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The Impact of Passenger Mix on Reported "Hub Premiums" in the U.S. Airline Industry

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This paper analyzes U.S. airline price and passenger data disaggregated at the fare class level for the year 2000. We find that although average prices to and from most airlines' hubs tend to be higher than those throughout the remainder of their systems, much of the difference can be explained by passenger mix (i.e., the proportion of leisure versus business passengers). Our results suggest, therefore, that many of the reported "hub premiums" in the previous literature may be overstated.

JEL Classification: L11, L93

1. Introduction

One of the most actively debated issues in the U.S. airline industry since its deregulation in 1978 has centered around the prices charged by network airlines for service to and from their hub airports. This topic, known as the "hub premium" debate, stems from the belief held by many travelers that they are being overcharged by network airlines on flights to and from their respective hubs.[1] In addition to much anecdotal evidence, numerous U.S. Government studies (e.g., U.S. Department of Transportation 1990; U.S. General Accounting Office 1990; U.S. General Accounting Office 1999) have found that average fares at concentrated hub airports tend to be higher—often substantially—than at other nonhub airports. For example, the U.S. General Accounting Office (1999) reported that average fares at one hub were 83% higher than the national average, and another recent study (U.S. Department of Transportation 2001) went so far as to refer to hubs as "pockets of pain."

The existing literature has studied and attempted to quantify the hub premium using—for the most part—one of two approaches. One set of studies (e.g., Morrison and Winston 1995; Morrison and Winston 2000) analyzes a cross section of airports and relates airport concentration to average fares. These studies improve on initial studies by the U.S. General Accounting Office (1990) and the U.S. Department of Transportation (1990) by attempting to control for factors known to impact average fares, such as average distance, the proportion of connecting passengers, and frequent flyer

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[1] See, for example, "High Air Fares Getting Attention," *Cincinnati Enquirer,* December 20, 1999, "Flying Into Pockets of Pain: How Hub Airports Keep Fares High," *USA Today,* February 23, 1998, or "Behind These Sky-High Fares," *Denver Business Journal*, April 30, 1999.

tickets. A second set of studies (e.g., Borenstein 1989; Evans and Kessides 1993) disaggregates data at the carrier and market level, thus controlling for structural differences between markets, and attempts to distinguish between market and airport characteristics as sources of potential pricing power.[2] In general, this latter group of studies argues that high concentration by a single airline at an airport can lead to entry barriers in the form of frequent flyer programs, travel agency commission overrides, and long-term leases on gates and airport facilities, among others, thus dampening nonstop competition and allowing the hub airline to charge supracompetitive fares. Borenstein (1989) also suggests that ownership of computer reservation systems (CRSs) serves as an entry barrier by allowing large network airlines to bias the information presented to both travelers and travel agents in favor of their own service.[3]

None of the mentioned studies, however, has directly controlled for the passenger mix (the proportion of leisure versus business travelers)—which is known to affect average fares—and thus, the estimation results in studies such as Borenstein (1989) and Evans and Kessides (1993) may suffer from omitted variable bias. Network airlines have long argued that average fares are higher in markets to and from their hubs compared to other markets within their networks because a greater proportion of passengers traveling to and from their hubs are business travelers, purchasing more flexible—and much more expensive—unrestricted tickets. Unrestricted tickets offer a number of attributes that make them both more attractive to customers as well as more costly for airlines to provide. For example, unrestricted tickets may be changed without any fees, are fully refundable, can be purchased at the last minute, and, depending on the airline and/or the traveler's frequent flyer status, may provide the traveler with a free first-class upgrade. Because unrestricted tickets can cost several times as much as restricted coach tickets, network airlines argue that even a few extra unrestricted passengers per flight can have a relatively large impact on average fares. For example, an Expedia.com search for restricted, roundtrip, nonstop coach class tickets between Boston and Los Angeles yielded fares of $281, $295, and $295 on Delta, American, and United, respectively. For unrestricted coach class tickets on the same flights, the fare was $2583.50 on the same three carriers.[4]

Most recent hub premium studies acknowledge that passenger mix may impact average fares, so it is somewhat surprising that only one study (Gordon and Jenkins 2000) has explicitly attempted to control for this factor.[5] Using proprietary data from Northwest Airlines, the authors found that after controlling for passenger mix, distance, and the number of stops, Northwest's hub passengers receive a hub discount compared to Northwest's passengers traveling throughout the rest of its network. This study, however, only focuses on Northwest Airlines, and its methodology has been subject to criticism (for example, the authors treat passengers connecting from one of Northwest's regional partners as hub-originating passengers). Thus, after more than a decade of debate, the hub premium controversy is still largely unresolved, a point echoed in a recent study by the Department of Transportation's Volpe Center:

> In analyzing these questions, researchers have employed various data sources and measurement techniques. Their studies also cover different time periods and use varying methods to control for

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[2] Whereas Borenstein (1989) finds evidence that concentration at either the market or airport level results in higher average fares, Evans and Kessides (1993), using a fixed-effects approach, find that a high market share at the market level does not confer pricing power, but high concentration at the airport level does. Other studies in this category include Berry, Carnall, and Spiller (2006).

[3] It should be noted that the major U.S. airlines divested the majority of their CRS holdings during the 1990s.

[4] Search performed on March 20, 2002 for travel April 19–24, 2002.

[5] Several authors have attempted to indirectly control for passenger mix. For example, Borenstein (1989) includes a tourist index, and Morrison and Winston (1995) exclude markets to and from popular tourist destinations.

> the factors that influence an airline's costs and travelers' demands for their services in order to isolate the degree to which airlines can set and maintain fares above competitive levels. None of these studies, however, has successfully isolated or controlled for differences in airlines' costs or in passengers' willingness to pay for different levels of service. As a result, the extent to which airlines are able to use "market power" to maintain high fares for trips to and from their hub airports remains controversial. (U.S. Department of Transportation 2000, p. 2.)

The purpose of this paper is to investigate the impact of passenger mix on the hub premium using fare data that have been disaggregated at the booking class level. To the best of our knowledge, this study is the first of its kind to use publicly available data that have been disaggregated at the fare class level.[6] At the outset, it is important to note that there is no universally accepted definition of the hub premium. Some studies are interested in the degree to which average fares (pooling all airlines) differ at hubs versus other airports (e.g., Morrison and Winston 1995; Morrison and Winston 2000), whereas others focus on comparing the prices of a network carrier's hub markets versus the prices of all airlines in otherwise similar markets (e.g., Borenstein 1989; Evans and Kessides 1993). In this paper, we define the hub premium explicitly as the ability of a given network airline to charge passengers in the same fare category more per mile in markets to and from its hubs than on otherwise similar markets throughout the remainder of its network (i.e., those markets that connect via one of its hubs or are between two nonhub airports). The prices in markets that neither originate nor terminate at a hub are widely considered to be good competitive benchmarks because the overwhelming majority of these markets are "spoke-to-spoke" markets that do not offer nonstop service but provide competing one-stop service from numerous hubbing carriers. Thus, our approach differs from most other hub premium studies in that our primary focus is on comparing prices across different markets for a given airline. By focusing our analysis on the prices of a given airline, we can effectively control for the variations in cost and quality of service across different airlines. Even among the six "full service" airlines we consider in this paper, costs and quality of service can differ significantly. For example, American, Continental, and Delta all use Boeing 737-800 aircraft in two-class configurations. However, Delta and Continental configure their 737-800 aircraft with 154 and 155 seats, respectively, whereas American uses 134 seats, thus increasing unit costs and improving product quality.[7] Moreover, it is important to emphasize that because the primary focus of our analysis compares fares within a given carrier, our main results do not depend on whether or not airlines use the same definitions of fare codes for Department of Transportation reporting purposes, a concern that has often been expressed by researchers relying on the U.S. Department of Transportation (DOT) data. For comparative purposes, we also estimate pooled ordinary least squares (OLS), two-stage least-squares (2SLS) regressions as well as fixed effects models similar to those of Borenstein (1989) and Evans and Kessides (1993).

In general, we find that much of the observed hub premiums can be explained by passenger mix. Indeed, controlling for passenger mix reduced the average hub premium at major U.S. hubs (i.e., those hub airports where over 50% of passengers make connections) from 19.5% to 12.2%. Likewise, we find evidence that some carriers are successful at extracting additional hub premiums from first,

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[6] The data relied on by Borenstein (1989) have some disaggregated fare information because he analyzes the 20th, 50th, and 80th percentile fares. However, the hub premium results reported in his table 1 are limited to average fares. Moreover, the proportion of leisure and business travelers varies widely across markets, and hence, although the 80th percentile fare may represent a business traveler in some markets (i.e., Boston to Washington, DC.), it may represent a leisure passenger on others (i.e., Buffalo to Orlando). Evans and Kessides (1993) use all "coach" fares; however, the overwhelming majority of "business" fares are in fact unrestricted coach fares, and thus, for all intents and purposes, their sample includes both types of travelers.

[7] Source: Airline websites.

business, and unrestricted coach (premium) passengers. In general, our findings are consistent with Ramsey pricing: leisure travelers have much more price-elastic demand than business travelers, and thus, the less convenient and lower quality connecting service offered by competing carriers is likely to have a greater disciplining effect on restricted coach fares than on premium fares for service to and from hubs.[8] Results from pooled estimation also show that indirectly controlling for passenger mix by using market fixed effects significantly reduces estimated hub premiums.

