Are Frequent-Flyer Programs a Cause of the "Hub Premium"?

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This paper estimates the relationship between frequent-flyer programs (FFPs) and fares at hub airports. I exploit the formation of partnerships that allowed members of one airline's FFP to earn that airline's points on flights operated by its partner. If FFPs allow an airline to charge higher fares on routes that depart from its hubs, these partnerships should allow an airline's partner *to charge higher fares on routes that depart from these same airports. I find that offering the FFP points of the dominant carrier at an airport does, indeed, lead to higher fares. Combining these estimates with estimates of the "hub premium" suggests that FFPs may account for at least 25% of the "hub premium."*

1. Introduction

Shortly after deregulation, many airlines replaced their point-to-point networks with hub-and-spoke systems. There is now considerable evidence documenting that hub-and-spoke networks provide airlines with cost and scheduling advantages.[1] However, there is also evidence indicating that hub-and-spoke systems provide airlines with market power at their hub airports. Studies have shown that airlines receive higher fares on hub routes than they do on comparable routes elsewhere in their network. In addition, studies have found that—on routes that

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1. See, for example, Brueckner et al. (1992) and Brueckner and Spiller (1994). As well, see Borenstein and Rose (forthcoming) for a discussion of both the benefits of hub-and-spoke networks and limitations to these benefits.

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depart from an airline's hub—the hub carrier receives higher fares than its competitors.[2]

Although the existence of a "hub premium" (measured in either of these two ways) has now been clearly established, evidence on the cause of the hub premium is in shorter supply. Such evidence is important, however, because the relationship between airport dominance and route market power may reflect several factors. As Borenstein (1991) explains, one can distinguish between the "natural advantages" that accrue to dominant airlines and those that result from institutions created by the airlines. For example, the former include the reputation that a dominant airline acquires as a result of offering the largest number of flights in and out of a particular city, whereas the latter include marketing programs such as frequent-flyer programs (FFPs). By rewarding consumers in a nonlinear way, FFPs create an incentive for consumers to concentrate their purchases with a single carrier. When selecting the airline with which to accumulate points, consumers will prefer the dominant carrier at an airport because it offers the best opportunities for earning points and redeeming rewards. Finally, dominant airlines may also be able to influence the allocation of scarce airport facilities such as gates. Understanding the relative importance of these factors is critical to designing policy that seeks to increase competition at hubs.[3] For example, if the primary advantage of airport dominance is the ability to offer a more attractive FFP, then encouraging small-scale entry into hub airports by improving access to airport facilities would do little toward increasing competition because these carriers would still be unable to match the dominant airline's FFP. On the other hand, banning FFPs might both encourage entry into dominated airports and allow small-scale entrants to better compete with the dominant carrier.

In this paper, I investigate whether the fare premium that hub carriers receive results from the fact that they have an advantage in the use of FFPs. I develop a novel empirical approach to estimating the fare premium that is associated with a hub carrier's FFP. The approach exploits three FFP partnerships formed in the late 1990s.[4] American

2. See Borenstein (1989, 1991), Evans and Kessides (1993), Berry et al. (1997), Lee and Prado (2005), Ciliberto and Williams (2007), and various U.S. General Accounting Office studies.

3. This is particularly true given that any policy intervention would need to balance any welfare losses due to reduced competition at hubs against the welfare benefits that result from hub-and-spoke systems.

4. Because data on individual FFP balances are not available and because all of the major airlines introduced FFPs at approximately the same time, it is difficult to directly estimate the relationship between FFPs and fares at dominated airports. An exception is Morrison and Winston (1989), which includes a measure of FFPs in a demand model. They use the number of FFP points available interacted with the number of destinations served by the airline. In their sample period, not all of airlines operated FFPs.

Airlines and US Airways, Delta Air Lines and United Airlines, and Continental Airlines and Northwest Airlines each formed a partnership that allowed members of one airline's FFP to earn and/or redeem that airline's frequent flyer points when traveling on flights operated by its partner.[5] These partnerships can be used to estimate the relationship between FFPs and hub airlines' fares because they effectively extend a hub airline's FFP to include a set of flights that was not previously included in the program. If FFPs allow a dominant airline to charge higher fares on routes that depart from its hubs, then these partnerships should allow a dominant airline's *partner* to charge higher fares on routes that depart from these same airports. Because partners' flights should not be affected by any of the dominant airline's other sources of advantage, any estimated change in fares on a partner's flights should capture only the premium that is associated with offering the dominant carrier's FFP points.

Consider, for example, the partnership between Delta and United. This partnership may affect Delta in two ways. First, consumers who collect Delta's FFP points may perceive the partnership with United to be an enhancement to Delta's FFP and may therefore perceive Delta's FFP points to be more valuable than they were before. All else equal, this may increase Delta's demand and fares from these consumers. Second, consumers who collect United's FFP points may find Delta's flights to be more attractive because they can now earn United FFP points on these flights. All else equal, this may increase Delta's demand and fares from these consumers. Although these two effects will operate simultaneously, note that they will, in general, operate at two different types of airports. To the extent that consumers who collect Delta's points are those who regularly fly out of airports at which Delta is dominant (e.g., Atlanta), the first effect is likely to occur on Delta's routes that depart from airports at which it is dominant. That is, this effect will *enhance* Delta's existing advantage at airports at which it is dominant. On the other hand, to the extent that consumers who collect United's FFP points are those that regularly fly out of airports at which United is dominant (e.g., Denver), the second effect is likely to occur on Delta's routes that depart from airports at which United is dominant. That is, this effect will *extend* United's advantage at these airports to Delta's flights. It is this second effect that can provide an estimate of the relationship between FFPs and fares at dominated airports. Specifically, the increase in fares that Delta experiences on its routes that depart from United's hubs—once United's FFP points can be earned on its

5. United and Delta and US Airways and American have since dissolved their respective FFP partnerships. United has since partnered with US Airways, whereas Delta has become a third member in the Continental and Northwest partnership.

flights—provides a lower-bound estimate of the fare premium that United experiences on its hub routes as a result of offering the most attractive FFP.

The empirical analysis proceeds in two stages. First, using data from the prepartnership period, I obtain estimates of the "hub premium" that I measure as the fare premium that a hub carrier receives relative to its competitors *on a given route*. Then, to determine how much of this premium results from the fact that the hub carrier offers the most attractive FFP, I investigate what happens when the hub carrier's FFP points can suddenly be earned on its partner's flights. Specifically, I estimate how the extension of a hub carrier's FFP to include its partner's flights increases the fares that the *partner* receives. I combine the results from these two empirical exercises to obtain an estimate of the fraction of the hub premium that is due to FFPs. As a check that I am indeed capturing an "FFP effect," I also investigate whether the partnerships had a larger impact on fares at the top of the price distribution than at the bottom. Because FFPs offer a kickback to business travelers, the effects should be greatest for tickets that are more likely to have been purchased by business travelers.

The paper's main set of results establishes that offering the FFP points of the dominant carrier at an airport confers a pricing premium. After the partnerships were in place, airlines received higher fares on routes that departed from specifically those airports at which their partner was dominant. This provides direct evidence that FFPs are at least one of the reasons why dominant carriers receive higher fares than their competitors. The estimates imply that allowing consumers to earn the dominant carrier's FFP points on its flights increased the mean fare that an airline received by between 3.7% and 5% and the 80^{th} percentile fare that an airline received by between 7% and 9%. Combining these estimates with estimates of the hub premium that are in the range of 14% suggests that FFPs account for between 25% and 37% of the fare premium that hub carriers receive.[6]

This paper contributes to the growing literature on the hub premium. This literature has established that airlines receive higher fares on their hub routes than on their nonhub routes, as well as receive higher fares than their competitors on routes that depart from their hubs.[7] Some papers also provide suggestive evidence that this premium

6. It is important to emphasize that the "experiment" provided by the partnerships allows me to investigate whether FFPs are one of the reasons why dominant carriers receive higher fares than their competitors on a route (or at an airport). The partnerships do not allow me to investigate whether FFPs discourage entry into hub airports and thereby affect fares on routes departing from these airports.

