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

Philip G. Gayle*
Kansas State University

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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 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 findings fail to support collusive behavior for approximately 64% of the codesharing between the three airlines. However, codeshare itineraries between them that do not involve at least two of the partners connecting their flights on the itinerary may be associated with collusive behavior.

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*Department of Economics, 320 Waters Hall, Kansas State University, Manhattan, KS, 66506, (785) 532-4581, Fax:(785) 532-6919, email: gaylep@ksu.edu.

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 connecting service seamless could facilitate collusion (explicit or tacit) on prices and/or service levels in their overlapping markets. 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) showed how a structural econometric framework can be used to quantify the extent to which potential alliance partners' prices may increase in their overlapping markets if they collude on price. As an illustrative example, Gayle (2007a) applied

[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.

the econometric model to the then potential Delta/Continental/Northwest alliance in 15 of their Hub-to-Hub overlapping markets. The model predicted that the partners' prices were unlikely to increase significantly (less than 5%) in these markets even in the worst case scenario where they colluded on prices without any associated cost efficiency gains from the alliance.[4]

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 various 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 various 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) found 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 about the Delta/Continental/Northwest alliance, Brueckner and Whalen (2000) and Brueckner (2003) find that fares are lower by 8% to 17% in markets where different national carriers codeshare.[5]

The aggregated analysis further found that: (1) the alliance accounted for 10.7% to 12.3%

[4] 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 code-share alliances on partners' cost. They found that code-share alliances reduce airlines' cost, albeit small in magnitude.

[5] See Ito and Lee (2007) for a comprehensive and interesting analysis of the effect of domestic codeshare alliances on fares in the U.S. airlines industry.

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 were no different on city pairs where at least two of the partners codeshare and each offer their own substitute products (overlapping service) in the pre- and post-alliance periods compared to other alliance city pairs. So even though the alliance was 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) found 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 three main types: (1) Traditional; (2) Single-carrier virtual; and (3) Interline mixed virtual. Traditional codeshare itineraries combine interline connecting operating services of partner carriers on a given route, where one of the operating carriers is the sole ticketing carrier for the entire trip.[6] In the case of single-carrier 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. Last, for interline mixed virtual codeshare itineraries, a passenger travels on an interline connecting itinerary, but the sole ticketing carrier for the entire trip is not an operating carrier. Furthermore, this virtual codeshare category captures instances where at least one of the operating carriers is neither Delta, Continental, or Northwest, but one of the three is the sole ticketing carrier, and at least one of the other two is an operating carrier. While my "Single-carrier virtual codeshare" definition is equivalent to Ito and Lee's "Fully virtual codeshare" definition, my "Interline mixed virtual codeshare" definition does not fall within any of Ito and Lee's defined categories.

I find that both traditional and interline mixed virtual codesharing exhibit features similar to results from the aggregated analysis. In particular, these types of codesharing formats are

[6] 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 the "operating carrier", while the carrier that marketed and sold the ticket for the seat is referred to as the "ticketing carrier".

associated with increased traffic. 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, neither of these type of codesharing are found to be strongly associated with price increases.

By contrast, single-carrier virtual codesharing is strongly associated with price increases. Furthermore, this type of codesharing is associated with a decline in city pair traffic levels on alliance city pairs in which the partners' own substitute service overlap. This finding suggests that single-carrier virtual codesharing could be associated with 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 were 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.[7] Note that the connecting 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.

