Limited Access to Airport Facilities and Market Power in the Airline Industry *

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Abstract

We investigate the role of limited access to airport facilities as a determinant of prices, and more specifically of the hub premium, in the US airline industry. To this purpose, we use original data from competition plans that airports are required to submit to the Department of Transportation in compliance with the Aviation Investment and Reform Act for the 21st Century. The competition plans must include information on the availability of airport gates and related facilities, leasing and sub-leasing arrangements, gate-use requirements, gate-assignment policies, and whether the airport intends to build or acquire gates that would be used as common facilities.

First, we find that the unconditional premium on the median fare is between 12 and 15 percent. After controlling for the markup that airlines can charge because they offer a differentiated product and for differences in costs achieved with economies of density, the hub premium is up to a magnitude between 20 and 25 percent. Second, the hub premium is increasing in the quantile of the fare distribution. Finally, we find that the conditional hub premium is halved once we control for airline specific barriers to entry. Exclusive access to and dominance of gates at the market endpoint airports is a key determinants of the hub premium.

Keywords: Market Power, Airline Industry, Barriers to Entry, Product Differentiation, Hub Premium, Airport Facilities.

JEL Codes: L13, L93.

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1 Introduction

In this paper, we investigate the size and the determinants of the "hub premium," by which we mean the difference between the fares charged for trips into and from airports where major airlines have their hubs, and the fares that are charged for analogous trips except that they do not originate from or end into a hub.

Previous empirical work on the size and determinants of the hub premium has concerned itself with four important features. First, the magnitude of the hub premium is still debated, ranging from around 20 percent (Borenstein (1989) and GAO 1989, 1990) to well below 10 percent (Morrison and Winston [1995], Lee and Luengo-Prado [2005]). Second, the network of markets served by one airline out of an airport, which in this paper we call "network extent," is an important determinant of product differentiation and of airline fares. To assess the extent to which firms use their dominant position at an airport, Berry (1990) and Berry, Carnall, and Spiller [BCS, 2007] pointed out that it is crucial to identify the portion of the hub premium that is "demand" driven, or explained by product differentiation, from the portion of the premium that is "supply" driven, or explained by the other determinants of the airlines' market power. Third, the emergence of dominated and hub airports is one of the consequences of the post-deregulation growth of hub-and-spoke networks. The operation of a network requires heavy use of a hub airport, which gives a carrier several natural advantages in competing for traffic originating and terminating in the hub (Brueckner and Spiller [1984]). In particular, the marginal cost of serving hub-bound or hub-originating passengers is lower for a hub carrier than for its competitors, and thus we need to control for economies of density to get a good measurement of the hub premium. Finally, Borenstein (1989) and studies by the Government Accounting Office [GAO 1989, 1990] identify operating practices that limit access to airport facilities and marketing practices to build consumer and travel agent loyalty, are in place. Unfortunately, data on these operating and marketing practices was not available until now and previous studies had to use proxies to investigate their effect on prices.

Our paper contributes to these literatures in several important ways. First, we use a unique and original dataset to measure the importance of operating barriers to entry as determinants of the hub premium. Exclusive access to and dominance of gates at the market endpoint airports are key determinants of the hub premium. The original data are from competition plans that airports are required to submit to the Department of Transportation in compliance with the Aviation Investment and Reform Act for the 21st Century (AIR 21). AIR 21, which was signed into law in April, 2000, stated that beginning in fiscal year 2001, no federal grant would be made to fund one of airports unless the airport had submitted a written competition plan. The competition plan must include information on the availability of airport gates and related facilities, leasing and sub-leasing arrangements, gate-use requirements, gate-assignment policies, and whether the airport intends to build or acquire gates that would be used as common facilities.[1]

Second, we find that the unconditional premium on the median fare is between 12 and 15 percent. After controlling for the markup that airlines can charge because they offer a differentiated product and for differences in costs achieved with economies of density, the hub premium is up to a magnitude between 20 and 25 percent. We also find that the hub premium is increasing in the quantile of the fare distribution. Finally, and most importantly, we find that the conditional hub premium is halved once we control for airline specific barriers to entry. Exclusive access to and dominance of gates at the market endpoint airports is a key determinants of the hub premium.

Our methodology consists of first estimating a reduced form model as in Borenstein [1989]. The reduced form model is useful because it gives a sense of the regularities in the dataset, and because it provides indirect support for the structural analysis. Then, we estimate a model of demand for air travel and a model of airline pricing behavior. We follow Berry (1990) and BCS (2007) and assume a nested logit model of demand for air travel.

In Section 2, we review the literature on the hub premium. We then provide a description of the new data that we collected from the airports' competition plans in Section 3. The fare and passenger data are described in Section 4. Our structural and reduced form econometric frameworks are provided in Section 5. We then provide a detailed description of the results of estimation in Sections 6 and 7. Section 8 concludes.

2 Literature Review

2.1 Prices and Airport Dominance

Borenstein (1989) and studies by the Government Accounting Office [GAO 1989, 1990] identify a set of barriers to entry in the airline industry to explain the hub premium, and more generally, high airline fares. In most airports, and especially in the hubs of the major airlines, "operating" practices that limit access to airport facilities and "marketing" practices to build consumer and travel agent loyalty, are in place. Airlines need ticket counters, baggage check-in rooms, baggage claim areas, and, most importantly, enplaning/deplaning gates to provide service at an airport. Access to these airport facilities is typically regulated by long term exclusive contracts between airlines and airports. Thus, new entrants typically can only gain access to an airport by paying sublease fees. In addition, even where new entrants can access airport facilities, incumbent airlines use frequent flyer programs (FFPs) and volume incentives to travel agents to build a loyal customer base, making entry by new carriers more difficult.

Because of data unavailability, Borenstein [1989] proxied these operating and marketing barriers to entry

[1] Section 155.f.(1-2), H.R. 1000.

with a measure of airline's "airport dominance," the percentage of passengers flying on one airline at an airport. Borenstein (1989) is the first to show that airlines' fares are positively correlated with the airline's share of passengers on the route and at the endpoint airports. Borenstein also shows that there is not an "umbrella" effect, in the sense that the positive correlation between prices and airport dominance do not extend to the airline's competitors. Evans and Kessides [1993] add market and firm fixed effects and confirm that airport dominance by a carrier is correlated with higher fares, but do not find that dominance at the route level is statistically or economically significant. Evans and Kessides conclude that the most promising direction for public policy aimed at improving the industry's performance is to ensure equal access to sunk airport facilities. This is also consistent with Borenstein's findings and is exactly what we confirm in this paper.

The exact magnitude of the correlation between prices and airport dominance is still debated. Morrison and Winston [1995] argue that comparison of fares across markets also requires taking into account other demand driven control variables, in particular "traffic mix" and frequent flyer tickets. Traffic mix is the fraction of business passengers flying on a route. Using the Data Bank 1A of the Department of Transportation (DB1A DOT), Morrison and Winston show that the premia are much lower, approximately 5 percent, after controlling for traffic mix and frequent flyer tickets.[2]

2.2 Product Differentiation

Berry (1990) investigates whether the correlation between airline fares and airport dominance is demand or supply driven. In particular, Berry proposes a model where airlines offer differentiated products and uses the number of cities served by an airline out of a given city as the measure of differentiation. Berry estimates demand and cost functions simultaneously and finds that the airline's network extent has a positive effect on the utility of consumers, as one would expect, and a negative effect on their marginal costs, suggesting the existence of economies of density. Thus, Berry finds that an airline's network extent at an airport provided both cost and demand advantages.

BCS also use a differentiated products equilibrium model to disentangle the separate effects of hubbing on costs and markups. BCS allow for the demand for travel originating at hubs to be different from the demand originating at other airports as well as for economies of spoke density at hubs. On the demand side, BCS assume that there are tourist and business travelers who differ in their price sensitivity, their willingness to pay for frequent flyer features and frequency of flights, and in their disutility from connecting flights. BCS find that hub airlines offer higher priced products to business travelers, but do not find it profitable to raise prices much to non-business passengers. The premium charged to business passengers by the hub airlines is

[2] We discuss some limitations of the "fare mix" data in the DB1A dataset in the Appendix.

estimated to be 20 percent over the non-hub competitors. Finally, using a polynomial function of distance, density (measured as the total number of passengers transported in each segment), and flight frequency to model the cost function, BCS find lower marginal costs for those airlines operating large hubs.

2.3 Economies of Density

Brueckner and Spiller [1994] estimate a structural model of competition among hub-and-spoke airlines in order to measure the strength of economies of traffic density on individual route segments. They find evidence of strong economies of density. Then, they ask the following questions: are most of the benefits from higher density passed on in fares? Or are the gains mostly retained by the airlines, so that fares understate the strength of the density effect? To address these questions, they use a much more restrictive model of demand than the one we use. In particular, they assume product homogeneity and do not build their demand functions from a discrete choice model of consumer behavior. Our cost specification is similar to theirs. They find that economies of density are very strong, and airlines pass somewhat more than half of the cost reduction due to these economies on to passengers in the form of lower fares

3 Limited Access to Airport Facilities

3.1 The Aviation Investment and Reform Act

In response to governmental, public and academic concern with the existence of institutional barriers to entry in the airline industry, President Clinton signed into law the Wendell H. Ford Aviation Investment and Reform Act for the 21st Century (AIR 21) on April 5, 2000. AIR 21 identified a set of "major airports" that had to be available on a reasonable basis to all carriers wishing to serve these airports. The set of airports identified by AIR 21 were commercial service airports that both had more than 0.25 percent of the total number of passenger boardings each year in the US and where one or two air carriers controlled more than 50 percent of the passenger boardings.[3]

As a result of AIR 21, all of these airports have compiled competition plans. We were able to collect the competition plans and construct a cross-section of data where the unit of observation is the airport. From these plans, we collected information on the availability of airport gates, leasing and subleasing arrangements of gates and other airport facilities, as well as airline-airport agreements.[4]

There is one potential limitation of the data that we collected. We only have one observation for each

[3]These airports consist of large and medium hubs at which one or two airlines board more than 50% of the passengers. See Section (9.2).

[4]Washington National, New York's La Guardia, and Dallas Love Field (the main hub of Southwest) have "perimeter rules," which limit long-haul flights to and from these airports. For example, non-stop flights from Phoenix to Washington National and New York's La Guardia were prohibited until 2004. Since in this paper we do not distinguish nonstop from connecting service as different products, we do not include perimeter rules in the analysis.

airport, and the observation is for one year between 2001 and 2004. To address this limitation of the data, we restrict our analysis to the years 2002, 2003, and 2004. For these years, the data on the limited access to airport facilities is appropriate, given the long-term nature of the contracts that airlines sign with airports for the use of gates. The 1990 study by the Government Accounting Office reported that 22 percent of the gates at the 66 largest airports were for $3-10$ years duration; 25 percent were for $11-20$ years duration; and 41 percent were for more than 20 years duration (GAO (1990)).[5] It is also worth noting that airlines can not terminate leases unilaterally. For example, in the case of Dallas Love airport, American Airlines was seeking termination of the gate lease agreements with the airport. American no longer used the gates but was obligated to continue paying $335,000 per year.[6] The Dallas Love airport declined to terminate the lease agreement and American will have to pay until 2011, when the lease expires.[7]

We now describe how we coded information contained in the competition plans to construct quantitative measures of limited access to airport facilities. In the following, markets are indexed by $m = 1, ..., M$ and year-quarter combinations by $t = 1, ...T$. Airport-to-airport routes are denoted by $r = 1, ..., R_{mt}$. The subindex $j = 1, ..., J_{mt}$ denotes an airline in market m at time t. A single product is then denoted by a combination jrt, which indicates that airline j (e.g. American) transports its passengers on the route r (Chicago O'Hare to Fort Lauderdale Airport) in the market m (Chicago-Miami) at time t (e.g. the second quarter of 2002).[8]

The number and identity of carriers changes by market, route, and time. In any market m and time t, the consumer can choose among C_{mt} choices, which is related to the number of airlines in a market (J_{mt}) and the number of airports in the two cities. In our dataset, there are $42,309$ route-carrier-year-quarter specific observations.

