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 the hub premium in the U.S. airline industry. We use original data from competition plans that airports are required to submit to the U.S. Department of Transportation in compliance with the Aviation Investment and Reform Act for the Twenty-First Century. We collect information on the availability and control of airport gates, leasing arrangements, and other restrictions limiting the expansion of airport facilities. We find that the hub premium is increasing in the ticket fare. We find that control of gates is a crucial determinant of this premium. Limits on the fees that airlines can charge for subleasing their gates lower the prices charged by airlines. Finally, control of gates and restrictions on sublease fees explain high fares only when there is a scarcity of gates relative to the number of departures from an airport.

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 out of airports where major airlines have their hubs and the fares charged for trips that are similar but do not originate from or end in a hub.

We focus on the role of operating practices limiting access to airport facilities

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that Borenstein (1989) and the Government Accounting Office (GAO) (1989, 1990) identify as a set of potential barriers to entry in the airline industry and that could explain the hub premium and, more generally, high airline fares.[1] Such operating practices are quite simple to describe. Airlines need ticket counters, baggage check-in rooms, baggage claim areas, and, most important, enplaning/deplaning gates to provide service at an airport. However, access to these airport facilities is typically regulated by long-term exclusive contracts between airlines and airports. Thus, new entrants typically can gain access to an airport only by paying sublease fees.[2] These institutional barriers to entry should be associated with higher prices, particularly at airports where gates are a scarce resource, such as airports where the number of departures is very large relative to the number of gates available.

We build a unique and original data set to measure the importance of operating practices as determinants of the hub premium. The data are from competition plans that airports are required to submit to the U.S. Department of Transportation in compliance with the Wendell H. Ford Aviation Investment and Reform Act for the Twenty-First Century (AIR 21). The act, which was signed into law in April 2000, states that beginning in fiscal year 2001, no federal grant would be made to fund any one of a set of major 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 subleasing arrangements, gate use requirements, gate assignment policies, and whether the airport intends to build or acquire gates that would be used as common facilities (106th Cong., 2nd Sess., sec. 155.f[1–2]).

We estimate a linear specification of the (reduced-form) pricing equation. To control for the significant number of unobserved factors affecting consumers' decisions to fly and the costs of offering service on any particular route, we 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 effect of time-invariant barriers to entry on equilibrium pricing decisions using the minimum distance procedure of Chamberlain (1982).

We report three main findings. First, the hub premium is increasing in the ticket fare. The hub premium is lower than 10 percent at the 10th percentile of the fare distribution and almost as high as 25 percent at its 90th percentile.

Second, we find that the hub premium is reduced by almost one-half if we include our measures of barriers to entry in the empirical analysis. We show that the control of gates leased on an exclusive basis by an airline is a crucial

[1] See Carlton (2004), Schmalensee (2004), and McAfee, Mialon, and Williams (2004) for a debate on the economics of barriers to entry. The institutional barriers to entry that we examine in this paper are the result of explicit contractual agreements that limit potential competitors' access to the necessary airport facilities to offer service.

[2] Borenstein (1989) and Government Accounting Office (1989, 1990) also identify marketing practices that might explain higher fares. Incumbent airlines use frequent-flyer programs and volume incentives for travel agents to build a loyal customer base, which makes entry by new carriers more difficult. Direct data on these practices remain unavailable.

determinant of the hub premium. In particular, if the percentage of gates controlled by the carrier increases from 10 to 30 percent, fare prices increase by 3 percent. Other variables that are associated with high premia are those that record the presence of restrictions on the fees that airlines can charge for subleasing their gates. Prices are 2 percent lower when limits on sublease fees are in place.

Finally, we construct a new measure of congestion, which is defined here as the ratio of the total number of quarterly departures from an airport to the number of gates at an airport. We show that the interaction of this new variable with the measures of barriers to entry plays a crucial role in explaining the hub premium. At an airport where there are approximately 600 departures per gate in a quarter (for example, Atlanta), a 30 percent difference in the gates leased would lead to a difference of 6 percent in fare prices. At an airport where there are approximately 200 departures per gate (for example, Nashville), a 30 percent difference would lead to a 2 percent difference in prices. Similarly, we show that at an airport where there are approximately 600 departures per gate, the presence of a limit on the sublease fees lowers the premium by approximately 11 percent but decreases it by only 2 percent at airports with 120 departures per gate. Thus, exclusive control of gates explains high fares only when there is a scarcity of gates relative to the number of departures at an airport. This finding suggests that efforts to improve access to gates should be concentrated on those major airports that are most congested (that is, airports that have a large number of departures relative to the number of boarding gates).

These results are novel and important because they show a direct, clear relationship between limited access to airport facilities and hub premia. Previous works could provide only indirect evidence of the relationship between limited access to airport facilities and hub premia. For example, Borenstein (1989) proxied limited access to airport facilities with a measure of an airline's airport dominance, the percentage of passengers flying on one airline at an airport. Borenstein showed that airlines' fares were positively correlated with the airline's share of passengers on the route and at the endpoint airports.[3] Clearly, the main limitation of using indirect evidence is that the proxy might capture only part of the effect of limited access to gates on hub premia. We show that this is the case: once we control for route-carrier fixed effects, the percentage of passengers flying on one airline at an airport does not pick up any of the effect of limited access to airport facilities on hub premia.

We provide a description of the data that we collected from the airports' competition plans in Section 2. The fare and passenger data are described in

[3] Evans and Kessides (1993) add market and, separately, firm fixed effects and confirm Borenstein's finding (1989) that airport dominance by a carrier is correlated with higher fares; however, they 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 exactly what we confirm in this paper.

Section 3. Our econometric specification is discussed in Section 4. We then provide a detailed description of the results in Section 5. Section 6 concludes.

2. Limited Access to Airport Facilities

2.1. The Aviation Investment and Reform Act for the Twenty-First Century

In response to governmental, public, and academic concern about the existence of institutional barriers to entry in the airline industry, President Bill Clinton signed AIR 21 into law on April 5, 2000. The act identified a set of major airports that, on a reasonable basis, had to be available to all carriers wishing to serve them. The set of airports identified by AIR 21 were commercial service airports that had more than .25 percent of the total number of passenger boardings each year in the United States and had one or two air carriers that controlled more than 50 percent of the passenger boardings.[4]

As a result of AIR 21, all of these airports compiled competition plans. We were able to collect the competition plans and construct a cross section of data for which the unit of observation is the airport. From these plans, we gathered information on the availability of airport gates, leasing and subleasing arrangements of gates and other airport facilities, and agreements between airlines and airports.[5]

There is one potential limitation of the data that we collected. We have only one observation for each airport, and the observation is for 1 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 Government Accountability Office (GAO 1990) reports 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.[6] It is also worth noting that airlines cannot terminate leases unilaterally. For example, in the case of Dallas Love Field airport, American Airlines sought termination of the gate lease agree-

[4] These airports consist of large and medium hubs at which one or two airlines board more than 50 percent of the passengers. See Section A2.

[5] Washington National, New York's LaGuardia, and Dallas Love Field (the main hub of Southwest) have perimeter rules that limit long-haul flights to and from these airports. For example, nonstop flights from Phoenix to Washington National and LaGuardia were prohibited until 2004. Because in this paper we do not distinguish nonstop service and connecting service as different products, we do not include perimeter rules in the analysis. Washington National, Chicago O'Hare, and New York's LaGuardia and Kennedy have slot controls to reduce congestion by limiting the number of takeoffs and landings per hour. However, we have only the competition plans for Washington Reagan and O'Hare, and including route-carrier fixed effects practically rules out the use of variables measuring the effects of slot restrictions.

[6] For example, in the competition plan submitted in 2000 by the Philadelphia International Airport, we read that the lease agreements were signed in 1974 and expire in 2006. In the competition plan submitted in 2000 by Hartsfield-Jackson Atlanta International Aiirport, we read that exclusive-use leases for gates and other facilities expire on September 20, 2010.

ments with the airport. American no longer used the gates but was obligated to continue paying $335,000 per year.[7] The Dallas Love Field airport declined to terminate the lease agreement, and American will have to pay until 2011, when the lease expires.[8]

2.2. 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 GAO (1990) reports 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-use basis, and 3 percent were leased on a preferential-use basis in 1996 (Transportation Research Board 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 1–3 months before losing the right to the gates, which is unlikely to occur (GAO 1990).

