AIRPORT PRICES IN A TWO SIDED FRAMEWORK: AN EMPIRICAL ANALYSIS

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May 11, 2011

First draft

Abstract

Airport industry has gained importance especially after the liberalization of air transport. In the previous literature, airport pricing is either discussed within a partial equilibrium model where the airline market is not formally modelled or through a vertical relation between airlines and airports taking the passengers as final consumers. This paper provides a methodology to analyze airports under two sided market setting, i.e, we consider airports as platforms which the airlines and passengers join to interact. After developing a structural model, we use data on US airports to provide empirical evidence for two-sidedness. Starting with a monopoly platform, we derive the demand equation of passengers and pricing equation of airlines which are then estimated simultaneously. To check the structure of the market, we examine the significance of network effect parameters. We find out that airports are indeed two-sided platforms since the coefficients of flight frequencies and airport characteristics are significant in passenger demand. And also, airports can cross-subsidize the two sides with respect to their elasticities. The methodology used in this paper should contribute to the guidance for the public policy of airport pricing.

Keywords: Two-sided markets, airport industry

JEL Classification: L93, C32

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Introduction

With the liberalization of air transport and the enlargement of air traffic, airports face insistent requests from airlines to perform and improve both service quality and cost efficiency. As a result; airport ownership, governance and regulations are debated and sometimes have already been changed. Airport pricing under different governance structure is a central issue in this context.

For long this question has been addressed in a framework where airports are considered as aviation service provider for the needs of airlines. However, almost everywhere around the world, airports provide both aeronautical and non-aeronautical services. Although aviation services are the main mission of airports, the revenues are coming from both sides: Airlines and passengers. As of 2009, the share of commercial revenues in airports' total operating revenues has increased to 60 percent according to the Airport Financial Report of the Federal Aviation Administration. Under this environment, airports are not only setting the price level for their aviation services, but they decide on a price structure in which they apparently cross-subsidize aeronautical operations by non-aeronautical revenues. Having two demand groups (i.e., airlines and passengers) who value each other's existence make us consider airports as platforms that connect different types of users. In this paper, we test a two-sided market theory in which airports are considered as platforms where airlines and passengers join to interact. In other words, airports internalize the network externalities arising from the two demands: Passengers are better off if there are more airlines and airlines are better off if there are more passengers.

There are two main features of two-sided markets. First there exist externalities between the two end users of the platform. Strictly speaking, decision of one side to enter the market or not depends on the decision of the other side. So, the platforms have to "get both sides on the board". The mostly studied platform examples in the literature are: Credit cards, magazines, academic journals and shopping malls. In the case of credit cards, a consumer wants to hold a card which is most widely accepted by retailers and a retailer would like to accept a card which is most widely used by consumers. In the magazine industry, firms would like to give adds to a magazine which has a large number of readers. On the other side of the market, readers may get either utility or disutility from the advertisements. The second noticeable aspect of two-sided markets is that the platform should be able to internalize these existing network externalities whilst deciding on its pricing scheme. For instance, platforms may discount prices on one side of the market to attract more agents in this side which would in return allow it to charge higher prices to the other side. As found by Kaiser and Wright (2006), readers are subsidized by the profit from advertising side in magazine industry, i.e., the cover prices are discounted for readers to attract more readers, thereby to attract more advertisers.

Following this literature, airports are candidates to be considered as two sided platforms, that is to say, as markets with externalities in which they can cross-subsidize the two sides through the pricing structure. Obviously the end users are the airlines and the passengers. The formers' demand depends on the aeronautical fees and the number of passengers using that airport. The latters' demand for airports depends on the number of airlines serving at that airport, airline services and airport passenger service related features such as accessibility of airport, parking or shopping. (See Starkie, 2008). An airline would choose to operate at an airport which is more popular amongst passengers and passengers would enjoy an airport where they can access more airlines and more destinations, as well as a wide range of shops and restaurants, and convenient parking and transportation facilities. Airports earn revenues from both sides and determine the prices of airport services used by both sides. Although the airport charges the airlines explicitly with their agreements and negotiations as in Starkie (2008), the case is different for the passengers. Mainly, the airport has two sources of pricing for the passengers. One is directly taken as airport taxes at the stage of ticket sale (through airlines). The other can be deduced via the non-aviation facilities that the airport serves such as parking, restaurants or stores. Considering the previous literature on airports, papers by L. Basso (2007), Brueckner (2002) or Starkie (2008) either make a partial equilibrium model where the airline market is not modelled formally or assume a vertical relation between the airlines and airports taking the passengers as final consumers. In addition to this, Gillen (2009) points out that in the last decades, airports have gone through a transition both because of privatization of the industry and increasing importance of commercial revenues. Given this transition and the structure that we have defined it is indispensable to look at airports as two-sided platforms.

In this paper, we examine airports under a two-sided market setting in which airports are two-sided platforms where airlines and passengers are the two end-users. After developing the structural model, we look for an empirical evidence for two-sidedness by using data on US airports. We begin with a monopoly platform and derive the demand equations of passengers and pricing equation of airlines which are estimated simultaneously. To check the structure of the market, we examine the significance of the externality effect parameters. That is to say, we check if the number of flights is significant in passengers' demand for an airport.

While payment cards, shopping malls, academic journals and magazines have all received a considerable attention as two-sided platforms, the airport industry has not yet been analyzed through this approach. The outcome of the test we perform has important policy applications. Within a framework considered by aforementioned literature that neglects the two-sidedness of airports, the public policy on airport could be misled an suboptimal if two-sidedness is relevant for airport because, as explained by Rochet and Tirole (2003), this feature has striking implications on pricing policy. For instance, prices can be below marginal costs in two-sided markets. It is also important to understand the business model of airports for the regulatory issues. This can be understood and tested only if the market structure is correctly identified. For that reason, the methodology proposed in this paper should contribute to the guidance for the public policy of airport pricing.

