Evidence on Pricing from the Continental Airlines and Northwest Airlines Code-Share Agreement.

Olivier Armantier* and Oliver Richard†

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Abstract

Recent code-share agreements among major US airlines represent a significant development in the airline industry, as these agreements allow the partner airlines to sell seats on each other's flights across the US. In this paper, we examine with original data how prices and passenger volumes were affected by the first significant alliance among major US carriers, the 1999 alliance between Continental Airlines and Northwest Airlines. We find evidence of higher passenger volumes and lower prices across markets in which CO-NW code-shared. However, we also find evidence of significantly higher prices across markets with nonstop flights from CO and NW. In these markets, our results suggest that, as CO-NW used their agreement to expand the pool of passengers to whom they can sell seats on their aircraft, they have in turn extracted a higher price, on average. Hence, airlines need not be colluding for prices to rise following code-share agreements. This finding is significant for policy-makers traditionally focus on collusion in their reviews of these agreements.

* Département de Sciences Economiques, CIRANO, CRT, and CIREQ. Université de Montréal, C.P. 6128, succursale Centre-ville, Montréal QC H3C 3J7. E-mail: olivier.armantier@umontreal.ca.

† Economic Analysis Group, Antitrust Division, US Department of Justice, 600 E Street N.W., Suite 10000, Washington, DC 20530. E-mail: oliver.richard@usdoj.gov.

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1. Introduction

Recent code-share agreements among major US airlines allow the partner airlines to sell seats on each other's flights across the US.[1] Code-share agreements are common at hub airports and internationally, but the new domestic agreements have distinctive features. Namely, the partner airlines are major rivals in the US and, in contrast to international agreements, they face no constraints on entry and must compete in prices, as they are not granted antitrust exemptions. Airline executives emphasize that the new domestic agreements allow the partner airlines to expand their range of products and introduce significant new competition.[2] Consumer advocates, however, are concerned that they may reduce competition and raise prices. In this paper, we analyze with original panel data how prices and passenger volumes across the US were affected by the first significant code-share agreement among major US carriers, the 1999 alliance between Continental Airlines ("CO") and Northwest Airlines ("NW').

The CO-NW code-share agreement was implemented in 1999, without being formally challenged by the US Department of Transportation or the US Department of Justice.[3] The agreement presumably remains subject to additional investigation under the antitrust laws, should evidence of significant harm be brought forward. In the present paper, we provide evidence that passenger volumes are higher in markets affected by the CO-NW code-share agreement, and that prices are lower in markets in which CO and NW code-share. These findings are consistent with other evidence on domestic and international code-share agreements.[4] However, in markets where CO and NW have

[1] See e.g. Continental Airlines and Northwest Airlines in 1999, US Airways and United Airlines in 2003, and Continental Airlines, Delta Airlines, and Northwest Airlines in 2003.

[2] From Gordon Bethume, chairman and CEO of Continental Airlines : "Our alliance demonstrates how consumers can win when two companies work together to provide our customers a dramatically larger range of services than either of us could offer on our own. We will deliver more choice, more frequencies, and more destinations to the traveling public." Source: Detroit Metro News, 12/1998.

[3] Following the CO-NW proposal, NW also acquired a controlling voting interest in CO equity. In October 1998, the US Department of Justice sued to block NW's acquisition. The matter was settled in November 2000, as NW divested most of its voting interest in CO.

[4] See Ito and Lee (2005a,b) for very insightful discussions of the CO-NW code-share agreement, and Bamberger, Carlton and Neumann (2000) for insights on the regional code-share agreements between

nonstop flights, we find that prices are significantly higher in the post-agreement period. In particular, the code-share agreement allows the partner airlines to expand their flight offerings without addition of aircraft and, thereby, increase the pool of passengers to whom they may sell seats on their aircraft. Our results then suggest that CO and NW have used this expansion to extract a higher price, on average. In other words, our analysis suggests that a code-share arrangement like this one sets up incentives for price increases independent of the question of whether it increases the likelihood of collusion. This finding is significant for policy-makers in their recent reviews of domestic and international alliances have focused on collusion when assessing the potential for price increases.

The paper is structured as follows. Section 2 outlines the basics of the CO-NW code-share agreement. Section 3 discusses the empirical methodology, and Section 4 describes the data. In Section 5, we discuss our findings, and we conclude in Section 6.

