Hubs versus Airport Dominance

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Abstract

We address the issue of the sources of dominant airlines' pricing power by separating premium due to hub operations from that due to airport dominance. Presence of airports serving as hubs for two carriers enables such identification via difference-in-differences. Moving from lower to higher prices, the total pricing premium of hub operators (both dominant and non-dominant) increases; while the share of the airport dominance premium diminishes relative to that of the hub premium. Absence of hub premium at the lower end of the price distribution (and lack of dominance premium at the higher prices) suggests frequent flier programs rather than product differentiation as the likely dominant source of hub operator's pricing power. Dominant airline's ability to charge higher fares due to either its airport market share or access to scarce airport facilities is confirmed.

Keywords: Airlines, Hub Premium, Airport Dominance, Frequent Flier Programs

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1. Introduction

Among the possible sources of market power in the airline industry, airport dominance is pointed to as a very important one. At a basic level, the airport dominance effect refers to an airline's ability to charge higher fares for travel to or from an airport, where it has a dominant position, relative to the fares it charges for travel elsewhere within its network. Evans and Kessides (1993) concluded that the airport dominance is a far more important source of market power than route dominance. They further suggested that the source of the dominant carrier's market power could be either in supplying a different product, or in attracting a different kind of (i.e., price insensitive) traveler as compared to other airlines serving the same airport.

An airline dominating an airport does offer a different product as compared to other carriers serving the same gateway. Specifically, it offers direct flights to many more destinations than any other carrier at the airport. The dominant carrier uses its frequent flier program to reinforce this difference: customers living around the airport dominated by a certain carrier will value this airline's frequent flier program more highly, since they will be able to both earn awards (free trips, upgrades, premium status) faster and redeem them for travel to more destinations.

Major businesses value locating at cities that house hubs of major airlines precisely to have access to the carriers' networks, presumably knowing they will have to pay premium fares to respective dominant airlines. For example, when Boeing decided in late 1990s to move its corporate headquarters from Seattle, the two candidate cities were Denver and Chicago, both major airline hubs. The company completed its move to Chicago in September 2001. Bel and Fageda (2008) provide more systemic evidence to this effect.

Identifying the sources of what is defined in the literature as the airport dominance premium is both a difficult and an important task. As Kahn (1993) points out, if the dominant carrier attracts a disproportionate share of price-insensitive customers, the welfare impact of the ensuing price discrimination is ambiguous. Further, if customers overpay the dominant carrier for access to the network of non-stop flights, this may amount to little more than 'quality-based' pricing, or distribution of the corresponding rent between the customer and the airline rather than the market power of the latter. At the same time, frequent flier programs are also considered sources of market power (they may both affect market structure at hub airports – for instance, by discouraging entry – and give the dominant airline an advantage over the competition it does face). Finally, we cannot rule out the potential contribution of the 'old-fashioned' market power, based on the dominant airline's airport market share.

The broad aim of this study is to address the issue of the sources of higher fares charged by the airlines in dominated airports. More specifically, we disentangle what manifests itself (and is referred to in the literature) as the airport dominance effect into the two components: the *hub premium* and the *dominance premium*. We exploit the fact that five US airports (Atlanta, Denver, Dallas-Fort Worth, Chicago O'Hare, and Phoenix) serve as a hub for *two* major airlines. Further, three of these five gateways have a clearly defined dominant carrier. The *hub premium* will then refer to the pricing differential commanded by a hub operator over the airlines not using a given airport as their hub. The *dominance premium* (if any) is commanded by the dominant hub operator over the airline operating its hub but not enjoying the dominant position.

If only the dominance premium (as we define it) is observed in the data, this will imply that establishing a hub does not by itself give the airline any pricing power. This result would be most consistent with 'classical' market power due to the airport dominance (and very consistent with Borenstein's (1989) conclusion that the airport dominance does not provide any umbrella for other carriers at the airport).

If we only observe the hub premium but not the dominance premium, we can say that establishing a hub is all an airline needs to be able to charge their customers higher fares. That is, an airline's market power is defined not by the size of its airport presence, but by the presence of a network of non-stop flights (quite possibly reinforced by a frequent flier program, attracting a disproportionate share of price insensitive business travelers).

For our analysis, we use a sample of actual itineraries collected quarterly by the US Department of Transportation (this dataset is known as DB1B). From this sample, we select non-stop and one-stop roundtrip itineraries that originate, terminate or go through one of the five hub airports. We apply a relatively simple difference-in-differences identification strategy, focusing on an airport-pair-market (APM) fixed effects model, and applying an instrumental variable technique to control for possible endogeneity in market concentration and market share. We also conduct our analysis focusing on both average fares and prices representative of the upper and lower end of the distribution.

We find rather robust evidence in support of the existence of the hub premium both in the middle and on the upper end of the price spectrum. The airport dominance premium is detected in regressions using average and lower fares as the dependent variable.[3] Our results effectively suggest that, contrary to Lee and Luengo-Prado (2005) and Berry et al. (2006), it is the average traveler who is paying the 'traditional' airport dominance premium; the price-insensitive business traveler pays equal premiums for traveling to/from an airline's hub, whether the airline has a dominant position at its hub airport or not. In other words, a substantial share of the premium paid by travelers at the upper end of the price distribution appears to be driven not by airport dominance, but by the nature of the (higher quality) product offered by the airline operating the hub. Evidence of the absence of hub premium at the lower end of price spectrum suggests that frequent flier programs rather than product differentiation is the source of the airport dominance premium.

Our results imply that both pure airport dominance and the nature of the product offered by an airline operating a hub-and-spoke network contribute to higher fares charged by dominant carriers.[4] The former is more pronounced at average fares/yields, while the latter dominates at the upper end of the price distribution. Carriers operating a hub at an airport, but not enjoying the dominant position are still able to charge the hub premium. Thus, the 'umbrella' initially thought to be available only to dominant carriers (and, according to recent results, to those carriers' frequent flier program partners) applies to any hub operator able to reinforce its hub position with the customer loyalty program.

Our analysis advances our understanding of the nature of fare premiums charged by the airlines dominating major airports. At the same time, a number of issues remain not addressed. While we are able to assert that frequent flier programs do reinforce

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[3] Some specifications suggest travelers at the upper end of the price distribution pay (on average) higher premiums for traveling with the non-dominant hub operator than with the dominant airline.

[4] Technically, the degree to which we have been able to disentangle the two effects is directly related to plausibility of our identifying assumptions. We will defer more detailed discussion to an appropriate section of this paper.

airlines' pricing power, we cannot pin down exact estimates of this role. We believe that to properly address this issue one would need much richer data than what is currently publicly available.

The rest of the paper is organized as follows. Section 2 provides a brief review of the relevant literature. Section 3 discusses identification strategy in general terms. Section 4 describes the data. Section 5 discusses results of the data analysis. Section 6 concludes.

2. Relevant Literature

Borenstein (1989) showed that an airline dominating an airport is able to charge higher fares. Airport dominance was not, however, found to provide other carriers serving the same gateway an 'umbrella' for also charging higher prices. The airport dominance effect was attributed to the airlines' frequent flier programs and a feature of the ticket distribution market prevalent at that time.[5] Further, Borenstein (1991) showed that a dominant airline had a disproportionately large market share of hub-originating passengers (as opposed to passengers terminating at the same hub). Evans and Kessides (1993) asserted that airport dominance was a more important source of market power than route dominance (Borenstein's 1989 study suggested route market share was also an important determinant of observed fare premiums).