Among the information included in the competition plans is airports' reports of the total number of gates available, the number of gates for common use (leased on neither an exclusive nor preferential basis), and the number of gates leased to each airline on an exclusive or preferential basis. We construct three variables to code this information. First, we define $\text{OwnGatesOrigin}_{jr}$ 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 end points of route r. We construct $\text{OwnGatesOrigin}_{jr}$ and OwnGatesDest_{jr} for the following airlines: American, Continental, Delta, Northwest, United, US Airways, and America West. We do not make a distinction between exclusive and preferential leases because even in this second framework, airlines can maintain 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 $\text{NumberGatesOrigin}_{jr}$ and $\text{NumberGatesDest}_{jr}$, which measure the total number of gates located at the origin and destination endpoints, respectively, of route r.

2.3. 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 Air-

[7] Letter from Kenneth W. Gwyn, Director of Aviation, City of Dallas, to Catherine M. Lang, Deputy Director of Airport Planning and Programming, Federal Aviation Administration, June 30, 2003.

[8] Letter from Kenneth W. Gwyn, Director of Aviation, City of Dallas, to Catherine M. Lang, Deputy Director of Airport Planning and Programming, Federal Aviation Administration, February 28, 2005.

Table 1

Measurement of Limited Access to Airport Facilities

Variable	Description	Mean	SD	Min	Max
OwnGates	Fraction of gates leased to an airline on an exclusive or preferential basis	.14	.20	0	.79
Limit	Binary variable indicating whether there is a limit on sublease fees	.50	.50	0	1
MaxLimit	Magnitude (%) of the maximum sublease fee conditional on the presence of a limit	.15	.06	0	.25
MII	Majority-in-interest agreement	.69	.46	0	1
NumberGates	Number of gates available at an airport (100s)	.75	.44	0	1.72

Note. The fraction of gates leased to an airline is computed as the ratio of the number of gates leased with exclusive or preferential use to an airline to the total number of gates at an airport. Summary statistics use the origin airport. $N = 42{,}269$.

lines, America West, and other airlines report 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 LimitOrigin_r and LimitDest_r as categorical variables that are equal to one, if, respectively, the origin or destination airport has set a maximum limit on sublease fees. 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 the prices should be in markets originating from and ending at that airport. Table 1 shows that the average maximum limit is 25 percent.[9]

2.4. Majority-in-Interest Agreements

Some airports (for example, Dallas/Fort Worth [DFW]) share the rights to decide on expansion projects with the airline controlling the majority of their operations (which at DFW is American). Airports and airlines sign majority-in-interest (MII) agreements for this purpose. Airports are willing to sign these agreements because they can get lower interest rates on their debt issues. Airlines are willing to sign MIIs 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 these agreements is that

[9] A negative correlation between the presence of a limit and fares assumes that incumbent carriers are willing to lease gates to competitors. If the maximum limit is set too low, a firm may choose to allow a gate to sit vacant rather than lease it to an entrant who will introduce an additional source of competition.

the carriers put themselves at risk because they bear some of the costs of the airport's facilities.

The airport competition plans report whether the airport has an MII agreement with airlines that serve the airport. However, the competition plans typically are quite vague in terms of the 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. Airline Data

Our empirical analysis relies on data from three publicly available sources other than the competition plans.[10] As with previous studies of the industry, a significant portion of our data comes from the Airline Origin and Destination Survey (DB1B). The DB1B is a 10 percent sample of tickets from all reporting carriers and includes information on the origin, destination, and fare paid as well as details regarding any connections an individual makes en route to his or her final destination.

In addition to the DB1B, we use information from the T-100 Domestic Segment data set, which provides details on each carrier's nonstop flights between two particular airports. The data are reported monthly and include information on the carrier, origin, destination, aircraft type, service class for transported passengers, freight and mail, available capacity (number of seats), scheduled departures, departures performed, aircraft hours, and load factor.

The remainder of the data are taken from the Schedule P-12 database, which reports quarterly profit and loss statements for carriers with annual operating revenues of $20 million or more. This database includes quarterly operating revenues and expenses, depreciation and amortization, operating profit, income tax, and net income.

3.1. Market

A market is defined as a unidirectional trip between two airports, regardless of the number of stops that the traveler had to make in between (see Peters 2006). This definition permits us to analyze whether the hub premium is different on routes to and from the hub. The data set includes all markets between airports identified by AIR 21 as the set of major airports that had to be available to all carriers on a reasonable basis. There are 1,375 unidirectional (airport-to-airport) routes.

3.2. Carrier

There were nine national carriers between 2002 and 2004: American, Continental, Delta, America West, Northwest, United, US Airways, and Southwest.

[10] A more detailed description of the data is provided in the Appendix.

In addition, 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 to avoid dropping small carriers that are present in few markets and to use a meaningful grouping while capturing the effect of their presence in the market.

3.3. Itinerary Fare

The DB1B is a 10 percent sample of tickets sold by airlines in a quarter. This data set does not provide information on either the date when the ticket was sold or used or the characteristics of the buyer. However, the DB1B does provide information on the characteristics of the trip, such as details of connections made by the passenger and whether the ticket is for round-trip travel. We summarize the airline pricing behavior using the mean, median, and the 25th, 75th, and 90th percentiles. By doing so, we use some information on the distribution of prices available from the DB1B data set while using as few statistics as possible.[12]

Table 2 presents summary statistics for the five 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) and the median ($121.9) is twice as large as the difference between the median and the 25th percentile of the fares ($97.1), which suggests that there is much more dispersion at the top of the distribution than at the bottom. This is confirmed by the average ticket fare, which is equal to $140.9, almost 1 standard deviation above the median.

3.4. Hub Categorical Variables

The classification of airports as hubs is to some extent arbitrary because it requires a threshold for 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." (See Table 3 for airports that we define as hubs. All airports shown were hubs during the period under study.)

We define $\text{HubUmbrellaOrigin}_{jr}$ to be equal to one if the origin airport is a hub of any of the national carriers. We define $\text{HubUmbrellaDest}_{jr}$ similarly, using the destination airport. Then, we define $\text{HubCarrierOrigin}_{jr}$ to be equal to one whenever the observation is for carrier *j* out of an airport where carrier *j* is the hub airline. Thus, $\text{HubUmbrellaOrigin}_{jr}$ is equal to one whenever Hub-CarrierOrigin_{r} is equal to one, but not vice versa. We define $\text{HubCarrierDest}_{jr}$ similarly. These four categorical variables play a critical role in our analysis

[12] See Armantier and Richard (2008) for an interesting way to use information from the distribution of prices.

Table 2
Summary Statistics

Variable	Description	Mean	SD	Min	Max
Ticket fares ($100):					
Median	Median of the fares charged by an airline in a quarter in each market	1.22	.33	.44	2.36
25th percentile	25th percentile of the fares charged by an airline in a quarter in each market	.97	.23	.42	2.16
75th percentile	75th percentile of the fares charged by an airline in a quarter in each market	1.67	.52	.44	5.25
90th percentile	90th percentile of the fares charged by an airline in a quarter in each market	2.24	.52	.44	7.35
Average	Average of the fares charged by an airline in a quarter in each market	1.41	.34	.45	3.35
Hub dummies:					
HubOrigin	Binary variable equal to one if the origin airport is a hub of any of the national carriers	.42	.49	0	1
HubCarrier	Binary variable equal to one whenever the observation is for a carrier in a market out of an airport where the carrier is a hub airline	.13	.34	0	1
Congestion measures:					
Congested	Ratio of the total number of departures in a given quarter to the total number of boarding gates (100s)	.50	.16	.13	1.07
CongestedDummy	Binary variable equal to one if Congested is larger than its 75th percentile value (550)	.34	.47	0	1
PotentialWN	Binary variable equal to one if Southwest is present at both the endpoints of a market	.35	.48	0	1
Firm specific:					
PctOriginMarkets	Network extent at the airport: percentage of markets by one airline out of the total number of markets served out of that airport by any airline	.44	.23	.01	1
NonStop	Binary variable equal to one for tickets for nonstop flight	.37	.48	0	1
Frequency	Average daily frequency (100s)	.04	.02	0	.28
Missing frequency	Percentage for which data on frequency are missing	.05	.14	0	.28
ExtraMiles	Ratio of distance flown by an airline to nonstop distance	.09	.14	0	1.60
Accounting cost	Average cost per seat-mile (ASM cost, cents) × flown miles (100s)	.87	.81	0	4.06
Market specific:					
Tourist destination	Binary variable equal to one if destination airport is in California, Florida, or Nevada	.22	.41	0	1
Market distance	Nonstop distance (1,000 miles)	1.21	.59	.10	2.68

Note. Summary statistics use the origin airport. The fares and cost data are in 1993 dollars. Details on the construction of NonStop and Frequency are provided in the Appendix. $N = 42{,}269$.