7. Related papers that investigate the relationship between airport dominance and demand include Borenstein (1991), Berry et al. (2006), and Lederman (forthcoming).

is at least partly due to FFPs. In early papers, Borenstein (1989) and Evans and Kessides (1993) show that increases in an airline's share of passengers at the end point airports of a route allow it to charge higher fares on that route. Evans and Kessides (1993) also show that airport capacity constraints and ownership of CRSs augment an airline's local market power, but do not fully explain it, suggesting that the cause must lie elsewhere. Using a structural model of supply and demand, Berry et al. (2006) find that hub airlines are able to charge higher fares on routes that depart from their hubs; however, this pricing advantage is limited to tickets that appeal to price-inelastic consumers. Their finding that the hub advantage is limited to "business travelers" suggests that FFPs are at least part of the story.[8] In a more recent paper, Lee and Prado (2005) estimate the relationship between hubs and fares, explicitly controlling for an airline's mix of tourist and business passengers. Without controlling for passenger mix (but controlling for market fixed effects), they find that hub carriers receive fares that are about 16% higher than their competitors. Once they also control for passenger mix, the find that hub carriers no longer receive a premium on leisure tickets, but a substantial premium (about 15%) remains for premium tickets.[9] This paper illustrates that the hub premium results from the fact that hub carriers are both able to charge higher fares for tickets that are identical on observable characteristics and attract a disproportionate share of passengers who purchase premium tickets. Finally, Ciliberto and Williams (2007) investigate the role of access to airport facilities in determining the hub premium. The find that including variables that measure airlines' access to airport facilities eliminates differences in an airline's fares across its hub and nonhub routes. However, they do not address differences in the fares of hub and nonhub carriers serving a given route.

The remainder of this paper is organized as follows. Section 2 describes the economics of FFPs. In Section 3, I discuss the three FFP partnerships studied. Section 4 describes the data and variables. Section 5 presents the empirical approach. In Section 6, I present and discuss the results. A final section concludes.

Morrison and Winston (1995, 2000) analyze a cross-section of airports and relate airport concentration to average fares.

8. Other papers that use structural models to estimate markups (but which do not focus on hubs) include Reiss and Spiller (1989), Berry (1990), and Aguirregabiria and Ho (2006).

9. Gordon and Jenkins (2000) also make use of disaggregated fare class data. Using data that only include Northwest Airlines, they find that there is no hub premium and, in fact, passengers flying on routes that originate or terminate at a Northwest hub pay slightly less than passengers flying through Northwest hubs. There are, however, a number of problems with the methodology used in their study. For example, passengers connecting from one of Northwest's regional partners are treated as hub originating passengers.

2. The Economics of FFPs[10]

FFPs award consumers points for purchased flights. The number of points awarded is typically equal to the distance of the flight but may also depend on the type of ticket purchased. Accumulated FFP points can be redeemed for rewards, the most common of which are free tickets or class upgrades. FFP reward schedules are structured such that a minimum number of points must be earned before any reward can be redeemed, after which the value of rewards generally increases nonlinearly with the number of points required.[11] In addition, FFPs have "elite programs" that award "status" to consumers who fly a minimum number of miles with the airline in a year. Most have three tiers, with qualification for each tier requiring an increasing number of miles flown. Each tier entitles a traveler to an increasing amount of preferential treatment. Because the elite programs entitle a consumer to preferential treatment on *all* flights taken with the airline in the year of qualification, they create large, discrete increases in the value of earning additional FFP points as one nears the thresholds. These nonlinearities give consumers an incentive to accumulate all of their points in a single airline's FFP. This is the sense in which these programs "create loyalty."

If consumers regularly fly to multiple destinations or are uncertain about where they will need to fly, then they will prefer the FFP of the airline that serves the largest set of routes out of their home airport. In addition to maximizing opportunities for earning points, this airline will also offer the largest selection of reward destinations. For these reasons, the dominant airline at an airport will offer the most attractive FFP, for consumers at *that* airport. Once consumers become invested in that airline's FFP, any flight not taken with that airline represents forgone FFP points. To induce consumers to purchase their flights, carriers that are not dominant at the airport (who cannot offer as attractive an FFP) must offer a lower price. By forcing competitors to offer this "extra" price reduction, the use of an FFP by the dominant airline at an airport can lower the profits of airlines that serve only a small set of routes out of

10. The first FFP was introduced by American Airlines in May of 1981, 3 years after the deregulation of the airline industry. For more on the history of FFPs, see http://www.frequentflier.com/ffp-005.htm and Mason and Barker (1996).

11. For example, in many FFPs, 25,000 points are required for an economy class reward flight within the United States, 40,000 points are required for a business class reward flight within the United States, and 50,000 points are required for an economy class reward flight between the United States and Europe. Assuming that the price of a business class domestic flight is more than 1.6 times the price of an economy class domestic flight and the price of an economy class flight to Europe is more than twice the price of an economy class flight within the United States, then the value of rewards increases nonlinearly with the number of points required. These assumptions may not necessarily be true for all possible ticket prices, but on average these relationships should hold.

that airport.[12] Note that the price reduction that competitors must offer is not simply offset by the revenue that the dominant carrier forgoes when consumers claim FFP rewards because airlines carefully restrict reward availability to minimize the extent to which rewards displace otherwise paid-for tickets. If so, then FFPs provide dominant airlines with a "cheap" way to give consumers utility that is not available to airlines that have only a small presence at the airport.

In this way, a dominant airline's FFP may deter entry by carriers that wish to serve only a small set of routes out of an airport or, if they do enter, make it difficult for them to attract consumers, in particular the lucrative ones (such as business travelers) who place a high value on FFP points and a low value on price. Indeed, one of the reasons why FFPs may be so effective is because they exploit a principal–agent problem between business travelers (who book their own travel and keep the associated FFP points) and their employers (who pay for this travel). The result is that, on many routes out of an airline's hubs, the hub carrier faces little competition and, on routes where competition does exist, the dominant carrier may be able to both charge higher prices and capture a greater share of passengers. That is, FFPs may both limit entry into airports that are dominated by a single carrier and provide that carrier with a competitive advantage vis-à-vis the competitors that it does face.

Clearly, one effect of FFPs may be to limit entry on routes that depart from dominated airports. This may both prevent a lower-cost firm from serving the market as well as lead to higher prices and fewer tickets sold by the higher cost incumbent. However, in addition to their impact on competition and prices, FFPs may affect welfare in two other ways. First, as mentioned earlier, FFPs may distort the purchasing behavior of business travelers whose tickets are paid for by their employer. This, in turn, may distort airlines' allocation of high- and low-priced seats. Second, by allowing airlines to bundle reward flights with paid-for flights, FFPs may be used as a form of price discrimination. If the products used as rewards would not otherwise be sold and if consumers' valuation of these products is greater than their cost to the airline, then this price discrimination may be welfare enhancing. Of course, the principal–agent problem may cause business travelers' valuation of the reward flights to be greater than their true reservation

12. Borenstein (1996) formalizes this argument and provides a discussion of the welfare effects of repeat-buyer programs. Other work on loyalty programs includes Banerjee and Summers (1987), Levine (1987), Cairns and Galbraith (1990), and Greenlee et al. (2004). In addition, within the switching-cost literature, FFPs are often used as an example of artificial or endogenous switching costs. See Klemperer (1987a, 1987b), for example.

value for these units. For the bundling aspect of these programs to increase overall welfare (and not just consumer surplus), travelers' true reservation values for the units must be greater than their opportunity cost.

3. The Domestic FFP Partnerships

3.1 Facts

In January 1998, Continental and Northwest announced a "strategic global alliance" that included FFP reciprocity, shared lounges, codesharing, and an equity purchase by Northwest in Continental.[13] On December 6, 1998, reciprocal earning took effect. Miles earned on either carrier would count toward elite status in either one of the programs. As of February 1, 1999, members of either airline's FFP could request reward flights on the other carrier, for travel beginning March 1, 1999. Codesharing between the partners began in December 1998.

In April 1998, American Airlines and US Airways announced a limited marketing relationship involving their FFPs and club facilities. The agreement took effect on August 1, 1998, when members of American's AAdvnatage program and members of US Airways' Dividend Miles programs could begin redeeming their FFP points for reward flights on the other carrier. As of August 24 of that year, members who belonged to both airlines' programs could combine miles from their accounts with both carriers when claiming travel awards on either airline. The American–US Airways partnership did not involve reciprocal earning, except for on select US Airways flights. However, because the partnership did allow for mileage pooling, it effectively made the two airlines' flights equally attractive to consumers invested in one of the airlines' FFPs.[14] This is similar to the effect of reciprocal earning. The partnership allowed for a limited amount of reciprocal elite-level benefits.