3.2 Access to Gates

Airlines require enplaning/deplaning gates to provide service at an airport. An exclusive-use lease gives the lessee the sole right to use the facilities in question. The 1990 study by the GAO reported that nearly 88 percent of the gates at the 66 largest airports were leased to airlines, and 85 percent of those were leased for exclusive use. Most of the remaining gates were leased on a preferential basis, giving the lessee the first right to use the facilities. For example, in Salt Lake City, 96 percent of the gates were leased on an exclusive

[5] For example, in the competition plan submitted by the Philadelphia airport (dated 2000), we read that the lease agreements were signed in 1974 and will expire in 2006. In the competition plan submitted by the Atlanta airport (dated 2000), we read that exclusive-use leases for gates and other facilities expire on September 20, 2010.

[6] See the June 30, 2003, Letter from Mr Gwyn, Director of Aviation, City of Dallas, to Ms. Lang, Deputy Director of Airport Planning and Programming, Federal Aviation Administration.

[7] See the February 28, 2005, Letter from Mr Gwyn, Director of Aviation, City of Dallas, to Ms. Lang, Deputy Director of Airport Planning and Programming, Federal Aviation Administration.

[8] Notice that a more precise notation would be $r(m)$, but for sake of brevity we will write r.

use basis, and 3 percent were leased on a preferential use basis in 1996 (TRB [1999]). Some airports (16 percent) have use-or-lose provisions for exclusive leases, allowing the airport to gain control of the gate if the lessee does not use the gates. However, an airline must cease all operations for 1 to 3 months before losing the right to the gates, which is unlikely to occur (GAO (1990)).

Among the information included in the competition plans, airports reported the total number of gates available, the number of gates for common use (neither leased on an exclusive or preferential basis), and the number of gates leased to each airline on an exclusive or preferential use basis. We construct three variables to code this information.

First, we define the variables $OwnGatesOrigin_{jr}$ and $OwnGatesDest_{jr}$, which measure the percentage of gates leased on an exclusive or preferential basis to airline j at, respectively, the origin and destination endpoints of route r. We construct $OwnGatesOrigin_{jr}$ and $OwnGatesDest_{jr}$ for the following airlines: American, Continental, Delta, Northwest, United, USAir, and America West. We do not make a distinction between exclusive and preferential leases because even in this second framework, airlines can keep the control of the gates as long as they use them. Table 1 shows that on average an airline controls 13.6 percent of the gates at an airport, but one airline can control up to 79 percent of them.

Second, we define the variables $CompGatesOrigin_{jr}$ and $CompGatesDest_{jr}$, which measure the fraction of gates leased on an exclusive or preferential basis to a competitor with the largest presence at, respectively, the origin and destination endpoints of route r. Again, we only use data for the seven airlines listed in the previous paragraph. On average the competitor with the largest number of gates at an airport controls 24.4 percent of them.

Finally, we define the variables $CommonOrigin_r$ and $CommonDest_r$, which measure the fraction of gates that are for common use or that are leased to low cost carriers, Southwest included. Thus, these variables are constructed by taking the difference between the total number of gates and the gates leased on an exclusive or preferential basis to the legacy airlines (American, Continental, Delta, Northwest, United, USAir, America West). On average, one third of the gates are for common use or leased to low cost carriers.

3.3 Sublease Fees

When an entrant wants to start service at an airport where most of the gates are leased on an exclusive or preferential basis, its main option is to sublease the gates and other facilities from an incumbent. Officials from Southwest Airlines, America West, and other airlines reported that subleases increased their costs by many times what they would face if they leased the gates directly from the airports (GAO [1989, 1990]).

To facilitate entry, some airports have introduced a limit to the fees that can be charged by an airline when subleasing their gates to a competitor. We define the variables $LimitOrigin_r$ and $LimitDest_r$ as categorical variables that are equal to one if, respectively, the origin or destination airport have set a maximum limit on sublease fees. Clearly, the presence of limits should lower the cost of serving an airport for new entrants and result in lower prices. The variables $MaxLimitOrigin_r$ and $MaxLimitDest_r$ measure the effect of the actual limit set on the sublease fees conditional on $LimitOrigin_r$ and $LimitDest_r$ being equal to one. The higher the maximum limit set by an airport, the higher should be the prices in markets originating and ending in that airport. Table 1 shows that the average maximum limit is 25 percent.

3.4 Majority-in-Interest Agreements

Some airports (e.g. Dallas/Fort Worth) share the rights to decide on expansion projects with the airline controlling the majority of their operations (e.g. American at DFW) . Airports and airlines sign Majority-in-Interest (MII) agreement to this purpose. Airports are willing to sign these majority-in-interest agreements because they can get lower interest rates on their debt issues. Airlines are willing to sign these agreements to ensure that the airport does not unilaterally issue additional debt, which the tenant airlines would have to pay with higher lease payments, landing fees, or other charges. In some cases, airlines even have veto power over airport expansions. One way to think of this agreements is that the carriers put themselves at risk as they bear some of the cost of the airport's facilities.

The airport competition plans report whether the airport has a Majority-in-Interest agreement with airlines that serve the airport. However, typically the competition plans are quite vague in the exact specifics of these agreements. We define two variables, $MiiOrigin_r$ and $MiiDest_r$ to measure the effect that these types of agreements have on prices.

3.5 Slot Controls

Four airports: Washington National, Chicago O'Hare, and New York's La Guardia and Kennedy have slot controls to reduce congestion by limiting the number of takeoffs and landings per hour. There are only two ways for an entrant to get a slot at these four airports: either the entrant is awarded a returned or forfeited slot by the FAA or the entrant buys or leases a slot from an incumbent airline, usually at a higher cost than the incumbent's (GAO (1990)). AIR 21 started to phase out the high density rule at Chicago's O'Hare airport and New York's LaGuardia and John F. Kennedy.[9] We define two dummy variables, $SlotOrigin_r$ and $SlotDest_r$ to indicate, respectively, whether the origin or the destination airport have slot controls.

[9] In particular, slot restrictions were eliminated for new or additional regional jet service effective March 1, 2000 at La Guardia and JFK. Effective January 1, 2007, slot restrictions will be eliminated entirely at the two New York airports. Similarly, slot restrictions were partially removed at Chicago's O'Hare airport effective March 1, 2000. Slot restrictions were eliminated entirely at O'Hare on July 1, 2002. Our dataset accounts for these changes.

4 Airline Data[10]

4.1 Market Definition

A market is defined as a *unidirectional* trip between two cities, here defined as Metropolitan Statistical Areas (MSAs), regardless of the number of stops that the traveler had to make in between.[11] Trips to the same city but to different airports are treated as different products. For example, consider **Figure 2**, where there are 3 airports in the Washington DC metropolitan area (IAD, BWI and DCA) and two airports in the Dallas metropolitan area (DFW and DAL). There are two markets and each firm may have up to six products in each market. In the previous literature, airport pairs have been treated as separate markets (BCS [2006]). Under a market definition of this type, these 5 airports would yield 12 independent markets, where each firm is a single product firm. The previous approach has the advantage of simplicity, but ignores the fact that some segments of the consumer demand may be willing to substitute between airports in the same city or metro area. We present evidence in support of the idea that firms take into account this substitutability across airports in their pricing decisions.

There are several reasons why we define a market as a unidirectional trip between two airports. First, this makes the analysis of the demand for airline travel much more intuitive. The potential demand for airline travel will be equal to the geometric mean of the number of all individuals of age between 21 and 65 at the origin and destination cities.[12] Second, this definition permits us to analyze whether the hub premium is different on routes to and from the hub.

The dataset includes all markets between the airports identified by AIR 21 as the set of "major airports" that had to be available on a reasonable basis to all carriers. There are $1,385$ unidirectional routes (airport-to-airport) and 983 unidirectional markets (MSA-to-MSA).

4.2 Carrier Definition

There are nine national carriers between 2002 and 2004: American, Continental, Delta, America West, Northwest, United, USAir and Southwest. Then, there are three low cost carriers with a strong national presence: Airtran, ATA, and Frontier. Finally, there is a remaining group of independent low cost carriers providing mostly regional service. We combine this third group of smaller carriers into one group, which we call the *LCC* type. This helps us avoid dropping small carriers that are present in few markets and use a meaningful grouping while capturing the impact of their presence in the market.

[10] A full description of the data is given in the Appendix.

[11] See Peters [2006] for an analogous definition of market.

[12] The total size of the population is from the Regional Economic Accounts (Local Area Personal Income). The fraction of individuals that are of age 21 to 65 years old is from the Current Population Survey.

4.3 Itinerary Fare

The Origin and Destination Survey (DB1B) is a 10 percent sample of airline tickets sold by airlines in a quarter. This dataset does not provide information on the date when the ticket was sold or used, or on the characteristics of the buyer. However, the dataset does provide information on characteristics of the trip, such as whether the ticket is for round-trip travel or whether the ticket is for a direct flight. With the notable exception of Borenstein (1989), the literature has summarized the airline pricing behavior in one market using the mean quarterly fare. As Borenstein noted, however, the mean fare can be affected by abnormally high or low fares, possibly included because of reporting errors. We will summarize the airline pricing behavior using the mean, median and the 25th and the 75th percentiles. By doing so, we use some information on the distribution of prices available from the DB1B dataset while using as few statistics as possible.[13]

Table 2 presents summary statistics for the four measures of itinerary fares used in this paper. The fares are measured in 1993 dollars. The difference between the 75th percentile of the fares (166.9 dollars) and the median (121.9 dollars) is twice as large as the difference between the median and the 25th percentile of the fares (97.1 dollars), suggesting that there is much more dispersion at the top of the distribution than at the bottom. This is confirmed by the average ticket fare, equal to 140.9 dollars, almost one standard deviation above the median.

4.4 Hub Categorical Variables

The classification of airports as hubs is to some extent arbitrary because it requires a threshold on the percentage of passengers using the airport who are traveling through, rather than to or from the airport. There are two problems with using such a threshold. First, the percentage of passengers traveling through an airport is a function of the price charged by the airlines, which is the dependent variable. Second, airlines can change their hubs over time. In light of these two observations, we use a conservative definition of hubs.

Those airports we define as hubs include: Dallas/Fort Worth, Chicago O'Hare, St. Louis for American Airlines; Houston Intercontinental, Newark, and Cleveland for Continental; Atlanta and Cincinnati for Delta; Phoenix for America West; Minneapolis and Detroit for Northwest; Chicago O'Hare and Denver for United; Charlotte and Philadelphia for USAir. All these airports were hubs over the time period under study.