Although passenger mix is an important element in understanding the hub premium debate, we stress that our analysis does not account for a number of other quality of service factors—and their associated time savings—that likely impact average prices at hubs such as greater flight frequency or preferences for nonstop service. Moreover, our analysis does not consider the effect of frequent flyer tickets.[9] Indeed, in light of the fact that we do not control for these factors, our estimated hub premiums are likely overstated relative to the constant-quality premiums.

Finally, we emphasize that our results are consistent with the long-observed practice of price discrimination in the airline industry. However, as has been recently pointed out in the context of the airline industry (among others), price discrimination need not imply market power (Levine 2002; Baumol and Swanson 2003). To the contrary, Baumol and Swanson (2003) argue that in markets where price discrimination is feasible and competitive pressures are suffciently strong, firms with high fixed costs must price discriminate to ensure their survival.

The remainder of this paper is organized as follows. Section 2 outlines the origins of the hub premium debate. Section 3 provides an overview of the data used for this study and presents preliminary findings. Section 4 summarizes the estimation results for individual, pooled, and fixed-effects regressions by fare class. Section 5 provides concluding remarks.

2. Origins of the Debate

The modern hub premium debate is rooted in airport level summary statistics linking above average fares at hub airports to various measures of concentration. Consider, for example, Table 1, which compares the average price per mile charged by hub carriers at their hubs, origin and destination (O&D) passenger shares, aircraft departure shares across the main U.S. airline hubs, and the largest 100 nonhub airports.[10] The hubs in Table 1 are ordered based on the percentage of the hubbing carrier's passengers making connections at the respective airport. Throughout this paper, we refer to those hubs where the connecting proportion is at least 50% as "primary hubs," whereas those hubs with a connecting proportion less than 50% are referred to as "secondary hubs."[11]

Although Table 1 demonstrates that average prices to and from hubs tend to be higher than those at other large U.S. airports, studies such as Morrison and Winston (1995) have shown that a simple comparison of average fares across airports can be misleading because it fails to control for a number of factors known to impact fares, such as the proportion of passengers traveling nonstop (presumably a higher-quality product), the proportion of travelers choosing to purchase more flexible—and more expensive—unrestricted tickets, average distance, frequent flyer awards, and market density. Table 2

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[8] For discussions of Ramsey pricing in the context of the airline industry, the reader is referred to Levine (2002) or Transportation Research Board (1999).

[9] Morrison and Winston (1995) found that controlling for frequent flyer awards (the majority of which are redeemed by hub-originating passengers) reduces the hub premium by 2.5 percentage points.

[10] O&D passengers are those who are either beginning or ending their journey at the given airport, and thus, O&D shares exclude "flow" passengers, that is, those who are merely connecting through that airport.

[11] We also include Chicago O'Hare as a primary hub for United.

Table 1. Major U.S. Airline Hubs: Some Key Statistics

		Hub Carrier Statistics			
	Hubbing Carrier	Percentage of Passengers Changing Planes	Average Price Per Mile (cents)	O&D Passenger Share (%)	Share of Domestic Aircraft Departures (%)
Largest 100 Non-Hubs	N/A	10.6	27.1	40.6	38.4
Primary Hubs					
Charlotte (CLT)	US Airways	78.4	52.7	68.3	87.2
Memphis (MEM)	Northwest	76.9	35.4	48.3	72.5
Cincinnati (CVG)	Delta	75.3	45.9	75.5	90.9
Pittsburgh (PIT)	US Airways	68.0	53.4	68.3	81.2
Atlanta (ATL)	Delta	64.7	33.5	61.3	75.8
Salt Lake City (SLC)	Delta	63.3	19.6	51.0	66.2
Dallas (DFW)	American	59.2	30.7	54.7	70.4
Denver (DEN)	United	59.0	29.2	50.0	71.8
Houston (IAH)	Continental	56.4	28.2	64.6	82.2
Minneapolis (MSP)	Northwest	53.3	31.0	61.0	81.0
Detroit (DTW)	Northwest	50.9	35.2	55.9	81.0
Chicago O'Hare (ORD)	American	50.0	30.2	32.0	43.4
Chicago O'Hare (ORD)	United	48.9	30.2	44.3	45.1
Secondary Hubs					
Philadelphia (PHL)	US Airways	41.9	44.4	50.8	62.5
Cleveland (CLE)	Continental	38.5	37.1	46.5	71.6
Miami (MIA)	American	38.2	22.4	39.2	62.2
Washington Dulles (IAD)	United	37.6	26.7	41.0	45.9
San Francisco (SFO)	United	26.5	23.1	44.9	53.3
Newark (EWR)	Continental	13.1	33.8	53.9	64.0

Calculations using domestic itineraries excluding interline, zero fare, and frequent flyer tickets. O&D Passenger Shares represent the hub carrier's market share of all passengers either beginning or ending their journey at the given hub airport. Share of domestic aircraft departures based on hubbing carrier's share of mainline aircraft departures at the given hub. Average price per mile includes all fees and taxes and is based on nonstop distance between airports. Passenger and aircraft departure shares for the Largest 100 Non-Hubs are computed as the average across airports of the maximum share at each airport. Source: U.S. DOT T100 and OD1B Databases, 2000.

illustrates how some of these factors varied across the networks of the six largest hub-and-spoke airlines in 2000. For example, Table 2 shows that a considerably higher proportion of passengers flying to and from hubs fly nonstop compared to nonhub passengers. Likewise, on average, hub passengers tend to fly shorter distances than their nonhub counterparts. Table 2 is also consistent with the assertion made by airlines that a greater proportion of passengers traveling to and from hubs purchase premium tickets compared to passengers in markets neither originating nor terminating at an airline's hub (i.e., the system remainder).

One question that comes to mind is whether or not hub cities generate proportionally more business travelers or whether the higher proportion of premium tickets is simply the result of airlines using their sophisticated yield-management systems to make fewer discount seats available on flights to and from their hubs, thereby "forcing" significant numbers of passengers to purchase less restrictive—and significantly more expensive—premium tickets than they would otherwise want to purchase. For the purposes of our analysis, we believe that it is reasonable to treat the fare class a passenger travels in (i.e., restricted coach or premium) as exogenous. The primary reasoning behind our assumption is as follows. First, it is well understood that hub-and-spoke carriers have successfully created techniques to differentiate between business and leisure passengers (such as 14- or 21-day

Table 2. Some Possible Explanations for Observed Higher Prices At Hubs

	Percentage of Passengers Flying Nonstop	Percentage of Passengers Using Premium Tickets	Percentage of Carrier's Total O&D Passengers	Median Passenger Trip Length (Miles)
American				
Dallas (DFW[a])	95.2	27.6	22.8	937
Chicago O'Hare (ORD[a])	93.8	25.2	17.8	802
Miami (MIA)	86.6	21.0	7.0	1,097
System Remainder	39.6	19.2	52.4	1,411
Continental				
Houston (IAH[a])	95.5	9.9	23.8	964
Cleveland (CLE)	91.4	14.1	12.5	622
Newark (EWR)	95.3	15.1	35.5	1,008
System Remainder	3.8	5.0	28.2	1,301
Delta				
Cincinnati (CVG[a])	87.3	28.9	5.3	623
Atlanta (ATL[a])	95.1	14.9	24.3	606
Salt Lake City (SLC[a])	80.0	6.1	6.5	630
System Remainder	31.2	9.3	63.9	1,005
Northwest				
Memphis (MEM[a])	85.0	23.0	5.4	683
Minneapolis (MSP[a])	93.0	18.0	26.1	980
Detroit (DTW[a])	93.3	13.4	25.6	534
System Remainder	2.0	7.8	42.9	1,182
United				
Denver (DEN[a])	89.3	12.9	16.1	905
Chicago O'Hare (ORD[a])	93.4	21.6	22.2	837
Washington Dulles (IAD)	79.2	17.0	6.3	1,452
San Francisco (SFO)	84.3	28.3	18.2	678
System Remainder	21.5	16.1	37.2	1,368
US Airways				
Charlotte (CLT[a])	88.7	44.4	8.0	543
Pittsburgh (PIT[a])	85.2	37.7	9.4	467
Philadelphia (PHL)	84.5	33.0	15.0	678
System Remainder	37.1	23.7	67.6	722

[a] Denotes a primary hub for the respective carrier. Calculations using domestic itineraries excluding interline, zero fare, and frequent flyer tickets. "Premium" tickets include unrestricted coach, business, and first class. System Remainder includes all passengers not traveling to/from one of the airline's hubs. "Percentage of Carrier's Total O&D Passengers" represent the proportion of the carrier's total passengers either starting or completing their travel at the given hub. Source: U.S. OD1B and T100 Databases, 2000.

advance purchase requirements, ticket refundability, or Saturday-night stay requirements). Therefore, carriers have (especially in 2000, the year of our data) driven a large wedge between the average restricted coach fare and average premium fare in most markets. Indeed, in our sample of markets, the average premium fare is nearly three times as expensive as the average restricted coach fare.[12] The large gap that exists between restricted coach and premium fares implies—in our view—that few

[12] The median ratio (across markets) of the average premium to average restricted coach fare in our dataset is: American (2.28), Continental (3.28), Delta (2.83), Northwest (2.77), United (2.58), and US Airways (2.23).