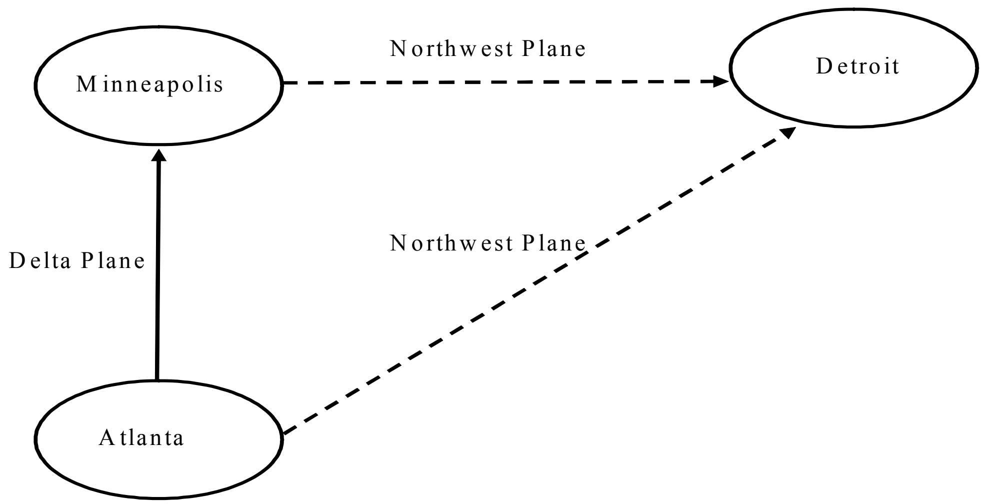

Figure 1: Route Network Diagram

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 connecting flights. Therefore, the quality of the connection is likely to be better between partner carriers than if the carriers are unaffiliated.[8] Second, if the Northwest passenger participates in its frequent-flyer program, the codeshare agreement allows the passenger

[7] 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.

[8] 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)].

to accumulate points on the Atlanta to Minneapolis St. Paul segment of the trip even though this segment is operated by Delta.

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 connecting 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.

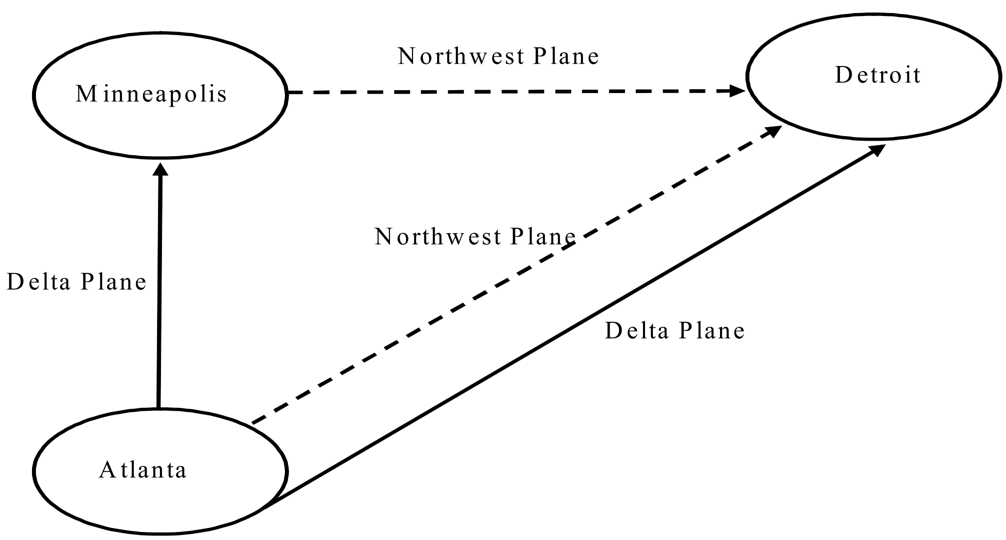

Figure 2: Modified Route Network Diagram

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.

I break down virtual codesharing into two main types: (1) Single-carrier virtual; and (2) Interline mixed virtual. In the case of single-carrier 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. So if Delta and Northwest codeshare on their nonstop flights between Atlanta and Detroit, this is an example of single-carrier virtual codesharing. 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.