We define $HubUmbrellaOrigin_{jr}$ to be equal to 1 if the origin airport is a hub of any of the national carriers. We define $HubUmbrellaDest_{jr}$ similarly, using the destination airport. Then, we define $HubCarrierOrigin_{jr}$ to be equal to 1 whenever the observation is for carrier j out of an airport where

[13] Notice that influential papers such as Bresnahan [1987], Berry [1990], Berry, Levinsohn, and Pakes [1995], Nevo [2000 2001, 2003] use mean prices even though cars or cereals might be sold at different prices across stores. A notable exception to using means is Armantier and Richard [Rand, forthcoming].

carrier j is the hub airline. Clearly, $HubCarrierOrigin_{jr}$ is equal to 1 whenever $HubUmbrellaOrigin_r$ is equal to one, but not vice-versa. We define $HubCarrierDest_{jr}$ similarly. These four categorical variables play a critical role in our analysis because their interpretation is related to the debate on the hub premium in a very simple fashion.

First, these four hub variables will measure whether prices and markups are still higher in hub markets, after we control for various determinants of prices, most importantly the new measures of barriers to entry. Second, we identify whether hub airlines charge a premium on tickets for markets out of their hub airport compared to tickets for markets into the same airport. The difference for tickets on markets out of the hub and tickets into the hub is the difference between the sum of the coefficients of the variables $HubUmbrellaOrigin_r$ and $HubCarrierOrigin_{jr}$ and the sum of the coefficients of the variables $HubUmbrellaDest_r$ and $HubCarrierDest_{jr}$. Finally, the coefficient estimate of $HubUmbrellaOrigin_r$ and $HubUmbrellaDest_r$ measure the presence of "umbrella effects," or a measure of the benefit to carriers with smaller operations in hub markets. Should we find $HubUmbrellaOrigin_r$ to be positive and significant, we would conclude that *all* carriers can charge a premium in markets out of a hub airport.

The main objective of our paper is to identify the determinants of the hub premium. Table 3 provides a preliminary look at the type of evidence that we are looking for. We list the airports at which one airline controls more than 30 percent of the gates, and we show how many of those airports are hubs, and the hub airline. Table 3 also shows how many of these airports have set limits on the sublease fees that can be charged and the maximum amount of the limit. For example, at Charlotte, USAir can sublease the gates for which USAir has preferential or exclusive use, but cannot charge a sublease fee that is more than 15 percent higher than the fee USAir pays to the airport. At Denver, United can charge any sublease fee, since the airport has not set a limit. In the empirical analysis, we will quantify the effect that each one of the three variables $OwnGates_{jr}$, $Limit_r$, and $MaxLimit_r$ has on the premium that airlines can charge on flights out of their hubs.

4.5 Measures of Product Differentiation

One crucial issue is whether airlines charge a premium at hubs because they provide a better, differentiated, product from their competitors, or whether they charge it because they control access to the airport facilities. We consider five measures of product differentiation.

The first measure is related to the network of an airline at an airport and is motivated by the work of Berry [1990, 1992], Bruecker, Dyer, and Spiller [1992], and Ciliberto and Tamer [2006]. We compute the *percentage* of all markets served out of an airport that are served by one airline and call this variable $PctOriginMarkets_{jrt}$. This measure captures the relative attractiveness of the airlines' frequent flyer programs and other services of the airline at the airport (the number of ticket counters, customer service desks, *etc*).[14] Similarly, we define the variable $PctDestMarkets_{jrt}$.

Airlines also differentiate their product by whether they provide non-stop or connecting service. The variable $NonStop_{jrt}$ is equal to 1 if airline j provides nonstop service on route r at time t.[15] When airlines provide connecting service, they must decide how many miles the passenger must travel in addition to the nonstop distance between two airports. We construct a variable, called $ExtraMiles$, which is equal to the ratio of the flown distance over the nonstop distance in miles between two airports. Thus, a direct flight will be associated with a value of $ExtraMiles_{jrt}$ equal to 1, while connecting flights will be associated with values larger than 1. Clearly, the larger the number of extra miles that a passenger must travel between two airports, the less attractive is to travel on a connecting trip than on a nonstop trip.

Finally, airlines serve markets with different flights in a day, or frequency.[16] The more flights per day, the more likely a passenger can fly at her preferred time. The variable $Frequency_{jrt}$ measures the average number of flights per day in a quarter by an airline. In 4 percent of the observations the variable $Frequency$ is missing, and in those cases it is set to zero and the related variable $MissingFrequency_{jrt}$ is set equal to 1; otherwise $MissingFrequency_{jrt}$ is equal to zero. We did the analysis with and without $Frequency$ and the results are analogous.

Institutional characteristics of the airline industry ensure that these five variables are determined prior to the airlines' choice of prices. This is because prices can be changed at any time by an airline, while none of these variables can be changed in the same short period of time. Flight schedules, which involve crew scheduling and aircraft assignments, are developed a year prior to departure and updated every three months.[17] We will maintain that these five variables are exogenous in the demand and supply equations, and thus in the reduced form equation as well.

4.6 Cost Variables

Basic economic principles are very useful to understand the notion of marginal cost in the airline industry. The accounting marginal cost is just the passenger cost associated with issuing tickets, processing passengers through the gate, in-flight food and beverages, and insurance and other liability expenses. This cost is very small relative to the fixed costs faced by an airline to fly a plane on a route. However, as Elzinga and Mills [forthcoming] convincingly argue, this definition of marginal cost does not include the opportunity cost of the aircraft, of the pilots and flight attendants, and of the rental values of airport facilities. In particular,

[14] Bamberger and Carlton [?] discuss at length why fares should be positively correlated to variables to this type of hubbing activity at an airport.

[15] For more details on the construction of the variable $NonStop$, see the Appendix.

[16] For more details on the construction of the variable $Frequency$, see the Appendix.

[17] For more on this, see Ramdas and Williams [2007], and references therein.

when using an aircraft on a route, an airline is not using it in on another route. The economic marginal cost includes the highest per unit net profit that the airline could have made on another route using the same plane, pilots and flight attendants. It also includes the rental rate at which the airline could have leased the gate. In other words, the economic marginal cost of serving an additional consumer on a route, or the cost of a unit of capacity (a seat) in a given route, is a function of a very complex calculation of the full network the airline serves.[18]

The economic marginal cost of serving an additional passenger is clearly not observable, but can be inferred from the firms' pricing decisions if we are willing to assume that airlines play a non-cooperative static Nash-Bertrand game with differentiated products. This behavioral assumption is the same as in Bresnahan [1987], Berry [1990], Berry [1994], Berry, Levinsohn, and Pakes [1995], Nevo [2000, 2001, 2003]. **N**otice that because the marginal cost is estimated, it will implicitly take into account the short run capacity constraints that airlines face in each market.

To help in the estimation of the marginal cost, we include three observable determinants of costs in the analysis.

First, it is reasonable to think that the economic marginal cost of transporting one passenger is a function of the average cost to carry one passenger for one mile, a concept known in the airline industry as the average cost per seat mile. We construct the average cost per seat mile using the ratio of the quarterly operating expenses available from the Air Carrier Financial Reports (Form 41 Financial Data) over the quarterly total of the product of the number of seats transported and of the number of miles flown by the airline. Data on the total number of seats and miles flown is from the Air Carrier Statistics (Form 41 Traffic). The mean of the average cost per seat mile is approximately 9 cents per seat mile, and can be as low as 4 cents and as high as 13 cents. Notice that this variable is not market specific.

We multiply this average cost per seat mile by the number of miles flown by an airline to provide service between two airports and call this variable $AsmCost_{jrt}$.

Then, we also include two variables that measure the *number* of markets served out of an airport by a carrier, $NumOriginMarkets_{jrt}$ and $NumDestMarkets_{jrt}$. Notice that they are different from $PctOriginMarkets_{jrt}$ and $PctDestMarkets_{jrt}$, which are equal to the *percentages* of all markets served out of an airport. The variables $NumOriginMarkets_{jrt}$ and $NumDestMarkets_{jrt}$ capture the fact that from a cost perspective, it is very different to serve two routes of four routes out of an airport versus serving 150 routes out of 300 routes out of an airport. There are economies of density that are important in the cost determination (Brueckner and Spiller [1994]), and we measure them with the two variables $NumOriginMarkets_{jrt}$ and $NumDestMarkets_{jrt}$.

[18] See also the discussion in Brueckner and Spiller [1994], page 395.

5 Econometric Model

We show results from a reduced and a structural form approach. Because we use route-carrier fixed effects, each of the specifications that we run, whether they are in reduced or structural form, consists of two main steps (called “First Stage” and “Second Stage” in the Tables). First we run the specifications with route-carrier fixed effects, and then we run the estimated fixed effects on the hub and barriers to entry variables, which do not change over time.

5.1 Reduced Form Analysis

The model of supply and demand that we will present could be solved to yield a reduced form, but the resulting regression equation would have a complex non-linear form. Instead, we propose to use the following simple linear version of the reduced form pricing equation, where m indicates a market and r denotes a route in that market:[19]

$$Log(itinfare_{jrt}) = W_{jrt}\pi + u_{jr} + u_{jrt}. \quad (1)$$

Here, W_{jrt} are control variables (see **Table 1** for a list of these variables); u_{jr} is a route-carrier fixed effect; and u_{jrt} is an idyiosincratic error.

To recover estimates of the hub premia and the impact of barriers to entry on equilibrium prices, we follow Nevo's [2001] application of the minimum distance methodology of Chamberlin [1982]. This entails performing a generalized least squares regression of the estimated fixed effects, $\hat{u}_{jr}$ on $HubUmbrellaOrigin_r$, $HubUmbrellaDest_r$, $HubCarrierOrigin_{jr}$, $HubCarrierDest_{jr}$, and the variables that measure limited access to airports, $\mathbf{BarriersOrigin}_{jr}$ and $\mathbf{BarriersDest}_{jr}$ such that

$$\widehat{\gamma} = (Z'_{jr}V_u^{-1}Z_{jr})^{-1}Z'_{jr}V_u^{-1}\widehat{u}_{jr}$$

where V_u is the variance covariance matrix of the estimated fixed effects, $\widehat{u}_{jr}$. In addition to the hub dummies and vectors measuring barriers to entry, two controls are also included in Z_{jr}; $MarketDis\tan ce_r$ is the non stop distance in miles between two airports and $TouristDest_r$ is a dummy variable equal to 1 if a route is from or to Florida or California.

The hub indicators are intended to capture any advantages for hub airlines out of and into their hubs as well as any of these advantages (or disadvantages) that carry over to their competitors at these airports. The $\mathbf{BarriersOrigin}_m$ and $\mathbf{BarriersDest}_m$ vectors are intended to capture the effect that concentrated

[19] This is the same regression commonly used in the literature discussed in Section (2.1), but we choose not include variables that are endogenous, such as the market or airport shares of passengers transported, or the Herfindhal-Hirschmann Index constructed using these shares. We only include variables that are predetermined to the pricing decision.

rights to gates, MII agreements, slot controls, and limits on subleasing fees have on pricing decisions of firms at these airports.[20]

5.2 Structural Analysis

5.2.1 Demand

Following Morrison and Winston (1989), Berry (1990), and BCS we model the demand for airline travel with a discrete choice model of demand. In particular, we assume the indirect utility that consumer i receives from purchasing airline product j belonging to group $g \in \{airtravel\ or\ outside\ option\}$[21] in market m at time t is given by

$$\begin{aligned} u_{ijrt} &= \alpha p_{jrt} + X_{jrt}\beta + \xi_{jr} + \xi_{jrt} + \zeta_{jgmt} + (1-\lambda)\epsilon_{ijrt} \\ &= \delta_{jrt} + \zeta_{jgmt} + (1-\lambda)\epsilon_{ijrt} \end{aligned} \tag{2}$$

where X_{jrt} includes airline-route-time specific characteristics. This nesting structure is similar to that of BCS [2007].