leisure passengers would be willing to purchase premium tickets even if no restricted coach fares were available.[13] Rather, passengers faced with such a large difference in fares would likely choose to fly on another carrier or take a connecting rather than a nonstop flight. Although we believe it is fairly unlikely that the "average" restricted coach passenger would be willing to pay the "average" premium fare rather than fly on another carrier or take a connecting flight, what about passengers at the top end of the restricted coach passenger distribution? Is it possible that they might be forced to purchase premium tickets as a result of inventory management? Again, we believe the data support our assumption of fare class exogeneity. This is because there is a fairly significant, discrete jump between the highest restricted coach fares and the lowest premium fares in most markets. In particular, we compute the ratio of the 20th percentile premium fare to the 80th percentile restricted coach fare for each of the markets in our dataset. The mean value of this ratio for the carriers in our dataset was: American (1.26), Continental (2.34), Delta (1.84), Northwest (1.97), United (1.57), and US Airways (1.24). This implies that, on average, passengers paying the lowest premium fare in a market are still paying 70% more than the passengers paying the highest restricted coach fare.[14]

Moreover, although an analysis of whether or not carriers systematically restrict discount seats more at their hubs than elsewhere throughout their networks is not possible using U.S. DOT data, Gordon and Jenkins (2000) also analyzed a snapshot of Northwest's seat inventory data and found no evidence that Northwest made fewer discounted seats available in markets to and from its largest hub (Minneapolis–St. Paul) compared to the remainder of its network.[15] Likewise, data from the DOT's 1995 American Travel Survey confirm that hub cities, in general, generate a lower proportion of vacation travel than nonhubs. For example, for all travelers in the survey traveling by air, we computed the proportion, by destination, who stated that the primary purpose of their trip was "vacation." Of the 18 hub cities listed in Table 2, only four (San Francisco, Denver, Salt Lake City, and Miami) had vacation proportions above the median value for the 161 MSAs in the survey (0.459), and eight hub cities were in the bottom quartile. Finally, the rapid growth of low-cost carriers such as Southwest Airlines and the advent of Internet-based travel websites such as Orbitz or Expedia that allow travelers to easily search for the lowest available fare across carriers in any given market have made it much more difficult for network carriers to use their yield-management systems to systematically force a significant proportion of hub-originating (or -destined) leisure passengers to purchase less restrictive—and consequently much more expensive—premium tickets.

3. Is There Evidence of a Hub Premium?

Our objective is to determine whether or not the six largest U.S. network airlines systematically charge higher prices to passengers traveling to and from their hubs compared to those traveling throughout the remainder of their networks after controlling for fare class, distance, and other factors. That is, is there evidence of a hub premium?

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[13] As an example, the average roundtrip premium fare in our dataset for Delta between San Francisco and Cincinnati (its hub) is $1820, whereas the average restricted coach fare is $436. Likewise, US Airways' average roundtrip fare between Pittsburgh (its hub) and Boston was $733 for premium passengers, and only $242 for restricted coach passengers.

[14] Even the carriers with the lowest ratios—American and US Airways—have fairly large jumps (i.e., 25%) considering the ratio is between the top quintile of restricted coach fares and the lowest quintile of premium fares.

[15] In particular, Gordon and Jenkins (2000) analyzed a sample of Northwest's proprietary inventory data and found that "on March 13, 1999, 88 percent of discount fares were available for April 1999 travel on Northwest's Minneapolis hub routes, slightly more than the 87 percent of the same fares available for the same travel period on routes connecting through Minneapolis."

Data

The data for this study are taken from the U.S. Department of Transportation's OD1B Origin and Destination Survey for the calendar year 2000, which represents a 10% sample of all tickets reported by U.S. Scheduled Passenger Carriers (a detailed description of how our data set was compiled is contained in the Appendix). For the purposes of this study, we consider all domestic passengers in 2000 traveling on round-trip and one-way itineraries with three or fewer flight coupons per directional trip leg.[16] Moreover, we excluded zero fare, bulk fare, and frequent flyer itineraries from our analysis. To account for possible coding errors in the raw DOT data, we also exclude tickets in which the price paid was less than 2.0 cents per mile for restricted coach and 5.0 cents per mile for unrestricted coach, business, or first class. From the "directional" itineraries in the OD1B data, we construct nondirectional airport-pair markets.[17] Thus, a market is a unique pair of airports that does not distinguish point of origin or the particular routing—i.e., nonstop Boston-to-Seattle passengers travel in the same market as Seattle-to-Boston passengers making a connection in Chicago. Note, therefore, that each market, as we have defined it, consists of potentially many "routings," depending on the connecting point(s).

We first aggregate business and unrestricted coach class tickets into a single "premium" fare-type category. Although the majority of premium tickets in our sample are unrestricted coach tickets, we believe that it is important to aggregate the three types of tickets together (first, business, and unrestricted coach) because carriers have largely blurred the distinction among these categories of premium tickets in many domestic markets. For example, a query for "Coach (Flexible)" tickets between Atlanta and either Boston or New York's LaGuardia airport on Delta Air Lines' website (Delta.com) returns primarily first class tickets, most of which have the same price as (or are less expensive than) the unrestricted coach class tickets Delta.com also offers.[18] Approximately 82% of all of the passengers in our sample traveled on restricted coach fares, and roughly 18% used premium fares. When an itinerary consisted of multiple coupons with different fare classes, the fare class of the longest distance coupon was used. Because the variance in the number of passengers for a given carrier across markets is fairly large, we consider only those airline-market pairs where the carrier served at least 100 restricted coach and 100 premium passengers.

Our measure of price is the price paid per mile, inclusive of all taxes and fees. In computing the price per mile, we use the nonstop distance between the two endpoint airports because passengers are not expected to want to pay more for circuitous routings.

Preliminary Findings

Table 3 summarizes the price differences paid by travelers for each of the six largest network carriers in markets to and from their respective hubs compared to travel throughout the remainder of their networks by fare class category. The percentage differences from the system remainder represent, by hub and fare class, the difference that passengers traveling to and from the hub paid

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[16] A separate flight "coupon" is required for each flight with a unique flight number on a given itinerary. We exclude "interline" passengers (those using multiple marketing carriers on a single itinerary), "open-jaw" (i.e., BOS-LAX-JFK) and "circle" (i.e., BOS-LAX-SFO-BOS) itineraries. The proportions of passengers flying on one, two, and three coupon directional legs are 64.25%, 34.33%, and 1.42%, respectively.

[17] While Evans and Kessides (1993) use "city-pair" markets (i.e., combine airports within a given city), we follow Borenstein (1989) in using "airport-pair" markets because we are interested in studying potential pricing power to and from particular hub airports.

[18] Likewise, a significant number of first-class tickets are sold as "Y-UP" tickets, where passengers pay the full unrestricted (i.e., "walk-up") coach fare but receive a first-class ticket.

Table 3. Price per Mile Percentage Differences from System Remainder

	Hubbing Carrier	All Passengers (a)	Restricted Coach (b)	Premium (c)
Primary Hubs				
Charlotte (CLT)	US Airways	51.8	22.5	34.1
Cincinnati (CVG)	Delta	48.7	26.0	14.8
Pittsburgh (PIT)	US Airways	40.5	21.7	34.8
Denver (DEN)	United	40.0	40.7	73.1
Dallas (DFW)	American	31.0	21.0	28.1
Chicago O'Hare (ORD)	United	29.1	6.6	59.8
Houston (IAH)	Continental	20.0	25.9	17.1
Chicago O'Hare (ORD)	American	20.0	6.4	36.8
Minneapolis (MSP)	Northwest	12.5	7.9	5.0
Atlanta (ATL)	Delta	10.7	12.9	9.4
Memphis (MEM)	Northwest	8.5	0.5	−3.6
Salt Lake City (SLC)	Delta	−12.1	−2.9	−2.5
Secondary Hubs				
Washington-Dulles (IAD)	United	38.1	35.9	42.6
Philadelphia (PHL)	US Airways	32.9	24.7	28.9
Newark (EWR)	Continental	29.6	33.8	19.4
Cleveland (CLE)	Continental	25.1	28.5	23.7
San Francisco (SFO)	United	16.0	9.7	8.7
Miami (MIA)	American	2.1	−4.2	1.5
Detroit (DTW)	Northwest	−3.2	8.9	9.7

Calculations using domestic itineraries excluding interline, zero fare, and frequent flyer tickets. Premium includes first, business, and unrestricted coach passengers. The sample focuses on city-pair markets where the carrier had at least 100 unrestricted coach and 100 premium passengers. Percentages represent price per mile differences to and from hubs versus system remainder. Average prices per mile are computed by 250-mile bands and are passenger weighted. Source: U.S. DOT OD1B Database, 2000.

vis-à-vis passengers traveling throughout the remainder of that airline's network. In computing these price differences, we first compute the average price per mile using 250-mile bands for each airline to and from each of their hubs as well as throughout the remainder of their respective networks. We then calculate the percentage price difference at each hub versus that carrier's system remainder by mileage band. Finally, we compute the average percentage price difference at each hub by weighting each of the mileage-band specific price differences by the number of passengers traveling to or from that hub within the given mileage band. Thus, column (a) of Table 3 indicates, for example, that US Airways passengers traveling to and from Charlotte (CLT) paid, on average, 51.8% more than what US Airways' passengers paid for travel in comparable distance markets that neither originated nor terminated at any of US Airways' primary or secondary hubs. This could include, for example, connecting passengers traveling on US Airways from Austin to Fort Lauderdale or nonstop passengers traveling from Washington-National to Orlando.