Table 3
Control of Gates at Hubs and Other Large Airports

Airport	Carrier	HubCarrier	OwnGates (%)	Limit	MaxLimit (%)
St. Louis	American	1	.22	1	.15
Washington Reagan	US Airways	0	.32	0	
Chicago O'Hare	American	1	.35	0	
Chicago O'Hare	United	1	.35	0	
San Jose, Calif.	American	0	.36	0	
Cincinnati	Delta	1	.42	0	
Charlotte, N.C.	US Airways	1	.43	1	.15
Atlanta	Delta	1	.55	1	0
Philadelphia	US Airways	1	.50	0	
Phoenix	America West	1	.40	1	.15
Baltimore	US Airways	0	.52	0	
Newark, N.J.	Continental	1	.58	0	
Denver	United	1	.60	0	
Cleveland	Continental	1	.60	1	.1
Detroit	Northwest	1	.68	1	.15
Dallas/Fort Worth	American	1	.64	0	
Salt Lake City	Delta	0	.67	0	
Minneapolis	Northwest	1	.72	1	.15
Houston (IAH)	Continental	1	.75	0	

Note. Airports shown are either the hubs of a legacy carrier or airports where one carrier controls more than 30 percent of the gates. OwnGates denotes the percentage of gates leased to the airline with the largest share at an airport (for example, American Airlines at St. Louis). Limit is a categorical variable equal to one if the airport has a limit on sublease fees. If the airport has a limit, then MaxLimit reports its magnitude.

because their interpretation is related to the debate on the hub premium in a very simple fashion.

First, these four hub variables measure whether prices and markups are still higher in hub markets, after we control for various determinants of prices—most important, 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 with tickets for markets into the same airport. The difference for tickets on markets out of the hub and tickets on markets into the hub is the difference between the sum of the coefficients of $\text{HubUmbrellaOrigin}_r$ and $\text{HubCarrierOrigin}_{jr}$ and the sum of the coefficients of HubUmbrellaDest_r and $\text{HubCarrierDest}_{jr}$. Finally, the coefficient estimates of $\text{HubUmbrellaOrigin}_r$ 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 $\text{HubUmbrellaOrigin}_r$ 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 for which we are looking. Limits on sublease fees are presented. For example, in Charlotte, N.C., US Airways can sublease the gates for which US Airways has preferential or exclusive use, but it cannot charge a sublease fee that is more than 15 percent higher than the fee that US Airways pays to the airport. In Denver, United can charge any sublease fee, since the airport has not set a limit. In the empirical analysis, we 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.

3.5. Control Variables

One crucial issue is whether airlines charge a premium at hubs because they provide a better, differentiated product than do 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 Berry (1990, 1992), Brueckner, Dyer, and Spiller (1992), and Ciliberto and Tamer (2009). 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 its other services at the airport (the number of ticket counters, customer service desks, and the like).[13] We define PctDestMarkets$_{jrt}$ similarly.[14]

Airlines also differentiate their product by whether they provide nonstop or connecting service. The variable NonStop$_{jrt}$ is equal to one 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, ExtraMiles$_{jrt}$, which is equal to the ratio of the distance flown to the nonstop distance in miles between two airports minus one.[16] Thus, a nonstop flight will be associated with a value of ExtraMiles$_{jrt}$ equal to zero, whereas connecting flights will be associated with values larger than zero. The larger the number of extra miles that a passenger must travel between two airports, the less attractive it is to travel on a connecting trip than on a nonstop trip. Airlines also serve markets with different flights in a day, or frequency.[17] 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 by an airline per day in a quarter.[18] Finally, we also include MarketDistance$_r$, the nonstop distance in miles between two airports, and

[13] Bamberger and Carlton (2002) discuss at length why fares should be positively correlated to variables of this type of hubbing activity at an airport.

[14] In a previous version of the paper, we also included the number of markets served out of an airport by a carrier. However, this measure is highly correlated (>.95) with PctOriginMarkets, which we defined in Table 2. So we decided to keep PctOriginMarkets, which is more naturally associated with the idea of frequent-flyer benefits.

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

[16] The distance flown varies across itineraries, because an airline may offer a number of alternative routings within an airport-pair. We use a passenger-weighted average across itineraries.

[17] For more details on the construction of Frequency, see the Appendix.

[18] In 4 percent of the observations, Frequency$_{jrt}$ is missing, and in those cases, it is set to zero and the related variable MissingFrequency$_{jrt}$ is set equal to one; otherwise, MissingFrequency$_{jrt}$ is equal to zero. We performed the analysis with and without Frequency$_{jrt}$, and the results are similar. We do not report the results for MissingFrequency$_{jrt}$ for sake of brevity.

TouristDest_r, a dummy variable equal to one if the route has an end point in Florida or California as additional market-specific controls.

Institutional characteristics of the airline industry ensure that NonStop_{jrt}, ExtraMiles_{jrt}, and Frequency_{jrt} are determined before the airlines' choice of prices. This is because prices can be changed at any time by an airline, whereas none of these variables can be changed in the same short period. Flight schedules, which involve crew scheduling and aircraft assignments, are developed a year before departure and are updated every 3 months (see Ramdas and Williams [2009] and the references therein). We maintain that these five variables are exogenous in the empirical analysis to follow.

As far as costs are concerned, it is reasonable to think that the economic marginal cost of transporting one passenger is a function of the average cost per seat-mile, which is the average operating accounting cost to carry one passenger for 1 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) to the quarterly total of the product of the number of seats transported and the number of miles flown by the airline. Data on the total number of seats and the total number of miles flown are obtained from the Air Carrier Statistics (Form 41 Traffic). The mean of the average cost per seat-mile is approximately 9 cents 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 we call this variable AsmCost_{jrt}.

3.6. Congested Airports

We expect that the control of gates is important when gates are a scarce resource, which is more likely to be the case at congested airports. An important concern is that if an airline leases a large share of gates at an airport, it may reflect the existence of entry barriers, but it may also reflect the efficiencies associated with hub operations or the outcome of a dynamic game in which airlines differentiate themselves by developing their services in different locations. Because we have information on the total number of gates at an airport, we now show how to infer the importance of gate scarcity as a barrier to entry.

We study the interaction of the information on gate leases with measures of airport capacity constraints. In particular, we use our new data set to define a measure of congestion, $\text{CongestedOrigin}_{rt}$, that is equal to the ratio of the total number of departures from an airport in a given quarter to the total number of boarding gates. We divide this ratio by 1,000 to simplify the interpretation of the estimation results. Table 2 shows that, on average, there are 350 departures per gate in a quarter. The minimum is 130 departures, and the maximum is 1,007 departures.

To construct $\text{CongestedOrigin}_{rt}$, we use data from the T-100 Domestic Segment data set to obtain information on the total number of carrier-specific departures from an airport each quarter. We aggregate over carriers and months and divide this aggregate measure of departures by the total number of boarding gates at each airport. We define $\text{CongestedDest}_{rt}$ similarly. In our analysis, we include $\text{CongestedOrigin}_{rt}$ and $\text{CongestedDest}_{rt}$ to control for any price differences that are related to a change in the extent to which an airport is congested.

3.7. Potential Competition of Southwest

Another context in which the control of gates is important should be at those airports where Southwest is not yet present. At these airports, controlling large enough shares of gates may allow the incumbents to prevent Southwest's entry. We construct a variable, WNatAirport_{rt}, that is equal to one if Southwest is present at both end points of a market. We conjecture that the control of facilities is less valuable at an airport where Southwest is already present than at an airport where Southwest is not yet active. For 35 percent of the markets that are included in our sample, Southwest is present at both the endpoints of the market.