An outside option, $j = 0$, is introduced to allow increases in the prices of all airline products to reduce aggregate demand. The share of the outside good and of the inside goods is a function of the potential demand for *unidirectional* air travel. Route-carrier fixed effects control for the fact that the appeal of the outside option in markets from the same city may differ.

The inclusion of carrier-route specific fixed effects, ξ_{jr} for all the airlines as well as year-quarter specific fixed effect, ξ_t controls for carrier and time specific attributes that are common across markets. The remaining route-time-airline specific deviate, ξ_{jrt}, is assumed to be observable to firms and consumers and take on a value that sets observed market shares equal those predicted by the model. The observability of ξ_{jrt} to both firms and consumers, implies that both price and within group market shares are endogenous. We address this correlation by constructing instruments using data on firm's costs as well as exogenous factors determining the availability of airport facilities.

The λ parameter governs consumers' substitution patterns across nests and is required to be between zero and one. As λ approaches 1, the within group correlation in the unobservable portion of utility goes to 1 and as λ approaches 0, the within group correlation goes to 0. Thus, higher values of λ imply that the consumer views products in different nests, here flying or not flying, as poor substitutes.

[20]Beside its simplicity, adding the barriers to entry and the hub dummies in this way is consistent with a two stage game where firms can make investments in the first stage that reduce their marginal costs in the second stage. For example, see the second model considered by Fudenberg and Tirole [1984]. On the other hand, adding the barriers to entry and the hub dummies is also consistent with a model where firms can invest to raise the rivals' costs, as illustrated by Salop and Scheffman [1983].

[21]Following Berry (1994), we normalize the value of the outside option to: $u_{0mt} = \zeta_{j0mt} + (1-\lambda)\epsilon_{i0mt}$

Following Berry (1994), we aggregate across consumers and transform the respective market shares such that

$$\ln(s_{jrt}) - \ln(s_{0mt}) = \alpha p_{jrt} + X_{jrt}\beta + \lambda \ln(s_{jrt|g}) + \xi_{jr} + \xi_{jrt} \tag{3}$$

where all the parameters of the consumers' utility function now enter the equation linearly. Here, s_{jrt} represents product $j's$ market share, s_{0mt}, the share of the outside good, and $s_{jrt|g}$ the group share of product j.

5.2.2 Supply

We write the profit function of an airline in each market m as follows (fixed costs and market size are omitted for simplicity):

$$\pi_{fmt} = \sum_{h \in F_{fmt}} (\underset{1\times1}{p_{hrt}} - \underset{1\times1}{mc_{hrt}}) \underset{1\times1}{s_{hrt}} \left(\underset{J_{mt}\times1}{\mathbf{p}_{rt}}, \underset{J_{mt}\times K}{\mathbf{X}_{rt}}, \underset{J_{mt}\times1}{\boldsymbol{\xi}_{rt}} \right).$$

The first order conditions for the price of product j produced by firm f in market m at time t satisfies

$$s_{jmt} + \sum_{h \in F_{fmt}} (p_{hrt} - mc_{hrt}) \frac{\partial s_{hrt}}{\partial p_{jrt}} = 0$$

where F_{fmt} represents the subset of products offered by firm f. The first order conditions for all the products sold in market m at time t can be described using vector notation as

$$\underset{J_{mt}\times1}{\mathbf{s}_{mt}} + \underset{J_{mt}\times J_{mt}}{\boldsymbol{\Omega}^{mt}} (\underset{J_{mt}\times1}{\mathbf{p}_{mt}} - \underset{J_{mt}\times1}{\mathbf{mc}_{mt}}) = \mathbf{0}$$

where

$$\Omega^{mt}_{jr} = \begin{cases} -\frac{\partial s_{rmt}}{\partial p_{jmt}} & if\ \exists f: \{r, j\} \subset F_{fmt} \\ 0 & otherwise. \end{cases}$$

We can then invert the $\boldsymbol{\Omega}^{mt}$ matrix in order to solve for the equilibrium price vector as

$$\mathbf{p}_{mt} = (\boldsymbol{\Omega}^{mt})^{-1}\mathbf{s}_{mt} + \mathbf{mc}_{mt}.$$

The marginal cost of each firm j is modeled as:

$$mc_{jrt} = \kappa w_{jrt} + \omega_{jr} + \omega_{jrt},$$

where w_{jrt} and ω_{jrt} are respectively, the observed and unobserved (to the econometrician) factors impacting the pricing decisions of airlines. w_{jrt} includes cost controls, such as $AsmCost_{jrt}$, $NumOriginMarkets_{jrt}$, and $NumOriginMarkets_{jrt}$. Moreover, it also includes the variables $PctOriginMarkets_{jrt}$ and $PctDestMarkets_{jrt}$. As Borenstein (1989) clearly pointed out, firms might use the extent of their network at an airport to leverage the consumers' loyalty and charge higher prices.

In practice, we estimate the following first order condition:

$$\mathbf{p}_{mt} - (\mathbf{\Omega}^{mt})^{-1}\mathbf{s}_{mt} = \kappa w_{jrt} + \omega_{jr} + \omega_{jrt}. \tag{4}$$

Notice that the term $(\mathbf{\Omega}^{mt})^{-1}\mathbf{s}_{mt}$ is derived from the demand, which is estimated separately.[22] After estimating the supply equation we run the route-carrier fixed effects on the hub and barriers to entry variables, in a similar fashion to what we do in the equation (**??**). The main difference with the reduced form approach is that now the route-carrier fixed effects are estimated after "cleaning out" the effect of markup term, $(\mathbf{\Omega}^{mt})^{-1}\mathbf{s}_{mt}$, on the prices.

5.2.3 Identification

Given the significant number of unobserved factors impacting both consumers' decisions to fly and the costs of offering service on any particular route, we chose to include route-carrier fixed effects. This has the advantage of providing a clear source of identifying variation for the parameters of interest while still allowing us to recover the impact of time invariant barriers to entry on equilibrium pricing decisions using the minimum distance procedure of Chamberlain (1982). Inclusion of route-carrier fixed effects in the specification of both consumer preferences and the pricing equation make the structural error terms, ω_{jrt} and ξ_{jrt} route-carrier-time specific. An endogeneity concern still arises when estimating demand in that airlines may acount for variability in ξ_{jrt} over time when making pricing decisions. For this reason, we construct a number of instruments using traditional cost side solutions for price endogeneity as well as more recent solutions that are now commonly applied in the discrete choice demand literature.

Following Bresnahan [1987] and Berry, Levinsohn, and Pakes [1995], we look at the first order conditions for price in order to gain intuition regarding appropriate instruments for the endogenous variables in the demand equation (price and within group shares). These authors' insight was that the closeness of competitors' products, measured in characteristic space, is an important and exogenous determinant of pricing behavior. Of course, this is under the assumption, maintained in the literature, that the location of products in characteristic space precedes the pricing decision, which reasonably holds in the airline industry.[23] The detailed description of the instrumental variables is given in the Appendix. In addition, we also include instruments that are constructed using cost information of the firm and of its competitors. We discuss the identification power of our instruments in the Appendix. Most importantly, the results of the paper are not dependent on which of the two sets of instruments we use.

[22] In previous version of the paper we estimated the parameters of our model using GMM, to exploit the cross-equation restrictions present in our model. However, we found that the GMM estimates were always very close to the one obtained when the model is seperately estimated.

[23] See our discussion in Section (4.5) for more on this.

6 Reduced Form Results

Table 4 presents the results of the first stage estimation, where the dependent variable is the natural logarithm of price. **Table 5** presents the main reduced form results of the paper. **Tables 5.A** describes the results concerning the hub premium and **Table 5.B** discusses how much of the hub premium is explained by the barriers to entry. The dependent variables in **Table 5** are the route-carrier fixed effects estimated in the first stage.

6.1 Control Variables (First Stage Estimation)

Table 4 presents the results for regression (1). The results for the control variables should be interpreted with caution, since they represent the net effect of the variables on the demand and supply. Overall, nonstop flights are associated with lower prices, and we will see that this is because they imply lower costs. Longer connecting flights, captured by a higher value of $ExtraMiles$, are charged at a higher price than shorter ones. A larger number of markets served by an airline out of an airport is associated with lower prices, which we will show that is related to the existence of economies of density. Finally, the coefficient of the unit cost, $AsmCost_{jrt}$, is negative, suggesting that the cost would decrease as the flown distance increases.

6.2 Quantifying the Hub Premium

Here, we quantify the hub premium, when we do not control for barriers to entry. We simply want to quantify the premium charged by hub carriers to high and low-fare paying passengers, and the magnitude of the "umbrella" effects. For this purpose we run the regressions presented in **Table 5.A**.

Column 1 presents the results when the dependent variable is the median itinerary fare. The coefficients of the dummy variables $HubUmbrellaOrigin_r$ and $HubUmbrellaDest_r$ measure whether carriers charge a hub premium. The coefficient of the dummy variables $HubCarrierOrigin_{jr}$ and $HubCarrierDest_{jr}$ measure whether the hub carrier charges an extra premium in hub markets (e.g. by American in markets originating or ending in Dallas/Fort Worth).

The main result is that the premium charged by the hub carrier exists and is of significant economic magnitude. In particular, it is equal to 12.4 $(0.009 + 0.115)$ percent for tickets out of a hub, and 15.2 percent for tickets into a hub. There is only limited evidence of "umbrella" effects, since $HubUmbrellaOrigin_r$ is essentially zero and $HubUmbrellaDest_r$ is equal to 2.3 percent.

A look at the results in **Columns 2** and **3** of **Table 5.A** suggests that, as discussed in Section (4.3), there is much more dispersion at the top of the fare distribution than at the bottom. In particular, at the top of the distribution the premium charged by the hub carrier is equal to 12.8 percent in markets out of a hub and 20 percent in markets into a hub. The premium is increasing as the dependent variable changes from the 25th percentile, to the median, to the 75th percentile of the fare distribution.

The differences in the estimated coefficients in **Columns 1**, **2,** and **3** suggest that the differences among mean and median ticket fares will have to be important. Not surprisingly, the results are not identical when we use means or medians of the ticket fares. The premia are 12.7 and 18.6 percent when we use means.

We reach two main conclusions from **Table 5.A**. First, it is misleading to use the average fare, since the distribution of market fares is skewed to the left. This is particularly true in hub markets. For this reason, the rest of the analysis will thus be carried out using the 25th percentile, the median, and the 75th percentile.

Second, the hub premia are increasing in the fare percentile. Notice that this finding is not immediately related to the "fare-mix" story proposed by Morrison and Winston [1995] and Lee and Luengo-Prado [2005]. The "fare-mix" story says that there is a larger percentage of business travelers flying out of hubs, and this explains the higher average fares. Here, we find that the hub premium is higher for higher fares, but we can not say anything on the "fare-mix" composition.