Also in April 1998, Delta and United announced their intentions to form a global alliance. The alliance was originally planned to include codesharing and reciprocal FFPs. However, talks on codesharing were discontinued in September 1998. FFP reciprocity was implemented on September 1, 1998, when members in one airline's FFP could begin earning that airline's FFP points on domestic flights operated by the

13. Northwest's purchase of an equity stake in Continental resulted in a suit by the Department of Justice against the two carriers. In 2000, Continental repurchased most of its stock from Northwest.

14. More formally, the mileage pooling meant that the marginal value of US Airways points, for example, depended on the consumer's balance in his American Airlines account. In this way, it is almost equivalent to reciprocal earning privileges.

other airline. Beginning October 15 of that year, members could redeem their points in one program for reward travel on either airline. The partnership included no reciprocal elite-benefits and miles flown on one airline did not count toward elite status in the other airline's FFP.

3.2 The Logic of FFP Partnerships

As described in the Introduction, the formation of an FFP partnership with another carrier may affect an airline's demand in two ways. First, it may enhance the value of the airline's FFP by expanding the set of flights on which consumers can earn and redeem the airline's FFP points. Second, an FFP partnership may increase the attractiveness of an airline's flights to members of its partner's FFP by allowing them to earn their preferred FFP points when traveling on theses flights. However, by allowing each carrier's FFP points to be earned on its partner's flights, a partnership effectively increases the degree of substitutability between the two airlines' products. Thus, on routes on which the partners overlap, an FFP partnership can cause the loyalty-inducing effects of the airlines' FFPs to effectively be eliminated. For example, if the dominant airline at an airport and its partner are identical on FFP dimensions, then—all else equal—these two airlines should experience similar demand. Although both airlines should still be able to price at a premium relative to other competitors on the route, the dominant carrier should have no particular advantage over its partner (controlling for other differences between them). Moreover, because the dominant airline's FFP points are now available on two different airlines' flights, competition between them should lower the price premium that the dominant airline's FFP affords, relative to the premium that the dominant airline could charge when it alone offered flights on which its FFP points can be earned. Note that, in general, all routes that an airline serves out of its partner's hubs will also be served by the dominant airline itself. This implies that any estimated increase in an airline's fares on routes that depart from its partner's hubs represents the price premium that association with the dominant airline's FFP affords, conditional on there being another airline (the dominant airline itself) on which these points can be earned. This premium should be lower than the premium that the dominant airline can charge when it is effectively a "monopolist" on its FFP points. For this reason and because points earned on partners often do not confer the exact privileges as points earned on the airline itself (e.g., Delta points earned on United flights do not count toward elite status in Delta's FFP, whereas Delta points earned on Delta flights do), the estimates of the change in an airline's fares on routes that depart from its partner's must be considered a lower bound on the price premium that FFPs afford dominant airlines.

3.3 So Why "Partner with the Competition"?

The discussion above begs the question of why the domestic partnerships were formed in the first place. Although not the focus of this paper, it is worthwhile to briefly comment on this issue. There are a number of possible reasons why these airlines partnered in 1998.[15] First, the partnership "wave" was begun by Continental and Northwest who—both significantly smaller than the other big domestic carriers—likely saw an extensive alliance as a way to increase their ability to compete against the larger domestic carriers. Estimates in a Government Accounting Office report (1999) show that the domestic market shares of Continental and Northwest in 1997 were 6.2% and 8.5%, respectively. These are substantially below the market shares of the other four major domestic carriers that ranged from 10.4% for US Airways to 17.6% for Delta. The alliances announced by American and US Airways and Delta and United might simply have been competitive responses to the Continental–Northwest alliance.

Second, because of regional differences in the airlines' networks, these partnerships could, in fact, lead to a reasonable amount of network expansion, both from an FFP and codesharing perspective. Each partnership combined carriers with different regional focuses. Delta has an extensive network in the East, Southeast, and Southwest, whereas United has an extensive network in the West and Midwest. Continental's principal service areas are the Northeast and Southwest, whereas Northwest's are the Midwest and Midsouth. Finally, US Airways has a strong presence in the Northeast and Southeast, whereas American's network extends across most of the rest of theUnited States. For example, according to airline officials, the American–US Airways partnership would give American's frequent flyers access to 105 new award destinations and US Airways' frequent flyers access to 120 new destinations.[16]

Table I shows the amount of overlap in the domestic networks of each set of partners. It also shows the amount of overlap for each other possible pairing that could have been formed. The table illustrates that there is, in fact, only a small number of routes on which both partners provide direct service. In addition, the airlines appear to have partnered with the carrier whose network was the least or one of the

15. See Bilotkach (2005) for one model of parallel FFP partnerships.
16. General Accounting Office (1999).

Table I.
Overlap on Domestic Routes, First Quarter of 1997, Routes between Top 150 U.S. Airports

Airline	No. of Domestic Routes Served Nonstop	No. of (%) Domestic Routes on Which Both Airlines Provide Nonstop Service					
		American	Continental	Delta	Northwest	United	US Airways
American	431		38 8.82%	166 38.52%	20 4.64%	172 39.91%	38 8.82%
Continental	462	38 8.23%		57 12.34%	15 3.25%	66 14.29%	49 10.61%
Delta	840	166 19.76%	57 6.79%		29 3.45%	74 8.81%	126 15.00%
Northwest	410	20 4.88%	15 3.66%	29 7.07%		26 6.34%	19 4.63%
United	540	172 31.85%	66 12.22%	74 13.70%	26 4.81%		55 10.19%
US Airways	872	38 4.36%	49 10.61%	126 15.00%	19 4.63%	55 10.19%	

Note: Nonstop service only.

least overlapping with their own, suggesting that the airlines did view these partnerships as being somewhat about expanding their networks or improving their competitive positions at airports or in regions in which they were weak.[17]

4. Data and Descriptive Analysis

4.1 Sources of Data and Construction of Sample[18]

The primary source of data is Databank 1A (DB1A) of the Department of Transportation's Origin and Destination Survey (O&D). This database is a random 10% sample of all domestic tickets that originate in the United States each quarter. The DOT data is supplemented with airline schedule data from the Official Airlines Guide (OAG). The analysis is restricted to direct coach-class round-trip tickets on the six airlines that formed the FFP partnerships. The sample is restricted to direct flights for two reasons. First, to the extent that consumers' valuation of direct

17. That being said, the fact that two of the three partnerships that I exploit have since been dissolved and replaced with other domestic alliances suggests that these relationships are somewhat fragile and still under experimentation. Indeed, Borenstein and Rose (forthcoming) identify alliances and organizational form decisions as "perhaps the most important ongoing business innovation in the airline industry."

18. Details on the data and construction of the sample can be found in the Appendix.

service is positively correlated with their valuation of FFP points, then it is an airline's direct flights that should experience the greatest increase in demand after the formation of an FFP partnership. Second, by restricting to direct flights, I ensure that the "treatment routes" (e.g., Delta's routes that depart from airports at which its partner United is dominant) and the two sets of "control routes" (e.g., Delta's routes out of nonpartners' hubs and other airlines' routes out United's hubs) are more likely to be similar to each other's unobservable dimensions.

The sample includes all routes between the top 35 U.S. airports, based on year 2000 enplanements.[19] This produces a sample of 877 distinct origin and destination pairs that had direct service by at least one of the six airlines included in my sample. On average, there are 1.4 carriers providing direct service on each route-quarter in my sample with 37% of the routes having direct service by two or more such carriers. The final data set has 23,282 observations (airline route quarters).

4.2 Variables and Summary Statistics[20]

For each airline route-quarter, I use the DOT data to calculate the passenger-weighted mean, 20th and 80th percentile fare paid (***Mean Fare***, ***20th Percentile Fare***, ***80th Percentile Fare***).[21] I construct the variable ***Frequency***, which measures the number of weekly departures the airline operates on the route. To measure each airline's own and partner's dominance at an airport, I use the OAG data to calculate an airline's and its partner's share of departing domestic flights from the origin airport of a route. These are calculated by dividing the number of direct domestic flights per week by an airline (or the airline's partner) from an airport by the total number of direct domestic flights by all airlines departing from that airport in a week. These are then used to create dummy variables for three levels of airport dominance. ***Hubsize0*** through ***Hubsize2***, respectively, equal one if an airline has less than 40% of departing domestic flights from an airport, between 40% and 58% of departing domestic flights from an airport, and greater than 58% of departing flights.[22,23] Most airlines' hubs fall into this top dominance category. ***Partner Hubsize0*** through ***Partner Hubsize2*** are similarly constructed

19. The enplanement data are taken from the Federal Aviation Administration (FAA).

20. Variable names, definitions, and summary statistics appear in Table II.

21. Fares have been converted to 2001 fares and are measured as half of the round-trip fare.

22. I construct analogous variables for the arrival airport of a route that I use in the regressions that estimate the hub premium.