4. Econometric Model

Because we use route-carrier fixed effects, each of the specifications that we run consists of two main steps. First, we run the specifications with route-carrier fixed effects, and then we run the estimated fixed effects on variables for the hub and barriers to entry, which do not change over time.[20]

We estimate the following linear specification of the (reduced-form) pricing equation, where r denotes a route and t denotes a year-quarter:

$$\text{Log}(\text{itinfare}_{jrt}) = \boldsymbol{W}_{jrt}\pi + u_{jr} + u_{jrt}. \tag{1}$$

Here, $\boldsymbol{W}_{jrt}$ are control variables (see Table 2), u_{jr} is a route-carrier fixed effect, and u_{jrt} is an idiosyncratic error.

To recover estimates of the hub premia and the effect of barriers to entry on equilibrium prices, we follow Nevo's (2001) application of the minimum distance methodology of Chamberlin (1992). This entails performing a generalized least squares regression of the estimated fixed effects $\hat{u}_{jr}$ on $\text{HubUmbrellaOrigin}_r$, HubUmbrellaDest_r, $\text{HubCarrierOrigin}_{jr}$, $\text{HubCarrierDest}_{jr}$, and the variables that measure limited access to airports, $\text{BarriersOrigin}_{jr}$ and BarriersDest_{jr}, such that

$$\hat{\gamma} = (Z'_{jr}V_u^{-1}Z_{jr})^{-1}\, Z'_{jr}V_u^{-1}\hat{u}_{jr}, \tag{2}$$

where V_u is the variance-covariance matrix of the estimated fixed effects $\hat{u}_{jr}$.

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 BarriersOrigin_r and

[20] Berry (1990), Berry, Carnal, and Spiller (2007), and Brueckner and Spiller (1984) estimate a structural model of demand and supply to control for product differentiation and economies of density. Here we take a reduced-form approach, given the focus of our paper on the effect of limited access to airport facilities on equilibrium prices.

BarriersDest_r vectors are intended to capture the effect that concentrated rights to gates, MII agreements, slot controls, and limits on subleasing fees have on firms' pricing decisions at these airports.

In some of our specifications, we also include the interaction terms of the BarriersOrigin_m and BarriersDest_m vectors with $\text{CongestedOrigin}_{rt}$, $\text{CongestedDest}_{rt}$, and WNatAirport_{rt}.

5. Results

5.1. Unconditional Hub Premium

We start our analysis by estimating the unconditional hub premium. This is a necessary first step because the exact magnitude of the correlation between prices and airport dominance is still debated. We use a constructive approach and show how the hub premium changes as we introduce variables that measure the degree to which airline products are differentiated and the extent to which access to airport facilities is limited.

Table 4 presents the first set of results for regression (2). Notice that we do not report the results from the corresponding first-stage regression (1), since we do not include any variables that vary over time and carrier. This set of results provides a useful starting point for our analysis because it illustrates how important it is to control for characteristics that differentiate the products among airlines.

Table 4 presents the results when the dependent variable is the median itinerary fare. The coefficients of $\text{HubUmbrellaOrigin}_r$ and HubUmbrellaDest_r measure whether all carriers are able to charge a premium in hub markets. The coefficients of $\text{HubCarrierOrigin}_{jr}$ and $\text{HubCarrierDest}_{jr}$ measures whether the hub carrier charges an extra premium in hub markets (for example, whether American charges in markets originating from or ending at Dallas/Fort Worth). The main result is that the premium charged by the hub carrier exists but is not of significant economic magnitude. In particular, it is equal to 6 (−.03 + .09) percent for tickets out of a hub as well as for tickets into a hub. There is no evidence of umbrella effects, since the coefficients for $\text{HubUmbrellaOrigin}_r$ and HubUmbrellaDest_r are negative.

The results in Table 4 suggest that the hub premium is increasing along the fare distribution. In particular, at the 75th percentile of the distribution, the premium charged by the hub carrier is equal to 10.5 percent.[21] At the 90th percentile of the distribution, the premium is equal to 17 percent. Thus, the premium is increasing as the dependent variable changes from the 25th percentile to the median and then to the 90th percentile of the fare distribution. The differences in the estimated coefficients in columns 1–4 suggest that the differ-

[21] When discussing the meaning of the coefficients in the tables, we use the correction introduced by Halvorsen and Palmquist (1980). Our correction takes into account the comment by Kennedy (1981).

Table 4
Unconditional Hub Premia

	50th% Fare (1)	25th% Fare (2)	75th% Fare (3)	90th% Fare (4)	Mean Fare (5)
Hub dummies:					
HubUmbrellaOrigin	−.03** (.01)	−.03** (.01)	−.02** (.01)	.02** (.01)	−.01 (.01)
HubUmbrellaDest	−.02** (.01)	−.03** (.01)	.00 (.01)	.03** (.01)	.00 (.01)
HubCarrierOrigin	.09** (.01)	.07** (.01)	.12** (.01)	.14** (.01)	.11** (.01)
HubCarrierDest	.08** (.01)	.06** (.01)	.14** (.01)	.21** (.01)	.14** (.01)
Controls:					
Tourist	−.05** (.01)	−.05** (.01)	−.07** (.01)	−.08** (.01)	−.06** (.01)
Distance	.15** (.01)	.18** (.00)	.13** (.01)	.17** (.01)	.16** (.00)
Constant	4.60** (.01)	4.34** (.01)	4.89** (.01)	5.09** (.01)	4.71** (.01)
R^2	.15	.26	.12	.17	.2

Note. N = 42,269.
** $p < .01$.

ences among mean and median ticket fares are important. Not surprisingly, the results are not identical when we use means or medians of the ticket fares. The premia are 11.6 percent (market out of a hub) and 15 percent (markets into a hub) when we use means.

We reach two main conclusions from Table 4. First, results based on the use of average fares must be interpreted with care because the distribution of market fares is not symmetric around the mean. This is particularly true in hub markets. For this reason, we perform the rest of the analysis using the 25th percentile, the median, the 75th percentile, and the 90th 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).[22] 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 larger for higher fares, but we cannot say anything about the fare mix composition.

5.2. Control Variables

We now include additional controls for product differentiation and costs (for example, economies of density). The results for regression (1) are presented in Table 5.

The results for the control variables should be interpreted with caution because they represent the net effect of the variables on the demand and supply. Overall, nonstop flights are associated with lower prices, which is related to the fact that

[22] 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 Department of Transportation's Data Bank 1A (DB1A), Morrison and Winston show that the premia are significantly lower—by approximately 5 percent—after controlling for traffic mix and frequent-flyer tickets. We discuss some limitations of the fare mix data in the DB1A data set in the Appendix.

Table 5
First-Stage Regressions

	50th% Fare (1)	25th% Fare (2)	75th% Fare (3)	90th% Fare (4)	Mean Fare (5)
Variable:					
NonStop	−.37** (.07)	−.43** (.05)	−.28** (.06)	−.31** (.08)	−.44** (.05)
ExtraMiles	.24** (.03)	.23** (.03)	.18** (.03)	.14** (.04)	.18** (.02)
PctOriginMarkets	−.16** (.02)	−.14** (.02)	−.21** (.02)	−.20** (.03)	−.18** (.02)
PctDestMarkets	−.17** (.02)	−.14** (.02)	−.21** (.02)	−.19** (.03)	−.17** (.02)
Frequency	−.76** (.15)	−.56** (.11)	−.76** (.13)	−.94** (.16)	−.91** (.11)
AsmCost	−.05** (.01)	−.06** (.01)	−.03** (.01)	−.04** (.01)	−.06** (.01)
Adjusted R^2	.664	.693	.673	.683	.745

Note. $N = 42{,}269$.
** $p < .01$.

they imply lower costs. Longer connecting flights, captured by a higher value of ExtraMiles, are charged at a higher price than are shorter ones. A larger number of markets served by an airline out of an airport is associated with lower prices. Notice that this is easily explained by the presence of economies of density. Higher frequency is associated with lower prices, and again this is easily explained by the presence of economies of density. Finally, the coefficient of the unit cost, AsmCost_{jrt}, is negative, which suggests that the effect of the average operating cost per seat-mile is decreasing as the flown distance increases.[23]

5.3. The Hub Premium

Table 6 presents the results for the regression after we have estimated the first stage, as discussed in Section 5.2. Notice that we do not yet include barriers to entry.