6.3 Hub Premia in the Reduced Form Model

What is the magnitude of the hub premium after including variables that measure the effect of barriers to entry and product differentiation?

Column 1 of **Table 5.B** shows the results when we add the barriers to entry in the regression but we do not include the measures of product differentiation. The hub premium is now significantly smaller. The premium charged by the hub carrier is now equal to 9.03 percent versus 12.4 percent for tickets out of a hub, and 11.8 versus 15.2 percent for tickets into a hub. So the hub premium is decreased by one third if we include the barriers to entry.

One variable, among those measuring the barriers to entry, play a crucial role: the gates leased on an exclusive basis by an airline. We estimate the coefficient of the variable $OwnGatesOrigin_{jr}$ to be equal to 0.155 and the coefficient of the variable $OwnGatesDest_{jr}$ to be equal to 0.151.

The other barriers to entry have only marginal economic impact on prices. The estimated coefficients are all small and very few are precisely estimated. For example, the coefficient of the variable $CompGatesOrigin_{jr}$ is equal to -0.0434. This means that if the percentage of gates controlled by the largest competitor increases from 10 to 30 percent, the prices decrease by only 0.9 percent.

Column 2, 3, and 4 largely confirm the results in **Column 1:** when running a reduced form model, approximately one third of the hub premium is explained by the concentration of gates owned at an airport by an airline.

7 Structural Form Results

The main limitation of the results presented in **Table 5** is that we cannot fully disentangle whether the hub premium, or at least part of it, is demand or supply driven. In particular, it is unclear whether consumers pay higher prices because they feel they are getting a better product, or because the airlines can use FFPs and volume incentives to raise their price. In this section we estimate a model of supply and demand in airline markets, to address these two concerns.

Tables 6 presents the results of the demand and supply equations. **Table 7** presents the main structural form results of the paper, the ones where the route-carrier fixed effects of the supply equation are regressed on hub dummies and barriers to entry variables.

7.1 Demand and Supply

Table 6 presents the estimates from demand the first order condition for price.[24] The results are all very intuitive and reasonable, and we will only briefly describe them here.

First, the price coefficient in the demand equation is negative and well estimated. In the Appendix we show how this price coefficient is associated with a median own price elasticity of -2.814, which in turn corresponds to a median price cost margin $((p - mc)/p)$ equal to 36.1 percent.

The coefficient of $Log\left(s_{jrt|g}\right)$, λ, is 0.348 and is precisely estimated. An estimate of λ significantly different from zero implies that there is a significant amount of correlation in the unobservable portion of consumers' utility for products in the same group. In the context of our model of demand with only two nests, $g \in \{airtravel\ or\ outside\ option\}$, this implies that consumers' do not view other forms of travel or not traveling as a good substitute for air travel and vice-versa.

The nonstop dummy is positive in the demand equation, implying that consumers prefer nonstop to connecting flights; and it is negative in the pricing equation, suggesting that the cost of a nonstop flight is lower than the cost of a connecting flight. The longer the connecting flight, the less attractive it is to the passengers and the more costly it is to the carrier. The variables $PctOriginMarkets_{jrt}$ and $PctDestMarkets_{jrt}$ determine the appeal of a frequent flyer program and have increase the attractiveness of flying in one particular airline. The variables $NumOriginMarkets_{jrt}$ and $NumDestMarkets_{jrt}$ have a negative effect on cost, supporting the notion of economies of densities. Finally, a higher frequency of flights makes the service of an airline more attractive. Interestingly, a higher frequency is associated with lower costs, which we interpret as further evidence of economies of density.

[24] We also considered a specification without frequency as an explanatory variable. Frequency might be thought of as determined at the same time as prices, and thus endogenous. To address this concern we checked the results with and without frequency and the results concerning the hub and barriers to entry variables are analogous.

7.2 Hub Premia in the Structural Form Model

Table 7 presents the main results from the structural estimation. **Column 1** shows the results when we do not include the barriers to entry, while they are included in **Column 2**. In both columns, the dependent variables are the route-carrier fixed effects from the pricing equation (4). The estimated parameters should be interpreted as percentage changes in the premium that airlines can charge on routes out and into their hubs after we have controlled for the differences in the services that they provide.

Column 1 presents the results when we do not include the barriers to entry. In this table, the coefficient of $HubUmbrellaOrigin_r$ is equal to 0.041 which corresponds to a 4.1 premium. Thus, we find evidence of a small umbrella effect. Notice that this result is different from those in **Table 4**, where we estimated a reduced form model. In the same manner, the coefficient of $HubUmbrellaDest_r$ is here equal to 0.051. These findings are interesting because they show that umbrella effects exist once we control for differences on the demand side across airlines and markets.

The coefficients of $HubCarrierOrigin_{jr}$ and $HubCarrierDest_{jr}$ are estimated, respectively, to be equal to 15.5 and 20.5 percent. Together with the estimates of the variables $HubUmbrellaOrigin_r$ and $HubUmbrellaDest_r$, these results imply that the premium charged by hub carriers is 20.9 percent in markets out of a hub and 25.6 in markets into a hub. Recall that in **Table 4** we found significantly lower premia. Hence, after we control for product differentiation across airlines, the hub premia are very large.

Column 2 presents the results when we include the barriers to entry. The effect of doing so on the coefficients of the hub variables is dramatic. The coefficient of $HubCarrierOrigin_{jr}$ is equal to 0.079 percent, down from 0.155 in **Column 1**. Similarly, the coefficient of $HubCarrierDest_{jr}$ is now 0.128, down from 0.209. These two results clearly show that half of the carrier hub premium can be explained by the barriers to entry variables, and in particular by the variables $OwnGatesOrigin_{jm}$ and $OwnGatesDest_{jm}$.

The effects of the $OwnGatesOrigin_{jm}$ and $OwnGatesDest_{jm}$ are precisely estimated and can be quantified. For example, if an airline controls 20% instead of 10% of the gates at an airport, it can charge a premium of $0.10 * 0.237 = 0.024$, or 2.4 percent over the normal prices. This is a large effect, considering that many airlines control high percentages of gates at their hub airport.

Overall, the results in **Table 7** are stronger than those from the reduced form regressions presented in **Table 4**. The hub premium is associated with the presence of barriers to entry, and it is much larger when we control for the ability of airlines to differentiate their products. Moreover, umbrella effects exists and are economically significant.

8 Conclusions

Following the deregulation of the US airline industry in 1978, there was a great deal of optimism that airline markets would become competitive and fares would decline substantially. The theoretical framework justifying this optimism was the "theory of contestable markets" developed by Baumol, Panzar, and Willig [1982]. Their basic insight was that airlines do not incur large sunk costs to enter into markets, and thus they can easily enter when prices are high and exit as soon as prices fall too much.

In this paper we show that airlines can still charge a large premium on markets into and out of their hubs, well and beyond what would be justified by their ability to differentiate their products from the competitors.

We have also studied how limited access to airport facilities is related to market power in the airline industry. Future research should focus on the role that barriers to entry have on the entry decisions, as that is also an important determinant of long run competition in airline markets.

The main conclusion of this paper is that, after controlling for the markup that airlines can charge because they offer a differentiated product, control of gates is the main determinant of the hub premium, or more generally of market power in the airline industry. We also find evidence of umbrella effects, whereby non-hub airlines can charge a premium out of hub airports.

Finally, we want to highlight that our research can explain approximately 50 percent of the hub premium. The other 50 percent is still to be explained. It could be a function of what Borenstein [1989] calls marketing barriers to entry: frequent-flyer programs (FFPs) and volume incentives to travel agents that might allow airlines to raise their prices above their marginal cost and above what a "fair" markup would justify. Unfortunately, data on FFPs are not available.

The remaining premium that needs to be explained could otherwise be a function of the strategic behavior of airlines, such as deterring or predatory practices.

References

[1] Aguirregabiria V. and Ho C., "A Dynamic Oligopoly Game of the US Airline Industry: Estimation and Policy Experiments," *Working Paper*, University of Toronto, 2006

[2] Anderson, Simon P.; DePalma, Andre' "Multi-Product Firms: A Nested Logit Approach" *The Journal of Industrial Economics* Vol. XL, No. 3 (September, 1992): 261-276

[3] Armantier O. and Richard O., "Domestic Airline Alliances and Consumer Welfare," Rand Jorunal of Economics, Forthcoming.

[4] Bamberger G. and Carlton D., "Airline Networks and Fares," >>>

[5] Baumol W.; Panzar J.; and Willig, R., *Contestable Markets and the Theory of Industry Structure*, San Diego: Harcourt Brace Jovanovich, 1982.

[6] Berry S., "Airport Presence as Product Differentiation," American Economic Review, Vol. 80, No. 2, Papers and Proceedings of the Hundred and Second Annual Meeting of the American Economic Association (May, 1990), pp. 394-399

[7] Berry, Steven "Estimating Discrete-Choice Models of Product Differentiation" Rand Journal of Economics 25 (Summer 1994): 242-262

[8] Berry, Steven; Carnal, Michael; Spiller, Pablo "Airline Hubs: Costs, Markups, and the Implications of Costumer Heterogeneity," in *Advances in Airline Economics, Competition Policy and Antritrust*, Volume 1, Edited By Darin Lee, Elsevier, 2006.

[9] Berry, Steven; Levinsohn, James; Pakes, Ariel. "Automobile Prices in Market Equilibrium" Econometrica 63 (July 1995): 841-890

[10] Borenstein, Severin "Hubs and High Fares: Dominance and Market Power in the U.S. Airline Industry" Rand Journal of Economics 20 (Autumn 1989): 344-365

[11] Bamberger G., Carlton D., and Neumann L., "An Empirical Investigation of the Competitive Effects of Domestic Airline Alliances, " *Journal of Law and Economics*, (forthcoming).

[12] Bresnahan, Timothy "Competition and Collusion in the American Automobile Industry: The 1955 Price War" Journal of Industrial Economics 35 (June, 1987): 457-482.

[13] Brueckner J. and Spiller P., "Economies of Traffic Density in the Deregulated Airline Industry," *Journal of Law and Economics*, Vol. 37, No. 2 (Oct., 1994), pp. 379-415

[14] Brueckner J., Dyer N., and Spiller P., "Fare Determination in Airline Hub-and-Spoke Networks," RAND Journal of Economics, pp. 309-333, 1992.

[15] Caplin, Andrew; Nalebuff, Barry "Aggregation and Imperfect Competition: On the Existence of Equilibrium" Econometrica Vol. 59, No. 1 (January, 1991): 25-59

[16] Chamberlain, G., "Multi Variate Regression Models for Panel Data," Journal of Econometrics, Vol. 18, (1982), pp. 5-46

[17] Ciliberto F. and Tamer E., "Market Structure and Multiple Equilibria in the Airline Industry," Working Paper, January 2006.

[18] K. Elzinga and D. Mills, "Predatory Pricing in the Airline Industry: Spirit Airlines vs. Northwest Airlines (2005)," in *The Antitrust Revolution*, 5th Edition, edited by J. Kwoka and L. White, Forthcoming.

[19] Evans W. and Kessides I., "Localized Market Power in the U.S. Airline Industry," Review of Economics and Statistics, Vol. 75, No. 1 (Feb., 1993), pp. 66-75.