23. I use 58% instead of 60% as the cutoff for the second category because there are several airports at which an airline has just below 60% of flights in some quarters and I want these to be counted in the highest category.

TABLE II.
VARIABLE DEFINITIONS AND SUMMARY STATISTICS

Variable	Definition	Mean	SD
Mean Fare	Passenger-weighted mean one-way fare paid, in 2001 dollars	213.38	89.29
20th Percentile Fare	Passenger-weighted 20th percentile one-way fare paid, in 2001 dollars	120.70	41.21
80th Percentile Fare	Passenger-weighted 80th percentile one-way fare paid, in 2001 dollars	301.43	178.52
Frequency	No. of weekly departures airline operates on this route	38.83	29.03
Partnership Period	= 1 airline's domestic FFP partnership is in place	0.47	0.50
Hubsize0	= 1 if 0 < Airline's share of departing flights $\leq$ 0.40	0.57	0.49
Hubsize1	= 1 if 0.40 < Airline's share of departing flights $\leq$ 0.58	0.09	0.29
Hubsize2	= 1 if 0.58 < Airline's share of departing flights	0.33	0.47
Partner Hubsize0	= 1 if 0 < Partner's share of departing flights $\leq$ 0.40	0.94	0.23
Partner Hubsize1	= 1 if 0.40 < Partner's share of departing flights $\leq$ 0.58	0.02	0.14
Partner Hubsize2	= 1 if 0.58 < Partner's share of departing flights	0.04	0.19

Note: Level of observation is the airline-route-quarter.

based on an airline's partner's share of flights at an airport.[24] All of the ***Hubsize*** variables are interacted with ***Partnership Period***, which is a dummy variable that equals one in quarters in which an airline's FFP partnership is in place.

It is worth emphasizing that although the sample itself is large, the number of observations used to identify the coefficients of interest

24. There are several reasons for using dummy variables to measure airport dominance. First, I expect that the relationship between an airline's level of dominance at an airport and fares to be nonlinear. For example, increases in an airline's share of flights should have a very small impact on fares when an airline has a very small or very large share of flights but a larger impact when an airline is on the verge of becoming dominant. Second, dummy variables are appropriate because the data on airport shares are fairly clustered. More specifically, airlines will generally have a very large share of flights at their own hubs, a very small share of flights at their competitors' hubs and, in a small number of cases, a moderate share of flights at either a small hub or an airport (like Boston) that is not a hub to any carrier. Finally, the use of dummy variables to measure airport dominance helps simplify the interpretation of the coefficients on the key variables that are an interaction between an airline's partner's level of dominance and an indicator for whether the airline's FFP partnership is in place.

is much smaller. Airlines, in general, do not operate very many direct flights out of another airline's hubs. In most cases, an airline will provide direct service to its own hubs and perhaps one or two large nonhub airports from an airport that is a hub to a competitor. In my sample, there are approximately 60 direct flights each quarter that are operated by an airline out of airports at which its partner has more than 40% of departing flights. This gives a total of 223 direct flights departing from airports in ***Partner Hubsize1*** in the postpartnership quarters and 395 direct flights departing from airports in ***Partner Hubsize2*** in the postpartnership quarters. It is these two sets of flights that identify the coefficients on the ***Partner Hubsize*** variables.

4.3 Descriptive Analysis

Tables III compares airlines' fares before and after the partnerships on three types of routes—those that depart from airports at which their partners have more than 58% of departing flights, those that depart from airports at which other carriers have more than 58% of departing flights, and those that depart from airports at which they have more than 58% of departing flights. The top panel of Table III suggests that, after the partnerships were formed, airlines' mean fares on direct flights departing from their partners' most dominated airports increased by

Table III.
Comparison of Fares Before and After Formation of Domestic Partnerships

	Before Partnership	After Partnership	Difference
Mean fare on routes departing from:			
Airports at which partner has >58% of departing flights	\$196.76	\$207.10	\$10.34^{+}
Airports at which other airline has >58% of departing flights	\$211.59	\$202.10	−\$9.49**
Airports at which airline has >58% of departing flights	\$238.38	\$239.37	\$0.99
80th percentile fare on routes departing from:			
Airports at which partner has >58% of departing flights	\$273.08	\$295.11	\$22.03*
Airports at which other airline has >58% of departing flights	\$298.70	\$277.96	−\$20.74**
Airports at which airline has >58% of departing flights	\$357.93	\$357.29	−\$0.64

Note: $^{+}$difference in means is significant at 10%; *difference in means is significant at 5%; **difference in means is significant at 1%.

about \$10 (or 5%). On the other hand, their fares on routes that depart from nonpartners' most dominated airports decreased by almost \$10. This suggests that inclusion in their partner's FFP did allow airlines to receive higher fares on routes that departed from their partner's hubs, both in absolute terms and relative to what they would have received. Airlines' fares on routes that depart from their own dominated airports are virtually unchanged.

The lower panel of the table carries out the same exercise using airlines' 80th percentile fare. This panel suggests that FFPs have a greater impact on airlines' 80th percentile fares. Airlines' 80th percentile fares on direct flights that depart from their partners' dominated airports increased by \$22 after the partnerships went into effect. This is in contrast to the almost \$20 reduction in the 80th percentile fares they received on direct flights that depart from airports at which a nonpartner was dominant. Interestingly, Table III also suggests that, prior to the partnerships, airlines received lower fares on routes that depart from their (future) partner's dominated airports than on routes that depart from other competitors' dominated airports. This may indicate that the airlines were intentionally partnering with carriers who served airports or regions where the airlines themselves were weak.

5. Empirical Specification and Identification

5.1 The Hub Effect

In the first part of the empirical analysis, I obtain estimates of the hub premium. As mentioned earlier, different authors have estimated hub effects in different ways. Here, I use data from the prepartnership period (1996 to the second quarter of 1998) to estimate reduced-form fare regressions that include route-quarter fixed effects. Thus, the hub effect that I estimate measures average fare differences between hub and nonhub carriers serving a route. I control for other differences between the carriers by including airline-quarter fixed effects (e.g., to capture cost and quality differences) and by controlling explicitly for the carrier's frequency on the route and whether or not the route arrives at one of its hubs.

Specifically, I estimate the following equation, where j indexes airline, r indexes route, and t indexes quarter:

$$\begin{aligned}\ln\left(MeanFare_{jr}^{t}\right) = \alpha_r^t + \delta_j^t + \beta_1 * Hubsize1_{jr} + \beta_2 Hubsize2_{jr} \\ + \beta_3 ArrivesHubsize1 + \beta_4 ArrivesHubsize2 \\ + \beta_5 Frequency_{jr}^{t} + \varepsilon_{jr}^{t} \qquad (1)\end{aligned}$$

α_r^t is a route-quarter fixed effect, δ_j^t is an airline-quarter fixed effects, and ε_{jr}^t is an error term. It is worth highlighting that with the inclusion of route-quarter fixed effects, the hub effect that I estimate is only identified off of routes that are served by more than one carrier. In my sample of direct flights, 37% of the routes are served by more than one carrier. To check that my estimates are not capturing something specific to those routes that have direct service by more than one airline, I also expand the sample to include connecting flights and estimate the hub premium using both direct and connecting flights. The addition of connecting service allows me to include route-quarter fixed effects and still estimate the hub variables off of a large set of routes.

5.2 The Effect of Extending a Dominant Carrier's FFP

After establishing that hub carriers do receive a fare premium, I then explore the relationship between FFPs and this premium. Specifically, how much of this premium results from the fact that the dominant carrier offers the most attractive FFP? To answer this question, I investigate what happens to fares when partnerships allow a hub carrier's FFP points to be earned on flights operated by the hub carrier's partner. Intuitively, I treat the partnerships as an "experiment" in which a hub airline's FFP is suddenly extended to include a set of flights that was not previously included in the program. If FFPs are one of the reasons why hub airlines receive higher fares than their competitors, then this set of flights should experience a fare increase once the partnerships go into effect. Moreover, the change in fares that these flights experience provides a lower-bound estimate of the fare premium that FFPs afford a dominant carrier.