2. The CO-NW Code-Share Agreement

A code-share agreement is a form of corporate integration that falls in between a traditional arm's length agreement between competitive airlines (known generally as an interline agreement) and an outright merger. In other words, the term "code-share" can mean as little as one airline allowing another airline to use its designator code to sell seats on its flights in markets in which the second airline does not compete, or as much as a comprehensive integration of marketing and operations that involves joint decisions on price, capacity, schedules, and other competitively sensitive matters. The level of integration ultimately depends on the level of antitrust exemptions they receive. For instance, code-share agreements between foreign airlines in international markets are

CO and America West, as well as NW and Alaska Airlines, which were implemented in 1994-1995. See, e.g., Brueckner and Whalen (2000), Brueckner (2001, 2003), as well as Park and Zhang (2000) for discussions of international alliances. See Bamberger, Carlton and Neumann (2000) for valuable insights on the regional code-share agreements between CO and America West, as well as NW and Alaska Airlines, which were implemented in 1994-1995.

typically granted partial antitrust immunity on prices, whereas domestic agreements, such as the CO-NW code-share alliance, are not granted any antitrust exemptions.[5]

In January 1998, CO and NW announced their intention to form a code-share agreement across the US.[6] Under the terms of this agreement, each airline is able to market seats on some of its partner's flights. The code-share flights are then listed twice in schedules and computer reservation systems, once by each airline with its own flight number and designator code. Moreover, the partners agree to coordinate flight schedules and operations to provide seamless service on code-share flights (e.g. one-stop check-in, automatic baggage transfers). The carrier operating the code-share flight determines seat availability for the marketing partner, but each airline commits to set prices competitively. All sales revenues go to the operating carrier, and the marketing partner gets only a booking fee to cover handling costs (as travel agents do). Finally, the airlines agree to implement linkages in their frequent-flyer programs.[7]

The principal argument advanced in favor of the code-share agreement was the opportunity for CO and NW to expand both flight offerings and markets served without any addition of aircraft. Executives at CO-NW emphasized that their alliance would not only open new markets to their consumers, but also expand the number of flights in markets in which they already operated. For instance, by pairing two of their existing flights, they would generate new code-share flights in addition to the flights they each already offered. Finally, they claimed that their alliance would promote competition over the US market by creating "a fourth network to compete with the existing 'Big Three' airlines in the U.S. ... Over 150 cities, 2,000 city-pairs, and three million passengers will gain a new airline competitor and new on-line connections through the alliance."[8]

[5]For more details, see Brueckner (2003) and pp.140-142 in Special Report 255, "Entry and Competition in the U.S. Airline Industry", from the Transportation Research Board.

[6]See Armantier, Giaume, and Richard (2005b) for an analysis of the airlines' incentives and decisions to code-share in specific markets.

[7]These reciprocal linkages allow a customer to use her frequent flyer miles with one airline to book awards from the other airline, but combining mileage across programs to redeem awards was not allowed in the CO-NW agreement. Hence, a consumer may find it preferable to keep accumulating points in a single program and, thus, book seats on code-share flights through her preferred airline.

[8]See p.6, Statement by Hershel I. Kamen, from CO, to the U.S. Senate, 06/04/98.

These claims were consistent with the evidence on regional and international code-share agreements. For instance, major airlines have long-standing code-share agreements at their hub airports with commuter carriers that serve smaller markets. US airlines, faced with restrictions on entry in foreign markets (cabotage laws), have agreements with foreign carriers that allow them to market flights within their partners' domestic network. CO and America West ("HP"), as well as NW and Alaska Airlines, also formed in 1994-1995 agreements in peripheral US markets in which neither partner had previously competed. Across the literature, these agreements have been associated with lower prices and higher passenger volumes. For instance, Brueckner and Whalen (2000) and Brueckner (2003) find that fares are lower by 8% to 17% in markets in which international airlines code-share, even when these airlines are granted antitrust exemptions on prices. Likewise, Bamberger, Carlton, and Neumann (2002) find that the CO-HP agreement has been pro-competitive, as prices fell and passenger volumes rose by an average of 6% in markets in which these airlines code-shared.