Our test is a first step in an extensive research agenda. First, our model can be extended to the case of competition between airports, in which we consider the case of competitive bottlenecks, where the airlines do multi-homing while the passengers do single-homing. Moreover, the competition between two asymmetric airports can be analyzed under this setting. Airports can also be examined for the optimal platform design like in Hagiu and Jullien (2007), which in turn can increase its profits by pricing optimally the stores. Besides all these, the structural parameters obtained from empirical examination can be used for policy issues.

The paper is structured as follows. In Section 1, we present the related literature on airports and two-sided markets. Section 2 explains the theoretical model in which passenger demand, airline demand and airport pricing scheme are introduced. Section 3 describes the data and provides some descriptive analysis while Section 4 presents the empirical specification. Section 5 contains the empirical results. Finally, we conclude in Section 6.

1 Related Literature

Although many theoretical and empirical articles deal with the economics of airports, none considers them as two-sided markets. Likewise, in spite of growing literature on two-sided markets, airport industry has never been considered under this approach. Our paper is indeed related to the literature on the airport industry and the literature on two-sided markets. Economic studies on airport industry generally focus on pricing, capacity, congestion and regulation issues. Previous studies that look at the question of airport pricing from a theoretical point of view such as L. Basso (2007) and L. J. Basso and Zhang (2008) or from an empirical angle like Gagnepain and Marin Uribe (2004 and 2005), consider that the airport-airline-passenger relationship is vertically integrated, taking passengers as final consumers. In other words, demand for airport services is a derived demand which comes from the necessity of the product of airlines (air transport demand) so that they consider airlines as intermediaries. In our setting alternatively, airlines and passengers are the two end users which use the platform, namely the airport, to interact with each other. However, as in these previous empirical papers, we also assume below that airlines maximize profit at each route they serve to account for airline and route characteristics. In addition to this, we allow passenger demand to depend on airport (i.e., origin) characteristics in our estimation which enables us to capture two-sided externalities.

There are other papers on airport economics related to ours. Berry (1990) mentions that when passengers are choosing an airline, they consider if the airline has a dominant position at an airport in terms of flight frequency, as well as some other airline characteristics (e.g. frequent flyer programs, travel agent commission overrides). In our model below the passenger demand depends on the total frequency at the airport, besides the flight frequency of airline itself and airline characteristics. Hess and Polak (2006) and Pels, Nijkamp, and Rietveld (2003) analyze the choice of airport in London and San Francisco Bay Area, respectively, using a nested logit specification for airport choice in which some route specific effects are included as explanatory variables nonetheless they do not measure the network effects of airlines by their approach. We also use a nested logit model below but we address the interrelations between the airlines and passengers.

As airports have had a monopoly position for many years, they were subject to the regulation of aeronautical charges. Especially, two price cap regulations, namely single-till and dual-till, are opposed. In single till approach the price-cap formula for aeronautical charges includes revenues derived from both aeronautical and non-aeronautical activities, while in dual till approach only the revenues from aeronautical activities are taken into account. The advocates of dual till, claim that regulation should concentrate on activities which are characterized by a natural monopoly, thus revenues from commercial activities should not be included in the formula. (See Beesly, 1999.) On the other hand, there is a strong complementary between the aeronautical and non-aeronautical activities. (See Starkie and Yarrow, 2009.) Some recent papers, like Zhang and Zhang (2010), study the airport decision on pricing and capacity both under single-till and dual-till approaches. Currier (2008) looks at a price cap regulation of airports and proposes a price capping scheme which yields Pareto improvements compared to the status-quo regardless of single-till or dual-till regulation. Czerny (2006) points out that single-till regulation is more welfare enhancing at non-congested airports compared to dual-till. Here we do not investigate the impact of different regulations. We first search for the empirical evidence of two sided structure at airport whose results would be crucial to implement appropriate price capping scheme. Secondly, finding that the airports are two sided platforms, one can extract business model of airports (e.g. profit maximization, budget balance, social welfare maximization, etc...) under a more realistic structure, which again would be critical for the regulatory issues. Our approach should help finding the adequate model to measure the effectiveness of regulation.

This paper is also related to the two-sided markets literature which has been grown substantially in the last decade. The theoretical side, Rochet and Tirole (2002 and 2003) and Armstrong (2006) are the kernels. Rochet and Tirole (2002) focus on credit cards, and the other two articles consider the platform competition in two-sided markets in a general setting. Rochet and Tirole (2003) point out that a market can be considered as two-sided if there are network externalities between the two sides, and if the platform choose a price structure not only a price level for its service, i.e., it decides on a pricing strategy which depends on the externalities between the two sides. Although airports fit to this definition, none of the aforementioned papers refers to airports as an example of two-sided platform. Additionally, Hagiu and Jullien (2007) consider platform design for new economies like Yahoo!, eBay, Amazon, Google, or platforms like shopping malls. As airports are providing non-aeronautical facilities such as shops and restaurants to passengers, they can also be studied in this dimension in the future.

Concerning empirical studies in two-sided markets, we have examples on media (Kaiser and Wright, 2006 and Argentesi and Filistrucchi, 2007), yellow pages (Rysman, 2004), and academic journals (Dubois, Hernandez-Perez and Ivaldi, 2007). The two-sidedness in these industries are proved empirically. The main novelty of our paper is that we first set up a structural two sided market model for airports, and then we estimate it and provide empirical evidence that the airports are indeed two-sided platforms.

2 Model

This paper presents the methodology to test that airports can be considered as two-sided platforms. To do so we combine aspects of the two-sided market theory with transportation models. Our model assumes the airport as a monopoly platform in which airlines and passengers join to interact. Thus, the industry is composed of a monopoly airport, J airlines and I passengers. We define the market as the set of directional origin-destination (O-D) routes. In this section we present the structural model be estimated. First, we derive the transport demand equation of passengers then the pricing and frequency equations that define the airlines' strategies are derived. Finally, we describe the airport's programme.