As above, I estimate reduced-form price equations. The effects of extending a dominant airline's FFP are estimated as the change in an airline's fares on routes that depart from airports at which its partner is dominant, after its FFP partnership is in place. This change is compared to any change in fares experienced by two alternate sets of "control routes." The first set of control routes is an airline's own flights out of airports at which neither it nor its partner is dominant. I estimate the effects of the partnerships relative to this set of control routes by including airline-quarter fixed effects in the model. The second set of control routes is nonpartners' flights out of a particular airport. I implement this by including origin-quarter fixed effects. I control for underlying differences in fares across routes in a very flexible way by including airline-route fixed effects.

Specifically, I estimate the following equation:

$$\begin{aligned}\ln\left(MeanFare^{t}_{jr}\right) = {} & \lambda_{jr} + \varphi + \beta_1 PartnerHubsize1_{jr} * ParntershipPd^{t}_{j} \\ & + \beta_2 PartnerHubsize2_{jr} * PartnershipPd^{t}_{j} \\ & + \beta_3 Hubsize1_{jr} * PartnershipPd^{t}_{j} \\ & + \beta_4 Hubsize2_{jr} * PartnershipPd^{t}_{j} + \beta_7 Frequency + \varepsilon^{t}_{jr}\end{aligned} \tag{2}$$

λ_{jr} is an airline-route fixed effect, φ is either an airline-quarter or origin-quarter fixed effect, and ε^{t}_{jr} is an error term. The effects of the partnerships are captured by interacting the dummy variables measuring an airline's partner's and an airline's own level of dominance at the origin airport of a route with a dummy variable that equals one when the partnerships are in place. Findings of $\beta_1 > 0$ and $\beta_2 > 0$ would indicate that offering the FFP points of the dominant carrier at an airport increases the fares that an airline receives. Note that the uninteracted effects of the ***Hubsize*** variables are not separately identified from the airline-route fixed effects.

The key identifying assumption of the model is that there are no unobserved factors that—over this period—differentially affect an airline's fares on flights that depart from its partner's dominated airports, relative to its fares on flights in these two sets of control routes.[25] Note that there may be unobservable factors that cause the *level* of an airline's fares on routes that depart from its partner's hubs to differ from fares on the control routes. These level differences, however, will be captured by the airline-route fixed effects. The identification strategy only requires that, over the period in which the partnerships are formed, there are no unobservable factors that would cause the time trends to differ.

6. Empirical Results

6.1 The Hub Effect

Table IV presents estimates of the hub premium in the prepartnership sample, using ***Mean Fare*** as the dependent variable.[26] Recall that I estimate the hub premium as the fare premium that hub carriers receive relative to nonhub carriers *on a given route*. The estimates in the first

25. Unobservables that do not differentially affect prices on an airline's routes out of its partner's hubs but rather affect prices on all routes by a particular airline or out of a particular airport will be captured by one of the two sets of time-varying fixed effects. Entry by low-cost carriers would be an example of this type of unobservable.

26. Analogous specifications that use ***80^{th} Percentile Fare*** as the dependent variable are presented in Appendix B.

Table IV.
Estimates of the "Hub Premium"
Prepartnership Sample

Dependent Variable	log(Mean Fare)		
Fixed Effects	*Airline-Quarter Route-Quarter*	*Airline-Quarter Route-Quarter*	*Airline-Quarter Route-Quarter*
Sample	*Direct Flights*	*Direct Flights*	*Direct and Connecting Flights*
Hubsize1	0.0731	0.0386	0.0959
	(0.0132)**	(0.0097)**	(0.0067)**
Hubsize2	0.1816	0.1396	0.2611
	(0.0127)**	(0.0061)**	(0.0052)**
Arrives Hubize1	0.0121		−0.0004
	(0.0145)		(0.0071)
Arrives Hubize2	0.0562		0.0815
	(0.0126)**		(0.0073)**
Frequency	0.0015	0.0018	0.0009
	(0.0002)**	(0.0002)**	(0.0001)**
Direct			0.0299
			(0.0047)**
Observations	11,553	11,553	70,009
R^2	0.98	0.98	0.63

Note: Robust standard errors in parentheses. $^+$significant at 10%; *significant at 5%; **significant at 1%. Sample includes the first quarter of 1996 until the second quarter of 1998. The third column also includes connecting tickets.

column of the table indicate that, during the prepartnership period, airlines' flights that departed from airports at which they have between 40% and 58% of departing flights (***Hubsize1***) received 7% higher fares. Their flights that departed from airports at which they had more than 58% of departing flights (***Hubsize2***) received 18% higher fares. These fare premiums are relative to the fares received by carriers for whom neither end point of the route is a hub of any size. The coefficient on the ***Arrives Hubsize2*** variable indicates that airlines' flights that arrive at their large hubs also enjoy a fare premium (about 5.6%), but this premium is considerably smaller than the premium on flights that depart from airports at which they are dominant. A comparison of the coefficients on ***Hubsize2*** and ***Arrives Hubsize2*** suggests that, all else equal, flights that depart from an airline's large hubs receive fares that are about 12.5% higher than flights that arrive at an airline's large hubs.

In the second column of the table, I exclude the variables measuring whether a flight arrives at an airline's hub so that I can estimate the hub effect as the fare premium that a carrier with a hub at the origin airport of a route receives relative to all other carriers serving that route (even carriers who have a hub at the destination airport). The results from this specification imply a premium of about 4% on routes that depart from an airline's small hubs and a premium of about 14% on routes that depart from an airline's large hubs. As expected, the estimates of the hub premium fall once routes that arrive at an airline's hubs are included in the control group.

Finally, in the third column of Table IV, I add connecting flights to the sample. By including connecting service, I have a larger number of carriers (and itineraries) for each route. This allows me to more easily estimate both the route-quarter fixed effects and the hub effects. Once connecting flights are included, I add a dummy variable that controls for whether a flight is direct. The inclusion of connecting flights increases the estimates on the hub variables significantly. Flights departing from airlines' small hubs now enjoy a premium of 9.5%, whereas flights departing from airlines' large hubs enjoy a premium of 26%. There are two likely reasons why the estimates increase. First, in this sample, the hub variables are identified off of both the direct and the connecting flights of hub airlines. However, an airline's connecting flights out of its own hubs is a somewhat strange set of flights to look at because airlines usually serve almost all routes directly out of their own hubs. Thus, the set of passengers flying a connecting itinerary on a hub carrier may have specific unobservable characteristics that are positively correlated with fares (e.g., they may be flying a connecting itinerary instead of a direct one because they booked last minute and all direct flights were sold out). Indeed, the average number of passengers flying direct itineraries on hub carriers is about 60 times the average number of passengers flying connecting itineraries on hub carriers. Second, in this sample, flights operated by nonhub carriers are now largely connecting service. To the extent that the dummy variable indicating direct service does not perfectly control for quality differences between direct and connecting flights, some of this may be captured by the hub variables.

It is useful to briefly compare the estimates of the hub premium that I obtain to those measured elsewhere in the literature. Lee and Prado (2005) is perhaps the most natural reference point because they too include market fixed effects and measure airport dominance using two dummy variables. However, because they do not distinguish between direct and connecting itineraries and because they do not define markets as directional, our results will not be identical. In specifications that include market fixed effects but do not exploit their fare class data (and so are roughly comparable to mine), they estimate a hub premium of 16.9% for flights that involve an airline's large hubs. This estimate falls well within the range of estimates that I obtain.