In the case of interline mixed virtual codeshare itineraries, a passenger travels on an interline connecting itinerary, but the sole ticketing carrier for the entire trip is not an operating carrier. Furthermore, this virtual codeshare category captures instances where at least one of the operating carriers is neither Delta, Continental, or Northwest, but one of the three is the sole ticketing carrier, and at least one of the other two is an operating carrier. An example of this type of codesharing occurs when Northwest is the ticketing carrier of an itinerary which uses ExpressJet Airlines[9] as the operating carrier from Atlanta to Houston, then the passenger connects to a Continental flight for the final leg of the trip from Houston to Denver.

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 11.99% of the codeshare products involving the three carriers, while virtual codeshare products account for a combine mean of 87.98%. So virtual codesharing is the more popular form of codesharing between the three carriers.[10] However, note that codesharing that involves interline connections (tradi-

[9] ExpressJet is a regional carrier that flies commercially under its own name, ExpressJet Airlines. It provides regional connecting flights for both Delta and Continental.

[10] This magnitude of virtual codesharing between these three airlines is consistent with the magnitude Ito and Lee (2007) reports for the U.S. domestic market as a whole when all carriers are considered. According to Ito and Lee, approximately 85% of U.S. domestic codesharing itineraries are "virtual".

tional and interline mixed virtual) constitute the majority (64.64%) of codesharing between the three airlines.

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

	Mean	Standard Deviation
Traditional Codeshare	0.1199	0.2923
Single-carrier Virtual Codeshare	0.3533	0.4286
Interline Mixed Virtual Codeshare	0.5265	0.451

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.

While it is easier to see the potential benefits to consumers from codesharing that involves interline connecting flights of partner carriers (traditional and interline mixed virtual), since partners coordinate their connecting flights to make connections seamless (increase product quality), the potential benefits to consumers from single-carrier virtual codesharing is less clear, especially in markets where both codeshare partners are already simultaneously offering their own single-carrier service. Since single-carrier virtual codesharing in markets where partners' service overlap is unlikely to be motivated by the partners' desire to increase the quality of their product offerings, it is interesting to see if this type of codesharing is more likely to be associated with collusive behavior.

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[11] 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. Further, by offering 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.[12]

[11] A pure online product is a single-carrier product in which the ticketing and operating carrier are the same for all trip segments on the itinerary.

[12] 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.

The DOT did not explicitly distinguish between types of codesharing (e.g., traditional versus virtual) when expressing their concern for potential collusive behavior. A summary of the six restrictions the DOT requested of the three airlines before approval of the alliance are:[13]

1. The carriers may not coordinate or agree among themselves on matters such as fares, route entry or exit, or capacity.

2. At their hub airports and at Boston, the carriers must at the airport authority's request return gates that are used less than six turns per day.

3. Delta may place its code on no more than 650 each of Continental's and Northwest's flights, while Continental and Northwest each may place their codes on no more than 650 Delta flights. Not less than 25% of each marketing carrier's new codeshare flights must be to or from airports the carrier and its regional affiliates either did not directly serve or served with no more than three daily round-trip flights as of August 2002. An additional 35% of each marketing carrier's new codeshare flights must either meet the above requirement or be to or from small hub and non-hub airports.

4. Restrictions will be placed on the carriers' ability to offer joint bids to corporate customers and travel agencies.

5. The carriers must request that their services be listed under no more than two codes in computer reservations systems (CRS) until the department completes its pending revision of the CRS rules.

6. The carriers may not enforce any provisions in their agreements that would restrict a partner's ability to enter into a marketing relationship with any other airline after the agreements have been terminated.

Condition (1) above is intended to reduce the possibility of collusion and is the main motivation for the empirical analysis in this paper. Conditions (2) to (6) are listed here to provide a complete picture of the DOT's concerns, but I leave analyzing these for future research and only briefly describe DOT's reasons for imposing them.

[13] 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.