2.1 Passenger Side

A passenger i, $i = 1,.,I$ has to decide between travelling to a given destination d, $d = 1,.,D$, from its home airport a, $a = 1,.,A$, and "not travelling" or "using other transport modes" which is its outside option referred by the index 0. Under the option of travelling, the passenger has to choose an airline j among the set of available airlines $j = 1,.,J_{ad}$ for this origin-destination. To represent this choice structure, we adopt a nested logit model.[4,5] The indirect utility level achieved by passenger i from choosing airline j at airport a for a given destination d is given by:

$$U^{i}_{adj} = V_{adj} + \epsilon^{i}_{adj} \quad (1)$$

where ϵ^{i}_{adj} is the consumer specific unobservable effects specified as follows:

[4] See Appendix A for the choice tree.

[5] Note that, including first the choice of using an airport or not using it, allows us to extend the model to competing platforms easily. As in that case, the choice of the outside good would comprise other airports.

$$\epsilon_{adj}^{i} = \nu_{ad}^{i} + (1-\sigma)\nu_{adj}^{i} \quad \forall i = 1,.,I \tag{2}$$

where σ is a parameter to be estimated. For a given origin-destination, the error terms ν_{ad}^{i} and ν_{adj}^{i} are common to all products in airport a to destination d and airport-destination-airline adj, respectively. In this specification, σ shows the within group correlation of unobserved utility; in other words, it is the substitutability of airlines operating at airport a. The higher the σ is, the more substitutable the products (airlines) are.

Let V_{adj} be the mean utility level of using airline j from airport a which is specified as:

$$V_{adj} = X_{adj}\beta + \beta^{j}\frac{1}{\sqrt{f_{adj}}} + \beta^{a} f_{a} - \alpha\,\tilde{p}_{adj} + \xi_{adj} \tag{3}$$

where X_{adj} is a vector of observable airport, destination and airline characteristics, ξ_{adj} is an error term. f_{adj} is the frequency of airline j at airport a to destination d. The term $1/\sqrt{f_{adj}}$ is the consumer's cost of schedule delay (the difference between the passenger's preferred departure time and the actual departure time). A passenger's schedule delay is inversely proportional to the frequency, assuming that desired departure times are uniformly distributed and an airline groups some of its departure times. (See Richard, 2003) Now, f_a is the airport capacity measures as the sum of flight frequencies of all airlines operating at airport a to all destinations d, i.e., $f_{a} = (\sum_{d}\sum_{j} f_{adj})$, and $\tilde{p}_{adj}$ is airline j's the effective price paid by the passenger as

$$\tilde{p}_{adj} = (p_{adj} + p_{c}) \tag{4}$$

where p_{adj} is the fare of airline j from airport a to destination d, which includes airport taxes (aeronautical fees), and p_c is the price of airport facilities for passengers, also called the concession fee. Note that the βs and α are parameters to be estimated.

The mean utility of outside option is normalized to 0, i.e, $V_0 = 0$. Following Berry (1994), the share of passengers using airline j in a given origin-destination market is given by:

$$ln(s_{adj}) = X_{adj}\beta + \beta^j \frac{1}{\sqrt{f_{adj}}} + \beta^a f_a - \alpha \tilde{p}_{adj} + \sigma ln(s_{j|ad}) + ln(s_0) + \xi_{adj} \quad (5)$$

where $s_{j|ad}$ designates the share of airline j within the nest "travelling on an airline from airport a to destination d," and s_0 is the probability of choosing the outside option. The market shares are measured as:

$$s_{adj} = \frac{q_{adj}}{M} \quad (6)$$

$$s_{j|ad} = \frac{q_{adj}}{\sum_{j \in J_{ad}} q_{adj}} \quad (7)$$

where M is the total market size. Additionally, J_{ad} is the total number of airlines operating from airport a to destination d.

2.2 Airline Side

Each airline j, $j = 1,..., J_{ad}$, sets its fare $\left(p_{adj}\right)$ and frequency $\left(f_{adj}\right)$ which maximizes its profit Π_{adj} on each market. The profit maximization problem of airline j is written as:

$$\max_{p_{adj} f_{adj}} \Pi_{adj} = (p_{adj} - c^q_{adj})q_{adj} - p_a f_{adj} - F_{adj} \quad s.t. \quad \Pi_{adj} \geq 0 \quad (8)$$

where p_a is the aeronautical fee charged by the airport a per flight (departure) and c^q_{adj} is the marginal cost per passenger of airline j for route ad. Since we do not observe this marginal cost, we posit that

$$c^q_{adj} = \lambda_0 + \lambda_1 Z_{adj} + u_{adj} \quad (9)$$

where Z_{adj} is the vector of cost shifters that includes airline, destination and airport specific dummies, and u_{adj} is an error term. Then, the optimal levels of price and frequency are given by:

$$p^*_{adj} = c^q_{adj} + \frac{1}{\alpha\left(\frac{1}{1-\sigma} - \frac{\sigma}{1-\sigma} s_{j|ad} - s_{adj}\right)} \tag{10}$$

$$f^*_{adj} = \left[\frac{2}{\beta^j}\left(\beta^a - \frac{\alpha p_a}{q_{adj}}\right)\right]^{-2/3} \tag{11}$$

Note that the price of product adj is equal to the marginal cost of product adj plus a mark-up term. The mark-up term decreases in increasing substitutability among the products in a given nest. Moreover, equation (10) shows that higher market shares leads to higher prices. If an airline has a dominant position at an airport, then it can use its market power to charge higher prices. (See Borenstein and Rose, 1994.) Equation (11) shows that the optimal level of frequency depends on the number of passengers and aeronautical fee charged by airport, as well as the parameters α, i.e., the marginal utility of income, β^j, i;e., the consumers' valuation of waiting time, and β^a, i.e., their valuation of total frequency at airport (in other words, the cost of congestion).