The US regulatory authorities have also paid attention to the airport dominance effect. In a 1990 report, the US Government Accountability Office (GAO) noted that airlines' transition to the hub-and-spoke networks following deregulation resulted in important airports being dominated by a single airline. The report further claimed that this position allowed the dominant airlines to charge a premium for their flights to/from the respective airport. Estimates of dominance premiums were also provided. In their 1995 book, Morrison and Winston criticized the GAO report for not controlling for many relevant factors (their analysis produced smaller hub premiums than those calculated by the GAO).

[5] Most of the tickets were then distributed by 'brick-and-mortar' travel agents, receiving commission from the airlines. Further, airlines often paid so-called TACOs (travel agent commission overrides), or payments to agents booking more than a certain share of itineraries with a single airline. Airlines discontinued commission payments to travel agents in 2001-2002; currently, travel service distributors charge their customers fixed per booking fees (see Bilotkach and Pejcinovska (2011) for further discussion).

Recently, there has been a revival of interest in the issue of airport dominance. Berry et al. (2006), having estimated a structural differentiated product model of the airline industry, suggested that airlines' ability to command airport dominance premium was limited to the upper end of the price distribution. Consistent with this finding, Lee and Luengo-Prado (2005) showed that the observed hub premiums could be explained by the passenger mix (proportion of leisure versus business travelers). Bilotkach (2007) demonstrated that the airport dominance effect applied to a number of transatlantic routes[6]. Lederman (2008) showed that uniting frequent flier programs was a way non-dominant airlines could get under the 'umbrella' available to the dominant carriers, thereby providing evidence of importance of frequent flier programs as a factor behind the airport dominance premium. Ciliberto and Williams (2010) demonstrated that the hub premium is higher on the upper end of the price distribution, also suggesting that limited access to airport facilities explains part of this premium.[7] Bilotkach and Lakew (2013) offer what they call a "30,000-feet view" at the airport concentration – price relationship, analyzing a 17-year panel of airport-level data for all airports in the US. This study confirms the role of airport dominance as the key source of market power, not only for large hubs, but also for the small airports, which tend to be concentrated as well.

3. Identification

3.1 Identifying Assumptions

Identifying assumptions which will enable our estimation strategy are the following. First, we suppose that *hub premium* applies to both carriers operating a hub at a given airport. Second, we assume that the *airport dominance* component of the fare premium only applies to the dominant carrier. We will discuss the plausibility of the first assumption in the next paragraph. The second assumption is clearly the less defensible of the two: we will see from the data that in all airports in our sample, each hub operator has a larger presence than any other airline. Therefore, it is possible that an airport dominance

[6] Evidence on the European side (Lijesen et al., 2001, Marin, 1995, Bachis and Piga, 2007) is inconclusive, perhaps due to the fact that researchers had to use either offered or aggregated actual fares in their research.

[7] All five of the airports included in our study are in Ciliberto and Williams' paper; however, they do not measure hub premiums for the non-dominant hub operators at Atlanta, Denver, and Dallas. Nor do they consider Southwest Airlines as operating a hub at Phoenix.

premium applies to both hub operators, and not only to the dominant carrier. We will return to this issue when discussing estimation results.

Next, let us discuss what is potentially behind the hub effect, and why it is reasonable to assume that it applies to both hub operators. Any hub operator provides residents of the respective metropolitan area access to a network of non-stop flights, unmatched by any other carrier serving the same airport, and the value of this network is enhanced by the airlines' frequent flier programs. At the same time, the dominant carrier supposedly offers a more extensive network as compared to that of the non-dominant hub operator. Hence, we hypothesize the existence of the airport dominance premium over and above the hub premium. Yet, in presence of the frequent flier programs this argument is not necessarily valid, since a frequent flier maximizes the payoff from his/her miles when collecting them with a single airline. Therefore, in the area around an airport with two hub operators the market for frequent fliers will likely be 'segmented' by the two airlines.

Shares of frequent fliers loyal to one or the other airline could be proportional to the carrier's respective market share at the airport. However, loyal travelers' willingness to pay for access to an airline's network (and the right to earn and redeem miles over this network) may not necessarily be proportional to the network size, but rather dictated by the travelers' idiosyncratic characteristics, as well as by features of the airlines' customer loyalty program. As an example, a traveler loyal to Delta could be drawn to that airline's frequent flier program because it allows him/her to use their miles for a vacation in Jackson Hole, WY (an airport served by Delta, United, and American); whereas a traveler loyal to AirTran may tend to vacation in Florida (both Delta and AirTran serve numerous destinations in this state), but may be drawn to this carrier by convenient schedules or excellent on-time performance on routes he/she typically flies on business throughout the year. Our hypothetical AirTran frequent flier may value access to the airline's network and miles less, more, or as much as our hypothetical Delta traveler may value access to Delta Air Lines' network and frequent flier program.

Also, a carrier with a relatively less extensive network as compared to the dominant airline can 'compensate' for this deficiency by offering its frequent travelers easier ways to earn or redeem miles. In fact, we do observe this strategy practiced by carriers central to our analysis. AirTran rewards its frequent travelers on the basis of flight segments rather than miles they fly (thereby making their frequent flier program more attractive to customers who have to take shorter-haul flights frequently). Frontier Airlines (airline sharing Denver hub with United Airlines) requires only 20,000 miles for a free ticket within the lower 48 states, whereas United Airlines' award tickets start at 25,000 miles.

3.2 Identification Strategy

Two approaches to measuring airport dominance effect (using the term as it has been previously defined in the relevant studies) have been employed in the literature. The first approach is to compare an airline's fares for flights to and from the airport where it has a dominant position to fares elsewhere within the airline's network. The second approach compares the dominant airline's fares for travel to or from the corresponding airport to prices charged by other airlines flying into or from the same airport, but not enjoying the dominant position. Neither of the two approaches, however, is able to disentangle the hub effect from the dominance effect, as we call them.

To separate the dominance effect on observed fares (and yields) from the hub effect, we examine price setting at airports serving as hubs for two carriers. We can say that our exercise combines the two above-discussed approaches to measuring airport dominance in the following way. In an airport used by two carriers as a hub, any premium charged by the dominant airline for non-stop flights to or from this hub relative to fares charged over the remainder of that airline's network includes both the hub effect and the dominance effect, whereas the same difference for the non-dominant hub operator only includes the hub effect. Both non-stop fares, however, also include airline-specific effects. To weed these effects out, we include into our sample the one-stop itineraries connecting via the respective hub airports – those itineraries do not include either dominance or hub effects, only the airline effects. Formally, we can express the corresponding fares in the following way:

$$P_{H,D}^{NS} = \delta_{Airline} + \delta_{Hub} + \delta_{Dominance}$$

$$P_{H}^{NS} = \delta_{Airline} + \delta_{Hub}$$

$$P_{Airline}^{Onestop} = \delta_{Airline}$$

Here $P_{H,D}^{NS}$ denotes price charged by the dominant hub operator for non-stop flights to/from the hub airport; P_{H}^{NS} is same for the non-dominant hub operator; and $P_{Airline}^{Onestop}$ is the price charged by a hub operator for one-stop flight connecting via the corresponding hub airport. Then, the difference-in-differences estimator that will identify the dominance effect is:

$$\Delta^{D} = \left(P_{H,D}^{NS} - P_{H,D}^{Onestop}\right) - \left(P_{H}^{NS} - P_{H}^{Onestop}\right)$$

That is, dominance effect is identified using the hub operators' fares charged by them for flights to/from their hubs relative to what they charge elsewhere (i.e., for flights connecting via those same hubs).