The main result is that the premium charged by the hub carrier is now of a more significant economic magnitude. In particular, it is equal to 11.9 percent for tickets out of a hub and 12.7 percent for tickets into a hub. There is only limited evidence of umbrella effects, because the coefficients for $\text{HubUmbrellaOrigin}_r$ and HubUmbrellaDest_r are less than or equal to 1 percent.

Again, the results suggest that the hub premium is still increasing in the ticket fare. In particular, at the 75th percentile of the distribution, the premium charged by the hub carrier is equal to 13.5 percent in markets out of a hub and 17.6 percent in markets into a hub. At the 90th percentile of the distribution, the premium is equal to 16.8 percent in markets out of a hub and 26 percent in markets into a hub.

Figure 1 illustrates the relationship between fares and hub premia in an explicit fashion by plotting the hub premium for each quantile of the fare distribution.

[23] As mentioned earlier, the results for the control variables should be interpreted with caution since we are estimating a reduced-form model. We interpret the finding that a higher average cost is associated with lower prices with the fact that a longer distance flown relative to the nonstop market distance is likely associated with lower demand.

Table 6
Hub Premia

	50th% Fare (1)	25th% Fare (2)	75th% Fare (3)	90th% Fare (4)	Mean Fare (5)
Hub dummies:					
HubUmbrellaOrigin	.00 (.01)	−.01* (.01)	.03** (.01)	.05** (.01)	.02** (.01)
HubUmbrellaDest	.01 (.01)	−.01+ (.01)	.04** (.01)	.06** (.01)	.03** (.01)
HubCarrierOrigin	.11** (.02)	.12** (.01)	.10** (.01)	.11** (.02)	.11** (.01)
HubCarrierDest	.11** (.02)	.11** (.01)	.12** (.01)	.15** (.02)	.13** (.01)
Controls:					
Tourist	−.06** (.01)	−.05** (.01)	−.07** (.01)	−.07** (.01)	−.06** (.01)
Distance	.16** (.01)	.17** (.01)	.09** (.01)	−.04** (.01)	.06** (.01)
Constant	4.75** (.04)	4.44** (.03)	4.72** (.04)	4.24** (.05)	4.37** (.03)
R^2	.15	.26	.16	.29	.30

Note. $N = 42{,}269$.
+ $p < .10$.
* $p < .05$.
** $p < .01$.

To construct the figure, we run the first-stage regression (1) and the second-stage regression (2) for each one of the 10 deciles. As Figure 1 demonstrates, the premium charged by a hub carrier increases by more than 60 percent from the 10th percentile to the 90th percentile of the fare distribution for both markets into and out of hubs. Figure 1 also shows that the umbrella effect is of significance only at the very high end of the fare distribution.

The main conclusion from Table 6 is that the hub premia are larger once we include variables that differentiate products across airlines and are associated with economies of density.

5.4. The Hub Premium and Institutional Barriers to Entry

Table 7 shows the results when we add the barriers to entry in regression (2). The hub premium is now significantly smaller. The premium charged by the hub carrier is now approximately 6 percent, down from 12 percent for tickets out of a hub. We find that the premium for tickets into a hub is now 9.3 percent, down from 12.7 percent. The results are stronger when we look at the 75th and 90th percentile of the fare distribution. Overall, the hub premium is reduced by almost one-half if we include the barriers to entry.

One variable, among those measuring the barriers to entry, plays a particularly important role: the gates leased on an exclusive basis by an airline. We estimate the coefficient of $\text{OwnGatesOrigin}_{jr}$ to be equal to .163 and the coefficient of OwnGatesDest_{jr} to be equal to .144. This means that if the percentage of gates controlled by the carrier increases from 10 to 30 percent, the prices increase by 3 percent ($.20 \times -.163$).

Next, we consider LimitOrigin_r and LimitDest_r. Recall that these variables record the presence of restrictions on the fees that airlines can charge for subleasing their gates. As we would expect, the presence of restrictions on sublease

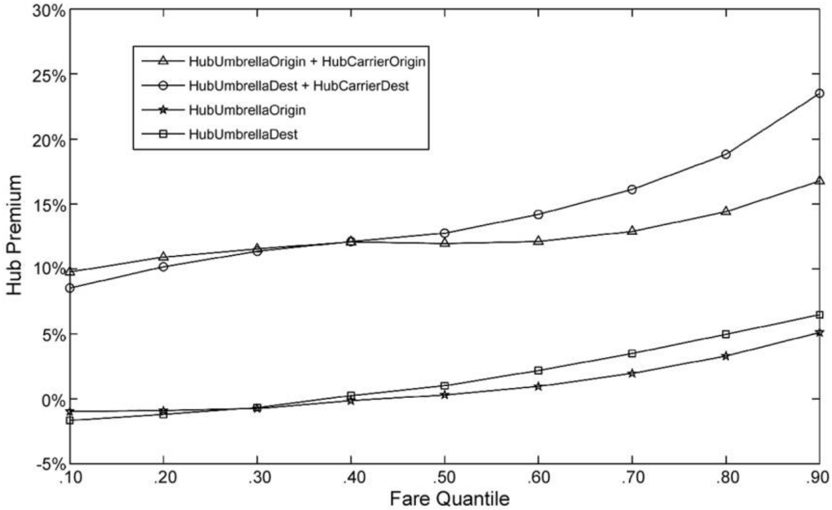

Figure 1. Distribution of the hub premium by ticket fare

fees decreases the premium that airlines can charge. For example, the coefficient of LimitOrigin_r is equal to −.02 when we look at the effects on median prices. This means that prices are 2 percent lower when limits on sublease fees are in place. Notice that the effect is equal to −6.2 percent when we consider the 90th percentile.

The coefficients of the other variables are estimated with considerable noise. The presence of limits on sublease fees is associated with an actual percentage limit. We do not find strong and consistent results for MaxLimitOrigin_r and MaxLimitDest_r, which suggests that the actual percentage limit (15 or 25 percent) is not as important as the presence of a limit. Airports that have MII agreements seem to have lower fares at the bottom of the fare distribution, but not at the 75th and 90th percentiles.

Finally, the coefficients of the number of gates also vary along the fare distribution because we find them to be negative at the bottom and positive at the top. This suggests that control of gates might be particularly important to serve business travelers, possibly because having a larger fraction of gates is associated with more flexible departure times.

Overall, Table 7 shows that access to gates is a crucial determinant of the hub premium in the airline industry. First, the higher the percentage of gates controlled at an airport, the higher the prices that airlines are able to charge. Second, the presence of a limit on sublease fees seems to play an important role in reducing the hub premium. There is only mixed evidence for the other institutional barriers to entry.

Table 7
Hub Premia with Gates

	50th% Fare (1)		25th% Fare (2)		75th% Fare (3)		90th% Fare (4)	
Hub dummies:								
HubUmbrellaOrigin	.01	(.01)	.01	(.01)	.02*	(.01)	.04**	(.01)
HubUmbrellaDest	.02**	(.01)	.01$^+$	(.01)	.05**	(.01)	.07**	(.01)
HubCarrierOrigin	.06**	(.02)	.07**	(.01)	.05**	(.02)	.04*	(.02)
HubCarrierDest	.07**	(.02)	.07**	(.01)	.07**	(.02)	.06**	(.02)
Barriers:								
OwnGatesOrigin	.16**	(.02)	.16**	(.02)	.15**	(.03)	.19**	(.03)
OwnGatesDest	.14**	(.03)	.14**	(.02)	.15**	(.03)	.27**	(.03)
LimitOrigin	−.02$^+$	(.01)	−.02$^+$	(.01)	−.03*	(.01)	−.06**	(.01)
MaxLimitOrigin	−.04	(.08)	−.06	(.06)	.01	(.09)	.19*	(.09)
LimitDest	−.01	(.01)	−.00	(.01)	−.02	(.01)	−.05**	(.02)
MaxLimitDest	−.07	(.08)	−.11$^+$	(.07)	−.08	(.09)	.09	(.10)
MiiOrigin	−.03**	(.01)	−.04**	(.01)	−.01*	(.01)	−.01	(.01)
MiiDest	−.01$^+$	(.01)	−.02**	(.01)	.01	(.01)	.01*	(.01)
NumberGatesOrigin	.01	(.01)	−.02*	(.01)	.03**	(.01)	.06**	(.01)
NumberGatesDest	−.01	(.01)	−.03**	(.01)	.00	(.01)	.02$^+$	(.01)
R^2	.20		.29		.18		.32	

Note. All regressions include controls for market distance and tourist market dummies. $N = 42{,}269$.
$^+$ $p < .10$.
* $p < .05$.
** $p < .01$.

