An Empirical Analysis of the Competitive Effects of the Delta/Continental/Northwest Codeshare Alliance

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Abstract

The U.S. Department of Transportation (DOT) expressed serious reservations before ultimately approving the Delta/Continental/Northwest codeshare alliance. The DOT's main fear is that the alliance could facilitate collusion (explicit or tacit) on prices and/or service levels in the partners' overlapping markets. However, since implementation of the alliance there has not been a formal empirical analysis of the alliance's effects on price and traffic (number of passengers) levels. The main objective of this paper is to conduct such an analysis with a particular focus on testing whether or not the data are consistent with collusive behavior by the three airlines. The evidence does not suggest that the alliance facilitated collusion on the partners' overlapping routes.

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1 Introduction

A codeshare agreement between airlines effectively allows each airline to sell seats on its partners' plane as if these seats are owned by the airline selling the seats.[1] In August 2002, three of the five largest airlines in the U.S. (Delta Airlines, Continental Airlines, and Northwest Airlines) submitted codesharing and frequent-flyer reciprocity agreements[2] to the U.S. Department of Transportation (DOT) for review. The DOT's review expressed concerns that the proposed three-airline alliance has the potential to significantly reduce competition.[3]

The DOT argues that the broad nature of discussions between partners that is required to make their interline[4] service seamless could facilitate collusion (explicit or tacit) on prices and/or service levels in the partners overlapping markets.[5] Furthermore, this potential problem is particularly troubling in the Delta/Continental/Northwest proposed alliance due to the significant extent to which the three airlines route networks overlap, which is unlike any other existing domestic alliance. The DOT remarked that the three airlines' service overlap in 3,214 markets accounting for approximately 58 million annual passengers. This is in contrast to the next largest alliance which is between United Airlines and US Airways who have overlapping service in only 543 markets accounting for 15.1 million annual passengers.

In June 2003, the three airlines began their codeshare alliance after satisfying the DOT that competition is unlikely to be harmed by the alliance and that consumers stand to gain from a greater choice of flights and greater opportunities to earn and redeem frequent-flyer miles across the three carriers. However, since implementation of the alliance there has not been a formal analysis of whether the alliance actually facilitated collusion on price or service levels, as the DOT feared, among the partner carriers.

In an ex-ante environment, Gayle (2007a) show how a structural econometric framework can be used to quantify the extent to which potential alliance partners' prices may increase in their

[1] In Section 2, I provide more detail on how a codeshare agreement actually works.

[2] An airline's frequent-flyer program normally allows passengers to accumulate miles flown over multiple trips on the airline. A passenger that accumulates miles beyond some threshold level can redeem the miles for a free or discounted trip. When alliance partners make their frequent-flyer programs reciprocal, passengers are allowed to accumulate and redeem miles across airlines within the alliance. See Suzuki (2003) for a detailed discussion of various types of frequent-flyer programs and their attractiveness to passengers. See Lederman (2003) for an analysis of the relationship between alliance formation and the value of alliance partners' frequent-flyer programs to passengers.

[3] See "Termination of review under 49U.S.C. § 41720 of Delta/Northwest/Continental Agreements," published by *Office of the Secretary, Department of Transportation*, January 2003.

[4] Interline means that at some point in the trip when passengers change planes they also change airlines.

[5] An overlapping market means that the potential partners' own flights are already competing between the origin and destination cities.

overlapping markets if they collude on price. As an illustrative example, Gayle (2007a) applied the econometric model to the then potential Delta/Continental/Northwest alliance in 15 of their Hub-to-Hub overlapping markets. The model predicts that the partners' prices are unlikely to increase significantly (less than 5%) in these markets even in the worst case scenario where they collude on prices without any associated cost efficiency gains from the alliance.[6]

Now that the alliance has been implemented, the main purpose of this paper is to provide a formal analysis of the actual effect of the alliance on prices and traffic (number of passengers) levels using a significantly larger sample of markets than in Gayle (2007a). Most important, I test if the data are consistent with collusive behavior of the alliance partners in their overlapping markets.

My analysis comprises two main segments. First I study the overall effects of the alliance on city pair price and traffic levels, and its effects on the alliance partners' city pair price and traffic levels. Following this aggregated analysis in the first segment, I then explore how different types of codesharing formats affect city pair price, traffic levels, and alliance partners' city pair prices and traffic levels. The second segment of the analysis is therefore a more disaggregated study of the market effects of different types of codesharing practiced between the three carriers.

The overall market effects of the alliance, and the specific market effects of each type of codesharing are uncovered by estimating a series of "before-and-after" regression models using a sample of 26,666 city pairs over the pre- and post-alliance periods. From the first segment of the analysis I find that, unlike most other codeshare alliances that have been formally studied, the Delta/Continental/Northwest alliance is associated with an overall marginal increase in average city pair price (a maximum of 1.8%) in the majority (77.57%) of city pairs in which the partners codeshare. In contrast, Bamberger, Carlton, and Neumann (2004) find that the Continental/American West and the Northwest/Alaska alliances that were both formed in the mid-1990s are associated with a 7.5% and 3.9% fall in average fares respectively. Also in contrast to my findings in the aggregated analysis, Brueckner (2003) finds that the presence of codesharing on international interline itinerary reduces the fare by 8% to 17%, and Brueckner and Whalen (2000) find that alliance partners charge interline fares that are approximately 25% lower than fares charged by nonallied carriers.[7]

[6]Alliances may result in cost savings since alliance partners often jointly use each others facilities (lounges, gates, check-in counters etc.), and may also practice joint purchase of fuel. Chua, Kew, and Yong (2005) present an interesting empirical analysis of the effect of codeshare alliances on partners' cost. They found that codeshare alliances reduce airlines' cost, albeit small in magnitude.

[7]See Ito and Lee (2007) for a comprehensive and interesting analysis of the effect of domestic codeshare alliances

The aggregated analysis further finds that: (1) the alliance accounts for 10.7% to 12.3% increase in overall city pair traffic on city pairs where they codeshare (alliance city pairs), and a 19.8% to 24.4% increase in the partners' city pair traffic on alliance city pairs; and (2) average price changes and total traffic changes are no different on alliance city pairs where the partners' service overlap compared to other alliance city pairs. In summary, even though the alliance is associated with price increases, the fact that it is also associated with increases in traffic levels is not suggestive of collusive behavior.

In a study of the Continental/Northwest alliance which was formed in 1999, Armantier and Richard (2006) find significantly higher prices across markets with nonstop flights from Continental and Northwest. They argue that as Continental and Northwest used their alliance to expand their pool of passengers, these carriers were able to extract a higher price from their passengers and therefore collusive behavior was not the reason for higher prices. As such, their results are consistent with results from my aggregated analysis of the three-airline alliance between Delta, Continental, and Northwest formed in 2003.

In the spirit of Ito and Lee (2007), I break down codesharing into two main types: (1) Traditional; and (2) Virtual. Traditional codeshare itineraries combine interline operating services of partner carriers on a given route, where one of the operating carriers is the sole ticketing carrier for the entire trip.[8] In the case of virtual codeshare itineraries, a passenger remains on a single carrier's plane(s) for the entire round-trip, but the ticket for the trip was marketed and sold by a partner carrier.

I find that traditional codesharing exhibits a feature similar to results from the aggregated analysis. In particular, this type of codesharing format is associated with traffic increases. The increased traffic is probably owing to higher quality product offerings (better variety of seamless connecting flights, greater opportunities for passengers to earn and redeem frequent-flyer miles, etc.). Furthermore, I find that this type of codesharing seem not to be associated with price increases. In fact, traditional codesharing seem to decrease average city pair price in alliance city pairs where the partners' service overlap.