[20] Drew Fudenberg and Jean Tirole, "The Fat-Cat Effect, the Puppy-Dog Ploy, and the Lean and Hungry Look," *American Economic Review,* Vol. 74, No. 2, Papers and Proceedings of the Ninety-Sixth Annual Meeting of the American Economic Association (May, 1984), pp. 361-36

[21] Goolsbee, Austan; Syverson, Chad "How do Incumbents Respond to the Threat of Entry? Evidence from the Major Airlines," Working Paper, 2006.

[22] Goolsbee, Austan; Petrin, Amil "The Consumer Gains From Direct Broadcast Satellites and the Competition with Cable TV," Econometrica Vol. 72, No. 2 (March, 2004): 351-381

[23] Lee, Darin; Luengo-Prado, Maria Jose "The Impact of Passenger Mix on Reported "Hub Premiums" in the U.S. Airline Industry" Southern Economic Journal 72 (2005): 372-396.

[24] Steven A. Morrison; Clifford Winston, "Enhancing the Performance of the Deregulated Air Transportation System," *Brookings Papers on Economic Activity*, Microeconomics, Vol. 1989. (1989), pp. 61-123.

[25] Morrison, Steven; Winston, Clifford, *The Evolution of the Airline Industry*, Washington, D.C.: The Brookings Institution, 1995.

[26] Nevo, Aviv "Mergers with Differentiated Products: The Case of the Ready to Eat Cereal Industry" The Rand Journal of Economics, Vol 31, No. 3 (Autumn, 2000), pp. 395-421

[27] Nevo, Aviv "Measuring Market Power in the Ready to Eat Cereal Industry", Econometrica, Vol. 69, No. 2 (March 2001): 307-342

[28] Peters, Craig. 2006. "Evaluating the Performance of Merger Simulations: Evidence from. the U.S. Airline Industry." Journal of Law and Economics 49:627–649.

[29] Petrin, Amil "Quantifying the Benefits of New Products: The Case of the Minivan" Journal of Political Economy, Vol. 110, No 4 (2002): 705-729

[30] Ramdas, Kamalini; Williams, Jonathan, "Putting Queuing Theory Fundamentals to Work: An Investigation into the Causes of Airline Flight Delays" Working Paper, January 2007

[31] Steven C. Salop; David T. Scheffman, "Recent Advances in the Theory of Industrial Structure: Raising Rivals' Costs," *American Economic Review*, Vol. 73, No. 2, Papers and Proceedings of the Ninety-Fifth Annual Meeting of the American Economic Association. (May, 1983), pp. 267-271.

[32] Special Report 255, "Entry and Competition in the U.S. Airline Industry: Issues and Opportunities," Transportation Research Board [TRB], National Research Council, 1999.

[33] U.S. General Accounting Office, "Barriers to Competition in the Airline Industry," September 20, 1989.

[34] U.S. General Accounting Office, "Airline competition: industry operating and marketing practices limit market entry," August 1990.

9 Appendix

9.1 Data Construction: Fare and Passenger Data

Fare and passenger information are from the Origin and Destination Survey (DB1B), which is a 10 percent sample of airline tickets from reporting carriers. The data from the DB1B are merged with data from the T-100 Domestic Segment Dataset by the operating carrier. The T-100 Domestic Segment Dataset contains domestic market data by air carriers, origin and destination airports for passengers enplaned. The T-100 is not a sample: it reports all flights occurred in the United States in a given month of the year. Data are from every quarter from the first quarter in 1993 to the third quarter in 2005. A market is defined as a unidirectional trip from one airport to another airport, with or without connections. The unit of observation is a market-carrier-year-quarter data point.

We drop: tickets that are neither one-way nor round-trip travel, such as open-jaw trip tickets; tickets involving a US-nonreporting carrier flying within North America and foreign carrier flying between two US points; tickets that are part of international travel; tickets including travel on more than one airline on a directional trip (known as interline tickets); tickets involving non-contiguous domestic travel (Hawaii, Alaska, and Territories); tickets with fares less than 20 dollars or larger than 9999 dollars; and tickets whose fares were in the bottom and top 5 percentile percentile in their year; tickets with more than 6 coupons. We then merge this dataset with the T-100 Domestic Segment (U.S. Carriers) and drop tickets for flights that have less than 12 departures over a quarter in *one* direction (this means less than 1 departure every week in one direction).

We code a round-trip ticket as *one* directional trip ticket, which costs half the full round-trip ticket fare. This avoids overcounting the lower fares associated with round-trip tickets relative to the higher fares associated with purchasing two one-way tickets. In this way, it is possible to make the comparisons between one-way and round-trip fares meaningful, by comparing what two passengers would pay for traveling the same distance. Each passenger is only counted once when constructing the market and airport market shares.[25]

We construct the $NonStop$ variable using the following procedure. For each ticket we know the number of segments flown by the passenger. If the passenger used one coupon for one-way travel and the airline provided nonstop service on that route, then we code this ticket as a non-stop ticket. If the passenger used two coupons for a round-trip ticket and the airline provided nonstop service on the two routes, then we code

[25] To check that this coding did not affect the result, we re-run **Column 1** of **Table 4**, considering only data from roundtrip tickets. The results were almost identical. In particular, we found the coefficient of $HubUmbrellaOrigin$ equal to 0.012 (and the standard error equal to 0.008); the coefficient of $HubUmbrellaDest$ equal to -0.018 (0.006); the coefficient of $HubCarrierOrigin$ equal to 0.109 (0.011); and the coefficient of $HubCarrierDest$ equal to 0.142 (0.010). The R^2 for the second stage was a bit higher, at 0.1831.

this ticket as a non-stop ticket. Otherwise, the ticket is for a connecting or direct (connecting but using only one coupon) flight. In principle, an airline can provide both non-stop and connecting service between two airports. It turns out that in our sample in 63 percent of the observations (year-quarter-route-carrier), a carrier only provided connecting service. Among the remaining 37 percent of the observations, a carrier might provide both non-stop and connecting service. However, it turns out that carriers sell a non-negligible number (at least 30 percent of the tickets on a route in a quarter) of connecting tickets when they also provide nonstop service *in less than* 2 *percent of the observations*. Because the price variable is constructed as a median, the median price is the price of the nonstop service in all but a very negligible number of markets. Thus, we coded $NonStop = 1$ if the carrier provided nonstop service between two airports.

We construct the $Frequency$ variable using the following procedure. If an airline provide non-stop service on a route, then $Frequency$ is simply the number of departures in a quarter divided by 91, and this provide the average number of flights per day. If an airline provides connecting service on a route, then the variable $Frequency$ is equal to the *minimum* number of daily flights among those in each segment that the airline flew on the route. This is the same approach as in Borenstein (1989). In some cases, airlines issue a coupon for two segments of flight. Then, data on frequency is missing. When this happens, we let the variable *MissingFrequency* be equal to 1.

Following Borenstein (1989), the mean, median, 25th percentile, and 75 percentile fares are from the distribution of fares weighted by the number of passengers paying each fare, not from a distribution that gives equal weight to each fare listed by the airline. We do not use data on fare class from Data Bank 1B because of the following reasons. First, in private communication with the National Transportation Library in the Bureau of Transportation Statistics, it came to our attention that it is possible that one airline may classify a ticket as falling into class X while another airline may classify the same ticket as falling into class Y. The reason for this is that there are no rules as to the standardization of what X and Y means. Second, Southwest codes all tickets under one fare class, despite selling tickets with different fare restrictions. As a result, it is questionable whether or not the information on fare classes contained in the US Department of Transportation O&D Survey can be used to build a reliable traffic mix variable. Finally, the number of frequent flyer tickets (and traffic mix) are endogenous, in the sense that prices, the number of frequent flyer tickets, and the fare mix are determined simultaneously.

One important issue is how to treat regional airlines that operate through code-sharing agreements with national airlines. As long as the regional airline sells tickets independently, we treat it separately from the national airline.[26] Another issue is that there are airlines that transport very few passengers in a quarter.

[26]The D1B1 dataset provides information on the "operating" and "ticketing" carrier, which might differ in the case of code share agreements. In their institutional analysis of airline alliances, Bamberger, Carlton, and Neumann [forthcoming] discuss

In particular, consider an airline using a small plane that has 20 seats to serve a regional market. One flight per week over a quarter tells us that the airline will transport 240 passengers at full capacity. A 10 percent sample should give the airline reporting 24 passengers in the dataset. If an airline reports less than 20 passengers in a quarter, we assume that the airline does not have an *active* presence in this market. Berry (1992) drops airlines which report less than 90 passengers in a quarter. We relax this condition to account for the progressive adoption of smaller regional jets by the US airlines.

9.2 Data Construction: AIR 21 Data

The data from the competition plans is a cross-section. Airports included: Atlanta (ATL), Baltimore (BWI), Charlotte (CLT), Chicago O'Hare (ORD), Cincinnati (CVG), Dallas Fort-Worth (DFW), Denver (DEN), Detroit (DTW), Houston (IAH), Washington Dulles (IAD), Miami (MIA), Minneapolis (MSP), Newark (EWR), Philadelphia (PHL), Phoenix (PHX), Pittsburgh (PIT), St. Louis (STL), Salt Lake City (SLC), San Francisco (SFO), Albuquerque (ABQ), Austin (AUS), Burbank (BUR), Chicago Midway (MDW), Cleveland (CLE), Dallas Love (DAL), El Paso (ELP), Houston Hobby (HOU), Jacksonville (JAX), Memphis (MEM), Nashville (BNA), Oakland (OAK), Providence (PVD), Reno (RNO), Sacramento (SMF), San Antonio (SAT), San Jose' (SJC), West Palm Beach (PBI).

We merge it with the fare and passenger data, which is a panel data set. During this process of merging the two data set, we need to clean the AIR 21 data set as follows. At JAX, American uses a gate that is for common use. We code that gate as for common use rather than as of American. The same is true for Southwest, who also uses a common-use gate. At SMF, the gates of AA include the activity of TWA. The gates of CO include the activity of HP. We have three competition plans for SMF. The number of gates and assignment change very little. Instead, the limit on sublease fees changed from not existing in 2000 to being 15% in 2001. At ATL, Atlantic Southwest Airlines is counted as Delta. At SLC, Skywest controls the gates and serves DL: we coded these gates as controlled by DL. At IAD, Atlantic Coast Airlines gates assigned to UA. At SLC, it says that an entrant was charged above 15% and airport helped negotiation but does not tell how lower the fee was charged. It says they are introducing a limit, but with new agreement. At PHL they were constructing 13 gates, which are included. We do no include 4 gates and 38 regional gates expected to be added after the period of interest. At DTW, 5 gates are assigned to both HP and CO, but we used the number of departures to split 4 to Continental and 1 to America West. At DAL, 25 gates were available but

how code-share agreements allow a carrier to independently set price and sell service between cities that it otherwise would not be able to serve. Code share agreements can involve different financial agreements between the operating carrier and its alliance partner. In some alliances ("free sale" agreement), the operating carrier determines seat availability and the ticketing carrier sets prices for its service. In other alliances ("blocked space" agreement), the ticketing carrier buys a block of seats on each code-share flight from the operating carrier. Since fares are set by the ticketing carrier in both cases, we use the ticketing carrier to assign a ticket to a specific airline. Notice that this approach addresses the issue of how to treat regional carriers that operate for major airlines.

only 18 operational. At CLE, USair sublets one gate to Midwest; Continental sublets one to America West; also, Continental has 4 gates that can serve 6 regional planes each. We coded them as counting for 4. At BUR, airlines cannot sublease gates. There are three overflow gates which we interpret as common use. At MIA, all gates are for common use, no subleasing necessary. At DFW, 37 are non-bridge positions. We do not count them. The TWA gates went to AA when TWA was acquired by AA. MKE converted one gate of TWA to common use. AA serves the airport through AA Eagle since 1996. Data for ORD, MDW, OAK, BWI was collected from the airport websites, their competition plans, direct contact with the airports, and from the publication "Airport Business Practices and their Impact on Airline Competition," published by the FAA/OST Task Force Study in October 1999.