2.3 Airport Pricing

We present now the platform's, namely the airport's, problem. Assume that the airport is privately owned and thus maximizes its profits. Given the total number of flights f_a and the total number of passengers departing from airport a, q_a, the equilibrium aeronautical fee per departure, p_a , and the concession fee per passenger p_c are solutions of the following maximization problem.

$$\max_{p_a, p_c} \Pi = (p_c - c_c) q_a + (p_a - c_a) f_a - F_a \tag{12}$$

where $q_a = \sum_d \sum_j q_{adj}$ and F_a is the fixed cost of airport a.

Note that $f_a = \sum_d \sum_j f_{adj}$, then f_a is endogenous in the demand equation of passengers for airline. When the airport changes its aeronautical fees, it affects the demand of airlines via Equation (11) and it also affects passenger demand via waiting time and congestion variables in demand equation (Equation (5)). Due to the two-sided externalities, a change in p_a affects the demand on both sides, namely airlines and passengers. Similarly, when airport changes p_c, it impacts passengers' demand and also airlines' demand.

The first order conditions of the profit maximization programme of airport are written as follows:

$$\frac{\partial \Pi}{\partial p_a} = (p_c - c_c)\sum_d \sum_j \frac{\partial q_{adj}}{\partial f_{adj}} \frac{\partial f_{adj}}{\partial p_a} + \sum_d \sum_j f_{adj} + (p_a - c_a)\sum_d \sum_j \frac{\partial f_{adj}}{\partial p_a} = 0 \tag{13}$$

$$\frac{\partial \Pi}{\partial p_c} = \sum_d \sum_j q_{adj} + (p_c - c_c)\sum_d \sum_j \frac{\partial q_{adj}}{\partial p_c} + (p_a - c_a)\sum_d \sum_j \frac{\partial f_{adj}}{\partial q_{adj}} \frac{\partial q_{adj}}{\partial p_c} = 0 \tag{14}$$

From equations (13) and (14) the optimal aeronautical fee of airports is obtained as:

$$p_a^* = c_a + \frac{\sum_d \sum_j f_{adj} \sum_d \sum_j \frac{\partial q_{adj}}{\partial p_c} - \sum_d \sum_j q_{adj} \sum_d \sum_j \frac{\partial q_{adj}}{\partial f_{adj}} \frac{\partial f_{adj}}{\partial p_a}}{\sum_d \sum_j \frac{\partial f_{adj}}{\partial q_{adj}} \frac{\partial q_{adj}}{\partial p_c} \sum_d \sum_j \frac{\partial q_{adj}}{\partial f_{adj}} \frac{\partial f_{adj}}{\partial p_a} - \sum_d \sum_j \frac{\partial f_{adj}}{\partial p_a} \sum_d \sum_j \frac{\partial q_{adj}}{\partial p_c}} \tag{15}$$

The optimal concession fee for passengers is given by the following formula:

$$p_c^* = c_c + \frac{\sum_d \sum_j q_{adj} \sum_d \sum_j \frac{\partial f_{adj}}{\partial p_a} - \sum_d \sum_j f_{adj} \sum_d \sum_j \frac{\partial f_{adj}}{\partial q_{adj}} \frac{\partial q_{adj}}{\partial p_c}}{\sum_d \sum_j \frac{\partial f_{adj}}{\partial q_{adj}} \frac{\partial q_{adj}}{\partial p_c} \sum_d \sum_j \frac{\partial q_{adj}}{\partial f_{adj}} \frac{\partial f_{adj}}{\partial p_a} - \sum_d \sum_j \frac{\partial f_{adj}}{\partial p_a} \sum_d \sum_j \frac{\partial q_{adj}}{\partial p_c}} \tag{16}$$

As mentioned before, the airport internalizes the two-sided network externalities between passengers and airlines when it is deciding on its price structure. The two-sidedness effect conveyed through the optimal aeronautical fee in Equation (15) and the optimal concession fee in Equation (16). The former shows that the airport authority takes into account the fact that p_a does not only affect the demand of airlines but also the demand of passengers for the airport. Since the passengers do care about the flight frequency of airlines, this interaction further affects the demand of airlines. The latter shows the airport internalizes the effect of a change in concession on airlines. For example, an increase in concession price would decrease the demand of passengers for the airport and it would also decrease the demand of airlines by two-sided network externalities. At the same time the airport authority could compensate this negative effect by decreasing aeronautical fees to attract more airlines, and thus to attract passengers.

Note that the resulting effect depends on the price elasticities for passengers and airlines, and the magnitude of externalities. Hence, for the policy point of view, when airports are analyzed as two-sided platforms instead of vertically integrated institutions, where the passengers are final consumers, the discussion on the difference between single-till or dual-till price cap regulation becomes meaningless since in a two-sided market setting, the airport can clearly do cross-subsidization between the two sides, and it is the single-till price cap regulation that can capture this cross-subsidization.

3 Data

This study uses mainly four sources of data. The *airline industry data* are drawn from the Airline Origin and Destination Survey Ticket (DB1B-Ticket) provided by the U.S. Bureau of Transport Statistics (BTS) and available on its web site. The DB1B-Ticket survey is a 10% sample of airline tickets from large carriers in US and comprises detailed information on ticket fares, itinerary (origin, destination, and all connecting airports), the ticketing and operating carrier for each segment, and the number of passengers travelled on the itinerary at a given fare. To construct our working sample we extracted from the DB1B-Ticket dataset the record corresponding to the 3rd quarter of year 2006 during which, for the first time after 2000, the US airline industry experiences a positive aggregate net profit of $3:04 billions excluding restructuring and bankruptcy costs. (See ATA, 2007.)

The *flight frequency data* is constructed from airline on-time performance data of BTS which contains the number of domestic flights by major carriers. It is worthwhile to note that to measure the impact of frequency on passenger demand, we need to use actual frequencies instead of gathering them from DB1B data, which is the 10% sample of airline tickets. In return this leads to a discrepancy between the frequency obtained from on-time data and the number of passengers coming from DB1B data. For that reason, the derived demand of airlines for airport (i.e. the frequency) cannot be included in the estimation procedure.