The CO-NW proposal generated much controversy at policy levels, however, prompting numerous hearings on its competitive implications.[9] Indeed, this proposal presented distinctive features. In contrast to regional domestic agreements, it would involve major and rival airlines across the US. In contrast to international agreements, CO and NW would face no restrictions on entry across the US, and they would have to compete in prices. Hence, key concerns were that the implementation of the alliance would lower the incentives of CO and NW i) to enter markets in which only one of the partners already operated, ii) to maintain competing flights in markets in which they jointly operated, and iii) to compete in prices. In October 1998, the US Congress granted the US Department of Transportation (DOT) the authority to delay the implementation of domestic alliances pending a review of their effects. In November 1998, the DOT decided to allow the implementation of the alliance without a formal investigation, after CO and NW consented not to code-share flights in markets between their respective hub airports.

[9] See, e.g., Statement from Joel Klein, Department of Justice (DOJ), to the Senate Committee on Commerce, Science, and Transportation, 03/12/99.

The CO-NW code-share agreement then became effective in the US in January 1999. The DOT presumably retained the right, however, to investigate the agreement after data become available, to ensure that the alliance is not anti-competitive.

3. Empirical Analysis

A market is defined as a pair of airports in a quarter. Markets are non-directional. For example, the airport-pairs Miami-Pittsburgh in quarter t and Pittsburgh-Miami in quarter t are the same market. A product in a market is a round-trip ticket for a seat on a sequence of flights (i.e. itinerary) between the two airports in the market. The product is either i) nonstop if it consists of a single flight each way, or ii) connecting if it requires at least one transfer at an intermediate airport. When the airline marketing the product is the airline operating the flights in the product, as is common in practice, then the product is said to be online. When the airline marketing the product differs from the airline actually operating one of the flights in the product, then the product is either i) a code-share if the two airlines have a domestic code-share agreement, or ii) an interline if the two airlines have no such agreement.[10]

We say that the partner airlines code-share *in* a market if they have code-share products *in* that market. We say that the partner airlines code-share *through* a market if a partner airline operates nonstop flights in the market and the itinerary of a code-share product includes one of these flights. For example, assume that CO pairs a nonstop flight that it operates in a market A-B together with a nonstop flight that NW operates in a market B-C to form a connecting code-share product in market A-C. In other words, a passenger buying this connecting code-share product takes CO's flight between A and B and NW's flight between B and C.[11] Then we say that CO-NW code-share *through*

[10] Given the focus is on alliances among major airlines, these definitions only apply to products where the carriers are major airlines. When the operating carrier is a commuter carrier that has a regional code-share agreement with the major airline marketing the product, then the product is solely associated to the major airline.

[11] Travelling between A and C was previously possible by purchasing an A-B ticket from CO and a B-C ticket from NW. Such trip arrangements are extremely rare in practice (see Morrison and Winston

market A-B because the itinerary of the code-share product in market A-C includes CO's nonstop flight in A-B. Likewise, in this example, CO-NW code-share *through* market B-C. Following the code-share agreement, CO may then use the new connecting code-share product in market A-C to sell seats in its A-B aircraft, and it may carry in its A-B aircraft i) passengers from market A-B who buy CO's nonstop product in A-B, and ii) passengers from market A-C who buy the connecting code-share product in A-C. In that regard, the code-share agreement may set up incentives to increase the demand for seats in an aircraft that an airline operates and, therefore, affect the airline's prices and passenger volume. Indeed, throughout the listing of a flight schedule, airlines use sophisticated *yield management* techniques to allocate seats on aircraft to any of a number of passengers with different valuations or origin and destination airports, as to maximize revenues (see, e.g., Boyd 1998 and Netessine and Shumsky 2004).

In the present paper, we examine how airline prices and passenger volumes varied with the set of products that each airline supplied in an airport-pair following the CO-NW code-share agreement. Specifically, we estimate the following models on panel data that overlap the implementation of the CO-NW code-share agreement:

$$Y_{i,t} = X_{i,t}\beta + Z_t\gamma + \mu_{i,t} + \varepsilon_{i,t} \quad , \tag{3.1}$$

where i indexes the airline and t indexes the market. The dependent variables $Y_{i,t}$ are either i) $PRICE_{i,t}$, the mean ticket price paid by passengers, or ii) $PASS_{i,t}$, the number of passengers. The μ's are fixed-effects for each of the airline, airport-pair, and quarter, respectively.[12] The $\varepsilon_{i,t}$ is an i.i.d. error term with zero mean. The $X_{i,t}$ and Z_t vectors consist, respectively, in airline and market attributes, and they are subsequently

1995), as they entail unfavorable features such as the need for double booking, multiple check-ins, longer distance between connecting gates, lack of responsibilities by carriers in case of missed connection or lost luggage, but mostly, higher prices. In contrast, the code-share A-C product is sold as a virtual online product with seamless service and, under the terms of the agreement, competitive prices.