By contrast, virtual codesharing is strongly associated with price increases. The estimated

on fares in the U.S. airlines industry.

[8] Details on the distinction between an "operating carrier" and a "ticketing carrier" are given in Section 2. Basically, the carrier whose plane actually transports a codeshare passenger is referred to as an "operating carrier", while the carrier that marketed and sold the ticket for the seat is referred to as the "ticketing carrier".

price effects therefore suggest that virtual codesharing could be associated with collusive behavior. However, I also find that virtual codesharing is associated with traffic increases, which is inconsistent with effective collusive behavior.

The rest of the paper is organized as follows. Section 2 provides more detail on how a codeshare agreement actually works, paying particular attention to the Delta/Continental/Northwest codeshare alliance. Section 3 discusses the research methodology used to analyze the price and traffic effects of the alliance. In Section 4, I discuss characteristics of the data used in estimation. Results are presented and discussed in Section 5, while concluding remarks are gathered in Section 6.

2 The Delta/Continental/Northwest Alliance

A codeshare agreement effectively allows one carrier to sell seats on its partners' plane as if these seats are owned by the carrier selling the seats. The carrier selling the ticket for the seat is called the "ticketing carrier" (or "marketing carrier"), while the carrier whose plane actually transports the passenger is referred to as the "operating carrier". Codesharing is achieved by the ticketing carrier placing its code on the operating carrier's flight so that a given flight has two separate listings on computer reservation systems that are used for booking flights. For example, suppose Delta operates a flight between Atlanta, Georgia and Minneapolis St. Paul, Minnesota. Northwest may place its code (NW) on this Delta flight and sell tickets for seats on this flight as if Northwest operated the flight. So this flight will be listed twice in computer reservation systems, once under Delta's code (DL) and again under Northwest's code (NW). Put simply, a codeshare agreement allows partner airlines to expand their flight offerings without addition of planes.

The example above may be used to illustrate two potential benefits of codesharing to consumers who want to travel between Atlanta, Georgia and say Detroit, Michigan. It is the case that Northwest operates nonstop flights between Atlanta and Detroit and between Minneapolis St. Paul and Detroit as illustrated in the route network diagram labeled Figure 1. Therefore, by codesharing with Delta between Atlanta and Minneapolis St. Paul, Northwest is able to offer consumers both a nonstop flight between Atlanta and Detroit and a one-stop connecting flight between Atlanta and Detroit, where the connection is made in Minneapolis St. Paul.[9] Note that the connecting

[9] See Chen and Gayle (2007) for a theoretical analysis of the price effects of codesharing when one of the partners offers a nonstop flight in the same market where it codeshares on an interline product.

Northwest passenger would fly on a Delta operated flight between Atlanta and Minneapolis St. Paul, then use a Northwest operated flight between Minneapolis St. Paul and Detroit.[10]

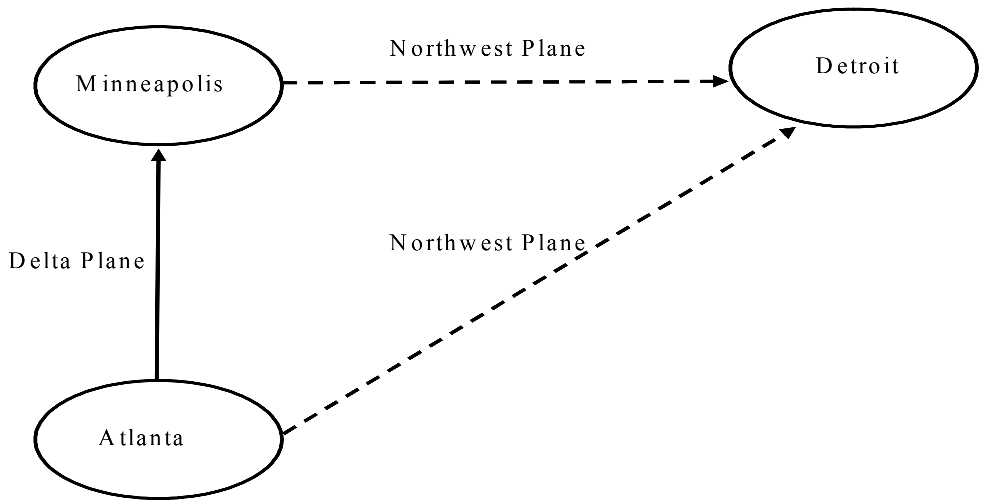

Figure 1: Route Network Diagram

The connecting Northwest passenger may benefit from the codeshare agreement in two ways. First, the passenger is likely to obtain a seamless interline connection which might not be the case if the two airlines were not partners. That is, partners attempt to coordinate schedules and proximity of gates for interline flights. Therefore, the quality of the connection is likely to be better between partner carriers than if the carriers are unaffiliated.[11] Second, if the Northwest passenger participates in its frequent-flyer program, the codeshare agreement allows the passenger to accumulate points on the Atlanta to Minneapolis St. Paul segment of the trip even though this segment is operated by Delta.

[10] At first glance it might seem counter-intuitive that a passenger would choose a one-stop itinerary even though a nonstop flight between the origin and destination is available. However, passengers often times do seem to choose less convenient routes (flight itineraries that require intermediate stops) to get from their origin to destination when such alternate routing is competitively priced. Thus, within reasonable bounds, some passengers are willing to trade-off travel itinerary convenience for lower price.

[11] Though rare in practice, a passenger may use two unaffiliated airlines to complete an interline trip. However, in such a case the passenger must purchase separate tickets from each airline operating different segment(s) of the trip. Furthermore, such an interline trip is likely to have unfavorable characteristics such as the need for multiple check-in, longer distance between connecting gates, lack of responsibilities by carriers in case of missed connection etc. [See Armantier and Richard (2006) and Morrison and Winston (1995)].

Using the language of Ito and Lee (2007), the codesharing example above is referred to as "traditional" owing to a certain feature of the travel itinerary. In particular, "traditional" codeshare itineraries combine interline operating services of partner carriers on a given route, where one of these operating carriers is the sole ticketing carrier for the entire trip.

An important part of the example above that has not been introduced is the fact that Delta also offers a nonstop flight between Atlanta, Georgia and Detroit, Michigan as illustrated in the modified route network diagram labeled Figure 2. Thus, Northwest and Delta's route networks overlap in the Atlanta to Detroit market and therefore they are competitors in this market. This provides an example where the DOT is concerned that the partnership may compromise how fiercely they compete. However, in defending the proposed alliance the three airlines pointed out that all the ticket revenue from a codeshare passenger goes to operating carrier(s). The ticketing carrier only receives a booking fee to cover handling costs. In other words, even though Northwest sold a seat on Delta's plane for the Atlanta to Minneapolis St. Paul segment of the trip, Delta ultimately gets the ticket revenue for this trip segment. As such, the airlines argue that each partner still has an incentive to independently compete for customers since there is no sharing of revenues.