The *airport data* is constructed from the Airport Financial Data and the Airport Data (5010) published by the Federal Aviation Administration (FAA), which give detailed information about airports' aeronautical and commercial activities as well as the facilities. Moreover, some of the airport characteristics, such as the number of parking and the number of concession contracts, are gathered directly from the airports.

Finally, the *demographic data* is obtained from U.S. Census Bureau. As is the assumption of monopoly airport, we consider the 31 Hubs among the top 50 U.S. airports (in terms of number of enplanements). After gathering the concession and parking data, we are left with 9 US hub airports that represent 42.1 % of 31 Hubs. (See Table 1). In Table 2, we present the shares of aeronautical and non-aeronautical revenues in airports' total operating revenue. Table 3 shows the airlines and their frequencies in our data. In the end of matching all four datasets together, our dataset contains 9468 observations.

We define a product as a directional trip between origin and destination airports. This allows us to capture the origin airport and city characteristics in passenger demand. In total we have 536 origin-destination pairs. (See Table 4.) The market size is measured by the population size at origin. Our nested logit demand specification necessitates to have a common market size for all the products from the same origin airport. For that reason, we do not relate destination population to market size. After all, since we are working on quarterly data, our market size specification gives reasonable market shares.

In DB1B dataset, there are three types of carriers defined: Operating carrier, ticketing carrier and reporting carrier. For more than 80% of tickets in the database, the three carriers are identical. Hence we use the ticketing carrier to identify the airline. Our product which is defined as origin-destination-airline (adj) appears several times in DB1B survey. Moreover, non-stop and connecting flights on each market by airline j are treated as two different products. Therefore, the price of a product, p_{adj} is computed as the ratio of the sum of fares to the sum of passengers for the same products.

4 Empirical Specification

In Section 2, we derive passenger demand (Equation 5), airline demand (Equation 11) and airline pricing (Equation 10) equations. The solution of these three equations gives us the equilibrium solution in prices and frequency. In other words, the number of passengers, the airlines' frequencies and the ticket prices are determined simultaneously.

The arguments of the passenger demand are the following: ticket fares, daily parking fee, frequency of airline, total frequency at airport, distance, origin airport characteristics, airline characteristics, origin and destination demographics, and dummy variables. Daily parking fee is used as a proxy for commercial fees charged by airport to passengers. We introduce also a hub dummy, which is equal to 1 if the origin airport is a hub for the airline offering the product and 0 otherwise, carrier dummies and airport dummies.[6] In Equation (5) the marginal utility of income, α, is assumed to be origin specific. More precisely, it is a function of the income at the origin city[7]:

$$\alpha_a = \alpha_0 + \alpha_1 INCOME_a \tag{17}$$

where α_0 and α_1 are parameters to be estimated. This specification allows us to capture the wealth effect. Assuming that income is a proxy for wealth, we expect α_1 to be negative and α_0 to be positive. Then, the overall effect should be positive.

The airline demand links the optimal frequency to the equilibrium number of passenger, up to a stochastic disturbance term which represents measurement errors. The marginal cost defined by Equation (9), which enters the optimal price equation of each airline contains the number of passengers, a measure of distance, the network size of the airline, the number of stops, an origin-destination hub dummy which is equal to one if either the origin or the destination airport is a hub for the airline, carrier dummies and airport dummies.[8]

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[6] We include American Airlines (baseline dummy), JetBlue Airways, Continental Airlines, Delta Airlines, Northwest Airlines, United Airlines, US Airways, Southwest Airlines and a dummy for the rest. Concerning airport dummies, Minneapolis-St.Paul (baseline dummy), Atlanta International, John F. Kenndy International, San Francisco International, Chicago O'Hare International and a dummy for the rest are included.

[7] Gross Domestic Product (GDP) per capita is used for income.

[8] The number of total destinations from the given airport represented by NETWORKSIZE includes stop and non-stop flights.

The system of simultaneous equations is estimated by means of the Nonlinear Three Stages Least Squares (N3SLS).[9] The econometric problem that we face is the endogeneity of market shares, price and frequency. The classical solution to this problem is to estimate three equations jointly by using instruments which are orthogonal to the unobservables in all three equations. So, in addition to exogenous variables of the model, we construct BLP type instruments. (See Berry, Levinsohn, and Pakes, 1995.) These are the average distance flown by rivals, the number of competitors on the same route, the percentage of direct flight in a route, the number of airlines operating at airport, the average price of airline's other products in the same market and the average price of airline's products in the other markets.

Nonetheless, the predicted frequencies are well below the actual ones. This is because the number of passengers in our data is 10% sample of airline tickets while the frequencies are the total number of flights. Thus, for some observations, frequency is much larger than the number of passengers. If only the DB1B data is constructed proportionate to the presence of airlines at the airport, one solution would be to scale either the number of passengers or the number of frequencies. However, an airline with many operations at a given airport may have been underrepresented in DB1B. In other words, the DB1B is not a homogenous representation of the whole survey. After all, we estimate simultaneously only the passenger demand and the pricing equations keeping frequency of airlines, $\left(f_{adj} \right)$ endogenous in these two equations.

5 Estimation Results

5.1 Parameter Estimates

Our estimation results are presented in Tables (5) and (6). All the estimated parameters have expected signs and most of them are significant. According to the nested logit model, products should have higher substitutability in the lower nest. Note that, σ is estimated to be 0.41, we can conclude that the airlines flying to the same destination from the same origin are substitutable. It is significantly different from zero; the simple logit model is therefore rejected against the nested logit model.

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[9] We also perform the generalized method of moments estimation, and our results remain similar which indicates that our estimations are robust.