The most direct comparison in the literature to the figures in column (a) of Table 3 are those reported in Borenstein (1989, table 1). In general, the fare class pooled hub premium figures in Borenstein (1989) tend to be somewhat higher than those reported in column (a) of Table 3—the notable exception being US Airways to and from Pittsburgh, which Borenstein (1989) finds to be 16.6% higher than the remainder of USAir's network, versus 40.5% in our Table 3. This difference is likely related to USAir's acquisition of Piedmont Airlines, which was completed in 1989. For the other hubs that can be compared directly, we find the following [Borenstein 1989, table 1, versus column (a)

in Table 3]: American at DFW (41.8% vs. 31.0%), Delta at ATL (56.1% vs. 10.7%), Northwest at MSP (21.7% vs. 12.5%), and United at ORD (40.7% vs. 29.1%). Thus, on a fare class aggregated basis, the unadjusted hub premiums at four of the five airports common to both studies appears to have declined since 1987 (the date of Borenstein's data). The large change in the pooled hub premium at Atlanta is almost certainly related to the growth of low-cost carrier AirTran (formerly ValuJet), which did not exist in 1987, but whose market share of O&D passengers at Atlanta had reached 14.1% by 2000.

The importance of controlling for passenger mix when attempting to quantify the hub premium can be seen by comparing column (a) to columns (b) and (c) in Table 3, which summarize the data for restricted coach and premium passengers separately. For restricted coach passengers (b), we see that the average percentage differences decline (relative to column a) at 12 of the 19 hubs. For Miami and Salt Lake City, the average price difference is negative, implying that restricted coach passengers originating or terminating at these hubs pay less per mile, on average, than their nonhub counterparts. At other hub airports such as Chicago O'Hare, Minneapolis, and Memphis, the average price difference is small (i.e., less than 8% for restricted coach passengers). Unlike Gordon and Jenkins (2000), we do not find—on average—that restricted coach passengers receive a hub discount at Northwest's three hubs, although the average premium is very small (i.e., roughly 6%) and is the lowest among the six carriers. On average, controlling for passenger mix reduces the average price difference from 25.1% to 15.8% for restricted coach passengers at primary hubs compared to the pooled (i.e., column a) results. For premium passengers (column c), the average price difference declines relative to column (a) at 14 of the 19 hubs (including 9 of the 12 primary hubs) but increases sharply at Chicago O'Hare (for both United and American) and Denver. Our results for Northwest's premium passengers are effectively the same as those of Gordon and Jenkins (2000), who found an average premium of roughly 2–3% across Northwest's three hubs.

It is important to note that the average price difference can decline—relative to column (a)—for both restricted coach and premium passengers at a given hub, and that this, in fact, is the case at 9 of the 19 hubs (and half of the primary hubs) in our sample. This is because premium tickets may cost several times as much as restricted coach tickets, and as indicated in Table 2, the proportion of passengers purchasing premium tickets is typically higher for travel to and from hubs than throughout the remainder of a carrier's network. When fares are aggregated across passenger types, the higher proportion of premium fares at the hubs—relative to the system remainder—results in average prices being biased upward at the hubs relative to the system remainder. Disaggregating passengers by fare class, however, allows us to remove this bias because premium (or restricted coach) tickets at the hubs are only being compared to premium (or restricted coach) tickets throughout the system remainder.

Although the results in Table 3 are illuminating, care must be taken in their interpretation. To begin with, a significantly greater proportion of passengers in the control group (i.e., the system remainder) are connecting, rather than nonstop, passengers and thus are effectively receiving a lower quality product than those passengers traveling to and from the various hubs. As seen in Table 2, the percentage of passengers flying nonstop to and from the 19 hubs in our analysis ranges from 79.2% at Washington-Dulles to 95.5% at Houston Intercontinental. Conversely, the proportion of the carriers' passengers flying nonstop throughout the remainder of their respective networks ranges from roughly 2% on Northwest to 39.6% on American. Second, during our sample period, United, Delta, and US Airways all had significant "low fare" divisions in their networks designed to compete directly with Southwest Airlines and other low-cost carriers. These divisions, known as Shuttle by United, Delta Express, and US Airways MetroJet, operated in short- and medium-haul markets, primarily along the East and West Coasts and to and from Florida. Because a disproportionate share of flights operated by these low-fare divisions neither originated nor terminated at one of their parent carrier's hubs—the one main exception

being Shuttle by United at San Francisco (SFO)—the average fares paid by the control group passengers (i.e., the system remainder) in markets of 1,250 miles or less will tend to be biased downward for these carriers, thus inflating the hub price differences. Third, the differences at Chicago O'Hare (ORD) vis-à-vis the remainder of American's and United's systems are likely to be biased upward because Chicago O'Hare was one of four airports in the United States operating under the High Density Rule in 2000, and thus, prices to and from O'Hare likely reflect the additional cost of acquiring slots or the scarcity rents caused by government-imposed limits on the number of flights.[19] Finally, Table 3 does not reflect the differences in average market density (the number of O&D passengers per day) across the various hubs.[20] For example, the median density on markets that Delta serves nonstop from Atlanta is 187 per day, compared to a median market density of 51 per day at Cincinnati. Similarly, the median market densities at Charlotte and Pittsburgh (US Airways' two primary hubs) are 127 and 128 passengers per day, respectively, compared to a median density at Philadelphia of 357. Because less dense markets necessitate the use of smaller aircraft with higher per seat-mile operating costs, markets served to and from hubs in small cities will tend to have higher costs, and hence prices, compared to hubs in larger cities.

In sum, even after controlling for passenger mix and distance, the observed price differences for travel to and from hubs compared to the remainder of each carrier's system will tend to be overstated in columns (b) and (c) because they do not control for a number of factors, many of which impact product quality or costs. Finally, we should emphasize that care must be taken when comparing the results of Table 3 across carriers because the premiums at each carrier's hubs are relative to the prices paid in the remainder of their own networks. Thus, although a given carrier may have small (or negative) hub premiums relative to the remainder of its own network, the absolute prices at its hubs may be higher than at other carriers' hubs if its overall prices tend to be higher.

4. Estimation of Hub Premiums

Our approach to assess the effect of hubs on airline prices is to estimate a price equation. In this equation, an appropriate measure of price for a given market and airline is regressed on hub indicators, measures of competition and control variables that may influence the cost and demand characteristics in that market. Thus, the price equation can be thought of as a reduced form specification in which demand and supply characteristics of the market are included as explanatory variables.

In general, the approach used in the literature to estimate airline price equations has been to pool the data of different carriers together and use firm dummy variables to control for firm-specific effects

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[19] For the period of analysis in our paper, the High Density Rule (HDR) applied to Chicago O'Hare, Washington National (DCA), and New York's LaGuardia (LGA) and JFK airports. In order to operate at these airports, carriers must possess take-off and landing "slots." Although many slots were initially grandfathered, a secondary market allows slots to be bought, sold, and leased. The HDR was lifted at ORD on July 1, 2002.

[20] It should be noted that there is a subtle but important nuance in the definition of a market's density. Although density—as we have defined it—is based on the number of O&D passengers, in a network setting, density is perhaps better measured by total passengers (O&D in additional to flow) because this ultimately determines suitable equipment type, which in turn influences costs (Brueckner, Dyer, and Spiller 1992; Brueckner and Spiller 1994). A complete measure of market density, therefore, would attempt to measure the number of onboard passengers traveling on each of the potential composite spokes that could be combined to create a feasible routing for the airport pair market. However, limitations in the data reported to the Department of Transportation make this approach difficult. For example, although onboard passengers are reported at the segment level in the DOT's T100 Database, there is no equivalent database for certain commuter carriers (those carriers reporting under the DOT's Form 298C), many of which serve as regional codeshare partners for some of the major network carriers. Thus, for the purposes of this analysis (including the estimations in Section 4), we proxy for density using O&D passengers only.

such as differences in costs or quality of service. This approach assumes, however, that the effects of the various right-hand-side variables on prices are constant across all carriers. There may be reasons to expect, however, that specific competitive factors affect carriers in different ways. For example, the degree of head-to-head competition from low-cost carriers varies substantially across the different network carriers, as has the way in which the network carriers have responded to them. Likewise, as discussed earlier, we suspect that there may be differences in how different carriers report unrestricted coach passengers to the Department of Transportation.[21] A Chow test on our data soundly rejects pooling, and thus, we begin by estimating ordinary least-square (OLS) and two-stage least squares (2SLS) models for each of the six large network airlines individually. In addition to the individual airline regressions, we also estimate pooled OLS, 2SLS, and fixed-effects models for the largest 1,000 markets, so that our results may be compared more directly to those in the literature.