Table V.
Change in Fares on Routes Departing from Partner's Hubs. Control Group: Airline's Own Routes Departing from Other Airports

Dependent Variable	*log(Mean Fare)*	*log(20^{th} Percentile Fare)*	*log(80^{th} Percentile Fare)*	*log(Mean Fare)*
Fixed Effects		*Airline-Route* *Airline-Quarter*		
Partner Hubsize1 ∗ Partnership Period	−0.0102	−0.0348	0.0258	0.0205
	(0.0116)	(0.0156)*	(0.0177)	(0.0102)*
Partner Hubsize2 ∗ Partnership Period	0.0376	0.0209	0.0716	0.0167
	(0.0114)**	(0.0131)	(0.0208)**	(0.0076)*
Hubsize1 ∗ Partnership Period	0.0033	−0.02085	0.0249	0.0695
	(0.0062)	(0.0075)**	(0.0101)*	(0.0113)**
Hubsize2 ∗ Partnership Period	0.0188	0.0190	0.0126	0.0929
	(0.0044)**	(0.0050)**	(0.0076)$^+$	(0.0095)**
Frequency	−0.0010	−0.0006	−0.0013	
	(0.0002)**	(0.0002)**	(0.0003)**	
Observations	23,282	23,282	23,282	117,324
R^2	0.91	0.82	0.83	0.54

Note: Robust standard errors in parentheses. $^+$significant at 10%; *significant at 5%; **significant at 1%. The fourth column includes only connecting tickets.

6.2 The Effect of Extending a Dominant Carrier's FFP

I now turn to the analysis that investigates what happens when a dominant airline's FFP is extended to include its partner's flights. Tables V estimates these effects using the first set of control routes—an airline's own flights that depart from airports at which neither it nor its partner is dominant. Column one estimates the impact of the partnerships on an airline's mean fare received. The insignificant coefficient on ***Partner Hubsize1 ∗ Partnership Period*** indicates that inclusion in its partner's FFP had no effect on an airline's fares on routes that departed from airports at which its partner has between 40% and 58% of flights. On the other hand, the positive and statistically significant coefficient on ***Partner Hubsize2 ∗ Partnership Period*** indicates that—once the its partner's FFP points could be earned its flights—the mean fare that an airline received on flights departing from airports at which its partner operated more than 58% of flights increased. The point estimate implies a fare increase of about 3.8%. At the average one-way mean fare on routes that depart from airports at which an airline has less than 40% of departing flights ($201), this is approximately equivalent to an $8 one-way fare increase. Recall that this change in fares is over and above any change in fares that the airline experiences on all of its direct flights in a given quarter (captured by the airline-quarter fixed effects). The positive coefficient on ***Partner Hubsize2*** $*$ ***Partnership Period*** provides the first piece of evidence of a positive relationship between fares and offering the FFP points of the dominant carrier at an airport. In addition, the fact that there is no estimated effect of the partnerships on an airline's flights that depart from airports at which its partner is only moderately dominant (***Partner Hubsize1***) suggests that what I am measuring is, in fact, an "FPP effect" and not, for example, the result of some of other change in demand, cost, or competition resulting from the partnerships.[27] Assuming that an airline's level of dominance at an airport is a good proxy for the extent to which consumers at the airport value its FFP points, then it is precisely at those airports at which an airline is most dominant that consumers will most value the ability to earn that airline's FFP points on another airline's flights.

With respect to the impact of the partnerships on an airline's fares on routes that depart from airports at which it itself is dominant, the estimates in column one indicate that there is no effect on an airline's fares on routes that depart from its small hubs, and there is a small effect (about 1.8%) on an airline's fares on routes that depart from its large hubs. This suggests that consumers may have viewed the FFP partnerships to be enhancements to the airlines' FFPs; however, this coefficient could also be capturing the fact that, over this period, these airlines are also increasingly entering in FFP partnerships with international carriers and this could be increasing hub fares as well.[28]

In the second and third columns of Table V, I investigate how the partnerships affect the 20^{th} and 80^{th} percentile fare paid for a flight. If FFPs are most highly valued by business travelers and if fares toward the top of the distribution represent tickets more likely to have been purchased by business travelers, then one would expect the impact of being able to earn the hub carrier's FFP points to be larger at the top of the distribution. The estimates in Table V suggest that this was the case. The partnerships had no effect on an airline's 20^{th} percentile fare on flights that depart from its partner's most dominated airports, whereas an airline's 80^{th} percentile fare on these routes increased by more than 7%. At the average 80^{th} percentile fare on flights that do not depart from an airline's own dominated airports ($274), this represents an increase

27. Note, as well, that the positive coefficient on ***Partner Hubsize2*** $*$ ***Partnership Period*** is not simply capturing the fact that most of an airline's routes that depart from its partner's hub airports arrive at one of its own hubs. In specifications not reported, I allow the partnerships to increase an airline's fares on all routes that arrive at its hubs. This has no impact on the coefficient on ***Partner Hubsize2*** interactions.

28. See Lederman (forthcoming).

of about $19 per one-way travel or $38 per round-trip. This is indeed a substantial increase in airlines' realized fares on these routes.

Interestingly, the pattern is somewhat different for an airline's flights that depart from its own hubs. The partnerships increase an airline's 80th but not its 20th percentile fare on routes that depart from airports in ***Hubsize1***, and increase an airline's 20th but not its 80th percentile fare on routes that depart from airports in ***Hubsize2***. This pattern is a little puzzling but could be capturing the fact that the enhancement effects of these partnerships are not straightforward. Consumers will perceive these partnerships to be enhancements to an airline's FFPs if they increase the set of available earning and redemption opportunities. If so, then this enhancement effect might, in fact, be largest not at an airline's most dominated airports, but rather at airports where the airline is dominant enough that consumers are invested in its FFP but not so dominant that the addition of its partner has no actual impact on consumers' available earning and redemption opportunities.

In the fourth column of Table V, I estimate the impact of the partnerships on an airline's connecting flights. As mentioned earlier, to the extent that consumers' valuation of direct service is positively correlated with their valuation of FFP points (as one might expect for business travelers), then it is an airline's direct flights out of its partner's hubs that should be most affected by the FFP partnerships. Nonetheless, it is worthwhile to briefly investigate the impact on connecting flights. The estimates indicate that an airline's mean fare on connecting flights that depart from its partner's large hubs increased by about 1.7%. This change in fares is over and above any change in fares that the airline experiences on all of its connecting flights in a given quarter (captured by the airline-quarter fixed effects that are now identified by an airline's connecting rather than direct flights). Thus, the point estimates imply that relative to their respective sets of control routes, an airline's direct flights departing from its partner's hubs experience a larger change in fares than its connecting flights. This is exactly what one would expect.

Interestingly, the pattern is reversed for an airline's connecting flights departing from its own hubs. Relative to their respective control groups, an airline's connecting flights departing from its own hubs experience a larger fare increase than its direct flights departing from its own hubs. Although this may seem surprising, recall that the coefficients on the ***Hubsize*** interactions must interpreted with caution because there may be other factors affecting an airline's fares out of its own hubs. Furthermore, as mentioned earlier, an airline's connecting flights out of its own hubs is a somewhat strange set of flights to look at because airlines usually serve almost all routes directly out of their own hubs. Thus, one might expect the set of passengers flying a connecting itinerary

Table VI.
Change in Fares on Routes Departing from Partner's Hubs. Control Group: Other Airlines' Routes Departing from Same Airport

Dependent Variable	*log(Mean Fare)*	*log(20th Percentile Fare)*	*log(80th Percentile Fare)*
Fixed Effects		*Airline-Route, Origin-Quarter*	
Partner Hubsize1 ∗ Partnership Period	−0.0168	−0.0243	0.0283
	(0.0138)	(0.0169)	(0.0213)
Partner Hubsize2 ∗ Partnership Period	0.0495	0.0068	0.0899
	(0.0127)**	(0.0142)	(0.0229)**
Hubsize1 ∗ Partnership Period	0.0088	−0.0017	0.03730
	(0.0091)	(0.0100)	(0.0149)*
Hubsize2 ∗ Partnership Period	0.0380	0.0161	0.0400
	(0.0066)**	(0.0073)*	(0.0111)**
Frequency	−0.0010	−0.0005	−0.0015
	(0.0002)**	(0.0002)*	(0.0003)**
Observations	23,282	23,282	23,282
R^2	0.91	0.83	0.84

Note: Robust standard errors in parentheses. $^+$significant at 10%; *significant at 5%; **significant at 1%.

on a hub carrier may have specific unobservable characteristics that are correlated with fares.

It is worth briefly commenting on the negative coefficient on the ***Frequency*** variable in Table V. In general, one expects that higher frequency of service is associated with higher fares. However, when airline-route fixed effects are included, ***Frequency*** is only identified off of changes over time in an airline's frequency on a given route, and these changes may be correlated with other factors that have a negative impact on fares.