Condition (2) is designed to limit the carriers' ability to prevent entry and future competition by "hoarding" underutilized facilities at their major airports. Condition (3) was imposed based on the carriers representation to the DOT that their alliance will benefit the public by extending each partner's route network. Thus, the DOT wants to ensure that a significant amount of the codeshare flights are to airports either not served by the marketing airline or received relatively little service from the airline.

Condition (4) is imposed because of the DOT's fear that the carriers would design joint bids to corporate customers and/or travel agencies in a manner that one carrier could use its dominant position in a given market to increase its partners' market share in other markets where these partners may not have a dominant position. For example, a corporate customer may be offered a contract where discounted fares on one of the partner carriers in a given market are conditional on the corporate customer booking a threshold amount of flights from another partner in another market.

Since codesharing allows partners to list a single flight multiple times on CRS (once under each ticketing carriers' code), condition (5) is an attempt to limit partners' ability to crowd out competitors flight listings on CRSs. Last, condition (6) is designed to prevent the alliance from limiting each partner to form partnerships with other carriers in the future that may be beneficial to consumers.

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 they do not codeshare (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.[14] 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 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.

Last, a set of regressions uses either percent change in city pair traffic, or percent change in alliance partners' traffic on a city pair as the dependent variable. The only difference in the process of constructing the traffic dependent variables compared to constructing the price dependent variables is that for the traffic variables, I sum the number of passengers over the relevant carriers for each city pair and time period instead of taking averages.

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, single-carrier virtual, interline mixed virtual) affect price and traffic levels. The disaggregated analysis will be able to shed light on whether collusive behavior is more likely under certain types of codesharing.

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

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 post- and pre-alliance periods respectively.[15] 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.

The effects of the alliance on average price and traffic 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).

[15] 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)].

$Alliance_i$ is a zero-one dummy variable that equals one only if at least two of the partners offered codeshare products in city pair i (alliance city pair) in the post-alliance period. 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).[16] $Overlap\_Alliance_i$ 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[17] products in the pre- and post-alliance periods. On these alliance city pairs, we say the partners are offering overlapping service. If the alliance facilitated price collusion we would expect $\beta_4 > 0$, while if it facilitated collusion on traffic levels we would expect $\alpha_4 < 0$.

While a change in the proportion of nonstop passengers on a city pair may have an effect on 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 in equations (1) and (2) above is the percent change in number of passengers that choose nonstop flights on carriers other than one of the three alliance partners.[18]

[16] 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.

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

[18] The variable is called "Change in Percent Nonalliance Direct" in Bamberger, Carlton, and Neumann (2004). See

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 tern affects measured concentration.[19]

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.

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 three variables: (1) Traditional Codeshare; (2) Single-carrier Virtual Codeshare; and (3) Interline Mixed Virtual Codeshare. The "Traditional Codeshare" variable measures the proportion of codeshare products between the three airlines in market i that are traditional. "Single-carrier Virtual Codeshare" measures the proportion of codeshare products between the three airlines in market i that are single-carrier virtual, while "Interline Mixed Virtual Codeshare" measures the proportion that are interline mixed virtual.

In essence, the three 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"

their paper for detail of how this variable is constructed.

[19] 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.

+ "Single-carrier Virtual Codeshare" + "Interline Mixed Virtual Codeshare" = 1. Conversely, any market i for which $Alliance_i = 0$, then "Traditional Codeshare" = "Single-carrier Virtual Codeshare" = "Interline Mixed Virtual Codeshare" = 0.