Individual Carrier Regressions

We begin by estimating the following equation for each of our six carriers:

$$\ln(P_j) = \mu + hub_j\,\beta + X_j\delta + \varepsilon_j \tag{1}$$

where $\ln(P_j)$ is the natural log of the carrier's average price per mile in market j, μ is a constant, hub_j is a matrix of hub dummies, X_j is a matrix of controls, and ε_j is a random error term assumed to be i.i.d. with mean zero and variance σ^2_ε. We want to determine if airlines systematically charge higher prices per mile to passengers originating or terminating at one of their hubs—beyond any potential pricing power conferred by market share—so we include hub dummies in our specification. Specifically, we include two hub dummies: *primary hub* and *secondary hub*. *Primary hub* equals 1 if either endpoint of market j is a primary hub (as enumerated in Table 1) for that airline and 0 otherwise. Likewise, *secondary hub* equals 1 if either endpoint of market j is a secondary hub for that airline and 0 otherwise. Our approach differs from Borenstein (1989) and Evans and Kessides (1993) in that we control explicitly for the presence of hubs as opposed to using airport market shares.[22] We believe that this approach may be more revealing than the ones used in previous studies, given the high correlation between market share and airport market share in the data.[23]

In order to study the effect of passenger mix on the hub premium, we also run the following augmented regression:

$$\ln(P_{jf}) = \mu + \alpha\, premium_{jf} + hub_j\,\beta + (hub_j \times premium_{jf})\gamma + X_j\delta + \varepsilon_j \tag{2}$$

where f denotes fare class (i.e., for each market we have two observations, one for restricted coach passengers and one for premium passengers), $premium_{jf}$ is a dummy variable that takes the value 1 for premium passengers and 0 otherwise. In this specification, α measures how high premium tickets

[21] For example, Continental and Delta have premium passenger proportions of 11.8% and 11.2%, respectively, and American's proportion is 22.6%, United's is 19.8%, and US Airways is 27.8%. Although some variation—based on the types of markets each carrier serves—is to be expected, we were surprised that Continental's proportion was so low, given that it derives over a third of its O&D traffic from the New York City area. If all carriers reported their unrestricted coach passengers using a "standard" definition, we would expect to see Continental with a proportion of premium passengers more similar to that of the other carriers.

[22] Whereas Evans and Kessides (1993) use the simple average of the carrier's market share of O&D passengers at both endpoints, Borenstein (1989) uses the weighted average.

[23] The average correlation is 0.75 for all carriers. The highest correlation is for US Airways (0.78), and lowest for Continental (0.72).

are—on average—relative to all of the respective carrier's tickets in the market, β measures the average effect of the hub dummy across fare classes, and γ measures the incremental effect of the hub dummy for premium passengers. If, as we suspect, passenger mix is an important determinant of the hub premium, we expect the estimate of the average hub premium, β, to be lower in Equation 2 than in Equation 1. Likewise, if airlines are successful at extracting additional hub premiums from their premium passengers, we would expect the estimated coefficients on γ in Equation 2 to be positive.

The matrix of controls, *X*, includes:

> $share_j$ (market share), the carrier's share of O&D passengers in 2000 in market *j*. Previous research (e.g., Borenstein 1989) shows that a high market share for an airline may confer pricing power in that market, so we expect the coefficient to be positive. In order to deal with the possible endogeneity in the determination of prices and market shares in a given market, our 2SLS estimations instrument for $share_j$ using 1999 market share.[24]
>
> $lowcost_j$ (low-cost competition), a dummy variable that takes the value 1 if low-cost carriers collectively have greater than a 1% share of O&D passengers in market *j* and 0 otherwise. We include in our list of low-cost carriers jetBlue, Frontier, Tower, AirTran, Midway, Legend, National, Vanguard, Spirit, ProAir, ATA, Southwest, Access Air, and Sun Country.[25] Numerous studies (e.g., Transportation Research Board 1999; Morrison and Winston 2000; Morrison 2001) find that competition by low-cost carriers has a large impact on the prices of all carriers serving that market, and thus, we expect the estimated coefficient to be negative.[26]
>
> $lnmiles_j$ (distance), the natural log of nonstop distance for market *j*. Other things equal, we expect average price per mile to decline as trip distance increases because the per-mile costs associated with a given flight decline sharply as distance increases. We use a market's nonstop distance as opposed to itinerary distance because passengers are not expected to be willing to pay more for circuitous routings.
>
> $lnmktpax_j$ (density), the natural log of total market passengers for all carriers serving market *j* in 1999. Greater market density allows airlines to exploit well-known economies of density by using larger, more cost-efficient aircraft (Brueckner, Dyer, and Spiller 1992; Brueckner and Spiller 1994).
>
> $owprop_j$ (one-way tickets), the proportion of the carrier's passengers purchasing one-way tickets in market *j*. We control for the fact that airlines tend to price one-way tickets more expensively (per leg) than round-trip tickets.
>
> *Slots*. For the period of our analysis, four airports in the United States had government-imposed limits on the number of takeoffs and landings that may take place each hour. To account for the effects of these restrictions on prices (either the scarcity value or the additional cost of acquiring slots), we include dummy variables for each slot-controlled airport, which take the value 1 if either endpoint of market *j* is one of the four slot-constrained airports—Chicago O'Hare (ORD_j), Kennedy (JFK_j), LaGuardia (LGA_j), and Reagan National (DCA_j)—and 0 otherwise.

Readers familiar with the literature will note that we do not include $nsprop_j$, the proportion of the carrier's passengers flying nonstop in market *j*, as one of our regressors. The reason we exclude it from this section of our analysis is that we cannot disentangle its effect from that of the various hub dummies.[27] Thus, the estimated coefficients on the hub dummies in these specifications reflect—in part—differences in the proportion of nonstop service at hubs versus nonhubs in addition to the hub premium. Indeed, because the overwhelming majority of passengers originating at or destined to hubs

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[24] We also tried the intramarket rank instrument used by Evans and Kessides (1993), which takes the values 1 and 2 for the carriers with the largest and second largest market shares, respectively, and takes the value 3 for all other carriers serving that market. However, we found that 1999 market share provided a better fit.

[25] The results do not vary significantly if the threshold is set at 5% or 10%.

[26] We also tried including the market's Herfindahl index, but it becomes insignificant when the low-cost dummy is included.

[27] Likewise, we do not include flight frequency as a control variable because the DOT's flight segment database (the T100 data set) in 2000 excludes a number of regional carriers that are responsible for operating a significant fraction of flights on behalf of the major carriers in some markets. Therefore, we cannot construct a frequency measure using these data without significant measurement error.

travel nonstop—in contrast to nonhub O&D passengers (see Table 2)—our estimated hub premiums likely overstate the constant-quality premiums.[28] Our fixed-effects results reported in Section 4 include $nsprop_j$ (in one of our specifications) so that we may compare our results with those in the previous literature.

The OLS and 2SLS (instrumenting for $share_j$) results for the six major network carriers are summarized in Tables 4 and 5. Note that US Airways did not serve JFK airport in 2000, and because American and United operate hubs at Chicago O'Hare, the *ORD* dummy variable is dropped in the corresponding regressions.

Discussion of Results

When we do not control for passenger mix—columns labeled (1)—the estimated hub premiums at the primary hubs in our 2SLS estimations (Table 5) range from 14.8% for Continental to 30.0% for United. Controlling for passenger mix—columns labeled (2)—reduces the hub premiums at the primary hubs for every carrier with the exception of Continental. For carriers with secondary hubs, controlling for passenger mix also tends to lower the hub premium (the exception being American's Miami hub, where the premium is already negative). Overall, the average hub premium (across carriers) at the primary hubs falls from 19.5% to 12.2% after controlling for passenger mix; for secondary hubs, the average premium falls from 16.3% to 13.0%.

Not surprisingly, prices for premium tickets are significantly more expensive than the average ticket, although the markup on premium tickets varies widely across carriers. For example, American's premium tickets are priced 92% higher than its average tickets, but Continental's premium tickets are 187% more expensive. We suspect that the large difference among carriers may be related to which tickets they classify as unrestricted coach tickets for DOT reporting purposes.

Somewhat surprisingly, we do not find that all carriers extract additional hub premiums from their premium passengers. For example, although American, US Airways, and United all appear to extract additional premiums from their premium passengers at their primary hubs (ranging from 7% for American to 12% for US Airways), the hub premium for Northwest's premium passengers is lower—on average—by nearly 9%.

In examining the other control variables, our primary interest is in the columns labeled (2) of Table 5 (2SLS). The estimated coefficients on share are typically positive when significant, with the exception of United, for which the coefficient is both negative and significant. This somewhat surprising finding is likely the result of the highly publicized labor problems that United experienced throughout the summer of 2000, which resulted in the cancellation or delay of thousands of its flights. For example, data from the Department of Transportation's *Air Travel Consumer Reports* for July of 2000 indicates that nearly one-third (31.5%) of United's scheduled flights arrived late 70% of the time or more compared to fewer than 1% for both Delta and American. In order to win back customers following these labor problems, United was forced to discount prices in addition to offering their top tier frequent flyers additional incentives (double the standard bonus miles) on all flights throughout the latter half of 2000.[29] For other carriers, the impact of higher market share on prices is relatively modest. For example, prices for Northwest are 2% higher in markets where Northwest has a 75% market share compared with an otherwise similar market where Northwest has a 25% market share.

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[28] Although one could conceivably control for this difference by restricting the analysis exclusively to nonstop itineraries, some hub-and-spoke carriers (in particular Continental and Northwest) offer very little nonstop service in their nonhub markets, and thus, the comparisons may not be meaningful.

[29] See, for example, "United Airlines tries to woo back wary travellers," *Cedar Rapids Gazette,* September 14, 2000.