5.5. The Hub Premium at Congested Airports

We now consider how the results change when we control for the level of congestion at an airport. In practice, we add a set of interaction terms for CongestedOrigin$_{rt}$ (CongestedDest$_{rt}$) and the variables that measure the availability of gates at airports. The results are presented in Table 8.

First, we find that the hub premium is now smaller than that shown in Table 7. The premium charged by the hub carrier for flights out of the hub is now less than 4 percent, down from 6 percent in Table 7 and 12 percent in Table 6. The hub premium in markets into a hub is now 7.2 percent, down from 12.7 percent in Table 6. Again, the results are stronger when we look at the 75th and 90th percentiles

Next, we consider the interaction terms. We start with OwnGatesOrigin$_{rt}$ × CongestedOrigin$_{rt}$ and OwnGatesDest$_{rt}$ × CongestedDest$_{rt}$. We find their coefficients to be positive and precisely estimated. In particular, the coefficient for OwnGatesOrigin$_{rt}$ × CongestedOrigin$_{rt}$ is equal to .325. Recall that CongestedOrigin$_{rt}$ is defined as the ratio of departures out of an airport to the number of gates at that airport and that we divide it by 1,000. Therefore, a finding of .325 means that at an airport where there are approximately 600 departures per gate (for example, Atlanta), a 30 percent difference in the gates leased would lead to a difference of 6 percent (.30 × .325 × .6) in fare prices. At an airport where there are approximately 200 departures per gate (for example,

Table 8
Hub Premia with Gates and Congestion

	50th% Fare (1)		25th% Fare (2)		75th% Fare (3)		90th% Fare (4)	
Hub Dummies:								
HubUmbrellaOrigin	.00	(.01)	.00	(.01)	.02*	(.01)	.04**	(.01)
HubUmbrellaDest	.03**	(.01)	.01*	(.01)	.04**	(.01)	.06**	(.01)
HubCarrierOrigin	.04**	(.02)	.06**	(.01)	.03+	(.02)	.02	(.02)
HubCarrierDest	.05**	(.02)	.05**	(.01)	.06**	(.02)	.06**	(.06)
Barriers:								
CongestedOrigin × NumberGatesOrigin	.33**	(.10)	.20**	(.08)	.41**	(.12)	.29**	(.12)
CongestedDest × NumberGatesDest	.26**	(.11)	.25**	(.09)	.20+	(.13)	.02	(.13)
OwnGatesOrigin	.01	(.05)	.07*	(.04)	−.04	(.06)	.06	(.06)
OwnGatesDest	.04	(.05)	.04	(.05)	.07	(.07)	.26**	(.07)
CongestedOrigin × LimitOrigin	−.34**	(.09)	−.21**	(.08)	−.38**	(.11)	−.48**	(.11)
CongestedDest × LimitDest	−.26**	(.09)	−.10**	(.07)	−.38**	(.11)	−.62**	(.11)
LimitOrigin	.16**	(.05)	.09*	(.04)	.17**	(.06)	.19**	(.06)
LimitDest	.12**	(.05)	.04	(.04)	.19**	(.06)	.28**	(.06)
CongestedOrigin × MaxLimitOrigin	1.73**	(.48)	1.12**	(.41)	2.07**	(.58)	2.75**	(.59)
CongestedDest × MaxLimitDest	1.76**	(.46)	.77*	(.39)	2.44**	(.55)	3.68**	(.57)
MaxLimitOrigin	−.88**	(.26)	−.54**	(.22)	−1.00**	(.32)	−1.13**	(.33)
MaxLimitDest	−.88**	(.25)	−.37*	(.21)	−1.28**	(.30)	−1.76**	(.31)
CongestedOrigin × MiiOrigin	.21**	(.05)	.26**	(.04)	.21**	(.06)	.35**	(.06)
CongestedDest × MiiDest	.26**	(.05)	.28**	(.04)	.16**	(.06)	.22**	(.06)
MiiOrigin	−.12**	(.02)	−.16**	(.02)	−.11**	(.03)	−.16**	(.03)
MiiDest	−.12**	(.02)	−.15**	(.02)	−.06*	(.03)	−.08**	(.03)
CongestedOrigin	−.17**	(.05)	−.20**	(.04)	−.19**	(.06)	−.30**	(.06)
CongestedDest	−.25**	(.05)	−.26**	(.04)	−.12*	(.06)	−.16**	(.06)
NumberGatesOrigin	.01	(.01)	−.01**	(.01)	.04**	(.01)	.06 **	(.01)
NumberGatesDest	−.01	(.01)	−.03**	(.01)	.2	(.01)	.04**	(.01)
R^2	.21		.34		.19		.33	

Note. All regressions include controls for market distance and tourist market dummies. $N = 42{,}269$.
$^+$ $p < .10$.
* $p < .05$.
** $p < .01$.

Nashville), a 30 percent difference would lead to a difference of 2 percent. Now consider the coefficients for $\text{OwnGatesOrigin}_{rt}$ and OwnGatesDest_{rt}. The results are striking. Controlling a large fraction of gates at airports that are not congested does not lead to higher prices. Hence, the control of gates is a crucial determinant of airline prices and hub premia only when there is a scarcity of gates relative to the number of departures from or into an airport. Interestingly, there does not seem to be a stronger effect at the higher end of the fare distribution: we find the coefficients of the interaction terms to be essentially the same.

Now consider the interactions $\text{LimitOrigin}_{rt} \times \text{CongestedOrigin}_{rt}$ and $\text{LimitDest}_{rt} \times \text{CongestedDest}_{rt}$. Both coefficients are negative and precisely estimated, and they should be interpreted as follows. At an airport where there are approximately 600 departures per gate, the presence of a limit on the sublease fees lowers the premium by approximately 11 percent ($[-.340 + .158] \times .600$). Notice that at the airports with the smallest value of $\text{CongestedOrigin}_{rt}$, where it is equal to approximately 120, the presence of a limit would lower the premium by just 2 percent.

The interactions $\text{MaxLimitOrigin}_{r} \times \text{CongestedOrigin}_{rt}$ and $\text{MaxLimitDes}_{r} \times \text{CongestedDest}_{rt}$ are positive, as expected. At congested airports, an increase in the limits to the sublease fee translates as higher prices. Again, to compute the magnitude of the effect, we need to take the sum of $\text{MaxLimitOrigin}_{r} \times \text{CongestedOrigin}_{rt}$ and $\text{MaxLimitOrigin}_{r}$ at a given value of $\text{CongestedOrigin}_{rt}$. Notice that this variable never takes a value less than 130, so the sum is never negative.

Finally, the interactions of $\text{MiiOrigin}_{rt} \times \text{CongestedOrigin}_{rt}$ and $\text{MiiDest}_{rt} \times \text{CongestedDest}_{rt}$ are also positive, as expected. More important, the sum of MiiOrigin_{rt} and $\text{MiiOrigin}_{rt} \times \text{CongestedOrigin}_{rt}$ is also positive (and, similarly, so is that for the corresponding destination variables). Thus, airports that are more congested are more likely to see higher prices when they share the rights to decide on expansion projects with the airline controlling the majority of their operations.

Overall, these results provide strong evidence that airlines controlling a larger number of gates benefit significantly more at congested airports than at airports where gates are not a scarce resource.

