago	San Diego, CA	Detroit, MI	Las Vegas, NV
Boston	Orlando, FL	Chicago	San Francisco, CA	Detroit, MI	Los Angeles, CA
Boston	Philadelphia, PA	Chicago	Tampa, FL	Detroit, MI	Miami, FL
Boston	Phoenix	Chicago	Washington	Detroit, MI	Minneapolis
Boston	Portland, OR	Dallas	Denver	Detroit, MI	New York City
Boston	Salt Lake City, UT	Dallas	Detroit, MI	Detroit, MI	Orlando, FL
Boston	San Diego, CA	Dallas	Houston, TX	Detroit, MI	Philadelphia, PA
Boston	San Francisco, CA	Dallas	Las Vegas, NV	Detroit, MI	Phoenix

Table 6 (continued)

U.S. domestic market routes that form the sample used

Origin	Destination	Origin	Destination	Origin	Destination
Detroit, MI	Salt Lake City, UT	Los Angeles, CA	Phoenix	Orlando, FL	Philadelphia, PA
Detroit, MI	San Diego, CA	Los Angeles, CA	Portland, OR	Orlando, FL	Phoenix
Detroit, MI	San Francisco, CA	Los Angeles, CA	Salt Lake City, UT	Orlando, FL	Portland, OR
Detroit, MI	Seattle	Los Angeles, CA	San Francisco, CA	Orlando, FL	Salt Lake City, UT
Detroit, MI	Tampa, FL	Los Angeles, CA	Seattle	Orlando, FL	San Diego, CA
Detroit, MI	Washington	Los Angeles, CA	Tampa, FL	Orlando, FL	San Francisco, CA
Houston, TX	Las Vegas, NV	Los Angeles, CA	Washington	Orlando, FL	Seattle
Houston, TX	Los Angeles, CA	Miami, FL	Minneapolis	Orlando, FL	Washington
Houston, TX	Miami, FL	Miami, FL	New York City	Philadelphia, PA	Phoenix
Houston, TX	Minneapolis	Miami, FL	Orlando, FL	Philadelphia, PA	Salt Lake City, UT
Houston, TX	New York City	Miami, FL	Philadelphia, PA	Philadelphia, PA	San Diego, CA
Houston, TX	Orlando, FL	Miami, FL	Phoenix	Philadelphia, PA	San Francisco, CA
Houston, TX	Philadelphia, PA	Miami, FL	Portland, OR	Philadelphia, PA	Seattle
Houston, TX	Phoenix	Miami, FL	Salt Lake City, UT	Philadelphia, PA	Tampa, FL
Houston, TX	Portland, OR	Miami, FL	San Diego, CA	Phoenix	Portland, OR
Houston, TX	Salt Lake City, UT	Miami, FL	San Francisco, CA	Phoenix	Salt Lake City, UT
Houston, TX	San Diego, CA	Miami, FL	Seattle	Phoenix	San Diego, CA
Houston, TX	San Francisco, CA	Miami, FL	Tampa, FL	Phoenix	San Francisco, CA
Houston, TX	Seattle	Miami, FL	Washington	Phoenix	Seattle
Houston, TX	Tampa, FL	Minneapolis	New York City	Phoenix	Tampa, FL
Houston, TX	Washington	Minneapolis	Orlando, FL	Phoenix	Washington
Las Vegas, NV	Los Angeles, CA	Minneapolis	Philadelphia, PA	Portland, OR	Salt Lake City, UT
Las Vegas, NV	Miami, FL	Minneapolis	Phoenix	Portland, OR	San Diego, CA
Las Vegas, NV	Minneapolis	Minneapolis	Portland, OR	Portland, OR	San Francisco, CA
Las Vegas, NV	New York City	Minneapolis	Salt Lake City, UT	Portland, OR	Seattle
Las Vegas, NV	Orlando, FL	Minneapolis	San Diego, CA	Salt Lake City, UT	San Diego, CA
Las Vegas, NV	Philadelphia, PA	Minneapolis	San Francisco, CA	Salt Lake City, UT	San Francisco, CA
Las Vegas, NV	Phoenix	Minneapolis	Seattle	Salt Lake City, UT	Seattle
Las Vegas, NV	Portland, OR	Minneapolis	Tampa, FL	Salt Lake City, UT	Washington
Las Vegas, NV	Salt Lake City, UT	Minneapolis	Washington	San Diego, CA	San Francisco, CA
Las Vegas, NV	San Diego, CA	New York City	Orlando, FL	San Diego, CA	Seattle
Las Vegas, NV	San Francisco, CA	New York City	Phoenix	San Diego, CA	Tampa, FL
Las Vegas, NV	Seattle	New York City	Portland, ME	San Diego, CA	Washington
Las Vegas, NV	Tampa, FL	New York City	Portland, OR	San Francisco, CA	Seattle
Las Vegas, NV	Washington	New York City	Salt Lake City, UT	San Francisco, CA	Tampa, FL
Los Angeles, CA	Miami, FL	New York City	San Diego, CA	San Francisco, CA	Washington
Los Angeles, CA	Minneapolis	New York City	San Francisco, CA	Seattle	Tampa, FL
Los Angeles, CA	New York City	New York City	Seattle	Seattle	Washington
Los Angeles, CA	Orlando, FL	New York City	Tampa, FL	Tampa, FL	Washington
Los Angeles, CA	Philadelphia, PA	New York City	Washington		

Demand, distance, competition, the number of frequencies and the Herfindhal index have an impact on the establishment of air transport prices

With regard to demographic factors, a 1% increase in the population would increase the passenger volume by 0.10%.