Table 4. Individual Carrier Regressions: OLS

	American		Continental		Delta		Northwest		US Airways		United	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
primary hub	0.150*	0.095*	0.139*	0.146*	0.182*	0.097*	0.143*	0.077*	0.207*	0.059*	0.266*	0.225*
	(0.015)	(0.017)	(0.025)	(0.024)	(0.012)	(0.010)	(0.012)	(0.011)	(0.016)	(0.016)	(0.016)	(0.018)
secondary hub	−0.085*	−0.069*	0.306*	0.302*					0.239*	0.162*	0.109*	0.063*
	(0.022)	(0.025)	(0.019)	(0.019)					(0.020)	(0.020)	(0.016)	(0.019)
premium		0.653*		1.054*		0.974*		0.962*		0.683*		0.850*
		(0.008)		(0.016)		(0.006)		(0.008)		(0.007)		(0.010)
primary hub × *premium*		0.068*		−0.030		−0.017		−0.084*		0.112*		0.071*
		(0.022)		(0.032)		(0.014)		(0.015)		(0.021)		(0.024)
secondary hub × *premium*		−0.047		−0.104*						−0.118*		0.023
		(0.041)		(0.037)						(0.035)		(0.034)
share	−0.003	0.017	−0.028	−0.010	−0.159*	−0.012	−0.068*	0.027*	0.058*	0.028*	−0.161*	−0.129*
	(0.016)	(0.013)	(0.027)	(0.020)	(0.013)	(0.008)	(0.017)	(0.011)	(0.015)	(0.010)	(0.017)	(0.014)
lowcost	−0.147*	−0.119*	−0.166*	−0.099*	−0.176*	−0.084*	−0.155*	−0.073*	−0.175*	−0.102*	−0.187*	−0.179*
	(0.009)	(0.007)	(0.016)	(0.012)	(0.009)	(0.005)	(0.012)	(0.008)	(0.011)	(0.008)	(0.011)	(0.009)
lnmiles	−0.605*	−0.537*	−0.663*	−0.569*	−0.737*	−0.620*	−0.725*	−0.614*	−0.821*	−0.740*	−0.568*	−0.475*
	(0.006)	(0.004)	(0.010)	(0.007)	(0.005)	(0.003)	(0.006)	(0.004)	(0.006)	(0.004)	(0.006)	(0.005)
lnmktpax	−0.042*	−0.027*	−0.078*	−0.038*	−0.101*	−0.043*	−0.080*	−0.027*	−0.067*	−0.046*	−0.066*	−0.040*
	(0.003)	(0.002)	(0.005)	(0.004)	(0.003)	(0.002)	(0.004)	(0.002)	(0.003)	(0.002)	(0.003)	(0.003)
owprop	1.227*	0.763*	1.036*	0.402*	0.889*	0.252*	0.963*	0.321*	1.138*	0.639*	0.663*	0.312*
	(0.054)	(0.026)	(0.088)	(0.034)	(0.050)	(0.017)	(0.061)	(0.020)	(0.054)	(0.027)	(0.060)	(0.029)
JFK	−0.006	0.043	−0.254	−0.060	−0.087*	−0.036*	−0.188*	−0.128*			0.233*	0.203*
	(0.030)	(0.025)	(0.162)	(0.119)	(0.028)	(0.018)	(0.058)	(0.040)			(0.040)	(0.033)
LGA	0.168*	0.166*	0.118*	0.132*	0.070*	0.051*	0.059*	0.072*	0.053*	0.065*	0.182*	0.213*
	(0.021)	(0.017)	(0.033)	(0.025)	(0.022)	(0.014)	(0.023)	(0.016)	(0.021)	(0.015)	(0.025)	(0.021)
DCA	−0.007	0.068*	0.020	0.057*	0.079*	0.060*	−0.022	0.020	0.061*	0.012	0.041	0.174*
	(0.023)	(0.019)	(0.034)	(0.025)	(0.023)	(0.014)	(0.023)	(0.016)	(0.022)	(0.015)	(0.035)	(0.029)
ORD			0.035	0.059	0.070*	0.087*	0.002	0.042*	0.033	0.091*		
			(0.043)	(0.032)	(0.022)	(0.014)	(0.022)	(0.015)	(0.025)	(0.018)		
Adjusted R^2	0.819	0.828	0.872	0.907	0.858	0.915	0.882	0.912	0.890	0.889	0.782	0.816
N	4263	8526	1347	2694	5778	11556	3165	6330	4409	8818	3807	7614

Independent variable: the natural log of average price per mile. Primary hubs defined as those where at least 50% of the hub carriers passengers are making connections. Primary hubs include: US Airways (CLT, PIT), Northwest (MEM, MSP, DTW), Delta (CVG, ATL, SLC), American (ORD, DFW), Continental (IAH), and United (DEN, ORD). Secondary hubs include: US Airways (PHL), Continental (CLE, EWR), American (MIA), United (IAD, SFO).

* Significant at the 5% level.

Table 5. Individual Carrier Regressions: 2SLS

	American		Continental		Delta		Northwest		US Airways		United	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
primary hub	0.148*	0.095*	0.138*	0.144*	0.175*	0.093*	0.139*	0.073*	0.200*	0.057*	0.263*	0.222*
	(0.016)	(0.017)	(0.025)	(0.024)	(0.012)	(0.010)	(0.012)	(0.011)	(0.016)	(0.016)	(0.016)	(0.018)
secondary hub	−0.085*	−0.069*	0.305*	0.300*					0.233*	0.160*	0.106*	0.061*
	(0.022)	(0.025)	(0.020)	(0.019)					(0.021)	(0.021)	(0.016)	(0.019)
premium		0.653*		1.053*		0.973*		0.961*		0.683*		0.849*
		(0.008)		(0.016)		(0.006)		(0.008)		(0.007)		(0.010)
primary hub		0.068*		−0.030		−0.016		−0.084*		0.112*		0.072*
× *premium*		(0.022)		(0.032)		(0.014)		(0.015)		(0.021)		(0.024)
secondary hub		−0.047		−0.104*						−0.118*		0.023
× *premium*		(0.041)		(0.037)						(0.035)		(0.034)
share	0.002	0.017	−0.025	−0.005	−0.140*	0.000	−0.054*	0.039*	0.082*	0.037*	−0.149*	−0.119*
	(0.018)	(0.015)	(0.029)	(0.021)	(0.015)	(0.009)	(0.018)	(0.012)	(0.016)	(0.012)	(0.019)	(0.015)
lowcost	−0.147*	−0.119*	−0.166*	−0.099*	−0.175*	−0.084*	−0.155*	−0.073*	−0.174*	−0.102*	−0.186*	−0.179*
	(0.009)	(0.007)	(0.016)	(0.012)	(0.009)	(0.005)	(0.012)	(0.008)	(0.011)	(0.008)	(0.011)	(0.009)
lnmiles	−0.605*	−0.537*	−0.663*	−0.569*	−0.736*	−0.620*	−0.724*	−0.614*	−0.818*	−0.739*	−0.567*	−0.475*
	(0.006)	(0.004)	(0.010)	(0.007)	(0.005)	(0.003)	(0.006)	(0.004)	(0.006)	(0.004)	(0.006)	(0.005)
lnmktpax	−0.042*	−0.027*	−0.077*	−0.038*	−0.099*	−0.042*	−0.078*	−0.025*	−0.064*	−0.045*	−0.065*	−0.039*
	(0.003)	(0.003)	(0.005)	(0.004)	(0.003)	(0.002)	(0.004)	(0.003)	(0.003)	(0.002)	(0.003)	(0.003)
owprop	1.227*	0.763*	1.036*	0.403*	0.905*	0.255*	0.975*	0.325*	1.153*	0.643*	0.669*	0.314*
	(0.054)	(0.026)	(0.088)	(0.034)	(0.050)	(0.017)	(0.062)	(0.020)	(0.054)	(0.28)	(0.061)	(0.029)
JFK	−0.007	0.043	−0.254	−0.059	−0.090*	−0.037*	−0.188*	−0.128*			0.232*	0.203*
	(0.030)	(0.025)	(0.162)	(0.119)	(0.028)	(0.018)	(0.058)	(0.040)			(0.040)	(0.033)
LGA	0.168*	0.166*	0.118*	0.132*	0.070*	0.051*	0.058*	0.072*	0.049*	0.063*	0.181*	0.213*
	(0.021)	(0.017)	(0.033)	(0.025)	(0.022)	(0.014)	(0.023)	(0.016)	(0.021)	(0.015)	(0.026)	(0.021)
DCA	−0.008	0.068*	0.020	0.057*	0.079*	0.060*	−0.023	0.019	0.057*	0.010	0.041	0.175*
	(0.023)	(0.019)	(0.034)	(0.025)	(0.023)	(0.014)	(0.023)	(0.016)	(0.022)	(0.016)	(0.035)	(0.029)
ORD			0.035	0.059	0.069*	0.087*	0.000	0.040*	0.031	0.090*		
			(0.043)	(0.032)	(0.022)	(0.014)	(0.022)	(0.015)	(0.025)	(0.018)		
Adjusted R^2	0.819	0.828	0.872	0.907	0.858	0.915	0.881	0.912	0.889	0.889	0.782	0.816
N	4263	8526	1347	2694	5778	11556	3165	6330	4409	8818	3807	7614

Independent variable: the natural log of average price per mile. Primary hubs defined as those where at least 50% of the hub carrier's passengers are making connections. Primary hubs include: US Airways (CLT, PIT), Northwest (MEM, MSP, DTW), Delta (CVG, ATL, SLC), American (ORD, DFW), Continental (IAH) and United (DEN, ORD). Secondary hubs include: US Airways (PHL), Continental (CLE, EWR), American (MIA), United (IAD, SFO).

* Significant at the 5% level.

In contrast, low-cost carriers have a very strong negative impact on prices. Overall, the presence of a low-cost carrier lowers prices in a market by between 8% and 20%. The estimated coefficients on *lnmiles* are consistently negative and significant and indicate that, controlling for other factors, doubling a flight's length roughly reduces the price per mile by 50% to 70%. Care must be taken when interpreting the coefficients on *lnmiles* because many airline taxes and fees are independent of trip length and will therefore have a disproportionate impact (per mile) on short flights.