Moreover, in the marginal utility of income, α_0 and α_1 are estimated to be equal to 0.029 and -4.6×10^{-7}, respectively, and both are significant. Then the marginal utility of income α_a is positive for each airport. Any rise in ticket fares and/or parking fees leads to a decrease in passenger demand. As ticket fares include aeronautical fees, any change in the latter would affect the market shares of airlines. Moreover, β^j, which is the coefficient of the schedule delay, is also found to be negative and significant. Hence, the passengers prefer to fly with a carrier with more frequent departures because it means that they could catch a flight as close as possible to their desired departure time. On the other hand, the coefficient of total frequency at airport β^a is found to be negative.. Although the passengers get benefit from an increase in the frequency of the airline that they choose, an increase in total frequency has a negative effect which captures congestion at airport.

Note that f_{adj} and f_a capture also two sided network externality in the demand of passengers. Thus, any change affecting the demand of airlines, f_{adj}, will be reflected on the passenger demand through β^j and β^a which will have a further impact on airline demand via Equation (11).

For the marginal cost parameter estimates, there are couple of points worth noting. (See Table 6.) The coefficient of origin-destination hub dummy is negative and significant. This estimate indicates a hubbing airline's ability to reduce marginal cost. The negative and significant estimate of the coefficient of q_{adj} shows that the marginal cost specification in Equation (9) captures the long-run effects. Finally, the coefficients of the dummies for two low cost airlines, namely, JetBlue Airways and Southwest Airlines are found to be negative as expected.

To sum up, concerning our main parameters of interest, we found empirical evidence of two-sidedness. One aspect is that passengers do care about the airport facilities as shop size is found to be significant. Another aspect is that both the number of flights of the airline and the total frequency at the airport are significant in demand of passengers. If an airline raises its frequency on a given route, it results in an increase in passenger demand through decreasing waiting cost. In addition to this, an increase in total frequency at airport would reduce passenger demand via congestion effect. Consequently, a change in aeronautical fees would not only lead to a change in airlines' demand but also passenger demand. Similarly, a change in concession fees would affect passengers, and then airlines through network effects.

5.2 Elasticities, Marginal Cost and Markups

Some statistics of estimated own and cross price elasticities as well as markups and marginal costs for airlines at the airport level are presented in Table (7). Before discussing these elasticities and mark-ups, it is useful to discuss the value of σ as this parameter plays a crucial role in the formulas of the different types of elasticities. (See Appendix B.) It is estimated at 0.41, which means that passenger preferences are correlated across products on the same route. Although the products are substitutes, the substitutability is not high. This can be seen in the estimated cross price elasticities. Regarding the estimates of own price elasticities, the demand of passengers for airlines is elastic. As we assess elasticities at hub airports which are richer in terms of product availability, that is, plenty of substitutes are present, it is intuitive to have high own price elasticities. The corollary of this result is that the markups are higher at hubs with relatively more elastic demand.

In Table (8), we present some statistics of elasticities, marginal cost and mark-ups for the whole sample. The average marginal cost is $194.67, and less than 15% of marginal costs are estimated to be negative.

5.3 Marginal Cost and Markups for Airports

Given the parameter estimates in Tables (5) and (6), we compute the margins for aeronautical and nonaeronautical activities of each airport using Equations (15) and (16). We obtain a proxy for aeronautical fee from Equation (11). Furthermore, as already mentioned before daily parking rate is used as a proxy to nonaeronautical fee. The results are presented in Table (9).

Two main remarks can be made on these results. First, for 8 airports out of 9 we obtain positive margin on one side, and negative margin on the other side. Considering the fact that in two sided markets, platforms can cross-subsidize the two sides, this result is not counterintuitive.

Second, for each airport one of the marginal costs appears to be negative, which is unnatural. There can be several reasons for negative marginal costs. On the one hand, it may stem from the fact that the business model of airports is not profit maximization hence the margins obtained under this assumption leads to negative marginal cost. On the other hand, it is very important to remark that ticket data is the 10% of whole operations and it is not drawn proportionate to the actual presence of products of an airport. Therefore, we cannot recover the full demand and this may also be a reason of negative marginal costs. It would be very useful to know how the tickets are drawn from the population in order to recuperate the actual full demand.

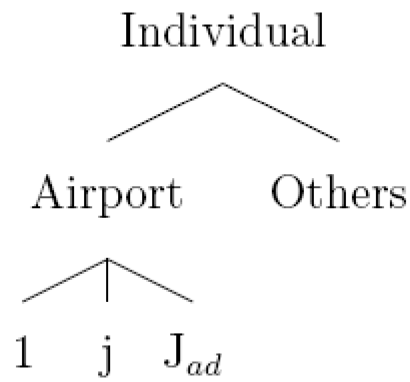
6 Conclusion

This paper has analyzed airports under a two-sided market setting with the available database. Starting with a monopoly platform, we derive the demand equation of passengers and pricing equation of airlines which are then estimated simultaneously. After explaining the framework, we specify the empirical model which allows us to assess network effects. We find empirical evidence about the two-sidedness of airports through the significant coefficients of flight frequencies and airport characteristics. Moreover, the pricing scheme of airports shows that they can cross-subsidize the two sides with respect to their elasticities. Using our estimated parameters, we compute the markups and marginal costs of airports under profit maximization scenario. At each airport, either the marginal cost of aeronautical operation or nonaeronautical operation is found to be negative. This may indicate that airports do not maximize profits. The paper as a whole is a contribution to air transport literature since airports have been considered as two-sided platforms neither theoretically nor empirically.

The topic is very fruitful for the future work. First, our model can be easily extended to the case of competition between airports. Moreover, airports can also be examined for the optimal platform design, which in turn can increase its profits by pricing the stores optimally. Besides all these, the correct market definition is crucial for regulators so the structural parameters obtained from empirical examination can be used for policy issues. Finally, the debate of single-till versus dual-till can be reconsidered under the structure provided in this paper.