To identify the hub effect from the data we will use the fares charged by *other carriers* (those not operating a hub at a given airport) offering services to/from a given airport. Presence in the data of other carriers' itineraries going via the hubs in question (more on this in the data section) allows us to identify a similar non-stop – one-stop price differential for those airlines, eventually permitting identification of the hub effect as:

$$\Delta^{H} = \left(P_{H}^{NS} - P_{H}^{Onestop}\right) - \left(P_{Other}^{NS} - P_{Other}^{Onestop}\right)$$

We will use the non-dominant hub operator for our identification here. The hub effect is identified by comparing fares charged by the hub operator to prices of the other airlines flying into the same hub airport.

Thus, our identification strategy is a simple difference-in-differences. Successful implementation of this strategy will require data on fares for travel to/from, as well as through the hub airports selected for the analysis. Note that this strategy is similar to that applied by Bilotkach (2007) to analyze price setting (including obtaining estimates of the airport dominance effect) on several transatlantic airline markets.

4. Data and Methodology

4.1 Airports – background

To enable separation of the hub premium from that due to the airport dominance, we selected five airports, each of which serves as a hub for two airlines. These are Atlanta Hartsfield International (airport code ATL); Chicago O'Hare (ORD); Dallas-Ft. Worth International (DFW); Denver International (DEN); and Phoenix Sky Harbor (PHX) airports. Of the five airports, three are clearly dominated by one of the two hub operators.

Specifically, ATL, being the world's busiest airport in terms of passenger volume, is the largest hub for both Delta Air Lines and low cost carrier AirTran,[8] and is dominated by the former airline. American Airlines has a clear dominant position at DFW, while Delta also used this airport as one of its hubs until February 2005. United is the dominant carrier at DEN, though the airport is also used by Frontier Airlines as its only hub.

Chicago O'Hare and Phoenix Sky Harbor are not dominated by any single hub operator. ORD is a hub for both American and United. US Airways[9] and Southwest Airlines channel their passenger traffic via PHX. Additionally, ATL, DEN, and PHX are the only major commercial airports in respective metropolitan areas. Besides ORD, Chicago metropolitan area is served by Midway (MDW) airport, used by Southwest Airlines as its 'quasi-hub'. While Dallas-Ft.Worth metropolitan area is also served by Dallas Love Field airport (DAL), also used by Southwest Airlines; Wright Amendment has at the time period covered by our data restricted Southwest Airlines' ability to fly non-stop from this gateway.[10]

Note that in two of the three airports dominated by a single carrier the dominant airline shares the gateway with a so-called low cost carrier (Frontier and AirTran). The conventional wisdom suggests that low-cost carriers do not operate hub-and-spoke networks in the same way as traditional legacy carriers do. However, on the US market Southwest Airlines is the only such carrier, still channeling over half of its traffic via its 'quasi-hubs' (PHX being one of them). AirTran and Frontier, on the other hand, operate clearly defined single-hub networks, with the former to a degree specializing in vacation traffic to Florida destinations, and Frontier running a rather typical 'coast-to-coast and in-between' hub-and-spoke network.

According to the US Department of Transportation, in 2007 the five airports we selected for our study handled over 270 million passengers in the US market (and another 40-plus million international travelers). To put these numbers in perspective, note that US

[8] In 2011, AirTran was bought by Southwest Airlines.

[9] Historically, America West Airlines was the carrier that established its hub at PHX; in 2005 America West acquired US Airways and kept that airline's name after the acquisition.

[10] Original law (called Amendment to the International Air Transportation Competition Act of 1979) allowed Southwest Airlines to fly non-stop from DAL only within Texas and the neighboring states. The law was repealed in October 2006. However, Southwest will not gain unlimited rights to non-stop services out of DAL until 2014.

airlines carried about 660 million passengers[11] in the domestic market in 2007. In that same year, the five airports included in our study handled about 1.7 million of the 10.3 million commercial passenger flights performed within the United States. Thus, one in six flights within the US that year took off from (or landed at) one of the five above listed airports. The disparity between the apparent passenger shares (it appears from the above numbers that 45 percent of all US passengers fly to/from/via the five gateways we selected) and flights most probably stems from the likely double-counting of connecting passengers at hub airports (once as arriving, and once more as departing, while on the same trip) in reported airport-level traffic statistics.

Table 1 lists the number of destinations served by each airport's two leading carriers (including regional airlines using the carriers' brands) in July of every year from 1999 to 2005 (the time period that our data spans). From that table we clearly observe that in ATL, DEN, and DFW a dominant carrier offers a much broader network as compared to the other hub operator at the same airport. Note also how fast Delta Air Lines dismantled its hub at DFW.[12] It is also interesting that AirTran and Frontier managed to grow their networks substantially, in spite of competing with such heavyweights as Delta and United on their home turf (or rather, home tarmac). In ORD and PHX we observe relative parity between the two biggest carriers, in terms of the number of destinations served. At Chicago O'Hare, both American and United added endpoints over the years. While the number of airports served by America West from Phoenix Sky Harbor did not change, Southwest added new destinations quite aggressively (though not nearly as aggressively as Frontier did at Denver).

4.2 Methodology

We will use two average price measures as dependent variable: natural logarithm of fare, as well as natural logarithm of yield (fare per mile). Fare is, as discussed above, the passenger-weighted average price aggregated at the airline-routing-quarter level. In addition to the passenger-weighted average price, we calculated standard deviation of the same. To be in line with previous studies considering airport dominance effect at the upper tail of the price distribution, we use the natural logarithm of average plus standard

[11] This is number of enplanements reported by the US Department of Transportation.
[12] Delta closed its hub at DFW in February 2005.

deviation fare (as well as of the corresponding yield) in some specifications. Using this measure to get an idea of how prices behave at the upper tail of the distribution might be unorthodox,[13] and it cuts off observations for airlines observed offering a single fare on a given airport-pair market.[14] But then, small players are also likely to introduce noise into our data, as we observe their behavior in a non-systematic way.