The overall impact of passenger density (*lnmktpax*) is, as expected, negative and significant for all carriers. In general, a tenfold increase in market density (i.e. 1000 versus 100 passengers per day) reduces prices by between 25% and 45%. The estimated coefficients on owprop are positive and significant for all carriers, as expected, because one-way tickets are generally more expensive (per leg) than roundtrip tickets.

The estimated coefficients for the various slot dummy variables indicate that there are substantial differences among the four slot-controlled airports. Flights to and from LaGuardia are more expensive on all carriers by between 5% and 23%. Likewise, flights to and from DCA tend to be more expensive for all carriers (except Northwest) by between 6% and 19%. The estimated coefficients on *JFK* tend to be mixed, with some carriers (i.e., United) charging higher prices for service to and from JFK and other carriers (i.e., Northwest and Delta) charging generally lower prices.[30] For the four network carriers that do not operate hubs at O'Hare, prices in markets to and from ORD are higher by between 4% and 9%.

Pooled Regressions

In order to compare our results more directly to those of Borenstein (1989) and Evans and Kessides (1993), the next step in our analysis is to pool carriers together and estimate an average hub premium. We estimate 2SLS, OLS, and fixed effects (FE) models for all carriers (not only the six network carriers) using the largest 1000 markets. Like Evans and Kessides (1993), we eliminate from our sample observations where a carrier has less than a 1% share of a market's total O&D traffic.

We first estimate a similar regression to the individual carrier regressions of Section 4 for the pooled data, with and without market fixed effects:

$$\ln(P_{ij}) = \mu + hub_{ij}\,\beta + X_{ij}\delta + \varepsilon_{ij} \tag{3}$$

$$\ln(P_{ij}) = \mu_j + hub_{ij}\,\beta + X_{ij}\delta + \varepsilon_{ij} \tag{4}$$

where $\ln(P_{ij})$ is the natural log of carrier i's average price per mile in market j, μ is a constant, hub_{ij} is a matrix of two hub dummies (primary and secondary) that take the value of 1 if either endpoint of market j is a hub (primary or secondary) for airline i, and X_{ij} is a matrix of regressors that varies with the airline's identity within a market. In Equation 4, μ_j are market fixed effects. The random error ε_{ij} is assumed to be i.i.d. with zero mean and variance σ^2_ε. X includes the same control variables as the individual airline regressions plus airline dummies that capture firm differences constant across markets (i.e., differences in costs or service quality, etc.). As was the case with our individual carrier regressions, we exclude nsprop from the specification because of its collinearity with the hub dummy variables.

[30] The negative and significant coefficient for *JFK* in the Delta regressions is almost certainly related to the competitive impact of low-cost carrier jetBlue, which began service from JFK in 2000, primarily in markets that overlapped heavily with Delta (i.e., to and from destinations in Florida).

The market fixed-effects model is our preferred specification. Including fixed effects allows us to control for unobservable effects correlated with the observed explanatory variables, lessening possible biases from omitted variables. While the market fixed effects control for demand and cost differences that are common for all airlines serving the same market (i.e., distance, market density etc.), they also indirectly control for the inherent business orientation of a particular market. If our hypothesis is correct, and the hub premium is inflated by failure to control for passenger mix, the estimated hub premium from the market fixed effects model should be lower than the hub premium from the model with a common intercept for all markets. It is important to emphasize, however, that market fixed effects alone cannot control for passenger mix entirely because a carrier's ability to attract business passengers depends critically on its service offering (i.e., flight frequency, service quality, etc.) in a particular market. Likewise, it is important to note that the fixed-effects approach does not permit identifying the effects of variables that do not vary within a market.[31]

As we did in our individual airline regressions, we also estimate augmented regressions that separate tickets by fare class, with and without fixed effects:

$$\ln(P_{ifj}) = \mu + \alpha\, premium_{ifj} + hub_{ij}\,\beta + (hub_{ij} \times premium_{ifj})\gamma + X_{ifj}\delta + \varepsilon_{ifj} \tag{5}$$

$$\ln(P_{ifj}) = \mu_j + \alpha\, premium_{ifj} + hub_{ij}\,\beta + (hub_{ij} \times premium_{ifj})\gamma + X_{ifj}\delta + \varepsilon_{ifj} \tag{6}$$

Finally, in order to compare our results to previous studies, we estimate a model that attempts to indirectly capture the effects of hubs on prices using $endptms_{ij}$, defined as the simple average of airline i's market share of O&D passengers at the two endpoints of market j, instead of using hub dummies. Consistent with Evans and Kessides (1993), we include *nsprop* in this case.

Summary statistics for the variables used in this section are presented in Table 6 and are similar to those reported by Evans and Kessides (1993, table 1).[32]

Discussion of Results

Results for our model using hub dummies are presented in Table 7. The estimated hub premiums without fixed effects for fare class aggregated data (2SLS) are 28.1% and 25.7% for primary and secondary hubs respectively. These numbers are higher than the average hub premiums from the individual airline regressions (18.2% and 16.3%) because the sample now includes low-cost carriers, which lower average fares for the control group. In other words, we are no longer comparing hub versus nonhub prices for a given airline; rather, we are now comparing hub prices versus nonhub prices for all airlines, including low-cost carriers.

Confirming our *a priori* belief, the estimated average hub premiums with fixed effects are substantially lower, 15.1% and 16.9% for primary and secondary hubs, respectively, in the fixed effects 2SLS (FE-2SLS) model. This result strongly suggests that failing to control for passenger mix tends to inflate the hub premium. However, because including fixed effects does not directly control for passenger mix, we also make use of our disaggregated fare data. Without fixed effects, the hub premiums for primary and secondary hubs are now 16.2% and 14.7%, respectively, substantially lower than the fare class aggregated data. With fixed effects and controlling for fare class, we do not find a significant hub premium for primary hubs and a hub premium of 6.6% for secondary hubs.

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[31] Like Evans and Kessides (1993), our data rejected the random effects model, and therefore, we do not report the results for this specification.

[32] Note that the fares in our dataset include all fees and taxes, which likely explains why our mean fare is somewhat higher than the mean fare reported by Evans and Kessides (1993).

Table 6. Variable Definitions and Descriptive Statistics for Largest 1000 Markets

Variable Name	Definition	Mean	Standard Deviation
$fare_{ij}$	Average one-way fare for airline i in market j	190.14	(78.39)
ppm_{ij}	Average price per O&D mile for airline i in market j	0.197	(0.127)
$mktpax_j$	Average number of O&D passengers in market j in 1999	234,411	(215,177)
$nsprop_{ij}$	Proportion of passengers for airline i in market j traveling nonstop	0.388	(0.436)
$owprop_{ij}$	Proportion of passengers for airline i in market j using one-way tickets	0.109	(0.086)
$miles_j$	One-way non-stop distance between airports in market j	1234.9	(703.4)
$share_{ij}$	Market share of airline i in market j	0.228	(0.271)
$endptms_{ij}$	Simple average of airline i's market share of O&D passengers at endpoint airports in market j	0.162	(0.132)
DCA_j	Dummy variable taking value 1 if either endpoint of market j is DCA and 0 otherwise	0.039	(0.194)
JFK_j	Dummy variable taking value 1 if either endpoint of market j is JFK and 0 otherwise	0.015	(0.123)
LGA_j	Dummy variable taking value 1 if either endpoint of market j is LGA and 0 otherwise	0.051	(0.220)
ORD_j	Dummy variable taking value 1 if either endpoint of market j is ORD and 0 otherwise	0.066	(0.249)
$lowcost_j$	Dummy variable taking value 1 if low cost carriers collectively account for more than a 1% share of O&D passengers in market j, 0 otherwise	0.670	(0.470)
$primary\ hub_{ij}$	Dummy variable taking value 1 if either end-point of market j is a primary hub for airline i, 0 otherwise	0.121	(0.326)
$secondary\ hub_{ij}$	Dummy variable taking value 1 if either end-point of market j is a secondary hub for airline i, 0 otherwise	0.048	(0.214)
Firms	Number of firms in sample	20	
Markets	Number of markets in sample	1000	
N	Number of observations	4101	

Largest 1000 markets in 2000 in terms of domestic O&D passengers.

Looking at the other control variables, we also find that for premium passengers, the price per mile is between 110% and 118% higher than the average price per mile, and that carriers–in general–extract additional hub premiums from their business passengers (between 14% and 16%). Estimated coefficients for the other regressors have the expected signs, including nonreported carrier dummies. For example, all other things being equal, Southwest Airlines' price per mile is—on average—47% less than American's.

Finally, results for OLS, 2SLS, FE, and FE-2SLS regressions replacing hub dummies with *endptms* are presented in Table 8. In general, the estimated coefficients are similar to those of Evans and Kessides (1993), except in our data, both *share* and *endptms* remain significant and positive in the FE-2SLS specification. As expected, using the fare class–disaggregated data decreases the estimated coefficient for *endptms*. Likewise, with our hub dummy specification (Table 7), *share* remains significant in all specifications. Recall that one of the primary findings of Evans and Kessides (1993) is that share at the market level was not important after controlling for endpoint market share. We suspect that this somewhat surprising result may result from multicollinearity between *share* and *endptms*. For example, in our data set, the correlation between these two variables is 0.83.