APPENDICES

A. Nested Choice Structure



B. Elasticities

Own price elasticity of airline *j* at airport *a* for a given destination *d* is given by:

$$\varepsilon_j = -\alpha p_{adj} \left(\frac{1}{1-\sigma} - \frac{\sigma}{1-\sigma} s_{j|ad} - s_{adj} \right)$$

Cross price elasticity between airline *j* and *k* at airport *a* for a given destination *d* is

$$\varepsilon_{jk} = \alpha p_{adk} s_{adk} \left(\frac{\sigma}{1-\sigma} \frac{s_{k|ad}}{s_{adk}} + 1 \right)$$

C. Tables

Table 1: Passengers Boarded at the 9 U.S. Airports (Values are sorted by the number of passenger (2006)

Airport	Code	City	State	Passenger (million)	GDP per Capita ($)	No. of Departures
Hartsfield-Jackson Atlanta	ATL	Atlanta	GA	40.56	37593	463644
Chicago O'Hare International	ORD	Chicago	IL	34.54	42829	448949
George Bush Intercontinental	IAH	Houston	TX	19.61	42701	284128
Minneapolis-St.Paul	MSP	Minneapolis	MN	17.13	44975	208952
John F.Kennedy International	JFK	NewYork	NY	14.97	50084	173344
San Francisco International	SFO	San Francisco	CA	13.91	59440	153800
Salt Lake City International	SLC	Salt Lake City	UT	10.28	36210	150628
Baltimore/Washington International	BWI	Baltimore	MD	10.02	44658	119487
Dulles International	IAD	Washington	DC	9.55	53401	151788
Top 31 Hub airports				458.69		
United States all airports				691.17		

Table 2: Aeronautical and Non-aeronautical Revenues for the 9 U.S. Airports

Airport	Aeronautical Revenue (million$)	Share	Non-aeronautical Revenue (million$)	Share
ATL	53.17	0.252	158.02	0.748
ORD	340.26	0.687	155.23	0.313
IAH	230.73	0.738	81.74	0.262
MSP	87.42	0.585	62.08	0.415
JFK	553.78	0.781	155.79	0.219
SFO	259.01	0.647	141.18	0.353
SLC	41.70	0.512	39.80	0.488
BWI	69.66	0.579	50.77	0.421
IAD	137.45	0.703	56.86	0.292

Table 3: List of Airlines

Airline	Code	Freq.	Percent
American Airlines	AA	1228	12.97
Alaska Airlines	AS	45	0.48
JetBlue Airways	B6	130	1.37
Continental Airlines	CO	641	6.77
Delta Airlines	DL	2652	28.01
Atlantic Southeast Airlines	EV	1	0.01
Frontier Airlines	F9	17	0.18
AirTran Airways	FL	242	2.56
Hawaiian Airlines	HA	8	0.08
Northwest Airlines	NW	1135	11.99
Sky West Airlines	OO	11	0.12
United Airlines	UA	2627	27.75
US Airways	US	311	3.28
Southwest Airlines	WN	420	4.44
Total		9,468	100.00

Table 4: The number of origin-destination

Origin Airport	Freq.	Percent
ATL	103	19.22
BWI	47	8.77
IAD	32	5.97
IAH	59	11.01
JFK	39	7.28
MSP	86	16.04
ORD	75	13.99
SFO	40	7.46
SLC	55	10.26
Total	536	100.00

Table 5: Estimation Results for the Passenger Demand Equation

Demand Function					
Variable	**Parameter**	**Estimate**	**Standard Error**	**t-stat**	**p-value**
PRICE	α_0	0.028946	0.00680	4.26	<.0001
PRICE*INCOME	α_1	-4.62E-7	1.315E-7	-3.51	0.0004
$\ln(s_{j\|ad})$	σ	0.410401	0.0293	14.02	<.0001
$1/\sqrt{f_{adj}}$	β^j	-18.7904	1.7592	-10.68	<.0001
f_a	β^a	-0.00003	5.697E-6	-5.35	0.8220
CONSTANT	β_0	-0.18276	0.9279	-0.20	<.0001
SHOPSIZE	β_1	0.019702	0.00125	15.71	<.0001
CONVENIENT	β_2	0.22216	0.1777	1.25	0.0596
INCOMEDEST*POPDEST	β_3	3.19E-13	1.17E-13	2.73	0.0005
MILESFLOWN	β_4	-0.00017	0.000119	-1.40	0.6799
$(\text{MILESFLOWN})^2$	β_5	9.992E-8	1.649E-8	6.06	0.0140
OHUB	β_6	-0.88384	0.1286	-6.87	0.2643
$(\text{INCOME})^2$	β_7	-2E-9	4.62E-10	-4.34	0.9736
B6	β_8	-0.40499	0.1843	-2.20	0.0280
CO	β_9	-0.44274	0.1304	-3.39	0.0007
DL	β_{10}	-0.09858	0.1087	-0.91	0.3646
NW	β_{11}	-0.19473	0.1186	-1.64	0.1007
UA	β_{12}	-0.04372	0.0655	-0.67	0.5043
US	β_{13}	-0.55834	0.1533	-3.64	0.0003
WN	β_{14}	-1.43999	0.2026	-7.11	<.0001
OTHER AIRLINES	β_{15}	-0.73259	0.1838	-3.99	<.0001
ATL	β_{16}	1.284455	0.4212	3.05	0.0023
JFK	β_{17}	-1.59685	0.1408	-11.34	<.0001
SFO	β_{18}	0.464259	0.1753	2.65	0.0081
ORD	β_{19}	0.618261	0.3598	1.72	0.0858
OTHER AIRPORTS	β_{20}	-0.40479	0.1315	-3.08	0.0021