In Table VI, I replace the airline-quarter fixed effects with origin-quarter fixed effects. Intuitively, this changes the set of control routes from an airline's own flights out of other airports to other airlines' flights out of the same airport. For example, if the "treatment" routes are Delta's flights out of its partner United's hubs, the control routes used in Table V are Delta's flights out of airports at which neither it nor United is dominant, whereas the control routes used in Table VI are American's, Continental's, Northwest's, and US Airways' flights out of airports at which United is dominant. This set of control routes is preferred if one is concerned that the estimates on the ***Partner Hubsize*** variables are capturing changes in airport-level unobservables that may be correlated with the formation of the partnerships rather than changes in airline-specific unobservables that may be correlated with the formation of the partnerships. The results using this set of control routes are extremely consistent with those in Table V. The first column of Table VI estimates the model using an airline's mean fare as the dependent variable. The results indicate a slightly less than 5% increase in fares on airlines' routes that depart from airports at which their partner has more than 58% of departing flights. Consistent with Table V, columns two and three of the table show no effect of the partnerships on airlines' 20th percentile fares on routes departing from their partners' dominated airports and a large impact (about 9%) on airlines' 80th percentile fares.

The estimates from Tables IV through VI can now be used to calculate approximately what fraction of the hub premium is due to the fact that the hub carrier offers the most attractive FFP. The results from the second column of Table IV indicate that, on average, hub carriers receive fares that are 14% higher than other carriers serving the same route (including carriers for whom the arrival airport of the route is a hub).[29] How much of this fare premium is due to the fact that consumers perceive the hub carrier to offer the most valuable FFP at the airport? The estimates from the first columns of Tables V and VI imply that once consumers are allowed to earn the hub carrier's FFP points on flights on which they previously could not earn these points, the mean fare received on these flights increased by between 3.5% and 5%. Thus, simply offering consumers the FFP points of the dominant carrier at an airport leads to a price premium of between 3.5% and 5%. Combining this with the estimates of the hub premium implies that FFPs account for at least 25–36% of the fare premium that hub carriers receive. Using the analogous estimates for the 80th percentile fare (in the second columns of Tables V and VI and the estimates in the second column of the table in Appendix B), I calculate the FFPs account for between 29% and 37% of the fare premium that hub carriers receive.

6.3 Robustness

In Table VII, I carry out several checks on the robustness of the results. I use the specification that appears in the third column of Table V. The results are similar when I use replace the airline-quarter fixed effects with origin-quarter fixed effects.

First, I reestimate the model excluding Continental and Northwest. Because the Continental–Northwest partnership also involved

29. I use the estimates in the second column of Table IV for this exercise because they represent the average fare premium that a hub carrier receives relative to all other carriers serving the route.

Table VII.
Robustness

Dependent Variable	*log(80th Percentile Fare)*			*log(Frequency)*
Fixed Effects	*Airline-Route Airline-Quarter*			*Airline-City Pair Airline-Quarter*
"Check"	*Drop CO & NW*	*"Collusion"*	*"Collusion"*	*"Collusion"*
Partner Hubsize1 ∗ Partnership Period	0.0276	0.0311	0.0391	−0.0547
	(0.0177)	(0.0201)	(0.0203)$^{+}$	(0.0197)**
Partner Hubsize2 ∗ Partnership Period	0.0869	0.0699	0.0853	0.0507
	(0.0225)**	(0.0235)**	(0.0245)**	(0.0141)**
Hubsize1 ∗ Partnership Period	0.0267	0.0294	0.0347	
	(0.0102)**	(0.0102)**	(0.0110)**	
Hubsize2 ∗ Partnership Period	0.0160	0.0170	0.0116	
	(0.0088)$^{+}$	(0.0078)*	(0.0081)	
Both Serve ∗ Partnership Period		0.0274	0.0085	
		(0.0123)*	(0.0151)	
Hubsize1 ∗ Partnership Period ∗ Both Serve			−0.0310	
			(0.0251)	
Hubsize2 ∗ Partnership Period ∗ Both Serve			0.0645	
			(0.0283)*	
Observations	17,785	22,036	22,036	11,043
R^2	0.84	0.82	0.82	0.94

Note: Robust standard errors in parentheses. $^{+}$significant at 10%; *significant at 5%; **significant at 1%. The first column excludes Continental and Northwest. *Frequency* is included in columns one through three but its coefficient is not reported. Columns two and three exclude airline-routes where there is entry or exit during the sample by the airline's partner Column four uses data at the airline–city pair level.

codesharing, this partnership could lead to changes in fares for reasons other than the FFP mechanism described earlier, in particular on routes on which they both provide direct service (such as routes between their respective hubs).[30] Because these are also the types of routes that identify the coefficients on the ***Partner Hubsize*** interaction terms, it is important to confirm that these coefficients are not simply capturing the effects of their codesharing. In addition, Continental and Northwest's codesharing arrangement could cause them to change scheduling or other unobserved characteristics of their flights in ways that could affect fares. The first column of Table VII shows that the coefficient on ***Partner Hubsize2 ∗ Partnership Period*** is very similar when Continental and Northwest are excluded.[31]

30. See Ito and Lee (2006, 2007) and Armantier and Richard (2005, 2006) for analyses of the effects of the Continental–Northwest codesharing arrangement.

31. Note also that, in an effort to gain Department of Transportation approval for their codesharing agreement, Continental and Northwest agreed not to codeshare flights in

Second, I investigate whether the price increases that I find may be capturing a reduction in the intensity of price competition. Almost all of the routes that an airline serves out of its partner's hubs are routes that the partner will serve as well. Therefore, could the observed increase in fares be the result of the partners competing less intensely with each other? To test this, I exploit the fact that there are routes on which an airline and its partner both offer direct service but which do not depart from the airline's partner's dominated airports. I construct the variable ***Both Serve***, which is a dummy variable that equals one for routes on which the airline and its partner both provide direct service and interact this variable with the dummy variable ***Partnership Period***. To avoid endogenous changes in whether or not both partners serve a particular route, I drop the small number of airline-routes on which there is either entry or exit by the airline's partner anytime during the sample (this drops 68 routes or about 1200 observations). Because this eliminates any variation in ***Both Serve*** within a given airline-route, the coefficient on ***Both Serve*** is not separately identified from the airline-route fixed effects. If the positive coefficient on ***Partner Hubsize2*** ∗ ***Partnership Period*** is capturing the fact that the partnerships are facilitating cooperation between the airlines, then this should be reflected in higher fares on *all* routes on which an airline and its partner both provide direct service, not just on those that happen to depart from the partner's dominated airports. On the other hand, if the fare increase is resulting from the extension of the partner's FFP, the inclusion of ***Both Serve*** ∗ ***Partnership Period*** should not eliminate the positive coefficient on ***Partner Hubsize2*** ∗ ***Partnership Period***. The results in the second column of Table VII indicate that this appears to be the case. After the partnerships are in place, airlines receive slightly higher fares on routes on which they overlap with their partners but still higher fares on routes that depart from their partner's most dominated airports.

In the third column of Table VII, I take this exercise one step further and explore the positive coefficient on ***Both Serve*** ∗ ***Partnership Period*** in a slightly more detailed way. There are effectively three "types" of routes that may be served by both an airline and its partner. These are (1) routes that depart from the airline's own hubs (and likely arrive at the partner's hubs); (2) routes that depart from the partner's hubs (and likely arrive at the airline's hubs); and (3) routes that depart from neither of their hubs. Although ***Partner Hubsize2*** effectively "selects" out the second set of routes, the first and third sets are both captured by ***Both***

markets between their respective hub airports. This means that even when Continental and Northwest are included in the sample, they are actually not even codesharing on many of the routes that would identify ***Partner Hubsize2***.

Serve* ∗ *Partnership Period. To investigate whether these two types of overlap routes are differentially affected by the partnerships, I interact the ***Hubsize*** interactions with the ***Both Serve*** dummy. This tests whether fares on an airline's routes that depart from its own dominated airports and that are also served by its partner are affected differently than fares on routes that depart from the airline's hubs that are not served by the partner. The results of this exercise indicate that an airline's flights on routes that depart from its own dominated airports that are also served by its partner experience 6% higher fares after the partnerships. There is no change in the airline's fares on other overlap routes, as implied by the now insignificant coefficient on ***Both Serve* ∗ *Partnership Period***.