[12] For parsimony in the presentation, the indices for airport-pairs and quarters are represented under a single "market" indice t. There are no fixed-effects for the "market" itself in the model, rather there are separate fixed-effects for each of the airport-pair and quarter.

described in Section 4.2.

4. Data

4.1. Sample Data

The data are for the period 1998 through 2001, which spans the 1999 implementation of the CO-NW code-share agreement. The data consist of quarterly data on flight schedules and prices obtained, respectively, from the US Department of Transportation ("DOT") and the Official Airline Guide (OAG).[13] The DOT data is the Origin-Destination Survey Databank 1B. This Databank is a 10% random sample of tickets sold by US airlines for travel in a quarter. A key feature of Databank 1B, relative to the routinely used Databank 1A, is that it reports each of the operating and marketing carriers, which makes it possible to identify separately online, code-share, and interline tickets. From the observed round-trip tickets, we obtain the number of passengers and mean price per airline in a market.[14] Following Evans and Kessides (1993), we include an airline in a market if the airline has at least 18 passengers in the DOT data (corresponding to an average of 180 in a quarter) and a 1% share of all passengers in the market. The OAG data list the time and itinerary for flights supplied by commercial US airlines. From this schedule, we construct the product set that each airline may supply in a market, and we identify which of these products include which nonstop flight.[15] When the set of products including a CO or NW nonstop flight contains CO-NW code-share products, then we say that CO-NW code-share *through* the market that includes the nonstop flight.[16] We

[13] The data are for the 1^{st} quarters of 1998 through 2001, and the 3^{rd} quarters of 1998 through 2000 (7 quarters in total).

[14] We use Borenstein and Rose (1994)'s guidelines to screen unusually high and low ticket prices.

[15] The flight schedule is constructed based on an airline's presence in a market, irrespective of which ticket itineraries are observed for that airline in that market in the DOT data. Following the General Accounting Office (see p.42 in 2000 report RCED-99-37), we consider connecting products with a transit time at each intermediate airport of at least 30 minutes and no more than 150 minutes. Following Armantier and Richard (2003), we consider connecting products with at most one stop each way.

[16] We hereby recognize that it is the size and mix of the set of *potential* marketing opportunities for flights, not just *realized* ones, that matter. Indeed, assume that an airline has one available seat. Consider two cases: i) the airline has a single potential customer A; and ii) the airline has two potential

then take our sample data to include airport-pairs between metropolitan areas in the continental US. Descriptive sample statistics are provided in Table 1. The sample data include 1,893 airport-pairs, 29 airlines, and a total of 46,679 airline-market observations. A market averages 288.6 products, 3.7 airlines, and 1385.3 passengers (corresponding to an average of 13,853 passengers in a quarter).

The CO-NW agreement became effective in the US in January 1999. The fraction of markets in which at least one of CO or NW sold tickets increased by 5% between 1998 and 2001, and the fraction of markets in which both CO and NW were present increased by 8%. The number of airport-pairs with nonstop flights from both CO and NW increased from 4 in 1998 to 9 in 2000, which represented only 3% of all airport-pairs where CO and NW had nonstop flights in 2000.[17] As a group, CO and NW supplied only 0.3% of their markets solely with code-share products; that is, without online products. In that regard, this alliance differs notably from traditional regional and international agreements, in which the partners essentially code-share products in markets where none of them would otherwise operate.

We observe that CO and NW code-shared products *in* 26% of the airport-pairs in which at least one of the two airlines was present in 2000-2001. When CO-NW code-shared *in* an airport-pair, an average of 9% of CO-NW passengers used a code-share ticket. CO-NW also code-shared *through* 81% of the markets where they had nonstop flights in 2000-2001. When CO-NW code-shared *through* a market, then the number of products marketing each nonstop flight increased by 136%, and 48% of these products were CO-NW code-share products, on average. Besides its code-share agreement with NW, CO also had a code-share agreement with America West ("HP") during the period 1998 to 2001.[18] In that period, CO and HP code-shared flights in 6.6% of the markets

customers, A and B. Even if we observe that the airline sold the seat to customer A in both cases, its price to customer A may differ across both cases. Indeed, the opportunity cost of not selling the seat in i) is an empty seat, whereas the opportunity cost in ii) may include selling the seat to customer B.