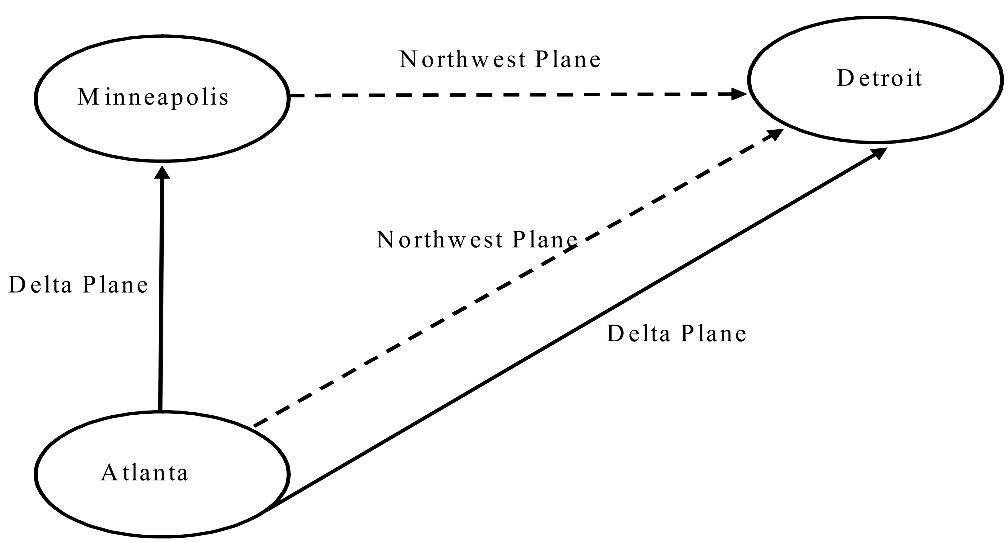

Figure 2: Modified Route Network Diagram

It is also possible that Delta and Northwest may codeshare on their nonstop flights between Atlanta and Detroit. In the case of these types of codeshare itineraries, Northwest may be the ticketing carrier and Delta the sole operating carrier, or vice versa. Using the language of Ito and Lee (2007), such a codesharing itinerary is referred to as "virtual" owing to the fact that the ticketing carrier is not an operating carrier on any trip segment of the itinerary.

In the case of virtual codeshare itineraries, a passenger remains on a single carrier's plane(s) for the entire round-trip, however the ticket for the trip was marketed and sold by a partner carrier. So another example is if Delta also has its own one-stop connecting flights between Atlanta and Detroit, and Delta allows Northwest to be the sole ticketing carrier for some passengers using this single-operating carrier one-stop itinerary.

Table 1 reports summary data on the share of each type of codesharing between Delta, Continental, and Northwest. Traditional codeshare products only account for a mean 23.7% of the codeshare products involving the three carriers, while virtual codeshare products account for a mean 76.3%. So virtual codesharing is the more popular form of codesharing between the three carriers.[12]

Table 1
Summary statistics on the distribution (share) of type of codesharing between Delta, Continental, and Northwest

	Mean	Standard Deviation
Traditional Codeshare	0.237	0.382
Virtual Codeshare	0.763	0.382

Notes: Entries in the first data column are mean shares of type of codesharing between the three airlines across the markets considered in the sample. Entries in the second data column are respective mean standard deviations of the shares.

Ito and Lee (2007) argue that passengers that are members of an airline's frequent-flyer program may view the airline's virtual codeshare product as an inferior substitute to its pure online[13] product since virtual tickets often do not allow the frequent-flyer to upgrade to first class even though the flights on the two itineraries (pure online and virtual) are the same. Furthermore, by offering

[12] Based on a sample in which codeshare arrangements between all U.S. domestic carriers are considered, Ito and Lee (2007) also report that virtual codesharing is by far the most popular type (approximately 85%).

[13] A pure online product is a single-carrier product in which the sole ticketing carrier for the entire trip is the operating carrier for all trip segments on the itinerary.

a branded (pure online) and a lower priced non-branded (virtual) product in the same market, a carrier is able to separate customers based on their price sensitivity. In summary, Ito and Lee argue that the primary motive for virtual codesharing is the carriers' desire to segment passengers based on their price sensitivity.[14]

3 The Empirical Model

Following the methodology in Bamberger, Carlton, and Neumann (2004), I study the competitive effects of the Delta/Continental/Northwest alliance using a series of "before-and-after" regressions. Effectively pre- and post-alliance periods are used to compute the change in average price, respectively total traffic, on a city pair and then compare the price, respectively traffic, changes of city pairs on which the partners codeshare (alliance city pairs) to city pairs on which at least one of the three provides service but there is no codesharing between any two of the three carriers (nonalliance city pairs).

First, note that analyses are done at the city pair level. I define a city pair as an origin and destination airport combination. City pairs are therefore treated in a direction-specific manner. That is, city pairs containing identical cities but differ in which city is the origin are treated as separate city pairs. This treatment allows for the possibility that market characteristics may be related to origin city characteristics.

Second, a city pair contains several different flight itineraries that are distinguished by routes. A flight itinerary is defined as a specific sequence of airport stops in traveling from the origin to destination city.[15] For purposes of the analyses, all itineraries that have identical origin and destination cities are treated as belonging to the same city pair irrespective of their differing route used in getting passengers from the origin to destination city.

Since regression analyses are done at the city pair level, relevant variables are either averaged (in the case of prices) or summed (in the case of number of passengers/traffic) to the city pair level. For example, the dependent variable for a set of regressions is percent change in average city pair price. This variable is constructed by taking the average price of all itineraries in a city pair for the pre-alliance period, repeating the process for the post-alliance period, then taking the log of the ratio of the two average prices. This computation is done for each city pair. For another

[14] See Gayle (2007b) for an empirical test of whether or not passengers' choice behavior is consistent with market segmentation being the primary motive for virtual codesharing.

[15] Some itineraries may not involve any intermediate stops (nonstop itineraries).

set of regressions, the dependent variable is percent change in alliance partners' average price on a city pair. In constructing this variable I follow the computation process described above with the exception that only Delta, Continental, and Northwest prices are used.

I start by analyzing the overall market effects of the alliance (aggregated analysis). Following the overall market effects analysis, I then take a more disaggregated approach to uncover whether, and in what ways, differing types of codesharing (e.g., traditional versus virtual) affect price and traffic levels. The disaggregated analysis is able to shed light on whether collusive behavior is more likely under a certain type of codesharing.

3.1 Regression Equations for Aggregated Analysis

The base empirical models used for the aggregated analysis are captured by the following two equations:

$$\begin{aligned}\ln\left(\frac{Average\ fare_{post-alliance,\ i}}{Average\ fare_{pre-alliance,\ i}}\right) &= \beta_0 + \beta_1\ Alliance_i \\ &+\beta_2\ Alliance_i \times HHI_{pre-alliance,\ i} + \beta_3\ HHI_{pre-alliance,\ i} \\ &+\beta_4\ Overlap\_Alliance_i \\ &+\beta_5\ Change\ in\ Percent\ Nonalliance\ Nonstop_i \\ &+\beta_6\ Change\ in\ City\ Pair\ Nonalliance\ HHI_i \\ &+\beta_7\ Entry\ by\ Southwest_i + \varepsilon_i\end{aligned} \tag{1}$$

and

$$\begin{aligned}\ln\left(\frac{Total\ Traffic_{post-alliance,\ i}}{Total\ Traffic_{pre-alliance,\ i}}\right) &= \alpha_0 + \alpha_1\ Alliance_i \\ &+\alpha_2\ Alliance_i \times HHI_{pre-alliance,\ i} + \alpha_3\ HHI_{pre-alliance,\ i} \\ &+\alpha_4\ Overlap\_Alliance_i \\ &+\alpha_5\ Change\ in\ Percent\ Nonalliance\ Nonstop_i \\ &+\alpha_6\ Change\ in\ City\ Pair\ Nonalliance\ HHI_i \\ &+\alpha_7\ Entry\ by\ Southwest_i + \mu_i,\end{aligned} \tag{2}$$

where $Average\ fare_{post-alliance,\ i}$ and $Average\ fare_{pre-alliance,\ i}$ are the average fares in city pair i for the post- and pre-alliance periods respectively, while $Total\ Traffic_{post-alliance,\ i}$ and $Total\ Traffic_{pre-alliance,\ i}$ are the total number of passengers travelling on city pair i in the postand pre-alliance periods respectively.[16] As mentioned above, these dependent variables are also computed just for the alliance carriers on a city pair, and therefore would result in two additional equations that are identical to equations (1) and (2) above with the exception of the dependent variables. Note that the dependent variables measure percent change since I take the log of the ratios.