This finding might, initially, seem surprising. One might expect that an airline's routes out of its own hubs on which it competes directly with its partner would be the *least* likely to experience fare increases because it is precisely these routes on which the partner's flights have now become closer substitutes. Although this reasoning is correct, this effect may be offset by two others working in the opposite direction. First, on routes on which both partners provide direct service, the "effective" frequency of flights on which the dominant airline's FFP points can be earned has increased. If consumers value the frequency of flights on which a particular airline's FFP points can be earned, then the fact that the dominant airline's points can be earned on both its own and its partner's flights on a route might have a positive impact on demand. Second, an airline's routes that depart from its own hub and that are also served by its partner are the "return flights" of routes that depart from the airline's partner's hubs. For example, Delta's flights from Atlanta (a Delta hub) to Chicago O'Hare (a United hub)—a route on which both Delta and United provide direct service—are the return flights of Delta's flights from Chicago O'Hare to Atlanta. Because the partnerships increase Delta's sales of high-fare tickets to passengers traveling O'Hare to Atlanta, this may reduce the number of lower-fare tickets that Delta sells from Atlanta to O'Hare, relative to the prepartnership period when its O'Hare-Atlanta flights were less attractive to consumers in Chicago. The fact there is no impact at all on an airline's fares on routes on which it competes with its partner that do not depart from either's hubs suggests that results are indeed detecting an FFP effect and not just capturing reduced competition between the partners.

In the final column of Table VII, I take the analysis one step further and directly investigate the impact of the partnerships on flight frequency. For this exercise, I take the data up to the airline–city pair (as opposed to airline-route) level because frequency (unlike fares) is generally the same in both directions of a city pair. That is, an airline will typically have the same frequency of flights between Boston and

Atlanta as it does between Atlanta and Boston.[32] In contrast, depending on the composition of tickets sold, realized fares may be quite different in the two directions of a city pair. The airline-route fixed effects are replaced with airline–city pair fixed effects. As before, airline-quarter fixed effects are included. The dependent variable is the natural log of the number of flights per week that the airline operates on the city pair (***Frequency***).

I investigate whether airlines are changing their frequencies on city pairs that have their partner's hubs on one of the end points (i.e., the city pairs on which the partnerships have been shown to affect fares). To do this, I redefine the ***Partner Hubsize*** variables to include either end point of the city pair. For example, ***Partner Hubsize2*** now equals one if *either* end point of the city pair is an airport at which the airline's partner has greater than 58% of departing flights. The estimates from this specification suggest that airlines are decreasing their frequency on city pairs that involve their partner's small hubs (captured by the ***Partner Hubsize1*** interaction) but increasing their frequency on city pairs that involve their partner's large hubs (captured by the ***Partner Hubsize2*** interaction). Recall that it is on routes that depart from their partners' large hubs that the majority of the price effects were detected. The finding of an increase in frequency on these particular city pairs provides additional evidence that the pricing effects found in the previous tables are not simply measuring a reduction in competition between the carriers.

7. Conclusion

This paper has estimated the relationship between FFPs and the fare premiums that hub carriers receive. To separate the effects of FFPs from the other advantages that may increase dominant airlines' fares, the paper developed a novel empirical approach that exploits variation resulting from the formation of three FFP partnerships. These partnerships are helpful for isolating the effects of FFPs because they effectively extend an airline's FFP to include a new set of flights—those operated by the airline's partner—which were not previously included in the program. If FFPs are one of the reasons why airlines receive higher fares on routes that depart from airports at which they are dominant, then these FFP partnerships should allow airlines' partners to also charge higher fares on routes that depart from these exact airports.

32. In the small number of cases where an airline had different frequency in the two directions of a city pair, I randomly chose which frequency to assign to the city pair. The results are quite similar when the regressions in Table VII are carried out at the route, rather than city pair, level.

The results indicate that this was indeed the case. After the formation of their FFP partnerships, airlines received higher fares on routes that departed from specifically those airports at which their partner was dominant. Consistent with an "FFP story," the effects were most pronounced at the top of the fare distribution. The estimates imply that allowing consumers to earn the hub carrier's FFP points on a flight increased the mean fare received by between 3.5% and 5% and the 80^{th} percentile fare that received by between 7% and 9%. Taking these as a lower-bound estimate of the impact that FFPs have on fares, they suggest that a dominant airline's FFP increases its one-way mean fare by at least \$7–\$10 and its one-way 80^{th} percentile fare by at least \$19–\$25. Combining these figures with estimates that indicate that hub carriers receive mean fares that are about 14% higher than other carriers serving the same route suggests that FFPs may account for over 25% of the fare premium that hub carriers receive.

Since the emergence of hub-and-spoke systems, the relationship between airport-level dominance and route-level market power has attracted considerable attention. Although there have been a number of studies documenting the existence and robustness of the hub premium, there has been limited research into the causes of the hub premium. However, understanding the various factors that may provide dominant airlines with an advantage is critical to designing any policy intervention that seeks to increase competition at hubs. Because of the welfare benefits that hub-and-spoke networks provide, an outright ban on hubs has never appeared a plausible or desirable response. Rather, targeting the specific sources of advantage (e.g., FFPs or control over scarce airport facilities) appears a more fruitful approach. Although I interpret the results of this paper somewhat cautiously because they are based on the "experiment" provided by FFP partnerships, they suggest that, all else equal, imposing restrictions on airlines' use of FFPs would indeed lower the fare premium that dominant airlines command.

Appendix A—Construction of Data Set

Databank 1A is a random 10% sample of all domestic tickets that originate in the United States on domestic carriers each quarter. Each observation in the databank contains information on the route traveled (the origin, destination, and any connecting airports), the carrier(s), the type of ticket (one-way, round-trip, or open-jaw), the class of service (coach, business, or first), the dollar fare, and the distance of the trip. Importantly, the data also contain a variable indicating the origin of the ticket, which allows the direction of travel on round-trip tickets to be distinguished (i.e., ATL-BOS-ATL or BOS-ATL-BOS). The data do not identify the exact date or time of travel and unfortunately do not contain any information on ticket restrictions, such as whether the ticket required a Saturday night stay-over or whether it was purchased more than 14 days in advance. As a result, a given carrier routing will appear in the disaggregated DB1A data with several different fares but otherwise identical on observable characteristics. Rather than treat each of these as a separate product, I aggregate the different fares paid for the same airline routing and calculate the passenger-weighted mean, 20th, and 80th percentile fare paid.

I restrict the data set to direct round-trip coach class flights on American, Continental, Delta, Northwest, United, or US Airways. Round-trip itineraries appear in the DOT data as two one-way trips, each with half of the total fare and half of the total distance of the complete trip. To avoid double counting the two halves of a round-trip, only observations on the departing leg of each round-trip itinerary are included. I include flights between the top 35 airports based on year 2000 enplanements. Observations satisfying any of the following criteria are eliminated: fare, measured in 2001 dollars, less than $25 or equal to $5000 or $9999 (these appear to be top codes and not actual fare observations); distance less than 50 miles (these are generally trips between airports located in the same city, such as JFK and LaGuardia); arrival or departure in Hawaii or Alaska; direct itineraries that appear in the DOT data but not in the OAG; direct itineraries that are traveled by fewer than 12 passengers per week. The final DOT data set contains 23,282 observations.

Appendix B
Estimates of the "Hub Premium" Prepartnership Sample, 80th Percentile Fare

Dependent Variable	log(**80th Percentile Fare**)		
Fixed Effects	Airline-Quarter Route-Quarter	Airline-Quarter Route-Quarter	Airline-Quarter Route-Quarter
Sample	Direct Flights	Direct Flights	Direct and Connecting Flights
Hubsize1	0.072518	0.031425	0.095426
	(0.025941)**	(0.018859)+	(0.009519)**
Hubsize2	0.286858	0.236487	0.303223
	(0.024741)**	(0.012825)**	(0.006833)**
Arrives Hubize1	0.009237		–0.041326
	(0.026821)		(0.009288)**

Continued

Appendix B
Continued

Sample	Direct Flights	Direct Flights	Direct and Connecting Flights
Arrives Hubize2	0.068824		0.081499
	(0.024223)**		(0.007269)**
Frequency	0.002357	0.002744	0.002541
	(0.000329)**	(0.000288)**	(0.000159)**
Direct			0.031516
			(0.007222)**
Observations	11,553	11,553	70,009
R^2	0.95	0.95	0.55

Note: Robust standard errors in parentheses. +significant at 10%; *significant at 5%; **significant at 1%. Sample includes direct coach tickets from the first quarter of 1996 until the second quarter of 1998. The third column also includes connecting tickets.

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