9.3 Validating the Exclusion Restrictions

The main concern in the estimation of the parameters entering the utility function of travelling is given by the endogeneity of price (Berry [1994]). Inclusion of route carrier fixed effects in the demand estimation reduces this correlation between prices and the structural error term ξ_{jrt} which is now a route-carrier-time specific deviation. However, in the discussion to follow, we demonstrate that if ignored these variations in consumer preferences can lead to biased estimates of elasticities. For this reason, we explore a variety of instruments and show that our results are not reliant on the particular subset chosen.

The first, and most natural, source of instrumental variables is given by the cost side. In particular, carrier-specific cost variables that are excluded from the utility function are ideal determinants of prices that do not affect the consumer's utility function. In our analysis, $NumOriginMarkets_{jrt}$ and $NumDestMarkets_{jrt}$ are excluded from the utility function as they capture economies of density and the possible attractiveness of frequent flyer programs is already proxied by the variables $PctOriginMarkets_{jrt}$ and $PctDestMarkets_{jrt}$. Also, $ASMCost_{jrt}$ is excluded. In addition, we construct a variable given by the sum of $ASMCost_{rt}$ across the competitors of a firm out of an airport, and we use all the markets to construct this measure.[27] We also use the sum of $ASMCost_{rt}$ among all the markets served by the airline whose utility function we are estimating. The idea is that if the cost of flying out of an airport is high, then the price of flying in any particular market should also be high. None of these five variables is crucial for the results, in the sense that we can drop any of the four and we still get similar results. However, using the four variables improves the precision of the estimates.

The second set of instrumental variables is constructed using the arguments in Bresnahan [1987] and

[27]Notice that approximately one fifth of the markets are monopolies. This creates two issues. We would have several zeros for the instrumental variables if we were to construct the sum of costs across competitors in the same market instead of out of the origin airport. In other words, the variable would be truncated on the left, and we do not believe that this truncation is exogenous.

Berry [1994]. Berry [1994] shows that using an appropriate inversion of the demand ("share") function, a second source of instrumental variables is given by variables that enter into the utility function of travelling on a competing airline. In particular, the exogenous characteristics, here captured by the variables $NonStop$, $ExtraMiles$, $PctOrigin\Pr esence$, $PctDest\Pr esence$, that enter into the utility function of travelling on one particular carrier can be used as instrumental variables in the estimation of the parameters of the utility function of its competitors. Here, we use the sum of these variables across competitors of a firm out of an airport, and the sum of these variables for the same firm out across other markets served out of the origin airport.

Table A.1 shows the results of our analysis of the exclusion restrictions.

Column 1 presents the results when we do not instrument for the prices and for $Log\left(s_{jrt|g}\right)$. The results are largely expected, with the coefficient of price negative, and with the other variables with the coefficients as interpreted in the main body of the paper. This regression does not include $Frequency_{jrt}$ because we want to verify that the results do not depend on whether frequency is well measured. **Column 2** includes $Frequency$ and the results are basically the same.

Column 3 presents the specification when prices are instrumented using cost side variables. The price coefficient is estimated to be equal to -2.430, almost ten times larger than when we do not instrument for prices. As a result the median elasticity is much larger in absolute value, and the median percentage contribution margin as well. The fit of the first stage regression is not particularly high for the price regression, but is higher for the $Log\left(s_{jrt|g}\right)$ regression.

Column 4 presents the resultswhen prices are instrumented using the "Bresnahan" instruments, that is the characteristics of the other products in the market. Now the price coefficient is estimated to be equal to -1.172, smaller than when we use cost side instruments.

Column 5 presents the resultswhen prices are instrumented using the "Bresnahan" and the cost side instruments, and the price coefficient is equal to -1.737. This is when we get the best fit in the first stage. Adding frequency, which is done in **Column 6** does not change the results. **Column 6** is the specification used in **Table 6**.

Figure 1: Nesting Structure

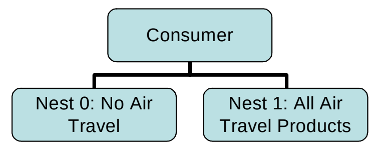
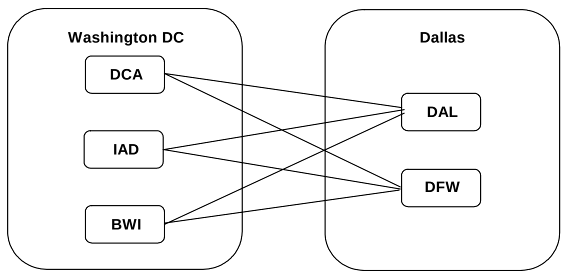
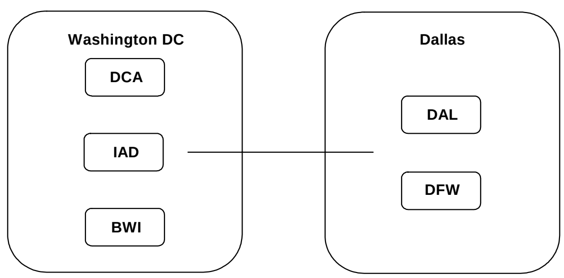


Figure 2: Market Definition

Airport Pairs: 12 Markets and Single Product Firms



MSA Pairs: 2 Markets and Multi-Product Firms



Variable	Description	Mean	Std. Dev.	Min	Max
OwnGates (%)	Fraction of Gates Leased on an Exclusive or Preferential Basis to an Airline	0.136	0.203	0	0.79
CompGates (%)	Fraction of Gates Leased on an Exclusive or Preferential Basis to the Largest Competitor of an Airline	0.244	0.246	0	0.79
Limit (0/1)	There is a Limit on Sublease Fees	0.496	0.500	0	1
MaxLimit (%)	Magnitude of the Maximum Sublease Fee Conditional on the Presence of a Limit on Sublease Fees	0.145	0.057	0	0.25
MII	Majority in Interest Agreement	0.690	0.462	0	1
Slot	The Airport uses slot controls to reduce congestion by limiting the number of takeoffs and landings per hour	0.033	0.178	0	1
42,309 observations					

Table 1 : Limited access to airport facilities

Notes: The "Fraction of Gates Leased" to an airline is computed as the ratio of the gates leased with exclusive or preferential use to an airline over the total number of gates at an airport. Summary statistics use the origin airport: the variables at the destination airports are the same as those for origin airports up to second decimal digit.

Data collected from the airports' competition plans that airports must compile in compliance to the Wendell H. Ford Aviation Investment and Reform Act for the 21st Century (AIR 21).

Table 2: Summary Statistics

		Mean	S.D.	Min	Max
	Ticket Fares				
Median Ticket Fare ($100)	Median of the fares charged by an airlines in a quarter in each market	1.219	0.326	0.435	2.355
25th Percentile Ticket Fare ($100)	25th Percentile of the fares charged by an airlines in a quarter in each market	0.971	0.232	0.415	2.160
75th Percentile Ticket Fare ($100)	75th Percentile of the fares charged by an airlines in a quarter in each	1.669	0.522	0.435	5.253
Average Ticket Fare ($100)	Average of the fares charged by an airlines in a quarter in each market	1.409	0.339	0.453	3.351
	Hub Dummies				
HubOrigin (0/1)	Equal to 1 if origin airport is a hub of any of the national carriers	0.423	0.494	0	1
HubCarrier (0/1)	Equal to 1 whenever the observation is for a carrier in a market out of an airport where carrier is hub airline	0.130	0.336	0	1
	Firm Specific Variables				
PctOriginMarkets (%)	Network Extent at the Airport: *Percentage* of markets served out of an airport by one airline out of the total number of markets served out of that airport by any airline	0.436	0.227	0.007	1
NumOriginMarkets	Network Extent at the Airport: *Number* of markets served out of an airport by one airline (00s)	0.420	0.249	0.01	1.28
Nonstop (0/1)	Dummy Equal to 1 for Tickets for Nonstop Flight	0.374	0.484	0	1
Frequency (00s)	Average Daily Frequency	0.043	0.022	0	0.278
Missing Frequency (0/1)	If data on Frequency is missing	0.043	0.022	0	0.278
ExtraMiles	Ratio of Distance Flown by an Airline over NonStop Distance	0.085	0.144	0	1.599
Accounting cost to serve a market	Average Cost per Seat Mile (ASM Cost, cents) * Flown Miles (00s)	0.869	0.813	0.000	4.063
	Market Specific Variables				
Tourist Destination (0/1)	Equal to 1 if destination airport is in either California, Florida, or Nevada	0.216	0.411	0	1
Market Distance (1000 miles)	Non Stop Distance	1.214	0.594	0.095	2.683
	42,309 Observations				

Notes: Summary statistics use the origin airport: the variables at the destination airports are the same as those for origin airports up to second decimal digit, hence they are not reported for sake of brevity. The fares presented and the cost data are in 1993 dollars. Details on the construction of the variables Non-Stop and Frequency are provided in the Appendix.
Data Sources: DB1B Origin and Destination Survey (2002-2004).

Table 3: Control of Gates at Hubs and other Large Airports

Airport, Carrier	HubCarrier (0/1)	OwnGates (%)	Limit (0/1)	MaxLimit (%)
	No Hubs	Less than 30%		
St. Louis, American	1	0.217	1	0.15
Washington Reagan, USAir	0	0.318	0	.
Chicago O’Hare, American	1	0.353	0	.
Chicago O’Hare, United	1	0.353	0	.
San Jose, American	0	0.355	0	.
Cincinnati, Delta	1	0.420	0	.
Charlotte, USAir	1	0.429	1	0.15
Atlanta, Delta	1	0.552	1	0
Philadelphia, USAir	1	0.500	0	.
Phoenix, America West	1	0.404	1	0.15
Baltimore, USAir	0	0.524	0	.
Newark, Continental	1	0.577	0	.
Denver, United	1	0.595	0	.
Cleveland, Continental	1	0.597	1	0.10
Detroit, Northwest	1	0.676	1	0.15
Dallas/Fort Worth, American	1	0.638	0	.
Salt Lake City, Delta	0	0.667	0	.
Minneapolis, Northwest	1	0.721	1	0.15
Houston (IAH), Continental	1	0.746	0	.

Notes: The airports included in this table are either the hubs of a legacy carrier or airports where one carrier controls more than 30 percent of the gates.
Data collected from the airports’ competition plans that airports must compile in compliance to the Wendell H. Ford Aviation Investment and Reform Act for the 21st Century (AIR 21).