Table 7. Pooled Regressions with Hub Dummies. Largest 1000 Markets

	Fare Class Aggregated				Fare Class Disaggregated			
	2-SLS	OLS	FE-2SLS	FE	2-SLS	OLS	FE-2SLS	FE
primary hub	0.248* (0.015)	0.259* (0.015)	0.141* (0.013)	0.156* (0.012)	0.150* (0.015)	0.159* (0.015)	0.017 (0.015)	0.028 (0.015)
secondary hub	0.229* (0.019)	0.239* (0.019)	0.143* (0.015)	0.154* (0.015)	0.137* (0.020)	0.144* (0.020)	0.064* (0.019)	0.072* (0.019)
premium					0.779* (0.010)	0.781* (0.010)	0.739* (0.009)	0.740* (0.009)
primary hub × *premium*					0.135* (0.018)	0.135* (0.018)	0.150* (0.015)	0.150* (0.015)
secondary hub × *premium*					0.093* (0.027)	0.092* (0.027)	0.105* (0.022)	0.105* (0.022)
share	0.124* (0.020)	0.099* (0.019)	0.264* (0.016)	0.235* (0.015)	0.082* (0.017)	0.063* (0.016)	0.221* (0.016)	0.200* (0.016)
lowcost	−0.178* (0.009)	−0.178* (0.009)			−0.129* (0.007)	−0.130* (0.007)		
lnmiles	−0.559* (0.007)	−0.561* (0.007)			−0.472* (0.005)	−0.474* (0.005)		
lnmktpax	−0.079* (0.006)	−0.079* (0.006)			−0.055* (0.005)	−0.055* (0.005)		
owprop	1.172* (0.069)	1.160* (0.069)	1.542* (0.066)	1.516* (0.066)	0.885* (0.027)	0.879* (0.027)	1.030* (0.024)	1.024* (0.024)
JFK	0.070* (0.030)	0.074* (0.030)			0.039 (0.024)	0.042 (0.024)		
LGA	0.160* (0.016)	0.161* (0.016)			0.148* (0.013)	0.149* (0.013)		
DCA	0.068* (0.018)	0.069* (0.018)			0.082* (0.015)	0.083* (0.015)		
ORD	−0.053* (0.016)	−0.056* (0.016)			−0.027* (0.013)	−0.029* (0.013)		
Adjusted R^2	0.798	0.798	0.913	0.912	0.864	0.864	0.904	0.904
N	4101	4101	4101	4101	8202	8202	8202	8202

Independent variable: the natural log of average price per mile. Primary hubs defined as those where at least 50% of the hub carriers passengers are making connections. Primary hubs include: US Airways (CLT, PIT), Northwest (MEM, MSP, DTW), Delta (CVG, ATL, SLC), American (ORD, DFW), Continental (IAH) and United (DEN, ORD). Secondary hubs include: US Airways (PHL), Continental (CLE, EWR), American (MIA), United (IAD, SFO). The specification includes (nonreported) carrier dummies.
*Significant at the 5% level.

Table 8. Pooled Regressions with End-point Market Share. Largest 1000 Markets

	Fare Class Aggregated				Fare Class Disaggregated			
	2-SLS	OLS	FE-2SLS	FE	2-SLS	OLS	FE-2SLS	FE
endptms	0.768* (0.059)	0.835* (0.057)	0.955* (0.044)	1.001* (0.043)	0.643* (0.048)	0.691* (0.046)	0.770* (0.047)	0.799* (0.046)
premium					0.814* (0.009)	0.816* (0.009)	0.774* (0.008)	0.775* (0.008)
share	0.051 (0.033)	−0.006 (0.030)	0.081* (0.024)	0.039 (0.022)	0.042 (0.026)	0.001 (0.024)	0.070* (0.025)	0.045 (0.023)
lowcost	−0.193* (0.009)	−0.194* (0.009)			−0.142* (0.007)	−0.142* (0.007)		
lnmiles	−0.544* (0.007)	−0.544* (0.007)			−0.460* (0.005)	−0.460* (0.005)		
lnmktpax	−0.075* (0.006)	−0.078* (0.006)			−0.049* (0.005)	−0.051* (0.005)		
owprop	1.118* (0.071)	1.090* (0.071)	1.478* (0.063)	1.448* (0.063)	0.831* (0.027)	0.824* (0.026)	0.984* (0.024)	0.980* (0.024)
JFK	0.027 (0.031)	0.027 (0.031)			0.007 (0.025)	0.006 (0.025)		
LGA	0.142* (0.016)	0.142* (0.016)			0.134* (0.013)	0.133* (0.013)		
DCA	0.052* (0.019)	0.053* (0.019)			0.068* (0.015)	0.069* (0.015)		
ORD	0.002 (0.016)	0.001 (0.016)			0.025 (0.013)	0.024 (0.013)		
nsprop	0.008 (0.016)	0.024 (0.016)	−0.021 (0.012)	−0.008 (0.012)	−0.012 (0.013)	−0.001 (0.012)	−0.031* (0.013)	−0.024 (0.013)
Adjusted R^2	0.793	0.793		0.372	0.860	0.860		0.865
N	4101	4101	4101	4101	8202	8202	8202	8202

Independent variable: the natural log of average price per mile. Primary hubs defined as those where at least 50% of the hub carriers passengers are making connections. Primary hubs include: US Airways (CLT, PIT), Northwest (MEM, MSP, DTW), Delta (CVG, ATL, SLC), American (ORD, DFW), Continental (IAH) and United (DEN, ORD). Secondary hubs include: US Airways (PHL), Continental (CLE, EWR), American (MIA), United (IAD, SFO). The specification includes (non-reported) carrier dummies.

* Significant at the 5% level.

5. Conclusions

What does our analysis add to the decade-long debate over hub premiums? Our analysis indicates that much of the observed difference in average prices charged by airlines at their hubs compared to the remainder of their networks can be explained by passenger mix. Controlling for passenger mix lowers the average hub premium at primary hub airports from 19.5% to 12.2%. Stated differently, failing to control for passenger mix overstates the hub premium at major hub airports by an average of 59.2% (see Table 5). For secondary hubs, explicitly controlling for passenger mix reduces the average premium from 16.2% to 13.0%. Our result are robust to whether or not we estimate individual or pooled models and to whether or not we control for passenger mix explicitly (i.e., by using the fare class–disaggregated data) or indirectly (i.e., by using market fixed effects).

Nevertheless, our analysis does find evidence that network airlines do indeed charge more per mile for service to and from most of their hubs compared to service throughout the remainder of their networks, even after controlling for factors such as passenger mix, density, distance, and a number of other factors. Furthermore, these hub premiums, when they exist, tend to be larger for passengers purchasing premium tickets for most carriers. However, it is these passengers who are most likely to place a high value on the time saving and convenience offered by the high-frequency, nonstop service to a wide array of destinations made possible by the hub-and-spoke system.

Data Description Appendix

The source of our ticket and price data is the U.S. Department of Transportation's (DOT) Domestic Origin and Destination Survey, Databank 1B (OD1B). The data represent a 10% sample of U.S. Scheduled Passenger Carriers providing service under the Code of Federal Regulations, Part 241. The particular version of the DB1A data we use was purchased from Data Base Product, Inc., a DOT-certified data vendor, and is called the "HUB Sup" Low Level O&D Data. Data for our analysis are for the full year 2000.

Each observation in the raw data is a unique airline/route combination, where a route is defined as a starting and ending airport, in addition to any intermediate connecting point(s). In the raw data, passenger itineraries have been broken into directional "legs" (i.e., outbound or return), and the reported fares represent the fare of the directional leg (i.e., roundtrip fares have been divided by two). Each observation also indicates the total number of flight coupons (a separate coupon is required for each flight segment) as well as the fare class associated with each coupon. Fares are inclusive of all taxes and fees.

The preparation of the raw data for our econometric analysis consisted of the following steps. First, we exclude the following types of tickets:

1. Tickets with four or more coupons per directional trip leg (these accounted for fewer than 0.1% of all tickets).
2. Tickets with "bulk fare" and "zero fare" types (both of which report a fare of $0), as well as tickets with fares of less than $26 (these are coded by Data Base Products as "Z" fare types in the raw data, signifying that they represent either frequent flyer award tickets or employee travel).
3. Open jaw trips (i.e., BOS-LAX-JFK).
4. Tickets with more than one marketing carrier (i.e., "interline" tickets).
5. First, business or unrestricted coach class tickets with an average price per mile of less than five cents.
6. Restricted coach class tickets with an average price per mile of less than two cents.
7. Tickets with "unknown" fare classes (these accounted for roughly 1.25% of the observations).

For the purposes of our analysis, we aggregate first, business, and unrestricted coach class tickets into a single "premium" fare type category. In the raw data, unrestricted coach tickets accounted for roughly 95% of the premium tickets. For multiple-coupon itineraries in which there are coupons with different fare classes, the fare class of the longest distance coupon was used. The raw data are then collapsed into nondirectional airport-pair markets. That is, nonstop Boston to Seattle passengers are considered to be in the same market as Seattle to Boston passengers making a connection. In collapsing the data, average fares for each carrier and fare class (restricted coach and premium) are weighted by the number of passengers. We then included only those market/carrier observations where the carrier had more than 100 restricted coach and 100 premium passengers. We also dropped a very small number of market/carrier combinations where the average premium fare was less than the average unrestricted coach fare.

The median ratio (across markets) of premium to restricted fares in our final data set is: American (2.28), Continental (3.28), Delta (2.83), Northwest (2.77), United (2.58), and US Airways (2.23). Overall, the percentage of passengers purchasing premium tickets in our data set is: American (22.6%), Continental (11.8%), Delta (11.2%), Northwest (14.1%), United (19.8%), and US Airways (27.6%).

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