Each city pair in the sample have at least one of the three alliance partners offering service between the two cities. $Alliance_i$ is a zero-one dummy variable that equals one only if at least two of the partners codeshare with each other in city pair i (alliance city pair) in the post-alliance period. Thus, $Alliance_i$ equals zero for city pairs in which at least one of the three carriers provides service but there is no codesharing between any two of the three carriers (nonalliance city pairs).

The effects of the alliance on average price and traffic level on a city pair are captured by the coefficients on $Alliance_i$ and any interaction variables that include $Alliance_i$ (β_1, β_2, $\alpha_1$and α_2). The coefficients associated with $Alliance_i$ effectively compare the price, respectively traffic, changes of city pairs on which the partners codeshare to city pairs on which they do not codeshare.

$HHI_{pre-alliance,\ i}$ is the passenger-based pre-alliance Herfindahl-Hirschman index of city pair i. It is meant to capture the degree of competition on a city pair before implementation of the alliance. As such, the interaction term, $Alliance_i \times HHI_{pre-alliance,\ i}$, is used to identify whether the effects of the alliance depend on the pre-alliance level of city pair competition.

The main variable of interest is $Overlap\_Alliance_i$, which is the only variable that distinguishes the empirical model specifications in equations (1) and (2) from the specifications used in Bamberger, Carlton, and Neumann (2004).[17] $Overlap\_Alliance_i$ is a zero-one dummy variable that equals one only if the alliance city pair has at least two of the partner carriers each offering their own substitute online[18] products in the pre- and post-alliance periods. On these alliance city pairs, we say the partners are offering overlapping service. If the alliance facilitate price collusion we expect $\beta_4 > 0$, while if it facilitate collusion on traffic levels we expect $\alpha_4 < 0$.

While a change in the proportion of nonstop passengers on a city pair may have an effect on

[16] Since a carrier's average fare reflects a wide variety of fares (business, leisure, etc.), Bamberger, Carlton, and Neumann (2004) point out that it is important to investigate the effect of an alliance on both fares and traffic. The idea is that a decline in average fare on a city pair is not necessarily associated with an increase in total traffic on the city pair [see pp. 204 in Bamberger, Carlton, and Neumann (2004)].

[17] By using empirical specifications that are almost identical to those used in Bamberger, Carlton, and Neumann (2004), the reader is able to easily compare results across papers.

[18] If a single airline is the "ticketing" and "operating" carrier for an itinerary, then this is referred to as an "online" product.

average city pair price and on city pair traffic, these effects are ambiguous. For example, a decrease in the proportion of nonstop passengers on a city pair may be reflective of better connecting flights (increased product quality), which may cause nonstop prices to fall but the price of connecting flights to increase. Second, higher quality connecting flights may have caused some existing nonstop passengers to switch to connecting flights without inducing more people to fly. As pointed out by Bamberger, Carlton, and Neumann (2004), better connecting flights could have resulted from an alliance, making the change in proportion of nonstop passengers on a city pair endogenous. To purge this variable of potential endogeneity problems, they used only passengers flying on carriers other than the relevant partner carriers to compute the percent change in nonstop passengers. As such, the $Change\ in\ Percent\ Nonalliance\ Nonstop_i$ variable is the percent change in number of passengers that choose nonstop flights on carriers other than one of the three alliance partners.[19]

$Change\ in\ City\ Pair\ Nonalliance\ HHI_i$ is change in passenger-based nonalliance carriers Herfindahl-Hirschman index on city pair i. If a city pair becomes more concentrated, we expect average city pair price to rise and city pair traffic to fall as a result of reduced competition on the city pair. Following Bamberger, Carlton, and Neumann (2004), I compute the Herfindahl-Hirschman index using only passengers that belong to nonalliance carriers in order to purge this variable of potential endogeneity problems in the regressions. The potential endogeneity problems stem from the possibility that the alliance resulted in at least one of the partners being a more effective competitor on a city pair. This implies that these partners' share of passengers would increase, which in turn affects measured concentration.[20]

$Entry\ by\ Southwest_i$ is a zero-one dummy variable that equals one only if Southwest has more than 5% passenger share in the post-alliance period and less than 5% in the pre-alliance period. Since Southwest airlines has become one of the more formidable competitors in the industry, this variable controls for the effect that Southwest's entry on a city pair may have on prices and traffic. I expect the coefficient on this variable to be negative in the price equations but positive in the traffic equations.

[19] The variable is called "Change in Percent Nonalliance Direct" in Bamberger, Carlton, and Neumann (2004). See their paper for detail of how this variable is constructed.

[20] I also estimated (not reported but can be made available upon request) the models using the change in city pair HHI, "$Change\ in\ City\ Pair\ HHI_i$" as a regressor, instead of "$Change\ in\ City\ Pair\ Nonalliance\ HHI_i$". I found that qualitative results for the marginal effects of all other regressors remain unchanged, but the sign of the coefficient on "$Change\ in\ City\ Pair\ Nonalliance\ HHI_i$" is usually opposite to the sign of the coefficient when "$Change\ in\ City\ Pair\ HHI_i$" is used. The change in sign of this estimated coefficient suggests that the inclusion of alliance partners when computing city pair concentration may introduce endogeneity into the model as expected.

3.2 Regression Equations for Disaggregated Analysis

To allow for the possibility that the market effects of codesharing may depend on the type of codesharing practiced by the three airlines, I replace the alliance dummy variable ($Alliance_i$) in equations (1) and (2) with the following two variables: (1) Traditional Codeshare; and (2) Virtual Codeshare. The "Traditional Codeshare" variable measures the proportion of codeshare products between the three airlines in market i that are traditional. "Virtual Codeshare" measures the proportion of codeshare products between the three airlines in market i that are virtual.

In essence, the two new variables are simply a disaggregation of the previous alliance dummy variable. For example, any market i for which $Alliance_i = 1$, then "Traditional Codeshare" + "Virtual Codeshare" = 1. Conversely, any market i for which $Alliance_i = 0$, then "Traditional Codeshare" = "Virtual Codeshare" = 0.