Our estimation technique of choice is the airport-pair-market fixed-effects. We estimate both the regular fixed effects and the instrumental variable specifications. We had to find instruments for the measures of market concentration (Herfindhal-Hirschmann Index) and market power (airline's market share on the route). Consistent with the previous literature, one-year lagged HHI was used as an instrument for the former. Evans and Kessides (1993) note that finding an appropriate instrument for market share is a difficult task. We decided to instrument the airline's route market share with the average of the airline's market shares across the routes originating at the respective airport, excluding the current route. This measure is generally in the spirit of using variables from other markets the firm operates in to instrument for the same measure on the current market. It also potentially suffers from the possibility of being correlated with the error term in case of a shock affecting an airline's flights to all destinations from a given airport.[15] Using the firm's intra-route rank of the market share as the instrument, as done by Evans and Kessides (1993), is complicated in our case by the fact that we calculate market shares for one-stop trips separately from those for non-stop flights. Markets end up being quite competitive at the one-stop level,[16] meaning that demand and other unobservable price shocks can lead to change in ranks of the firms' market shares – according to Evans and Kessides, in such a case intra-route rank will no longer be a valid instrument for the market share. In our data, our instrument of choice turned out

[13] Upper percentiles (such as upper quartile, 80th or 90th percentile) of observed price distributions have been typically used in the literature. If we believe that distribution of fares is close to log-normal; our measure corresponds to approximately 85th percentile (based on one-sigma rule for normal distributions).
[14] For these observations, standard deviation cannot be obtained.
[15] Such as an unusually aggressive advertising campaign at the city of origin – just as using a variable from another market as an instrument can make it correlated with the error term if a firm undertakes a nation-wide advertising campaign.
[16] While mean HHI for one-stop itineraries (0.48) is not that lower than for non-stop ones (0.57); there is an appreciable mass of routes that are competitive at the one-stop level. More specifically, lower quartile of HHI at one-stop level is close in value (0.31) to the lower decile for HHI at the non-stop level.

reasonably well correlated with the variable it instruments for – with correlation coefficient of 0.51.

In all specifications, we make a distinction between the following indicators of airlines' hub and dominant positions (these will be our key variables):

- Hub operator's non-stop itinerary indicator – takes value of 1 for direct flights by an airline operating a hub at the airport (i.e., Delta at ATL and DFW, American at DFW and ORD, United at ORD and DEN, America West and Southwest at PHX, Air Tran at ATL, and Frontier at DEN). We will denote the corresponding coefficient via β_{Hub}
- Dominant airline's non-stop itinerary – takes value of 1 for direct flights by an airline dominating the airport (Delta at ATL, United at DEN, and American at DFW). The notation for the corresponding coefficient is $\beta_{Hub}^{Dominant}$
- Non-dominant hub operator's non-stop itinerary – takes value of 1 for direct flights by an airline operating a hub at the airport, but dominated by another carrier (Delta at DFW, Frontier at DEN, and Air Tran at ATL). The notation is $\beta_{Hub}^{Non-Dominant}$
- Other airline's non-stop itinerary to/from either of the five hub airports in our dataset, denoted via β_{Other}

We can write the specification to be estimated as:

$$logP_{ijt} = \alpha_j + \gamma_t I_t + \theta_i I_i + \beta_{Hub} I_{Hub} + \beta_{Hub}^{Dominant}\, I_{Hub}^{Dominant} + \beta_{Hub}^{Non-Dominant}\, I_{Hub}^{Non-Dominant} + \beta_{Other} I_{Other} + \psi X_{ijt} + \varepsilon_{ijt}$$

Where P_{ijt} is the measure of price (airfare or yield) charged by airline *i* on market *j* in quarter *t*. Further, α_j represent market fixed effects; γ_t denote time effects; θ_i are airline effects; X_{ijt} is the vector of control variables, as discussed above; and ε_{ijt} is the error term. Corresponding indicator variables are denoted via I_{ijt}.

The dominance effect is identified by the difference between the coefficients for dominant and non-dominant hub operator's non-stop itineraries. The hub effect is identified via the difference between the sum of β_{Hub} and $\beta_{Hub}^{Non-Dominant}$ and β_{Other}. Formally, the estimate of the dominance effect is obtained from the regression results as:

$$\hat{\Delta}^D = \hat{\beta}_{Hub}^{Dominant} - \hat{\beta}_{Hub}^{Non-Dominant}$$

Whereas the estimate of the hub effect, assuming $\hat{\Delta}^D$ is positive, is obtained as:

$$\hat{\Delta}^H = \hat{\beta}_{Hub} + \hat{\beta}_{Hub}^{Non-Dominant} - \hat{\beta}_{Other}$$

More generally, we can write the above expression as:

$$\hat{\Delta}^{H} = \hat{\beta}_{Hub} + \min\{\hat{\beta}_{Hub}^{Dominant}, \hat{\beta}_{Hub}^{Non-Dominant}\} - \hat{\beta}_{Other}$$

4.3 Sample and Variables

Our main data source is the US Department of Transportation Origin and Destination Survey, databank DB1B. The DB1B is a 10 percent sample of actual itineraries, collected by the US Department of Transportation. In this databank, the itineraries are grouped at the fare-airline-service-class-routing level (e.g., $400 for trip from Los Angeles to Denver to Boston and back to Los Angeles via Denver on United Airlines). The number of passengers found to pay a certain fare flying a certain airline on a certain route is also reported. The data is collected quarterly and is made available for download from the Department's web site free of charge.[17] We use DB1B for all quarters from 1999 through 2005.

Each entry in the DB1B includes fare paid (net of taxes and fees), class of service,[18] and detailed information on routing, including identity of airlines selling the ticket and operating each flight, distance traveled, and all intermediate airports visited. The destination of the trip is coded through the directional break in itinerary.

Our sample consists of trips that originate, terminate, or connect through Denver, Atlanta, Dallas-Ft. Worth, Phoenix, or Chicago O'Hare airports. We apply the following filters to arrive at the final sample of itineraries that will be used for analysis.

- Each segment in the itinerary had to be served by the same airline, with regional carriers re-coded as corresponding major airlines. We therefore excluded interline itineraries.
- To ensure consistency across all years and quarters, we only include restricted economy class itineraries for all airlines except Southwest Airlines (which reports all its itineraries as restricted first class). Lee and Luengo-Prado (2005) used data from the third quarter of 2000 and separated restricted economy class itineraries from unrestricted economy class and first class itineraries as a way to capture passenger mix on the markets. We, however, found that the carriers are rather inconsistent in

[17] This relates to the dataset for the US market. The International DB1B remains a restricted dataset – permission from the Department of Transportation is required to obtain access to this data.

[18] Technically, services are classified as first unrestricted, first restricted, business unrestricted, business restricted, economy unrestricted, economy restricted.

separating the unrestricted economy itineraries from the restricted ones across the quarters in our sample. At the same time, the restricted economy[19] classification is used most frequently (over 85 percent of the time), and restricted economy fares appear to span the expected range of economy class fares rather well.

- We converted all fares into real dollars (with 2000 as the base year), using seasonally adjusted GDP price index, reported by the Bureau of Economic Analysis.
- In line with previous studies (e.g., Lee and Luengo-Prado, 2005), itineraries with yield less than 2 cents per mile in year 2000 prices (i.e., about $100 for a coast-to-coast roundtrip ticket) were dropped.
- We only selected non-stop or one-stop roundtrip flights without open jaws (i.e., return trips to the same airports) and with a single directional break (i.e., no multi-city trips).
- One-stop roundtrip itineraries had to connect through the same airport in both directions.
- To avoid contaminating our data with small markets (for which obtaining a representative picture will be difficult), we only chose those markets where 100 or more passengers were observed in our sample in a given quarter. This means, roughly speaking, that we only look at markets with annual passenger traffic of over 4000 passengers, or about eleven passengers per day. It should be noted that looking only at sufficiently large market is a typical practice in the airline industry studies.