5.6. The Hub Premium at Airports Where Southwest Is Present

We now look at the extent to which the control of gates is important at airports where Southwest is present. The idea here is quite simple. If Southwest is present at an airport, then it is also present in some of the routes out of that airport. Hence, the prices out of that particular airport should be, ceteris paribus, lower than at airports where Southwest is not yet present. In particular, we are interested in the sign and magnitude of the interaction of $\text{WNatAirport}_{\text{rt}}$ with the variables that measure the access to the airport's facilities. The results are presented in Table 9.

First, consider the coefficients of $\text{OwnGatesOrigin}_{rt}$ and OwnGatesDest_{rt}. They are positive and slightly larger than in Table 7. Recall that this means that the control of a larger share of airport gates is associated with higher prices. Now, consider the interactions $\text{WNatAirport}_{\text{rt}} \times \text{OwnGatesOrigin}_{rt}$ and $\text{WNatAirport}_{\text{rt}} \times \text{OwnGatesDest}_{rt}$. We find that these interactions have a negative effect on prices. This means that in markets between two airports where Southwest is present ($\text{WNatAirport}_{\text{rt}} = 1$), controlling 10 percent more of the gates would increase the prices by a negligible amount (.25 percent at the origin). These results suggest that control of gates is an important determinant of higher airline prices only where Southwest is not already present at the airport.

Table 9
Hub Premia with Gates and Potential Competition from Southwest

	50th% Fare (1)		25th% Fare (2)		75th% Fare (3)		90th% Fare (4)	
Hub dummies:								
HubUmbrellaOrigin	.01^{+}	(.01)	.01	(.01)	.03**	(.01)	.04**	(.01)
HubUmbrellaDest	.03**	(.01)	.01*	(.01)	.06**	(.01)	.07**	(.01)
HubCarrierOrigin	.07**	(.01)	.08**	(.01)	.07**	(.02)	.06**	(.02)
HubCarrierDest	.07**	(.01)	.08**	(.01)	.08**	(.02)	.08**	(.02)
Barriers:								
OwnGatesOrigin × WNatBothAirports	−.16**	(.03)	−.11**	(.03)	−.24**	(.04)	−.15**	(.04)
OwnGatesDest × WNatBothAirports	−.14**	(.03)	−.09**	(.03)	−.24**	(.04)	−.20**	(.04)
OwnGatesOrigin	.18**	(.03)	.17**	(.02)	.19**	(.03)	.21**	(.03)
OwnGatesDest	.16**	(.03)	.14**	(.02)	.20**	(.03)	.29**	(.03)
LimitOrigin × WNatBothAirports	−.03^{+}	(.03)	−.03^{+}	(.02)	−.06*	(.03)	−.03	(.03)
LimitDest × WNatBothAirports	−.03	(.03)	−.03	(.02)	−.06*	(.03)	−.03	(.03)
LimitOrigin	.01	(.01)	.01	(.01)	.00	(.02)	−.03*	(.02)
LimitDest	.01	(.01)	.02	(.01)	.01	(.02)	−.02^{+}	(.02)
MaxLimitOrigin × WNatBothAirports	.05	(.15)	.03	(.12)	.19	(.18)	.05	(.18)
MaxLimitDest × WNatBothAirports	−.06	(.14)	−.01	(.12)	.10	(.18)	.01	(.18)
MaxLimitOrigin	−.06	(.09)	−.07	(.08)	−.06	(.12)	.17^{+}	(.12)
MaxLimitDest	−.01	(.09)	−.06	(.08)	−.07	(.12)	.13	(.12)
MiiOrigin × WNatBothAirports	.01	(.01)	.02*	(.01)	−.01	(.02)	.01	(.02)
MiiDest × WNatBothAirports	.01	(.01)	.02*	(.01)	−.02^{+}	(.02)	−.02	(.02)
MiiOrigin	−.05**	(.01)	−.06**	(.01)	−.03**	(.01)	−.03**	(.01)
MiiDest	−.03**	(.09)	−.05**	(.01)	−.01	(.01)	−.00	(.01)
WNatBothAirports	−.07**	(.02)	−.10**	(.02)	−.02	(.02)	−.10**	(.02)
NumberGatesOrigin	−.03**	(.01)	−.05**	(.01)	−.01	(.01)	.01	(.01)
NumberGatesDest	−.05**	(.01)	−.06**	(.01)	−.04**	(.01)	−.03*	(.01)
R^2	.25		.35		.23		.37	

Note. All regressions include controls for market distance and tourist market dummies. $N = 42{,}269$.
$^{+}$ $p < .10$.
* $p < .05$.
** $p < .01$.

Interestingly, the presence of Southwest has a policing effect only with regard to the control of gates. The effect of the other variables measuring access to airport facilities (Limit, MaxLimit, and MII) is essentially unchanged.

5.7. Airport Dominance and Limited Access to Airport Facilities

Finally, we check the robustness of our results when we include in the first-stage regression the measure of airport dominance used by Borenstein (1989). For each market, we define a measure of airport dominance for the origin and

Table 10
Hub Premia with Airport Share

	50th% Fare (1)		25th% Fare (2)		75th% Fare (3)		90th% Fare (4)	
Hub dummies:								
HubUmbrellaOrigin	.01	(.01)	.01	(.01)	.03**	(.01)	.04**	(.01)
HubUmbrellaDest	.03**	(.01)	.01+	(.01)	.06**	(.01)	.07**	(.01)
HubCarrierOrigin	.05**	(.02)	.06**	(.01)	.04*	(.02)	.04*	(.02)
HubCarrierDest	.05**	(.02)	.06**	(.01)	.05**	(.02)	.06**	(.02)
Barriers:								
OwnGatesOrigin	.17**	(0.03)	.16**	(.02)	.15**	(.03)	.19**	(.03)
OwnGatesDest	.15**	(0.03)	.15**	(.02)	.17**	(.03)	.27**	(.03)
NumberGatesOrigin	.01	(.01)	−.01**	(.01)	.04**	(.01)	.06**	(.01)
NumberGatesDest	−.01	(.01)	−.02**	(.01)	.01	(.01)	.02	(.01)
MiiOrigin	−.02**	(.01)	−.04**	(.01)	−.01	(.01)	−.01	(.01)
MiiDest	−.01	(.01)	−.02**	(.01)	.01	(.01)	.01+	(.01)
LimitOrigin	−.02+	(.01)	−.02	(.01)	−.03**	(.01)	−.06**	(.01)
MaxLimitOrigin	−.03	(.07)	−.06	(.06)	.03	(.09)	.19*	(.09)
LimitDest	−.01	(.01)	−.01	(.01)	−.02	(.01)	−.05**	(.01)
MaxLimitDest	−.05	(.08)	−.10	(.07)	−.05	(.09)	.09	(.10)
AirportPresenceOrigin	.22+	(.13)	.15	(.11)	.25	(.16)	.25	(.16)
AirportPresenceDest	.36**	(.14)	.21+	(.12)	.33*	(.16)	.07	(.17)
R^2	.21		.29		.18		.31	

Note. All regressions include controls for market distance and tourist market dummies. $N = 42{,}269$.
+ $p < .10$.
* $p < .05$.
** $p < .01$.

destination as $\text{DominanceOrigin}_{jrt}$ and $\text{DominanceDest}_{jrt}$, respectively. As in Borenstein (1989), these variables are constructed as the sum of passengers transported out of (or into) an airport by a carrier over the total number of passengers traveling out of (or into) an airport in a quarter. A subtle point is worth making here: because the number of passengers transported is a function of the fare charged by the carrier, the first-stage regression is no longer a reduced-form regression. However, we believe that this approach still provides a useful robustness check for our findings.

We also define $\text{MeanDominanceOrigin}_{jr}$ and $\text{MeanDominanceDest}_{jrt}$. These are route-carrier-specific averages of $\text{DominanceOrigin}_{jrt}$ and $\text{DominanceDest}_{jrt}$, respectively. These averages are not used in the first stage, but are used in the second stage, to pick up any effect of the presence of airport dominance that can be measured cross-sectionally.

The results from these regressions are presented in Table 10.[24] By comparing Table 7 and Table 10, it is clear that the addition of these controls has a negligible effect on our estimates of the hub premium and the effect of the barriers to entry. This is true for each quantile of the fare distribution that we consider. Notice that

[24] We do not report the results from the first-stage regression, for the sake of brevity. They are available from the authors.

the coefficients of $\text{MeanDominanceOrigin}_{jr}$ and $\text{MeanDominanceDest}_{jrt}$ have the expected positive sign.