The following two equations capture the price and traffic effects of the different types of codesharing between Delta, Continental, and Northwest:

$$\ln\left(\frac{Average\ fare_{post-alliance,\ i}}{Average\ fare_{pre-alliance,\ i}}\right) = \gamma_0 + \gamma_1\ TraditionalCodeshare_i + \gamma_2\ VirtualCodeshare_i$$
$$+\gamma_3\ Traditional\ Codeshare_i \times HHI_{pre-alliance,\ i} + \gamma_4\ Virtual\ Codeshare_i \times HHI_{pre-alliance,\ i}$$
$$+\gamma_5\ HHI_{pre-alliance,\ i} + \gamma_6\ Overlap\_Alliance_i \times Traditional\ Codeshare_i$$
$$+\gamma_7\ Overlap\_Alliance_i \times Virtual\ Codeshare_i + \gamma_8\ Change\ in\ Percent\ Nonalliance\ Nonstop_i$$
$$+\gamma_9\ Change\ in\ City\ Pair\ Nonalliance\ HHI_i + \gamma_{10}\ Entry\ by\ Southwest_i + \varepsilon_i \tag{3}$$

and

$$\ln\left(\frac{Total\ Traffic_{post-alliance,\ i}}{Total\ Traffic_{pre-alliance,\ i}}\right) = \delta_0 + \delta_1\ Traditional\ Codeshare_i + \delta_2\ Virtual\ Codeshare_i$$
$$+\delta_3\ Traditional\ Codeshare_i \times HHI_{pre-alliance,\ i} + \delta_4\ Virtual\ Codeshare_i \times HHI_{pre-alliance,\ i}$$
$$+\delta_5\ HHI_{pre-alliance,\ i} + \delta_6\ Overlap\_Alliance_i \times Traditional\ Codeshare_i$$
$$+\delta_7\ Overlap\_Alliance_i \times Virtual\ Codeshare_i + \delta_8\ Change\ in\ Percent\ Nonalliance\ Nonstop_i$$
$$+\delta_9\ Change\ in\ City\ Pair\ Nonalliance\ HHI_i + \delta_{10}\ Entry\ by\ Southwest_i + \mu_i. \tag{4}$$

The price and traffic effects of each type of codesharing are identified by interpreting the coefficients on the codeshare variables and interactions of these codeshare variables with other relevant variables. Since the codeshare variables in equations (3) and (4) are essentially a decomposition of the $Alliance_i$ variable, the coefficients associated with the codeshare variables in equations (3) and (4) effectively compare the price, respectively traffic, changes of city pairs on which the partners practice a particular type of codesharing to city pairs on which they do not codeshare.

4 Data

Data are drawn from the Origin and Destination Survey (DB1B), which is a 10% random sample of airline tickets from reporting carriers. This database is maintained and published by the U.S. Bureau of Transportation Statistics. Some of the items included in DB1B are: number of passengers that chose a given flight itinerary; fares of these itineraries; the specific sequence of airport stops each itinerary uses in getting passengers from the origin to destination city; the carrier(s) that marketed and sold the travel ticket; and the carrier(s) that passengers actually fly on for their trip. The time periods used for the analyses are the fourth quarters of 2002 (pre-alliance) and 2003 (post-alliance).

A few filters and cleaning are applied to the original data set in order to arrive at the final sample used for estimation. First, following the standard practice for empirical analyses of airline codesharing, I recode regional feeder carriers to have their major carrier codes. In the absence of such recoding of feeder carriers, products that only include a major carrier and its associated regional feeder carrier(s) may mistakenly be counted as codeshare products since the operating and ticketing carrier codes would differ.[21] Second, I focussed on round-trip itineraries and thus deleted all one-way tickets. Third, itineraries with fares equal to zero are dropped as these may be due to coding errors when entering the data.[22] Fourth, subsequent to applying the filters above, a city pair of itineraries survives elimination only if the city pair has itineraries in both the pre- and post-alliance periods. The final sample contains 3,059,377 itineraries that are contained in 26,666 city pairs over the pre- and post-alliance periods.

[21] I identify codeshare products as products where the marketing and operating carriers differ on at least one segment of the trip.

[22] Zero fare itineraries are separate from itineraries with missing fares. Itineraries with missing fares are also dropped for obvious reasons.

Table 2 provides descriptive information of the sample. The first four data columns give descriptive statistics of variables for the entire sample of city pairs, the next four data columns provide similar statistics for the alliance city pairs, while the last four data columns provide similar statistics for the nonalliance city pairs.

Of the 26,666 city pairs, 5,671 are alliance city pairs while the remaining 20,995 are nonalliance city pairs. There are a number of interesting observations to be made about the simple descriptive information in Table 2. First, the mean percent price change is marginally lower on alliance city pairs compared to nonalliance city pairs. A similar pattern exists for alliance partners on alliance versus nonalliance city pairs. Second, the mean percent change in traffic on alliance city pairs is distinctively larger than mean percent change in traffic on nonalliance city pairs. Third, and most interesting, the mean percent change in alliance partners' traffic on alliance city pairs (0.17) is substantially larger than mean percent change in these partners' traffic on nonalliance city pairs (-0.026).

The trend of these observations is indicative of evidence against the codeshare alliance being a facilitator of collusive behavior. This is because standard economic theory predicts that colluding firms will lower output relative to output in a competitive equilibrium and conversely for price. However, since Table 2 only presents unconditional means, I reserve judgment until formal regression analyses are done in the next section.

Table 2 offers other observations worthy of mention before moving on to regression analyses. First, the "Overlap_Alliance" dummy reveals that 21.9% of the alliance city pairs in the sample involves overlap in the partners' service and therefore offer the potential for collusive behavior. Second, the Southwest entry dummy reveals that Southwest only entered 0.32% of the city pairs in the sample but was approximately three times as likely ($\frac{0.0069}{0.002}$) to enter an alliance city pair than a nonalliance city pair. Third, the mean pre-alliance city pair HHI is lower for alliance city pairs (0.532) compared to nonalliance city pairs (0.734).

Table 2
Descriptive Statistics

	Total				Alliance				Nonalliance			
Variable	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
Percent Change in Average City Pair Price	0.01	0.28	-4.23	1.82	0.0069	0.170	-1.06	1.081	0.012	0.306	-4.23	1.822
Percent Change in Partners' Average City Pair Price	0.01	0.33	-4.23	1.83	0.0067	0.219	-1.70	1.243	0.010	0.354	-4.23	1.829
Percent Change in City Pair Traffic	0.06	0.66	-3.99	4.16	0.145	0.453	-2.51	2.80	0.037	0.707	-3.99	4.159
Percent Change in Partners' City Pair Traffic	0.02	0.80	-5.14	4.18	0.172	0.613	-3.09	3.28	-0.026	0.839	-5.13	4.18
Alliance (Dummy)	0.21	0.41	0	1	1	0	1	1	0	0	0	0
Overlap_Alliance (Dummy)	0.05	0.21	0	1	0.219	0.413	0	1	0	0	0	0
Entry by Southwest (Dummy)	0.0032	0.06	0	1	0.0069	0.083	0	1	0.002	0.047	0	1
$HHI_{pre\text{-}alliance}$	0.69	0.26	0.16	1	0.532	0.236	0.17	1	0.734	0.253	0.164	1
Change in Percent Nonalliance Nonstop	0.03	5.95	-98.08	80	-0.17	7.306	-85.10	63.59	0.082	5.523	-98.08	80
Change in City Pair Nonallaince HHI	0.002	0.18	-0.9931	0.9933	0.011	0.204	-0.993	0.985	-0.001	0.174	-0.9928	0.993

Notes. HHI: Herfindahl-Hirschman index
SD: Standard Deviation.
Sample size is number of city pairs: Total city pairs = 26666; Alliance city pairs = 5671; Nonalliance city pairs = 20995.

5 Results

I start by analyzing the aggregated price and traffic effects of the alliance. Robust standard errors are used for all regressions to account for possible heteroskedasticity.