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

$$\begin{aligned}
\ln\left(\frac{Average\ fare_{post-alliance,\ i}}{Average\ fare_{pre-alliance,\ i}}\right) = {} & \gamma_0 + \gamma_1\ Traditional\ Codeshare_i \\
& +\gamma_2\ Single-carrier\ Virtual\ Codeshare_i \\
& +\gamma_3\ Interline\ Mixed\ Virtual\ Codeshare_i \\
& +\gamma_4\ Traditional\ Codeshare_i \times HHI_{pre-alliance,\ i} \\
& +\gamma_5\ Single-carrier\ Virtual\ Codeshare_i \times HHI_{pre-alliance,\ i} \\
& +\gamma_6\ Interline\ Mixed\ Virtual\ Codeshare_i \times HHI_{pre-alliance,\ i} \\
& +\gamma_7\ HHI_{pre-alliance,\ i} \\
& +\gamma_8\ Overlap_Alliance_i \times Traditional\ Codeshare_i \\
& +\gamma_9\ Overlap_Alliance_i \times Single-carrier\ Virtual\ Codeshare_i \\
& +\gamma_{10}\ Overlap_Alliance_i \times Interline\ Mixed\ Virtual\ Codeshare_i \\
& +\gamma_{11}\ Change\ in\ Percent\ Nonalliance\ Nonstop_i \\
& +\gamma_{12}\ Change\ in\ City\ Pair\ Nonalliance\ HHI_i \\
& +\gamma_{13}\ Entry\ by\ Southwest_i + \varepsilon_i \qquad (3)
\end{aligned}$$

and

$$\ln\left(\frac{Total\ Traffic_{post-alliance,\ i}}{Total\ Traffic_{pre-alliance,\ i}}\right) = \delta_0 + \delta_1\ Traditional\ Codeshare_i$$
$$+\delta_2\ Single-carrier\ Virtual\ Codeshare_i$$
$$+\delta_3\ Interline\ Mixed\ Virtual\ Codeshare_i$$
$$+\delta_4\ Traditional\ Codeshare_i \times HHI_{pre-alliance,\ i}$$
$$+\delta_5\ Single-carrier\ Virtual\ Codeshare_i \times HHI_{pre-alliance,\ i}$$
$$+\delta_6\ Interline\ Mixed\ Virtual\ Codeshare_i \times HHI_{pre-alliance,\ i}$$
$$+\delta_7\ HHI_{pre-alliance,\ i}$$
$$+\delta_8\ Overlap\_Alliance_i \times Traditional\ Codeshare_i$$
$$+\delta_9\ Overlap\_Alliance_i \times Single-carrier\ Virtual\ Codeshare_i$$
$$+\delta_{10}\ Overlap\_Alliance_i \times Interline\ Mixed\ Virtual\ Codeshare_i$$
$$+\delta_{11}\ Change\ in\ Percent\ Nonalliance\ Nonstop_i$$
$$+\delta_{12}\ Change\ in\ City\ Pair\ Nonalliance\ HHI_i$$
$$+\delta_{13}\ Entry\ by\ Southwest_i + \mu_i. \quad (4)$$

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 were applied to the original data set in order to arrive at the final sample used for estimation. First, I focussed on round-trip itineraries and thus deleted all one-way tickets. Second, I selected city pairs that have at least one of the three alliance partners offering service between the two cities. Third, itineraries with fares equal to zero are dropped as these may be due to coding errors when entering the data.[20] Fourth, a city pair of itineraries survives elimination only if the city pair has itineraries in both the pre- and post-alliance periods that satisfy the three requirements above. The final sample contains 3,059,377 itineraries that are contained in 26,666 city pairs over the pre- and post-alliance periods.

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. Alliance city pairs are the city pairs on which at least two of the partners offer codeshare products in the post-alliance period. I identify codeshare products as products where the marketing and operating carriers differ on at least one segment of the trip.

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

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.

Of the 26,666 city pairs, 5,671 are alliance city pairs while the remaining 20,995 city pairs had at least one of the partners offering service between the cities but none of the three codeshared with each other on these city pairs (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).

5 Results

First, I analyze the effect of the alliance on alliance city pairs' average prices and total traffic. I then analyze how the partners' average price and total traffic are affected by the alliance on the said city pairs. As mentioned above, the effect of the alliance is identified by using pre- and post-alliance periods 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 to city pairs on which they do not codeshare.