We then constructed our dependent variable as the passenger-weighted mean fare at the airline-routing-quarter level (we will use natural logarithm of this in our regressions). This means, for instance, that American Airlines' fares between the same airports via different hubs (Chicago and Dallas-Ft. Worth) are viewed separately. Also, should an airline offer both non-stop and one-stop products on the same market (e.g., Delta might, in addition to offering non-stop Los Angeles–Atlanta flights, channel some of the traffic between the two cities via Dallas), average fares for such non-stop and one-stop services were computed separately. We also computed passenger-weighted standard deviations at the airline-routing-quarter level. Finally, the passenger-weighted mean yields (fare per mile) were computed.

[19] We found no information on whether there are any formal criteria to differentiate between restricted and unrestricted fares: while non-refundable ticket requiring 21-day advance purchase is clearly 'restricted', we are not sure, for instance, how a refundable ticket requiring 3-day advance purchase would be coded.

Having applied the above restrictions, we ended up with over 600,000 observations, spanning over 5,400 unique directional airport-pair markets. We are thus looking at approximately 2,700 relatively large airport-pair markets in the country[20] – a typical restriction the literature is to consider up to top 1000 city-pair or airport-pair routes. Since all the passengers at the airline-routing-quarter level are collapsed into a single observation corresponding to the average fare, most of our observations correspond to one-stop products.[21] We should also note that not all of the one-stop observations correspond to the airlines channeling passengers via their own hubs. For example, in addition to the hub operators United and Frontier; American, Alaska, Delta, Northwest, and US Airways are also found to channel their passengers via Denver. Same holds true for other hub airports we focus on.

Before we continue with discussion of control variables, it pays to clarify our definition of airlines. In the US market, some of the commercial passenger services (particularly on thinner markets) are performed by so-called regional carriers, effectively operating as agents of major airlines. These carriers' business model relies on operating smaller aircraft on shorter-haul routes, exploiting cost savings due to less diverse fleet and outsourced marketing. Interestingly enough, Jordan (2008) showed that, by looking at exit rates in the US airline industry since deregulation, regional airlines' model appears the most successful one – fewer regional carriers exited, both in absolute and relative terms, as compared to both legacy, new full-service, and discount airlines. Those regional carriers can be either independent companies (SkyWest, Atlantic Southeast); or fully owned subsidiaries of major carriers (American Eagle); some of them (ExpressJet) market services under their brands in addition to acting as major carriers' agents. Moreover, several of those regional carriers perform services for more than one major airline (e.g., SkyWest flies as a Delta, United, and Midwest agent). We decided to assign regional carriers' services to respective major airlines (since pricing decisions are made at the major airline level). More detailed information about this assignment can be found in the Appendix.

[20] Due to the geographical location of the airports included into our study, some of the largest markets (e.g., Los Angeles to San Francisco) were most probably not included into our dataset.
[21] An airline operating a hub-and-spoke network with n spoke airports will offer n non-stop products and up to $0.5n(n+1)$ one-stop products.

We will use respective indicator variables to control for year-specific, quarter-specific, year-quarter-specific, and airline-specific heterogeneities.[22] We should also note that, since our specifications will effectively include indicator variables for all non-stop services, airline indicator variables will measure the effects of through-hub services.

Distance and an indicator for non-stop flights are the two itinerary-specific controls we use. In the airport-pair market fixed effects model, we expect the coefficient on distance to have a negative sign, as it measures the effect of a more circuitous (and therefore less desirable) route on the fares between two airports. Non-stop flights, however, should be more expensive than one-stops, other things equal.

For the measure of market concentration, we will use the regular Herfindhal-Hirschmann Index (HHI). Market share is used as the measure of the airline's market power. The measures were calculated from DB1B passenger numbers. As far as market boundaries are concerned, for each origin-destination airport-pair we consider non-stop services separately from one-stop flights. As an example, for the Los Angeles-Atlanta airport-pair market we calculated HHI and market shares for non-stop and one-stop services separately.

Finally, market-specific control we use is the geometric average of endpoints' population, at the Metropolitan Statistical Area level. We used Census data for the year 2000, as well as population and per capita income estimates for 2006, interpolating for other years in our sample. The list of the variables is in the Appendix. The basic descriptive statistics are in Table 2.

5. Data Analysis

5.1 Results and Discussion

Tables 3 and 4 report our estimation results. Table 3 shows results for both average and high fare, reporting the output for both price and yield as dependent variables. Table 4 presents the estimation results for the lower end of the pricing distribution. The dependent variable in these specifications is the natural logarithm of weighted average yield minus one third of the standard deviation of the same.

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[22] We have repeated our analysis excluding last two quarters of 2001 and first two quarters of 2002 to control for the shock associated with events of September 11, 2001. Results were similar to those reported here.

We have also conducted our estimation exercise on sub-samples of itineraries going via either of the five hub airports. These results – available from the authors upon request – largely confirm our findings reported in Tables 3 and 4.

The main conclusion that follows from Tables 3 and 4 is that *airport dominance effect is more pronounced in average and low fares than at the upper end of the price distribution, whereas hub effect is clearly present at the high end of price distribution*. There is also some evidence that hub carrier's pricing power extends to the middle of the fare distribution. However, pricing premium present in the low fares is due to airport dominance rather than hub operations. Another interesting and unexpected result from the high end of the price distribution is that both fares and yields of the non-dominant hub operators are higher than same for the dominant airlines – hence the negative estimate of the dominance effect reported for instrumental variable specifications in Table 3.

To appreciate the magnitude of the effects and put our results into clearer perspective, consider the following example. We will focus on specifications with the natural logarithm of yield as the dependent variable, and considering results for two-stage least squares regressions. From Table 3 it is evident that for the average yield hub operators enjoy about 8.3 percent premium above other carriers flying from/into the same hub (the difference between the estimates on Hub Operator*Direct and Other Carriers*Direct interaction variables). With the mean yield for non-stop trips in our sample at 25.5 cents per mile (same number for the entire sample is 14.9 cents per mile[23]), our estimate suggests that an airline operating a hub charges on average 2.1 cents per mile more than an airline flying to/from the same airport and not operating a hub there. To put this in perspective, consider a route between Atlanta and Denver – two of the hubs included into our analysis. With the roundtrip distance for the non-stop journey between the two airports at 2400 miles, the average total premium implied by our above estimate is $50.40 in year 2000 prices, or $60.14 in year 2007 prices. Note also that the mean roundtrip price for a non-stop itinerary in our sample is $349.41 in year 2000 dollars.

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23 According to the US Department of Transportation, the average nominal yield for the entire US market in 2000 was 14.57 cents per mile.

The estimate of the dominance effect for average yield in the instrumental variable specification suggests that the non-dominant hub operators' average yields are about 5.5 percent lower than their dominant counterparts. Given the sample average yield for non-stop itineraries reported above, our estimate of the airport dominance effect is equivalent to about 1.40 cents per mile. The corresponding estimate of the hub effect implies that the non-dominant hub operator's yields for non-stop flights out the hub airport are 6.2 percent (1.58 cents per mile) higher than same for an airline not operating a hub but flying to/from a given airport. Thus, of the total of about 3 cents per mile average yield premium the dominant carrier is estimated to charge in our sample, about 53 percent is due to the hub operation of this airline, and 47 percent – due to airport dominance.