5.1 Aggregated Analysis

Table 3 reports regression results for the determinants of a change in average price on a city pair. The alliance dummy is the only regressor in the first column of Table 3. The negative and statistically significant coefficient on the alliance dummy suggests that the alliance may have marginally (0.5%) reduced average price on alliance city pairs compared to nonalliance city pairs. However, when I control for the pre-alliance level of city pair competition in column (2), the results suggest that average price actually increased marginally (a maximum of 1.8%) in alliance city pairs that have pre-alliance HHI less than 0.7232.[23] 55.07% of the city pairs in my sample satisfy this threshold while, 77.57% of the alliance city pairs satisfy this threshold. In other words, average city pair price marginally increased in a majority of alliance city pairs.

The finding that the alliance tends to cause prices to increase the more competitive (lower HHI) the city pair is prior to the alliance is consistent with predictions from the theoretical model in Chen and Gayle (2007). This theoretical prediction in Chen and Gayle is partly owing to the possibility that the alliance may force some competing non-partner carriers to exit the market. In reality, while an alliance may stop short of forcing competing non-partner carriers to exit the market, it is possible that the alliance could increase the partners' market share relative to their competitors. This could happen because it is likely that the new products being offered by partners are relatively more attractive to consumers compared to the partners' own product offerings in the pre-alliance period. As such, the increased dominance of partner carriers could ultimately result in higher prices, and this effect is likely more pronounced the closer competitors are to being symmetric prior to the alliance.

[23] 0.7232 is obtained by dividing the coefficient on "*Alliance*" by the coefficient on "$Alliance \times HHI_{pre-alliance}$".

Table 3
Regression Results for Effect of Alliance on Average Price
(All Carriers)

	Dependent Variable: Percent Change in Average Price			
Independent Variables	(1)	(2)	(3)	(4)
Intercept	0.012171**	-0.02395**	-0.02395**	-0.02398**
	(0.00211)	(0.00536)	(0.00536)	(0.00537)
Alliance	-0.0053*	0.01808**	0.02013**	0.02018**
	(0.00309)	(0.00802)	(0.0082)	(0.0082)
Alliance × $HHI_{pre\text{-}alliance}$		-0.025*	-0.027*	-0.027*
		(0.015)	(0.015)	(0.015)
$HHI_{pre\text{-}alliance}$		0.049**	0.049**	0.049**
		(0.008)	(0.008)	(0.008)
Overlap_Alliance			-0.0050	-0.0049
			(0.0037)	(0.0038)
Change in Percent Nonalliance Nonstop				0.00014
				(0.00015)
Change in City Pair Nonallaince HHI				-0.0034
				(0.0056)
Entry by Southwest				-0.005
				(0.0186)
R^2	0.0001	0.002	0.002	0.002
N = 26,666				

Notes: Robust standard errors are in parentheses. ** indicates statistical significance at 5% level while, * indicates statistical significance at 10% level. The sample size, *N*, is the number of city pairs. Models are estimated using ordinary least squares.

Column (3) of Table 3 allows us to analyze the extent to which the alliance may have facilitated price collusion in alliance city pairs where partners' own service overlap. If price collusion is effective, we expect average price to be higher on these city pairs compared to others. The statistical insignificance of the coefficient on the "Overlap_Alliance" dummy suggests that price changes are no different on alliance city pairs where the partners' service overlap compared to other alliance city pairs. Therefore, even though the alliance was not associated with lower prices in a majority of alliance city pairs, the evidence thus far does not suggest that the alliance facilitated price collusion in the partners' overlapping markets.

Column (4) of Table 3 includes additional regressors to control for other potential determinants of changes in average city pair price. However, based on an F-test, we cannot reject the null hypothesis that these additional regressors jointly have no effect on change in average city pair price. As we will observe in subsequent regression results, they do play an important role in explaining changes in total traffic.

Table 4 reports regression results for the determinants of a change in total traffic on a city pair.

Column (1) reports the regression results when the only regressor is the alliance dummy. There is strong evidence that the alliance resulted in increased traffic on alliance city pairs compared to nonalliance city pairs. Depending on included regressors (columns (1) through (4)), the alliance dummy coefficient estimates suggest that the alliance accounts for 10.7% to 12.3% increase in traffic.

In column (2) I control for the pre-alliance level of city pair competition. The statistical insignificance of the coefficient on the interaction term suggests that alliance city pairs with differing pre-alliance level of competition experienced equivalent increases in traffic.

Table 4
Regression Results for Effect of Alliance on Traffic
(All Carriers)

	Dependent Variable: Percent Change in Traffic			
Independent Variables	(1)	(2)	(3)	(4)
Intercept	0.037**	0.022*	0.022*	0.013
	(0.0049)	(0.0134)	(0.0134)	(0.013)
Alliance	0.1074**	0.122**	0.123**	0.120**
	(0.0077)	(0.0201)	(0.021)	(0.021)
Alliance × $HHI_{pre\text{-}alliance}$		-0.02	-0.02	-0.01
		(0.035)	(0.035)	(0.035)
$HHI_{pre\text{-}alliance}$		0.02	0.02	0.03
		(0.019)	(0.019)	(0.018)
Overlap_Alliance			-0.00097	0.0035
			(0.012)	(0.012)
Change in Percent Nonalliance Nonstop				0.015**
				(0.0008)
Change in City Pair Nonallaince HHI				0.097**
				(0.016)
Entry by Southwest				0.190**
				(0.067)
R^2	0.0044	0.0044	0.0044	0.023
N = 26,666				

Notes: Robust standard errors are in parentheses. ** indicates statistical significance at 5% level while, * indicates statistical significance at 10% level. The sample size, *N*, is the number of city pairs. Models are estimated using ordinary least squares.

Column (3) allows us to analyze the extent to which potential collusion by codeshare partners affected total traffic on alliance city pairs where the partners' service overlap. If the partners were effective at colluding on traffic levels, we expect to see a lowering of traffic levels on these alliance city pairs. Even though the coefficient on the "Overlap_Alliance" dummy is negative, its statistical insignificance suggests that the alliance did not result in reduced traffic on these alliance city pairs. This further supports the previous conclusion that the evidence does not suggest that the alliance facilitated collusion in city pairs where partners' service overlap.

The previous qualitative results on the effect of the alliance on total traffic are robust to the addition of other determinants of a change in traffic. In column (4) I add "Change in Percent Nonalliance Nonstop", "Change in City Pair Nonalliance HHI", and "Entry by Southwest". All these variables are statistically significant determinants of a change in traffic.

First, a city pair's change in traffic level is positively associated with the percent change of passengers that use nonstop flights ("Change in Percent Nonalliance Nonstop"). If quality of connections improve on a route, this may cause some passengers who would normally choose a nonstop flight to instead use connecting flights (fall in proportion of nonstop passengers). But such a change in consumer choice behavior could result in higher prices for connecting flights even though products with connections might still be cheaper relative to a nonstop flight. The increase in price for the relatively cheaper product could ultimately result in some consumers choosing an alternative to air travel (fall in city pair traffic). This sequence of changes would be one reason why the coefficient on "Change in Percent Nonalliance Nonstop" is positive. While there might be other plausible explanations for the positive coefficient on "Change in Percent Nonalliance Nonstop", more important is that its statistical significance suggests that this variable captures changes in city pair characteristics that we might want to control for.