Table 6: Estimation Results for the Airline's Cost Function

		Cost Function			
Variable	**Parameter**	**Estimate**	**Standard Error**	**t-stat**	**p-value**
CONSTANT	λ_0	1089.858	112.5	9.69	<.0001
MILESFLOWN	λ_1	-0.0487	0.0226	-2.16	0.0309
$(MILESFLOWN)^2$	λ_2	0.00002	4.557E-6	4.39	<.0001
ODHUB	λ_3	-69.4166	28.1963	-2.46	0.0138
q_{adj}	λ_4	-1.03569	0.1011	-10.24	<.0001
NETWORKSIZE	λ_5	-0.071	0.0244	-2.90	0.0037
NOOFSTOPS	λ_6	-376.63	46.0794	-8.17	<.0001
B6	λ_7	-317.826	59.9741	-5.30	<.0001
CO	λ_8	115.3789	31.3542	3.68	0.0002
DL	λ_9	15.77558	26.4077	0.60	0.5503
NW	λ_{10}	-42.5639	32.8239	-1.30	0.1948
UA	λ_{11}	1.860355	21.4018	0.09	0.9307
US	λ_{12}	-166.59	40.2754	-4.14	<.0001
WN	λ_{13}	-270.864	49.5824	-5.46	<.0001
OTHER AIRLINES	λ_{14}	-250.536	43.1779	-5.80	<.0001
ATL	λ_{15}	41.15175	33.7856	1.22	0.2232
JFK	λ_{16}	-99.7895	45.1813	-2.21	0.0272
SFO	λ_{17}	-320.914	331.2	-0.97	0.3326
ORD	λ_{18}	20.57891	32.9679	0.62	0.5325
OTHER AIRPORTS	λ_{19}	-84.6025	34.6371	-2.44	0.0146

Table 7: Price Elasticities, Marginal Cost and Markups

		Mean	Std. Dev.	Min	Max
ATL	**Own Price Elasticity**	-5.49999	3.986705	-27.1006	-0.30786
	Marginal Cost	230.0391	202.6218	-59.8291	1330.013
	Markup	52.57001	6.117688	50.92515	86.47698
	Cross Price Elasticity	0.000221	0.000862	3.99E-07	0.010025
BWI	**Own Price Elasticity**	-3.50062	2.198055	-17.585	-0.20865
	Marginal Cost	176.969	156.7554	-95.457	1176.464
	Markup	72.65674	7.397338	70.91935	120.6254
	Cross Price Elasticity	0.000171	0.000703	1.89E-06	0.008761
IAD	**Own Price Elasticity**	-2.46028	1.570939	-10.8897	-0.1094
	Marginal Cost	200.1465	218.8034	-210.949	1364.134
	Markup	140.9031	14.20334	137.9355	236.9975
	Cross Price Elasticity	0.000538	0.003199	3.64E-06	0.054802
IAH	**Own Price Elasticity**	-5.0773	3.35538	-23.6842	-0.23994
	Marginal Cost	260.2043	215.8806	-82.5124	1451.033
	Markup	67.76321	11.77411	63.96438	109.3337
	Cross Price Elasticity	0.000216	0.000717	3.99E-07	0.006689
JFK	**Own Price Elasticity**	-2.91407	2.139933	-14.5072	-0.16665
	Marginal Cost	193.263	218.9016	-142.027	1371.492
	Markup	104.0649	11.51524	101.5316	172.2079
	Cross Price Elasticity	4.06E-05	0.000247	8.54E-08	0.00372
MSP	**Own Price Elasticity**	-3.96171	2.912531	-19.5737	-0.28993
	Marginal Cost	214.1985	210.6059	-75.7573	1340.973
	Markup	76.05196	11.93954	72.19122	122.8875
	Cross Price Elasticity	0.000285	0.001068	6.35E-07	0.011298
ORD	**Own Price Elasticity**	-4.80895	3.25929	-24.681	-0.29496
	Marginal Cost	245.2552	210.0567	-70.477	1524.484
	Markup	65.69338	5.965621	64.37518	109.3561
	Cross Price Elasticity	9.67E-05	0.000424	3.36E-07	0.006316
SFO	**Own Price Elasticity**	-0.87158	0.559714	-3.92762	-0.05317
	Marginal Cost	-57.5512	232.7389	-638.67	1162.649
	Markup	405.1927	38.61266	397.1244	676.0891
	Cross Price Elasticity	4.32E-05	0.000226	8.78E-08	0.002948
SLC	**Own Price Elasticity**	-6.34079	4.464135	-29.8586	-0.36638
	Marginal Cost	258.9862	214.9713	-51.8638	1393.793
	Markup	50.01199	6.005008	48.26374	83.1019
	Cross Price Elasticity	0.000721	0.002588	2.03E-06	0.022721

Table 8: Elasticities, Marginal Cost and Markup

		Mean	Std. Dev.	Min	Max
	Own Price Elasticity	-4.164145	3.496256	-29.85859	-.053174
ALL AIRPORTS	**Marginal Cost**	194.6745	230.6019	-638.6705	1524.484
	Markup	111.2617	110.5988	48.26374	676.0891
	Cross Price Elasticity	.0002353	.0013568	8.54e-08	.0548018

Table 9: Prices, Marginal Costs and Markups of Airports

	Aeronautical			Non-Aeronautical		
	Fee	**Marginal Cost**	**Markup**	**Fee**	**Marginal Cost**	**Markup**
ATL	80.033729	568.82133	-488.7876	16	-178.73237	194.73237
BWI	118.9401	-1120.23	1239.17	12	181.63076	-169.63076
IAD	273.03456	-1821.13	2094.16	17	404.56675	-387.56675
IAH	61.834296	-1057.85	1119.69	17	302.05647	-285.05647
JFK	138.20993	-3347.73	3485.94	18	626.55729	-608.55729
MSP	253.68341	212.20118	41.482239	18	-79.445391	97.445391
ORD	126.01012	232.96961	-106.95948	31	-74.725253	105.72525
SFO	1280.66	2424.2	-1143.54	20	-782.77354	802.77354
SLC	60.587819	-211.53976	272.12758	28	61.039961	-33.039961

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