[17] The 9 airport-pairs with nonstop flights from both CO and NW are the ones that pair their respective hub airports together, which are Detroit, Minneapolis-St Paul, and Memphis for NW and Cleveland, Houston, and Newark for CO.

[18] This agreement was implemented in 1994-1995. Alaska Airlines ("AS") and NW also had a domestic

in which at least one of the two airlines was present and, when CO-HP code-shared *in* a market, an average of 9.8% of their passengers used a code-share ticket.

4.2. Variables in the Model

We include in the vector $X_{i,t}$ in (3.1) variables that describe the set of products for airline i *in* market t:

- $online\_in_{i,t}$, the number of online products for the airline in the market. As more products provide more flight options, we expect demand for travel with the airline to increase with the number of products, resulting in higher prices and quantities.

- $csconw\_in_{i,t}$, the number of CO-NW code-share products in the market. This variable only applies to CO, NW in markets *in* which they code-share. We expect the demand for travel with the airline to increase with the number of code-share products. Competition between the partner airlines may mitigate any price increases as code-share products may be marketed by both airlines.

- $cscohp\_in_{i,t}$, the number of CO-HP code-share products in the market. This variable only applies to CO, HP in markets *in* which they code-share.

- $interline\_in_{i,t}$, the number of interline products for the airline in the market.

- $traveltime\_in_{i,t}$, the average travel time (including transit times) across the airline's products in the market.

When airline i operates nonstop flights in market t, we have the following variables to denote the set of products marketing these flights:

- $flights_{i,t}$, the number of nonstop flights for the airline; and

- $flight\_online\_in_{i,t}$, the number of online products in market t that have their customers use a nonstop flight from airline i in market t, divided by the number of nonstop flights for airline i in market t.[19] In other words, this variable represents the

code-share agreement at the time, but its presence was negligible in our sample data. For parsimony, we aggregate AS-NW code-share products together with interline products. This is of no significance for our results.

[19] These online products include nonstop products in the market as well as connecting products where the outbound (inbound, respectively) itinerary is a single nonstop flight and the inbound (outbound,

average number of online products *in* the market that may be used by the airline to sell seats on each of its aircraft in the market (i.e. this variable and the following ones are computed on a per-flight basis). How a change in this variable may affect prices and quantities is not clear, a priori. There is evidence of economies of density in the airline industry, whereby a larger passenger volume may be accommodated by larger planes that have a lower cost per passenger.[20] Hence, an increase in the set of products that may be used to sell seats on an aircraft may afford an airline better opportunities to exploit economies of density and lower costs. On the other hand, following yield management practices, an increase in the pool of passengers to whom a seat may be sold may enable an airline, depending on its (lack of) capacity adjustments, to extract a higher yield per passenger.[21]

- $flight\_online\_thru_{i,t}$, the per-flight number of online connecting products *in* markets other than market t that include as part of their itinerary a nonstop flight from airline i in market t (i.e. passengers buying these products fly on a nonstop flight from airline i *through* market t as part of their itinerary).

- $flight\_csconw\_thru_{i,t}$, the per-flight number of CO-NW code-share products that include as part of their itinerary a nonstop flight from airline i in market t. This variable only applies to CO, NW.

- $flight\_cscohp\_thru_{i,t}$, the per-flight number of CO-HP code-share products that include as part of their itinerary a nonstop flight from airline i in market t. This variable only applies to CO, HP.

- $flight\_interline\_thru_{i,t}$, the per-flight number of interline products that include as part of their itinerary a nonstop flight from airline i in market t.

The code-share *through* variable $flight\_csconw\_thru$ is specific to markets where CO-NW have nonstop flights. To ensure that systematic variations (e.g. in costs) that

respectively) itinerary requires a stop at an intermediate airport.