In the case of the aggregated analysis, the overall price and traffic effects are identified by interpreting the coefficients on an alliance dummy variable and interactions of this variable with other relevant variables in a regression where the dependent variable is either percent change in average price or percent change in traffic. The alliance dummy equals one if the city pair is an alliance pair and zero otherwise.

In the case of the disaggregated analysis, I use the same regression structure as used for the aggregated analysis, with the exception that the alliance dummy is replaced by variables that measure the share of each type of codesharing between the three airlines in a market. The price and traffic effects of each type of codesharing are identified by interpreting the coefficients on these share variables and interactions of these share variables with other relevant variables. 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.[21] 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).

[21] 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 codeshare partners colluded on price in alliance city pairs where at least two of them also offer their own substitute online products. If price collusion is effective, we expect average price to increase on these city pairs compared to others. The statistical insignificance of the coefficient on the "Overlap_Alliance" dummy suggests that price changes were no different on alliance city pairs that have at least two of the partners each offering their own online products 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 this is related to price collusion of alliance partners.

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 lead to 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 accounted 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 they offer their own substitute online service. 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 on the partners' overlapping routes.

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. For example, entry by Southwest airlines on a city pair increased the city pair traffic by 19%.

Having analyzed how the alliance affected average city pair price and total city pair traffic, I now turn to the alliance effect on the 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 were effective at colluding on price, we expect them to increase price on alliance city pairs where at least two of them each offer substitute online products. 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 these alliance city pairs 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.

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 other city pairs. This is because an alliance is likely to expand the capacity and route network of each partner since they are able to sell seats on each others plane, which then reduces each partners' incentive to expand their own service. If this is the case, then an alliance may well serve to reduce future competition. However, this argument finds little support from the results above and results in Bamberger, Carlton, and Neumann (2004). In fact, the results above suggest the complete opposite, that is, the alliance actually lead to 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 at least two of them each offer substitute online products. The statistical insignificance of the coefficient on the "Overlap_Alliance" dummy suggests that the alliance partners' did not restrict traffic on these alliance city pairs 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, some formats of codesharing may be more conducive for collusive behavior than others. I now explore this possibility.[22]

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 suggest that, at best, traditional codesharing has a weak positive effect on price. However, 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 at least two of the partner carriers each offer their own substitute online products in the pre- and post-alliance periods. This is strong evidence against the hypothesis that traditional codesharing facilitate collusive behavior, even in city pairs where the partners' network overlap.