Coming back to our Atlanta-Denver example; our estimates suggest that due to the airport dominance effect, the dominant hub operators (Delta and United) will charge on average $33.60 in year 2000 prices more than the non-dominant hub operators (AirTran and Frontier) on the same route. The estimate of the hub effect tells us that all four airlines, due to operating hubs at one or the other endpoint, are able to charge $37.94 more than would a hypothetical carrier wishing to operate on this route outside of its general hub-and-spoke network. Note also that all these estimates are over and above the airline specific effects.

At the upper tail of the price distribution, however, the non-dominant hub operators enjoy about 6.3 percent premium over dominant airlines.[24] This amounts to 2.7 cents per mile, given that the average 'high yield' for non-stop roundtrip itineraries in our sample is 43 cents per mile. This translates into $64.80 price differential for our Atlanta – Denver non-stop roundtrip (the average 'high price' – weighted average fare plus standard deviation – for the non-stop roundtrip itineraries in our sample is about $602). While a hub operator on average enjoys a higher premium at the upper end of the yield distribution than in the middle (eighteen percent, or 7.74 cents per mile), there is strictly speaking no dominance effect to speak about. The magnitude of the hub premium at the upper end of yield distribution is then 21.8 percent, or 9.4 cents per mile. Thus, at the

24 An alternative interpretation – higher market power of the non-dominant hub operators – is not very plausible, since non-dominant operators' market shares are much lower than those of the dominant airlines.

upper end of the yield distribution, most (if not all) of the pricing premium of the hub operator can be attributed to the operation of the hub, and not the carrier's dominant position at the airport.

Note also that the airport-pair market fixed effects regressions not controlling for potential endogeneity paint a somewhat different picture. At the average yields, there is *no* hub premium. The hub operator's 'averaged' premium for its non-stop flights to/from the hub is still about 8 percent, the dominance premium is estimated at 15 percent, while there is no hub premium. At the upper end of the yield distribution, simple fixed effects regression suggests the airport dominance premium of almost 11.2 percent, and the hub premium of about 15.6 percent.

Notwithstanding the discrepancy between the fixed effects and the instrumental variable estimation results, there is clear evidence that the estimated airport dominance premium is smaller relative to the hub premium at the upper end of the price distribution than at the average fares. We should also note that of the two estimation approaches we tend to put more faith into the instrumental variable specifications – market concentration and market shares are clearly endogenously determined in the price regressions, implying that fixed effects least squares estimates will be both biased and inconsistent.

In general, we found that airlines enjoying the dominant position at an airport are able to extract the airport dominance premium from an *average* and more price conscious travelers. Premium charged to the higher paying customers appears to be related more to the fact that the airline operating a hub offers its customers a different product, perhaps the main differentiating characteristic of which is the access to a network of destinations other carriers do not offer, rather than to the carrier's market share at the hub airport.

The only real surprise in coefficients on the control variables is lower fares for direct flights in some specifications. The possible explanation of this result is that the direct flights in our sample are shorter than the one-stop itineraries, and the logarithm of distance alone does not cope with this well. Note that this counterintuitive relationship is far less common in the regressions where yield is used as a dependent variable.

One may find it strange that our results appear to suggest that firms on more concentrated markets charge lower fares. However, one has to note that our specifications include both market share and HHI, and that we examine price-setting at the individual airline rather than the market level. Holding the market share fixed, higher HHI simply means that competitors an airline faces in the market have become stronger. Expected effect of this change on fares charged by an individual carrier is actually uncertain. On one hand, more concentration can lead to all airlines involved raising their fares due to higher market power. On the other hand, stronger competitors may mean fiercer competition and lower fares to keep market share intact. The latter effect appears to dominate. Note also that higher market share holding HHI constant leads to higher fares, as expected. For instance, our results indicate that, other things equal, a monopoly airline's average yield will be 3.7 percent higher than same for an airline operating on a symmetric duopoly market.[25] For an airline holding 50 percent market share, a merger between the two competitors each holding 25 percent market share will imply – assuming the carrier still has 50 percent market share after the merger – a 4.5 percent decrease in average yield (HHI changes from 0.375 to 0.5 as a result of such a merger). The merged airline, however, will be able to command a 6.4 percent higher average yield as compared to what the carriers would have charged before the merger.

5.2 Interpretation

Let us discuss what our results tell us about the possible sources of pricing premiums charged by the airlines operating hubs at the airport. Our main result is that this premium applies to either airline operating a hub, whether it dominates the airport or not. Another result that appears robust is that the composition of the pricing premium is different at the upper end of the pricing distribution, with the airport dominance premium playing a lesser role than at the average fares/yields.

The proposed explanations of the dominant airline's pricing power at the respective airports included airport market share, product differentiation, airlines' loyalty programs, and control of scarce airport resources. While we are unable to directly comment on the latter, we can say that our results show two things. First, there appears to be something different in the product that the hub operators offer as compared to other airlines. Second, the firm's market share at the airport does play a role. At the same time,

[25] The calculation behind this is (0.437-0.363)*(1-0.5), where 0.437 is the regression coefficient for HHI, -0.363 is same for the market share, and 1 and 0.5 are both HHI and market share for monopoly and symmetric duopoly, respectively. The relevant regression from Table 3 is the IV specification for average yield.

the diminishing share of the airport dominance premium as we move up the fare distribution suggests product differentiation appears a more important determinant than the airport market share for the price insensitive consumers.

But, where are the frequent flier programs in this? The airlines do use their loyalty programs to reinforce product differentiation and extract some premium from their customers. Lederman (2008) exploited the airlines' frequent flier program partnerships to show that partner airlines without the dominant position at the airport are able to charge the fare premium just like the dominant carrier – that is, carriers offering a different product are able to charge premium prices despite lack of dominance. Our finding that the airport dominance premium becomes smaller, while hub premium grows more important at the upper end of the distribution is evidence that frequent flier programs play some role as the determinant of the hub operators' price premium. Indeed, at the upper end of the price distribution we are more likely to encounter tickets purchased by frequent business travelers, who appear to be paying premium for the product differentiation aspect of hub operations (potentially reinforced by loyalty programs) rather than the dominant carrier's market share.

Presence of the hub effect in the middle of the price distribution is subject to a number of interpretations. On one hand, we can suggest this is the evidence favoring the product differentiation story behind the hub premium. At the same time, we cannot rule out that the non-dominant hub operator's fares and yields could also include the market share based effect (non-dominant hub operators boast larger airport market shares than other carriers). Additionally, loyalty programs could also affect the non-dominant operator's fares in the middle of the price distribution.

At the lower fares, however, we can expect relatively little effect of the loyalty programs, assuming those tickets are predominantly purchased by the leisure travelers who simply go for the best price. Therefore, any hub effect observed at the lower fares is likely due to product differentiation rather than loyalty programs. Recall that our estimation results demonstrate no hub premium at the lower end of the price distribution, consistently with this expectation, so that leisure travelers are paying premium prices based on the higher market share of the dominant carrier.