Thus, these additional and potentially endogenous controls that are commonly used in the literature do not change our results or the conclusions made above regarding the magnitude of the hub premium. In addition, the effect of the barriers to entry is nearly identical with or without these measures of airport dominance. We still consistently find that concentrated control of boarding gates results in significantly higher fares. Again, the effect of the size of the limit on subleasing fees (MaxLimitOrigin_r and MaxLimitDest_r) and the presence of MII (MiiOrigin_r and MiiDest_r) agreements are estimated imprecisely, and no definitive conclusions should be drawn from the results.

6. Conclusions

After deregulation of the U.S. airline industry in 1978, there was a great deal of optimism that airline markets would become more competitive and fares would decrease substantially. The theoretical framework justifying this optimism was the theory of contestable markets developed by Baumol, Panzar, and Willig (1992). 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 in markets into and out of their hubs. In particular, we find that the hub premium is influenced by gate ownership, particularly when gate utilization is high at an airport, and that the hub premium is larger at the high end of the fare distribution. Future research should focus on the role that barriers to entry have on the entry decisions, because that is also an important determinant of long-run competition in airline markets.[25]

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 and volume incentives to travel agents that might allow airlines to raise their prices above their marginal cost. Unfortunately, data on frequent-flyer programs are not available. The remainder of the premium may also be explained as a function of the strategic behavior of airlines.[26]

[25] Williams (2009) finds that improved access to boarding gates at hub airports is the most significant determinant of the sunk cost of entry, particularly for low-cost carriers.

[26] For example, Miller (2010) studies the U.S. Department of Justice's suit against eight major domestic airlines and the Airline Tariff Publishing Company. The purpose of the suit was to reduce opportunities for collusion in the industry. The lawsuit ended with consent decrees limiting the ability of airlines to communicate surreptitiously through the shared fare database. Direct data on these practices remain unavailable.

Appendix

Data Construction

A1. Fare and Passenger Data

Fare and passenger information are from the Airline 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 data set by the operating carrier. The T-100 Domestic Segment data set contains domestic market data by air carriers and origin and destination airports for passengers enplaned. The T-100 is not a sample: it reports all flights 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 exclude tickets that are neither one-way nor round-trip travel, such as open-jaw trip tickets, tickets involving a nonreporting U.S. carrier flying within North America and a foreign carrier flying between two points in the United States, 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 noncontiguous domestic travel (Hawaii, Alaska, and territories), tickets with fares less than $20 or higher than $9,999, tickets with fares that were in the bottom and top fifth percentile in their year, and tickets with more than 6 coupons. We then merge this data set with the T-100 Domestic Segment (U.S. Carriers) and exclude tickets for flights that have fewer than 12 departures over a quarter in one direction (this means less than one departure every week in one direction).

We code a round-trip ticket as one directional trip ticket that costs one-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 meaningful the comparisons between one-way and round-trip fares by comparing what two passengers would pay for traveling the same distance. Each passenger is counted only once when constructing the market and airport market shares.[27]

We construct NonStop 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, we code this ticket as a nonstop ticket. If the passenger used two coupons for a round-trip ticket and the airline provided nonstop service on the two routes, we code this ticket as a nonstop ticket. Otherwise, the ticket is for a connecting or direct (connecting but using only one coupon) flight. In principle, an airline can provide both nonstop and connecting service between two airports.

[27] To check that this coding did not affect the result, we reran our regressions with only data from round-trip tickets. The results were almost identical.

It turns out that, in our sample, in 63 percent of the observations (year-quarter-route-carrier), a carrier provided only connecting service. For the remaining 37 percent of the observations, a carrier might provide both nonstop and connecting service. However, it turns out that carriers sell a nonnegligible number of connecting tickets (at least 30 percent of the tickets on a route in a quarter) 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 as equal to one if the carrier provided nonstop service between two airports.

We construct Frequency using the following procedure: If an airline provides nonstop service on a route, then Frequency is simply the number of departures in a quarter divided by 91, and this provides the average number of flights per day. If an airline provides connecting service on a route, then 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 a flight, so data on frequency are missing. In these cases, we let MissingFrequency equal one.

In accordance with Borenstein (1989), the mean, median, 25th percentile, and 75 percentile fares are derived 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 for 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 belonging to class X, whereas another airline may classify the same ticket as belonging to class Y. The reason for this is that there are no rules for standardizing what X and Y mean. Second, Southwest codes all tickets under one fare class, despite selling tickets with different fare restrictions. As a result, it is questionable whether the information on fare classes contained in the U.S. Department of Transportation Origin and Destination Survey can be used to build a reliable traffic mix variable. Finally, the number of frequent-flyer tickets (and traffic mix) is 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.[28]

[28] The DB1B data set 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 (2004) discuss 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 agreements), the operating carrier determines seat availability and the ticketing carrier sets prices for its service. In other alliances (blocked-space agreements), the ticketing carrier buys a block of seats on each code-share flight from the operating carrier. Since

Another issue is that there are airlines that transport very few passengers in a quarter. 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 have the airline reporting 24 passengers in the data set. If an airline reports fewer than 20 passengers in a quarter, we assume that the airline does not have an active presence in this market. Berry (1992) excludes airlines that report fewer than 90 passengers in a quarter. We relax this condition to account for the progressive adoption of smaller regional jets by U.S. airlines.

A2. Aviation Investment and Reform Act for the Twenty-First Century Data

The data from the competition plans are a cross section. The airports included are those in Albuquerque (ABQ), Atlanta (ATL), Austin (AUS), Baltimore (BWI), Burbank (BUR), Charlotte (CLT), Chicago O'Hare (ORD), Cincinnati (CVG), Dallas/Fort Worth (DFW), Denver (DEN), Detroit (DTW), Houston (IAH), Washington Dulles (IAD), Washington Reagan (DCA), Tucson (TUS), Miami (MIA), Milwaukee (MKE), Minneapolis (MSP), Newark (EWR), Philadelphia (PHL), Phoenix (PHX), Pittsburgh (PIT), St. Louis (STL), Salt Lake City (SLC), San Francisco (SFO), Chicago Midway (MDW), Cleveland (CLE), Dallas Love Field (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), and West Palm Beach (PBI).

We merge the data from the competition plans with the fare and passenger data, which is a panel data set. During this process of merging the two data sets, we needed 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 being for common use rather than for American. The same is true for Southwest, which also uses a common-use gate. At SMF, the gates of American Airlines include the activity of TWA. The gates of Continental include the activity of America West. We have three competition plans for SMF. The number of gates and the assignment change very little. Instead, the limit on sublease fees changed from not existing in 2000 to being 15 percent in 2001. At ATL, Atlantic Southwest Airlines is counted as Delta. At SLC, Skywest controls the gates and serves Delta: we coded these gates as controlled by Delta. At IAD, Atlantic Coast Airlines gates are assigned to United Airlines. At SLC, SLC's competition plan says that an entrant was charged more than 15 percent and that the airport helped negotiation, but it does not tell how much lower of a fee was charged. It says that they are introducing a limit but with a new agreement. At PHL, the airport authorities were constructing 13 gates, which are included. We do not include four gates and 38 regional gates

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.

expected to be added after the period of interest. At DTW, five gates are assigned to both HP and CO, but we use the number of departures to attribute four to Continental and one to America West. At DAL, 25 gates were available but only 18 were operational. At CLE, US Airways sublets one gate to Midwest, Continental sublets one to America West, and Continental also has four gates that can serve six regional planes each. We coded them as having four. At BUR, airlines cannot sublease gates. There are three overflow gates that we interpret as being available for common use. At MIA, all gates are for common use, and no subleasing is necessary. At DFW, 37 are nonbridge positions, so we do not count them. The TWA gates were assigned to American Airlines when TWA was acquired by American Airlines. MKE converted one gate of TWA to common use. American Airlines has served the airport through American Airlines Eagle since 1996. Data for ORD, MDW, OAK, and BWI were collected from the airport Web sites, their competition plans, direct contact with the airports, and Federal Aviation Administration (1999).

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