[22] 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)	0.0134 (0.0132)	-0.0325** (0.0068)	-0.0894** (0.0172)
Traditional Codeshare	0.0466* (0.0265)	-0.0179 (0.0699)	0.0350 (0.0330)	0.2929** (0.0848)
Single-carrier Virtual Codeshare	0.0481** (0.0104)	0.1856** (0.0290)	0.0499** (0.0143)	0.2804** (0.0417)
Interline Mixed Virtual Codeshare	0.0039 (0.0110)	0.1096** (0.0263)	0.0091 (0.0135)	0.1991** (0.0338)
Traditional Codeshare × $HHI_{pre\text{-}alliance}$	-0.0222 (0.0447)	0.1931* (0.1082)	-0.0053 (0.0495)	-0.1006 (0.1189)
Single-carrier Virtual Codeshare × $HHI_{pre\text{-}alliance}$	-0.0923** (0.0184)	-0.0874* (0.0497)	-0.1038** (0.0246)	-0.0590 (0.0699)
Interline Mixed Virtual Codeshare × $HHI_{pre\text{-}alliance}$	-0.0024 (0.0213)	-0.0130 (0.0466)	0.0012 (0.0238)	-0.0289 (0.0548)
$HHI_{pre\text{-}alliance}$	0.0492** (0.0083)	0.0302 (0.0185)	0.0580** (0.0095)	0.0868** (0.0217)
Overlap_Alliance × Traditional Codeshare	-0.0665** (0.0143)	0.0279 (0.0443)	-0.0887** (0.0217)	0.0676 (0.0618)
Overlap_Alliance × Single-carrier Virtual Codeshare	0.0002 (0.0061)	-0.0366** (0.0185)	0.0117 (0.0091)	-0.0183 (0.0296)
Overlap_Alliance × Interline Mixed Virtual Codeshare	0.0044 (0.0068)	0.0349 (0.0245)	0.0090 (0.0106)	0.0267 (0.0390)
Change in Percent Nonalliance Nonstop	0.0001 (0.0002)	0.0147** (0.0008)	0.00001 (0.0003)	-0.0044** (0.0009)
Change in City Pair Nonalliance HHI	-0.0032 (0.0056)	0.0969** (0.0163)	-0.0043 (0.0110)	0.0059 (0.0292)
Entry by Southwest	-0.0076 (0.0185)	0.1875** (0.0674)	0.0177 (0.0262)	-0.0422 (0.0909)
R^2	0.0022	0.0233	0.0022	0.0122
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 insignificance of the coefficient on the overlap interaction variable ("Overlap_Alliance × Traditional Codeshare") suggests that the increased traffic was no different on alliance city pairs where at least two of the partner carriers each offer their own substitute online products in the pre- and post-alliance periods 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 single-carrier 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 single-carrier virtual codesharing on the partners' price. Interestingly, single-carrier virtual codesharing is associated with a decline in city pair traffic levels on alliance city pairs where at least two of the partner carriers each offer their own substitute online products in the pre- and post-alliance periods. This finding suggests that single-carrier virtual codesharing could be associated with collusive behavior. However, the statistical insignificance of the coefficients on "Overlap_Alliance × Single-carrier Virtual Codeshare" in the price regressions and the traffic regression for the alliance carriers suggest that the evidence supporting collusive behavior is not overwhelming.

Now focussing on interline mixed virtual codesharing, the coefficient estimates suggest that this type of codesharing was not associated with price increases. However, the coefficient estimates in traffic equations suggest that this type of codesharing is associated with traffic increases. The increased traffic levels suggest that this type of virtual codesharing, like traditional codesharing, is likely associated with higher quality product offerings due to partners' efforts to coordinate flight schedules for interline connections and or greater opportunities for passenger to earn and redeem frequent-flyer miles. Last, there is no evidence that this type of codesharing is associated with collusive behavior since the coefficient estimates on "Overlap_Alliance × Interline Mixed Virtual Codeshare" are all statistically insignificant.

I conclude discussions of the results by noting that the coefficient estimates of the regression models do help us better understand the economics of codesharing between Delta, Continental, and Northwest. However, 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.

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 found that: (1) the alliance accounted 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 were no different on city pairs where at least two of the partners codeshare and each offer their own substitute products (overlapping service) in the pre- and post-alliance periods 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 both traditional codesharing and virtual codesharing that involves interline connections (Interline mixed virtual) exhibit features similar to results from the aggregated analysis. In particular, these types of codesharing formats are associated with increased traffic. 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.).

Both traditional and interline mixed virtual codesharing, which constitute a combined 64.64% of the codesharing between the three airlines, seem not to be strongly associated with price increases. In fact, I found that traditional codesharing decreases average city pair price in alliance city pairs where at least two of the partner carriers each offer their own substitute online products in the pre- and post-alliance periods. As such, the majority (64.64%) of the codesharing between Delta, Continental, and Northwest does not seem to be associated with collusive behavior.

By contrast, single-carrier virtual codesharing, which accounted for approximately 35.33% of the codesharing between the three airlines, is strongly associated with price increases. Furthermore, this type of codesharing is associated with a decline in city pair traffic levels on alliance city pairs where at least two of the partner carriers each offer their own substitute online products in the pre- and post-alliance periods. This finding suggests that single-carrier virtual codesharing could be associated with collusive behavior.

Notwithstanding the pro-competitive findings for much of the 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 some types of 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.

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