In turn, elasticity of the demand as compared to income is 0.81. In other words, with a 1% increase in income, the number of passengers transported would increase by 0.81%.

Moreover, the elasticity of the demand as compared to the number of frequencies is 0.66. That is to say that a 1% increase in frequencies suggests a 0.66% increase in the number of passengers. Finally, and analyzing the effect a hub airport has on overall traffic, we can conclude that this variable has a value of 0.16, which implies that the existence of this type of airports contributes to increasing the passenger volume by as much as 16%.

Analyzing the data in Table 5, we can see that the explanatory variables have the expected sign and are significant at 1%. In this way, it is shown that demand, distance, whether or not there is competition, the number of frequencies and the Herfindhal index are important determining factors in the establishment of air transport prices in the United States of America.

Price elasticity with regard to the demand is -0.07 , i.e., with a 1% price increase, the demand for air transport would be affected by a drop of 0.07%.

The coefficient of the distance variable, D_k , has a value of (0.28). A priori, this effect is the opposite of what is expected and could reveal diseconomies of scale, as the greater the distances, the higher the prices are.

The elasticity of the price to the number of operators is significant and has a negative sign (-0.24). This implies that if more than one operator is competing on a route, the price per mile decreases by 24%.

With regard to the coefficient of the daily frequencies variable with regard to the market average, it is significant at 1% and with a value of (-0.01), i.e., the greater the frequencies, the lower the prices.

Finally, the Herfindhal index shows a value of 0.18, in other words, with every 1% increase in the concentration index, the prices will tend to increase by 0.18%.

7. Conclusions

This article has provided an original theoretical model for airlines in the air transport market in the United States. A theoretical model of competition among airlines has been empirically tested by estimating two equations of demand and price fixing.

This estimation was carried out for 239 routes and 23 airports, which represents 90% of the total traffic, measured in terms of the number of passengers transported.

The econometric analysis of this study has served to be able to provide estimates of the elasticities of demand and price fixing with regard to frequencies, which allows us to introduce the new concept of “frequency economics” for the airlines. It also provides elasticities of demand with regard to price and income.

The most interesting result, in our opinion, is that the frequencies variable shows a positive elasticity (0.66). This implies that the greater the number of frequencies, the more possibilities

Regulators should support increased frequencies, since there are seen as greater service quality, thus generating greater demand

consumers have to save time and thus increase their incomes, which in turn will result in a greater demand for air transport.

This result fully coincides with most of the previously cited authors, especially Ippolito (1981), whose demand function had a value of 0.75 for its frequencies variable.

After income, the frequencies variable in this case is identified as the most important variable when generating passengers, which is consistent with most of the results presented by the scientific literature in this field, especially in the most recent times (Mohammadian et al., 2019).

The proper scheduling of the frequencies can be considered a key parameter when evaluating the quality of airline services, since one of the major attributes of quality, according to the scientific literature, is the number of frequencies that are offered by the airlines. Accordingly, a low level of frequencies can cause the market share of the airlines to drop, and thus a loss in passenger demand.

On the contrary, an increase in frequencies reduces the total travel time for passengers and increases demand. As a result, there is a trend to compete to offer more frequencies and thus attain greater market power.

On the price side, the frequencies variable on each route, f_{ik} , also reflects a positive effect on costs, and therefore on prices. However, the price increases are not proportional, rather given the estimated value of the elasticity (0.014), 100% increases in the frequencies only produce increases of 1.4% in price.

This means that there are “frequency economies”, understood to mean those situations in which the 100% increases in the number of frequencies produce increases in costs that are less than 100% and therefore make it possible to increase prices in proportions of less than 100%.

This paper not only provides a tool to support the decisions of airline managers to determine flight frequencies and the airfares offered, it also estimates the key variables in generating demand and in determining prices such as income, the population, distance or the Herfindahl index.

The political economic recommendations drawn from our results is that regulators should support the increase in frequencies, since these are seen as greater quality in the service offered and generate a greater demand. However, the limited capacity of airports to absorb this increased number of flights must also be taken into consideration. This challenge faced by managers to assign airport capacity to the airlines could be a future line of research to consider.

8. Acknowledgments

The authors appreciate all the comments and suggestions made by the editor and the anonymous reviewers, which have noticeably improved this study. Any possible error should only be attributed to the authors.

9. Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

10. Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

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