Second, a city pair's change in traffic level is positively associated with a change in its concentration ("Change in City Pair Nonalliance HHI"). The sign of this marginal effect is contrary to expectation since an increase in competition (fall in HHI) on a city pair should result in more traffic.

Third, entry by Southwest airlines on a city pair increases the city pair traffic by 19%. This effect is consistent with expectation as Southwest is one of the most successful low-cost carriers whose entry serves to substantially increase competition [see Morrison (2001)].

The relatively low R^2 measures suggest that we do have some distance to go in fully explaining changes in city pair average price and traffic levels. However, the coefficient estimates of the regression models do help us better understand the economics of codesharing between Delta, Continental, and Northwest.

Having analyzed how the alliance affected average city pair price and total city pair traffic, I now turn to the alliance's effect on alliance partners' average price and total traffic. Table 5 reports regression results for the determinants of a change in the alliance partners' average price on a city pair. In column (1) the only regressor is the alliance dummy. The statistical insignificance of the coefficient on the alliance dummy in column (1) suggests that the alliance is not associated with a lowering of the alliance partners' average price.

Table 5
Regression Results for Effect of Alliance on Average Price
(Alliance Carriers)

	Dependent Variable: Percent Change in Average Price			
Independent Variables	(1)	(2)	(3)	(4)
Intercept	0.010**	-0.032**	-0.032**	-0.033**
	(0.0024)	(0.0068)	(0.0068)	(0.0068)
Alliance	-0.0033	0.022**	0.023**	0.023**
	(0.0038)	(0.01)	(0.01)	(0.01)
Alliance × $HHI_{pre\text{-}alliance}$		-0.026	-0.027	-0.027
		(0.017)	(0.017)	(0.017)
$HHI_{pre\text{-}alliance}$		0.058**	0.058**	0.058**
		(0.0095)	(0.0095)	(0.0095)
Overlap_Alliance			-0.003	-0.003
			(0.0055)	(0.0055)
Change in Percent Nonalliance Nonstop				0.00002
				(0.0003)
Change in City Pair Nonallaince HHI				-0.005
				(0.011)
Entry by Southwest				0.019
				(0.026)
R^2	0.00002	0.002	0.002	0.002
N = 26,666				

Notes: Robust standard errors are in parentheses. ** indicates statistical significance at 5% level while, * indicates statistical significance at 10% level. The sample size, *N*, is the number of city pairs. Models are estimated using ordinary least squares.

In column (2), where I control for the pre-alliance level of competition on a city pair, I find that alliance partners' average price marginally increased (2.2%) in alliance city pairs compared to nonalliance city pairs. The statistical insignificance of the coefficient on the interaction term suggests that the marginal price increase that is associated with the alliance did not differ according to the city pair's pre-alliance level of competition.

Column (3) in Table 5 provides a more accurate picture, compared to column (3) in Table 3, of whether the alliance partner's colluded on price. This is because the dependent variable in Table 5 is the change in alliance partners' average price on a city pair instead of the change in the average city pair price. A change in average city pair price nests both the partners' and their rivals' price response to the alliance, but whether the partners' collude on price or not relates solely to their pricing behavior on a city pair. If the partners are effective at colluding on price, we expect them to increase price on alliance city pairs where they collude. The statistical insignificance of the coefficient on the "Overlap_Alliance" dummy suggests that the alliance partners' average price did not change in any way different on alliance city pairs that have service overlap compared to other alliance city pairs. In fact, even if the coefficient on the "Overlap_Alliance" dummy was statistically significant, its negative sign does not support collusive pricing behavior.

In column (4) I include additional regressors to control for other potential determinants of changes in the alliance partners' average city pair price. Based on an F-test, I cannot reject the null hypothesis that these additional regressors jointly have no effect on change in the alliance partners' average city pair price.

Table 6 reports regression results for the determinants of a change in the alliance partners' traffic on a city pair. There is strong evidence that alliance partners' traffic increased substantially on alliance city pairs compared to nonalliance city pairs. Depending on included regressors (columns (1) through (4)), the alliance dummy coefficient estimates suggest that alliance partners' traffic increased by 19.8% to 24.4%. The statistical insignificance of the coefficient on the interaction term in column (2) suggests that the alliance partners' increased traffic did not differ according to city pairs' pre-alliance level of competition.

Table 6
Regression Results for Effect of Alliance on Traffic
(Alliance Carriers)

	Dependent Variable: Percent Change in Traffic			
Independent Variables	(1)	(2)	(3)	(4)
Intercept	-0.026**	-0.092**	-0.092**	-0.089**
	(0.0058)	(0.017)	(0.017)	(0.017)
Alliance	0.198**	0.244**	0.232**	0.233**
	(0.01)	(0.026)	(0.027)	(0.027)
Alliance × $HHI_{pre\text{-}alliance}$		-0.052	-0.042	-0.045
		(0.041)	(0.042)	(0.041)
$HHI_{pre\text{-}alliance}$		0.0895**	0.0895**	0.087**
		(0.022)	(0.022)	(0.022)
Overlap_Alliance			0.0278	0.025
			(0.0184)	(0.018)
Change in Percent Nonalliance Nonstop				-0.004**
				(0.0009)
Change in City Pair Nonallaince HHI				0.0062
				(0.029)
Entry by Southwest				-0.034
				(0.091)
R^2	0.01	0.01	0.01	0.012
N = 26,666				

Notes: Robust standard errors are in parentheses. ** indicates statistical significance at 5% level while, * indicates statistical significance at 10% level. The sample size, *N*, is the number of city pairs. Models are estimated using ordinary least squares.

As discussed in Section 2, an alliance allows an airline to offer products that use segments of their partners' network. In essence, the airline is able to offer products that are outside the scope of what the airline's own network would allow it to offer. As such, it is argued that in the absence of an alliance, potential partners may have expanded their own service either between cities they already have service or between other city pairs. If this argument is true, then an alliance may well serve to reduce future competition. However, the argument finds little support from results above and results in Bamberger, Carlton, and Neumann (2004). In fact, the results above suggest the complete opposite since the alliance actually resulted in partners increasing their traffic substantially.

Column (3) in Table 6 provides a more accurate picture, compared to column (3) in Table 4, of whether the alliance partners colluded on traffic levels. The reason is similar to the explanation above as to why column (3) of Table 5 is a more accurate investigation of collusive behavior compared to column (3) of Table 3. The only difference in the arguments is that now I make reference to change in traffic instead of change in average price. Specifically, a change in city pair traffic nests both the partners' and their rivals' traffic response to the alliance, but whether the partners collude on traffic levels or not relates solely to their capacity choice on a city pair. If collusion is effective, we expect partners to restrict their traffic on alliance city pairs where they collude. The statistical insignificance of the coefficient on the "Overlap_Alliance" dummy suggests that the alliance partners did not restrict traffic on alliance city pairs in which the partners' service overlap compared to other alliance city pairs. In fact, the positive sign of this coefficient suggests that partners may have increased their traffic on these city pairs.

Column (4) suggests that the previous qualitative results on the effect of the alliance on the alliance partners' traffic levels are robust to the addition of other determinants of the change in their traffic levels. The results suggest that change in city pair nonalliance concentration and entry by Southwest on the city pair did not affect the change in alliance partners' traffic. However, an increase in the percent of nonalliance nonstop passengers had a negative effect on alliance partners' traffic.