Table 4: Control Variables in the Reduced Form Price Regressions

Variable	Dependent Variable: Log(Median Fare) **Coefficient (Std. Error)**	Dependent Variable: Log(25th Pct Fare) **Coefficient (Std. Error)**	Dependent Variable: og(75th Pct Fare) **Coefficient (Std. Error)**	Dependent Variable: Log(Mean Fare) **Coefficient (Std. Error)**
NonStop	-0.442***	-0.513***	-0.346***	-0.495***
	(0.062)	(0.053)	(0.072)	(0.050)
ExtraMiles	0.236***	0.228***	0.176***	0.177***
	(0.029)	(0.025)	(0.034)	(0.024)
PctOriginMarkets	0.052	0.156***	-0.118***	-0.082***
	(0.038)	(0.033)	(0.044)	(0.031)
PctDestMarkets	0.280***	0.225***	0.315***	0.219***
	(0.039)	(0.033)	(0.045)	(0.032)
Frequency	-0.662***	-0.455***	-0.683***	-0.847***
	(0.129)	(0.111)	(0.151)	(0.105)
MissingFrequency	-0.031***	-0.032***	0.016	0.005
	(0.010)	(0.008)	(0.011)	(0.008)
NumOriginMarkets	-0.235***	-0.331***	-0.083*	-0.091***
	(0.038)	(0.032)	(0.044)	(0.031)
NumDestMarkets	-0.499***	-0.406***	-0.574***	-0.431***
	(0.038)	(0.033)	(0.044)	(0.031)
Log(ASM*Flown Distance)	-0.058***	-0.072***	-0.043***	-0.065***
	(0.009)	(0.008)	(0.010)	(0.007)
Observations	42,309	42,309	42,309	42,309
R^2	0.709	0.734	0.716	0.779

Notes: Standard errors in parentheses. Carrier-route fixed effects are included in the First Stage of all specifications. A Generalized Least Squares routine (which includes a not reported constant term) is used to estimate the coefficients and standard errors in the second stage.

Table 5.A: Hub Premia

Variable	Dependent Variable: Route-Carrier FE Log(Median Fare) **Coefficient (Std. Error)**	Dependent Variable: Route-Carrier FE Log(25th Pct Fare) **Coefficient (Std. Error)**	Dependent Variable: Route-Carrier FE Log(75th Pct Fare) **Coefficient (Std. Error)**	Dependent Variable: Route-Carrier FE Log(Mean Fare) **Coefficient (Std. Error)**
HubUmbrellaOrigin	0.009 (0.007)	-0.003 (0.006)	0.027*** (0.009)	0.023*** (0.007)
HubUmbrellaDest	0.023*** (0.007)	0.000 (0.006)	0.057 *** (0.009)	0.041*** (0.007)
HubCarrierOrigin	0.115*** (0.013)	0.123*** (0.011)	0.101*** (0.016)	0.104*** (0.012)
HubCarrierDest	0.129*** (0.013)	0.126*** (0.011)	0.143*** (0.016)	0.145*** (0.012)
TouristDest	-0.058*** (0.008)	-0.049*** (0.007)	-0.072*** (0.009)	-0.062*** (0.007)
MarketDistance	0.155*** (0.010)	0.159*** (0.009)	0.079*** (0.012)	0.057*** (0.009)
Route-Carriers	5,401	5,401	5,401	5,401
R^2	0.184	0.289	0.162	0.152

Notes: Standard errors in parentheses. The First Stage of all specifications are reported in Table 4. A Generalized Least Squares routine (which includes a not reported constant term, TouristDest, and MarketDistance) is used to estimate the coefficients and standard errors in the second stage.

Table 5.B: Hub Premia and Barriers to Entry

Variable	Dependent Variable: Route-Carrier FE Log(Median Fare) Coefficient (Std. Error)	Dependent Variable: Route-Carrier FE Log(25th Pct Fare) Coefficient (Std. Error)	Dependent Variable: Route-Carrier FE Log(75th Pct Fare) Coefficient (Std. Error)	Dependent Variable: Route-Carrier FE Log(Mean Fare) Coefficient (Std. Error)
HubUmbrellaOrigin	0.028*** (0.008)	0.017** (0.007)	0.050*** (0.001)	0.042*** (0.007)
HubUmbrellaDest	0.035*** (0.008)	0.017* (0.007)	0.064*** (0.010)	0.051*** (0.008)
HubCarrierOrigin	0.065*** (0.015)	0.072*** (0.013)	0.054*** (0.018)	0.051*** (0.014)
HubCarrierDest	0.083*** (0.015)	0.076*** (0.013)	0.102*** (0.019)	0.085*** (0.014)
OwnGatesOrigin	0.155*** (0.024)	0.157*** (0.021)	0.127*** (0.030)	0.165*** (0.023)
OwnGatesDest	0.151*** (0.025)	0.143*** (0.022)	0.170*** (0.031)	0.216 *** (0.024)
CompGatesOrigin	-0.035*** (0.015)	-0.051*** (0.013)	-0.044*** (0.019)	-0.016** (0.014)
CompGatesDest	-0.000 (0.016)	-0.041*** (0.013)	0.040 (0.019)	0.038* (0.015)
MIIOrigin	-0.025*** (0.006)	-0.033*** (0.005)	-0.012 (0.007)	-0.020*** (0.006)
MIIDest	-0.010 (0.006)	-0.020*** (0.005)	0.000 (0.007)	-0.005 (0.006)
LimitOrigin	-0.023** (0.012)	-0.022*** (0.010)	-0.030** (0.014)	-0.036*** (0.011)
MaxLimitOrigin	-0.072 (0.070)	-0.041 (0.060)	-0.071 (0.086)	-0.012 (0.066)
LimitDest	-0.013 (0.012)	-0.013 (0.010)	-0.014 (0.014)	-0.024** (0.011)
MaxLimitDest	-0.082 (0.071)	-0.053 (0.061)	-0.133 (0.086)	-0.050 (0.066)
SlotOrigin	0.003 (0.015)	-0.016 (0.013)	0.015 (0.020)	0.017 (0.014)
SlotDest	-0.006 (0.016)	-0.018 (0.014)	0.006 (0.020)	0.007 (0.015)
Number Route-Carrier	5,401	5,401	5,401	5,401
R^2	0.234	0.336	0.172	0.253

Notes: Standard errors in parentheses. The First Stage of all specifications are reported in Table 4. A Generalized Least Squares routine (which includes a not reported constant term, TouristDest, and MarketDistance) is used to estimate the coefficients and standard errors in the second stage.

Table 6: Demand and Supply

Variable	Demand Depend Variable: Log(S_jt-S_0) **Coefficient (Std. Error)**	Pricing Function Dependent Variable: Log(Median Fare) **Coefficient (Std. Error)**
Median Fare	-1.670***	
	(0.074)	
Log(S_jg)	0.348***	
	(0.043)	
NonStop	0.512***	-0.093***
	(0.034)	(0.016)
ExtraMiles	-0.305***	0.403***
	(0.089)	(0.049)
PctOrigin Presence	0.721***	0.052
	(0.073)	(0.066)
PctDestPresence	0.885***	0.396***
	(0.075)	(0.068)
NumOrigin Presence		-0.395***
		(0.066)
NumDestPresence		-0.775***
		(0.067)
Frequency	3.882***	-1.612***
	(0.313)	(0.227)
Missing Frequency	0.112***	-0.056***
	(0.025)	(0.017)
Observations	42309	42309
Route-carriers	5401	5401
		0.729

Notes: The table presents a system of demand and pricing equations. The equations are estimated sequentially: First we estimate the demand parameters and then we estimate the pricing equations, subtracting the demand derived markup from the price and regressing this difference on the cost variables.

Table 7: Fixed Effects Regressions

Variable	Dependent Variable: Pricing Function Route-Carrier Fixed Effects **Coefficient (Std. Error)**	Dependent Variable: Pricing Function Route-Carrier Fixed Effects **Coefficient (Std. Error)**
HubUmbrellaOrigin	0.041*** (0.013)	0.071*** (0.014)
HubUmbrellaDest	0.051*** (0.014)	0.074*** (0.015)
HubCarrierOrigin	0.155*** (0.024)	0.079*** (0.027)
HubCarrierDest	0.205*** (0.024)	0.128*** (0.028)
OwnGatesOrigin		0.237*** (0.043)
OwnGatesDest		0.250 *** (0.045)
CompGatesOrigin		-0.049* (0.028)
CompGatesDest		-0.009 (0.028)
MIIOrigin		-0.044*** (0.011)
MIIDest		-0.021* (0.011)
LimitOrigin		-0.033 (0.021)
MaxLimitOrigin		-0.177 (0.128)
LimitDest		-0.023 (0.021)
MaxLimitDest		-0.173 (0.129)
SlotOrigin		0.032 (0.027)
SlotDest		0.020 (0.028)
Observations	5,241	5,241
R^2	0.139	0.184

Notes: The parameters are estimated regressing the route carrier fixed effects of the pricing equations whose results are reported in the second and fourth columns of Table 6. A Generalized Least Squares routine (which includes a not reported constant term, TouristDest, and MarketDistance) is used to estimate the coefficients and standard errors in the second stage.

Table A.1: Validating Exclusion Restrictions

	Log(S_jt-S_0)	Log(S_jt-S_0)	Log(S_jt-S_0)	Log(S_jt-S_0)	Log(S_jt-S_0)	Log(S_jt-S_0)
Median Fare	-0.321***	-0.317***	-2.430***	-1.172***	-1.737***	-1.670***
	(0.006)	(0.006)	(0.118)	(0.081)	(0.075)	(0.074)
Log(S_jg)	0.718***	0.715***	0.265***	0.243***	0.337***	0.348***
	(0.004)	(0.004)	(0.078)	(0.050)	(0.044)	(0.043)
NonStop	0.277***	0.380***	0.441***	0.489***	0.426***	0.512***
	(0.013)	(0.013)	(0.049)	(0.032)	(0.032)	(0.034)
ExtraMiles	-0.195***	-0.200***	-0.252*	-0.579***	-0.329***	-0.305***
	(0.040)	(0.040)	(0.145)	(0.095)	(0.095)	(0.089)
PctOriginPresence	0.724***	0.663***	0.675***	0.993***	0.767***	0.721***
	(0.030)	(0.029)	(0.116)	(0.077)	(0.075)	(0.073)
PctDestPresence	0.873***	0.809***	0.847***	1.168***	0.936***	0.885***
	(0.030)	(0.030)	(0.120)	(0.080)	(0.078)	(0.075)
Frequency		4.768***				3.882***
		(0.184)				(0.313)
Missing Frequency		0.083***				0.112***
		(0.014)				(0.025)
Constant	-6.332***	-6.536***	-4.712***	-6.558***	-5.478***	-5.701***
	(0.022)	(0.023)	(0.366)	(0.251)	(0.221)	(0.222)
Median Elasticity	-1.094	-1.071	-3.629	-1.709	-2.814	-3.378
Median Percentage Contribution Margin	0.950	0.970	0.279	0.591	0.361	0.299
Observations	42309	42309	42309	42309	42309	42309
Route-carriers	5401	5401	5401	5401	5401	5401
IV: Origin Characteristics	No	No	No	Yes	Yes	Yes
IV: Airline Cost Variables	No	No	Yes	No	Yes	Yes
First Stage Within R2 (Price)			0.027	0.034	0.039	0.039
First Stage Within R2 (Log(S_jg))			0.125	0.134	0.141	0.144

Standard errors in parentheses. Bresnahan IV include …. Airline IV include … Carrier-route fixed effects are included in all specifications.
The analysis in the main body of the paper uses the specifications in the last two columns of this Table.