Given the above considerations, we can conclude that the dominant airline's market share at the airport allows it to charge a premium pretty much across the entire price spectrum. At the same time, the airline operating a hub at the same airport but holding a smaller market share is able to charge the corresponding premium to the price insensitive customers. Further, as the hub premium is more visible at higher prices (and dominance premium disappears on that end of price/yield distribution), this suggests that the source of this premium for the non-dominant hub operator is predominantly in its frequent flier program rather than access to a network of destinations served with non-stop flights. We however admit that this statement is subject to a number of caveats, most importantly the assumption that prices observed at the high-end of the distribution represent trips by business travelers that are loyal to a particular airline.

These findings suggest the following implications. First, the sources of the pricing premium by the hub operator are frequent flier programs and airport market share – product differentiation might also play a role, but our evidence does not point to this consistently. Further, importance of the airport market share relative to frequent flier programs diminishes as we move to the higher fares. Higher magnitude of the total pricing premium on the upper tail of the distribution is consistent with previously reported findings that the dominant airline's pricing power applies more to the price insensitive than to average travelers. At the same time, we can claim that the dominant airline is able to charge premium prices to the business travelers thanks at least in part to the frequent flier program it operates. Most importantly, we demonstrate that any airline establishing a hub at an airport will be able, through its customer loyalty program (and presumably a product differentiation component), to attract some loyal price insensitive passengers and charge premium prices to them.

6. Conclusions

Airlines' ability to charge higher fares for flights to/from airports where they enjoy a dominant position has been a rather established fact More recent studies (Lee and Luengo-Prado, 2005; Berry et al., 2006) suggested that the observed airport dominance premium appears to apply to price-insensitive business travelers.

The goal of our study is to approach the issue of sources of dominant airlines' pricing power by separating the "hub effect" from the "dominance effect". We note that every large airport which is dominated by a single carrier also serves as a hub in the respective carrier's network. The "hub effect" may exist due to the fact that the airline operating a hub at an airport will offer its customers access to a larger network of non-stop flights, possibly reinforced by the hub operator's frequent flier program. Thus, we define "hub effect" as premium charged by a hub operator; and "dominance effect" is then price premium charged by the dominant airline above that due to its hub operation. Estimation of the two effects requires examining pricing at airports that serve as hubs for more than one carrier.

We use a sample of actual itineraries collected quarterly by the US Department of Transportation (this dataset is known as DB1B). For our analysis, we select non-stop and one-stop roundtrip itineraries that originate, terminate or go through one of the five airports which serve (or served) as a hub for two carriers: Atlanta, Chicago O'Hare, Dallas-Ft. Worth, Phoenix, and Denver. Data analysis shows that as we go from the lower to the higher prices, the total pricing premium increases, while the relative importance of the airport dominance component of this premium diminishes relative to the hub premium component. Further, while the source of the airport dominance premium appears to be the airline's dominance in terms of the airport market share (we cannot, however, exclude the possibility of the dominant airline's control of airport facilities as an explanation), the hub premium appears to be driven by the hub operators' frequent flier programs rather than by the potential product differentiation by itself.

We have effectively found additional evidence for the airlines' loyalty programs as a factor beyond the pricing premium charged by the dominant airlines at their hubs. Yet, we clearly show that any hub operator, and not only the dominant airline, is capable of creating the pricing 'umbrella' at the airport where it has established significant presence. We also demonstrate that airport dominance remains an important determinant of the respective airline's market power, due to either the carrier's airport market share, or access to the airport's facilities.

One will be right to question the applicability of our results outside of our sample. Especially interesting is the question of our study's implications for airports which are dominated by a single hub operator. Since identification of components of apparent fare premium will be impossible for such airports, we can only speculate on the distribution of the fare premium into the “hub effect” and “dominance effect” for those airports. We can, however, state that what this premium reflects is not only airlines exercising their market power, but also consumers’ willingness to pay for the extensive network of non-stop flights not available from other cities, reinforced by the frequent flier programs which enable customers to accumulate miles faster, other things equal.

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Appendix

Table A.1 Description of Variables

Dependent Variables	
Natural logarithm of passenger weighted fare	Weighted at the airline-routing level for each quarter. All fares are in year 2000 dollars
Natural logarithm of 'high' fare	Weighted fare plus the corresponding passenger weighted standard deviation, at the airline-routing level.
Natural logarithm of passenger weighted yield	Passenger weighted fare divided by the total roundtrip distance
Natural logarithm of 'high' yield	Passenger weighted fare plus the passenger weighted standard deviation, divided by the total roundtrip distance
Hub/ Airport Dominance Indicator Variables	
Hub Operator*Direct	Indicator variable for direct itineraries by an airline operating hub at an airport included into our analysis to/from the respective airport.
Dominant*Direct	Indicator variable for direct itineraries flown by a dominant airline to/from the airport at which it has dominant position (DL at ATL; UA at DEN; AA at DFW)
Non-dominant*Direct	Indicator variable for direct itineraries flown by a hub operator without the dominant position at the airport, to/from the respective airport (DL at DFW; F9 at DEN; FL at ATL)
Other Carriers*Direct	Indicator variable for direct itineraries flown by an airline not operating a hub at a given airport
(Carrier 1)*Direct; (Carrier 2)*Direct	Indicator variables for direct itineraries by hub operators in airports without the dominant airline (AA and UA at ORD; WN and HP at PHX). Used in regressions on respective sub-samples
Control Variables	
Distance	Total roundtrip distance, in miles
Direct Flights	Indicator variable for non-stop roundtrip itineraries
Market Share	Airline's market share, computed separately for non-stop and one-stop itineraries
HHI	Herfindhal-Hirschmann Index, computed separately for non-stop and one-stop itineraries
Population average	Geometrical average of endpoints' MSA population
Instruments	
Lagged HHI	One-year lagged Herfindhal-Hirschmann index, instrument for HHI
Mean market share on other routes	Instrument for market share. Computed as the average market share for airline's services out of a given airport (separately for non-stop and one-stop itineraries), excluding the current service.

In addition to the variables listed above; we have included year, quarter, year-quarter, and airline indicator variables into all regressions reported in the paper.