5.2 Disaggregated Analysis

The analyses thus far have not allowed for the possibility that the market effects of codesharing may depend on the type of codesharing practiced by Delta, Continental, and Northwest. Arguably, one format of codesharing may be more conducive for collusive behavior than another. I now explore this possibility.[24]

Table 7 reports regression results when the alliance dummy is disaggregated according to type of codesharing among the three carriers. First, if we focus on traditional codesharing, the results do not suggest that traditional codesharing is associated with a positive effect on price. In fact, the statistically significant negative coefficient on "Overlap_Alliance $\times$ Traditional Codeshare" strongly suggests that traditional codesharing decreases average city pair price in alliance city pairs where the partners' service overlap. This is strong evidence against the hypothesis that traditional codesharing facilitate collusive behavior, even in city pairs where the partners' network overlap.

[24] I thank an anonymous referee and the editor for suggesting that I explore this possibility.

Table 7
Regression Results for Effect of Alliance Broken Down by Type of Codesharing

	Dependent Variable (all carriers):		**Dependent Variable (alliance carriers):**	
Independent Variables	%Δ Avg. Price	%Δ Traffic	%Δ Avg. Price	%Δ Traffic
Intercept	-0.0240** (0.0054)	0.0133 (0.0132)	-0.0326** (0.0068)	-0.0894** (0.0172)
Traditional Codeshare	0.0077 (0.0189)	-0.0302 (0.0462)	0.0013 (0.0243)	0.2137** (0.0587)
Virtual Codeshare	0.0299** (0.0087)	0.1543** (0.0220)	0.0354** (0.0110)	0.2347** (0.0294)
Traditional Codeshare × $HHI_{pre\text{-}alliance}$	0.0230 (0.0316)	0.1616** (0.0716)	0.0393 (0.0360)	-0.0569 (0.0816)
Virtual Codeshare × $HHI_{pre\text{-}alliance}$	-0.0577** (0.0165)	-0.0512 (0.0388)	-0.0632** (0.0193)	-0.0325 (0.0488)
$HHI_{pre\text{-}alliance}$	0.0492** (0.0083)	0.0302* (0.0185)	0.0580** (0.0095)	0.0868** (0.0217)
Overlap_Alliance × Traditional Codeshare	-0.0287** (0.0104)	0.0536* (0.0318)	-0.0519** (0.0155)	0.1937** (0.0479)
Overlap_Alliance × Virtual Codeshare	0.0018 (0.0043)	-0.0086 (0.0134)	0.0110* (0.0064)	-0.0189 (0.0213)
Change in Percent Nonalliance Nonstop	0.0001 (0.0002)	0.0147** (0.0008)	0.00002 (0.0003)	-0.0044** (0.0009)
Change in City Pair Nonalliance HHI	-0.0032 (0.0056)	0.0965** (0.0163)	-0.0043 (0.0110)	0.0058 (0.0292)
Entry by Southwest	-0.0058 (0.0186)	0.1924** (0.0674)	0.0185 (0.0262)	-0.0329 (0.0908)
R^2	0.0021	0.023	0.002	0.012
N = 26,666				

Notes: Robust Standard errors are in parentheses. ** indicates statistical significance at the 5% level, while, * indicates statistical significance at the 10% level. The sample size, N, is the number of city pairs. Models are estimated using ordinary least squares.

The traffic equations suggest that traditional codesharing is associated with an increase in the alliance partners' traffic levels. Furthermore, the statistical significance of the positive coefficient on the overlap interaction variable ("Overlap_Alliance × Traditional Codeshare") suggests that the increased traffic is more pronounced on alliance city pairs where the partners' service overlap compared to other alliance city pairs. Again, the evidence is not supportive of collusive behavior in the case of traditional codesharing. Instead, the increased traffic levels are consistent with the argument that traditional codesharing results in higher quality connecting flights due to partners' efforts to coordinate flight schedules for interline connections.

If we now focus on virtual codesharing, the coefficient estimates strongly suggest that this type of codesharing is associated with increases in average city pair price in city pairs with sufficiently strong pre-alliance level of competition (HHI below 0.52). This qualitative result also holds for the effects of virtual codesharing on the partners' price. There is also weak evidence that the partners' price increase, which is associated with virtual codesharing, may be more pronounced on alliance city pairs where the partners' own service overlap in the pre- and post-alliance periods. This inference is drawn from the coefficient on "Overlap_Alliance × Virtual Codeshare" in the alliance carriers' price regression, where the coefficient is positive but statistically significant only at the 10% level. So based solely on the estimated price effects associated with virtual codesharing, we cannot rule out the possibility that this type of codesharing could be associated with collusive behavior.

Results from the traffic regressions suggest that virtual codesharing is associated with traffic increases. Furthermore, these traffic increases are no different on alliance city pairs where the partners' own service overlap in the pre- and post-alliance periods. The traffic increases could have resulted from new opportunities for passengers to cumulatively earn and redeem frequent-flyer miles across carriers in the partnership. In summary, whatever the reason for the increased traffic associated with virtual codesharing, this increase is not suggestive of collusive behavior.

6 Conclusion

The main objective of this paper is to empirically investigate the price and traffic effects of the Delta/Continental/Northwest codeshare alliance, with a particular focus on whether or not the alliance facilitated collusion on price or traffic levels in the partners' overlapping markets. I find that, overall, the alliance is associated with a marginal increase in average city pair price (a maximum of 1.8%) in the majority (77.57%) of city pairs in which the partners codeshare. The aggregated analysis further finds that: (1) the alliance accounts for 10.7% to 12.3% increase in overall city pair traffic and a 19.8% to 24.4% increase in the partners' city pair traffic on city pairs where they codeshare; and (2) average price changes and total traffic changes are no different on alliance city pairs where the partners' service overlap compared to other alliance city pairs. In summary, results from the aggregated analysis are not suggestive of collusive behavior.

I then explored a more disaggregated analysis by examining whether the market effects of codesharing may depend on the type of codesharing practiced by Delta, Continental, and Northwest. The findings for this disaggregated analysis suggest that traditional codesharing exhibits a feature similar to results from the aggregated analysis. In particular, this type of codesharing format is associated with a traffic increase. The increased traffic is probably owing to higher quality product offerings (better variety of seamless connecting flights, greater opportunities for passengers to earn and redeem frequent-flyer miles, etc.).

Traditional codesharing, which constitutes 23.7% of the codesharing between the three airlines, seem not to be associated with price increases. In fact, I find that this type of codesharing decreases average city pair price in alliance city pairs where the partners' own service overlap compared to other alliance city pairs.

By contrast, virtual codesharing, which accounts for approximately 76.3% of the codesharing between the three airlines, is strongly associated with price increases. Furthermore, there is weak evidence that the partners' price increase, which is associated with virtual codesharing, may be more pronounced on alliance city pairs where the partners' own service overlap in the pre- and post-alliance periods. The estimated price effects, by themselves, suggest that virtual codesharing could be associated with collusive behavior. However, I also find that virtual codesharing is associated with traffic increases, which is inconsistent with effective collusive behavior.

Notwithstanding evidence of pro-competitive effects associated with codesharing between the three carriers, there are other important market effects that I did not explore which may be fruitful topics for future research. For example, how has the alliance affected entry and exit strategies of existing and potential rivals? Second, even though codesharing seem to have increased consumer demand for air travel, can we quantify the extent to which consumer welfare increased? Exploring each of these issues may require structural econometric models. For example, entry models such as those in Ciliberto and Tamer (2006), Berry (1992), or Mazzeo (2002) may be useful in exploring the first question. While structural models such as those in Armantier and Richard (2005) and Gayle (2007c) may be useful in exploring the second question.

References

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