Table A.2 Assignment of Regional Carriers

Major Carrier	Regional Carrier
American Airlines (AA)	American Eagle* Executive Airlines* Regions Air Chautauqua Airlines Trans States
Alaska Airlines (AS)	Horizon Air*
Continental Airlines (CO)	ExpressJet Commutair Colgan Skywest
Delta Air Lines (DL)	ASA/ Atlantic Southeast Airlines* Comair* Skywest Chautauqua Airlines[a] Republic Freedom[b]
Northwest Airlines (NW)	Mesaba Airlines Express Airlines
United Airlines (UA)	Air Wisconsin[c] GoJet Shuttle America Trans States Skywest[d] Mesa Chautauqua Airlines Colgan[e]
US Airways (US)[f]	Air Wisconsin Chautauqua Airlines Mesa

Regional carriers that serve multiple majors are assigned based on hub identities.
Notes:
[a] Only routes involving cities in Florida and Raleigh-Durham (RDU)
[b] Only routes involving Orlando, FL (MCO)
[c] Only on routes involving Chicago O'hare (ORD) and Washington Dulles (IAD)
[d] Including routes involving Portland, OR (PDX), Medford, OR (MFR), and Eureka-Arcata, CA (ACV)
[e] Only routes involving Washington Dulles (IAD)
[f] The following airlines, which are observed in the database, are also assigned to US Airways: PSA Airlines, Piedmont, and America West

Table 1 Domestic Destinations Served by Main Airlines

	Atlanta		Denver		Dallas		Chicago		Phoenix	
	Delta	Air Tran	United	Frontier	AA	Delta	AA	United	America West	South west
July 1999	124	30	86	17	120	58	91	88	53	32
July 2000	134	29	80	20	120	63	96	96	54	37
July 2001	138	32	83	29	118	65	93	103	56	38
July 2002	138	36	80	29	119	60	96	84	55	43
July 2003	137	38	81	30	116	66	82	91	58	41
July 2004	137	42	75	36	126	72	109	116	56	42
July 2005	154	45	75	39	135	6[3]	110	119	56	45

Notes:

1. Numbers obtained from analysis of dataset T100 Segment for the US market
2. Includes destinations served by regional carriers operating under the major airline's name
3. In July of 2005, US Airways was technically the second-largest airline in terms of destinations served from DFW, with flights to seven airports.
4. America West merged with US Airways in September of 2005; transition to the "new" US Airways with PHX as one of the hubs was completed over the next two years.
5. No other carrier serves more than thirteen unique airports from any of the above gateways in July of any given year.

Table 2 Descriptive Statistics for Main Variables

Variable	Mean	Standard Deviation	Median
Price (Year 2000 dollars)	395.37	224.32	334.33
High Price (mean plus standard deviation)	542.10	259.51	453.31
Low Price (mean minus 1/3 standard deviation)	342.73	225.21	269.70
Yield, year 2000 dollars per mile	0.1488	0.1365	0.1094
High Yield	0.2069	0.1734	0.1605
Low Yield	0.1309	0.1353	0.0921
HHI	0.4845	0.2268	0.4380
Market Share	0.2661	0.2896	0.1454
Distance, miles roundtrip	3,263.5	1,472.0	3,106.0
Average Population	2,739,395	2,938,662	1,820,924

Note: construction of the sample is discussed in Section 4 of this paper

Table 3 Main Estimation Results

Variable	Price				Yield			
	Average		High		Average		High	
	FE	IV	FE	IV	FE	IV	FE	IV
Log(Distance)[5]	-0.146 (0.003)	-0.051 (0.006)	-0.039 (0.003)	0.116 (0.005)	-0.0004 (1.2E-06)	-0.0003 (2.0E-06)	-0.0003 (1.0E-06)	-0.0003 (1.7E-06)
Direct Flights	0.021 (0.004)	-0.074 (0.006)	0.240 (0.003)	0.079 (0.005)	0.086 (0.004)	-0.013 (0.006)	0.294 (0.003)	0.126 (0.005)
HHI	0.051 (0.005)	-0.363 (0.040)	0.048 (0.004)	-0.391 (0.033)	0.043 (0.005)	-0.363 (0.040)	0.041 (0.004)	-0.394 (0.034)
Market Share	0.141 (0.003)	0.441 (0.014)	0.185 (0.002)	0.711 (0.012)	0.141 (0.003)	0.437 (0.014)	0.185 (0.002)	0.714 (0.012)
Population Average	5.99E-09 (5.2E-10)	6.14E-09 (5.3E-10)	5.78E-09 (4.1E-10)	6.13E-09 (4.3E-10)	5.84E-09 (5.3E-10)	5.99E-09 (5.3E-10)	5.79E-09 (4.1E-10)	6.12E-09 (4.4E-10)
Hub Operator*Direct (A)	0.092 (0.002)	0.111 (0.002)	0.069 (0.002)	0.095 (0.002)	0.101 (0.002)	0.120 (0.002)	0.078 (0.002)	0.102 (0.002)
Dominant Airline*Direct (B)	0.031 (0.006)	-0.005* (0.006)	0.062 (0.005)	0.007* (0.005)	0.072 (0.006)	0.033 (0.006)	0.098 (0.005)	0.038 (0.005)
Non-dominant*Direct (C)	-0.141 (0.008)	-0.078 (0.009)	-0.071 (0.006)	0.051 (0.007)	-0.078 (0.008)	-0.021 (0.009)	-0.014 (0.006)	0.101 (0.007)
Other Carriers*Direct (D)	0.022 (0.006)	0.039 (0.006)	-0.093 (0.004)	-0.079 (0.004)	0.020 (0.006)	0.037 (0.006)	-0.092 (0.005)	-0.078 (0.005)
$\Delta^D = B - C$	0.172 (0.014)	0.073 (0.015)	0.133 (0.011)	-0.044 (0.012)	0.150 (0.014)	0.054 (0.015)	0.112 (0.011)	-0.063 (0.012)
$\Delta^H = A + \min\{B, C\} - D$	-0.071 (0.016)	-0.006* (0.018)	0.091 (0.012)	0.067 (0.013)	0.003* (0.016)	0.062 (0.017)	0.156 (0.015)	0.218 (0.012)
Adjusted R-squared	0.448	0.462	0.482	0.411	0.614	0.604	0.712	0.673
Number of Observations	634,895		538,501		634,895		538,501	

Notes:

1. Dependent variable is natural logarithm of price or yield. Average price/yield corresponds to passenger-weighted mean, as discussed in text; high price/yield is passenger-weighted mean plus standard deviation, as discussed in text.
2. FE stands for airport-pair market fixed effects model; IV is fixed effects model with instrumental variables.
3. All specifications include other control variables as indicated in the text, which are not reported.
4. Star indicates *lack of statistical significance* at 5 percent level.
5. Distance was used instead of log(distance) as independent variable in specifications with yield as the dependent variable.

Table 4 Results for the Lower End of the Price Distribution

Variable	Fixed Effects	Instrumental Variable
Distance	-0.0003 (1.0E-06)	-0.0003 (1.7E-06)
Direct Flights	0.0408 (0.0059)	0.0610 (0.0052)
HHI	0.0884 (0.0051)	-0.2480 (0.0717)
Market Share	0.1165 (0.0077)	0.0653 (0.0064)
Population Average	3.46E-09 (6.06E-10)	6.01E-09 (5.61E-10)
Hub Operator*Direct	0.0857 (0.0023)	0.0923 (0.0029)
Dominant Airline*Direct	0.0833 (0.0046)	0.0796 (0.0047)
Non-dominant*Direct	-0.0589 (0.0046)	-0.0814 (0.0069)
Other Carriers*Direct	0.0380 (0.0048)	0.0418 (0.0051)
$\Delta^D = B - C$	0.1422 (0.0092)	0.1610 (0.0116)
$\Delta^H = A + \min\{B, C\} - D$	-0.0112* (0.0161)	-0.0309 (0.149)
Adjusted R-squared	0.7979	0.7927
Number of Observations	538501	

Notes:

1. Dependent variable is natural logarithm of passenger-weighted mean minus one third of standard deviation of the same.
2. All specifications include other control variables as indicated in the text, which are not reported.
3. Star indicates *lack of statistical significance* at 5 percent level.