[20] See Caves, Christensen, and Tretheway 1984, Brueckner, Dyer and Spiller 1992, and Brueckner and Spiller 1994

[21] Capacity adjustments may include a change in the number of seats supplied or in the fraction of seats filled by passengers at take-off (i.e. load factor). We have no reliable data on either measures.

are specific to CO-NW's operation of nonstop flights are not attributed by default to this variable, we include the following dummy variables:

- $dum\_conw_{i,t}$, which equals 1 for CO or NW when it has nonstop flights.

- $dum\_conw\_expost_{i,t}$, which equals 1 for CO or NW when it has nonstop flights and the period is 1999 to 2001. This variable captures any change in $dum\_conw_{i,t}$ in the post-agreement period.

- $dum\_csconw_{i,t}$, which equals 1 for CO or NW when it has nonstop flights and this is an airport-pair *through* which CO-NW code-share ex-post their agreement. This variable captures any change in $dum\_conw_{i,t}$ for airport-pairs *through* which CO-NW code-share.

- $dum\_csconw\_thru_{i,t}$, which equals 1 for CO or NW when it code-shares *through* the market (i.e. when $flight\_csconw\_thru_{i,t}>0$). This variable captures any change in $dum\_csconw_{i,t}$ ex-post the agreement, beyond that already captured by $dum\_conw\_expost_{i,t}$.

We also denote the presence of code-sharing with the following dummy variables:[22]

- $dum\_csconw\_in_{i,t}$, which equals 1 for CO, NW when they code-share *in* a market; that is, when $csconw\_in_{i,t}>0$.

- $dum\_cscohp\_in_{i,t}$, which equals 1 when $cscohp\_in_{i,t}>0$.

- $dum\_cscohp\_thru_{i,t}$, which equals 1 when $cscohp\_thru_{i,t}>0$.

Finally, the vectors $X_{i,t}$ and Z_t include measures of airline presence and of competitive interactions:

- $dum\_nonstop_{i,t}$ which equals 1 when $nonstop_{i,t}$ is greater than 0;

- $dum\_connect_{i,t}$, which equals 1 when the airline has connecting products;

- $share_{i,t-1}$ is the airline's average share of passenger enplanements at the endpoint airports in the market, lagged by one quarter. Following Borenstein (1989, 1991), we recognize that a larger airport presence may confer an airline greater visibility and allow it to offer a wide array of services and options.

- $herf_t$ is the Hirschmann-Herfindal Index ("HHI", measured as 0 to 1) for passenger

[22] Similar dummy variables were defined for interline products, but they were not statistically significant at standard levels. For parsimony, they were dropped from the model.

enplanements across airlines in the market. As is common in antitrust work, this variable is used as a proxy for competitive interactions. The variable $herf_t$ is endogenous, and we use the following instruments: i) lagged values $herf_{t-1}$ and $herf_{t-2}$, ii) $comp_t$, the number of airline present in the market, and iii) $hairp_t$, the average of the HHI (measured as 0 to 1) for passenger enplanements at the endpoint airports in the market.[23]

- $strike_{i,t}$ is a dummy variable equal to 1 in the 3^{rd} quarter of 1998 for NW in markets where NW competed in the 1^{st} quarter of 1998. This variable should capture the impact that the NW strike may have had during that period. We also interact the variable $strike_{i,t}$ with each of $online\_in_{i,t}$ and $in\_nonstop_{i,t}$.

5. Results

Estimation results are listed in Table 2.[24] Given the large number of observations, we use a 1% level to test for statistical significance. The models fit the data well, with R-square values of 0.76 for the price regression and 0.90 for the passenger one. Coefficients on product, airline, and market variables have the expected signs, which are consistent with findings in the literature. For example, airport presence (*share*) increases prices but not necessarily passenger volumes, suggesting the exercise of market power.[25] We also find that a larger set of online products in a market (*online_in*) is associated with higher prices and passenger volumes, and that nonstop flights (*flights*) are associated with substantially larger passenger volumes (see, e.g., Morrison and Winston 1995, and Richard 2003).[26] This finding is consistent with the DOT data, where we observe that

[23] $HAIRP_{j,t} = \sum_i (SHAIRP_{i,t} / \sum_i SHAIRP_{i,t})^2$, where both summations apply to all airlines i present in market t.

[24] We consider a simple version of the model that estimates a single parameter, common to all airlines, for each variable, as well as a full version that allows for the parameters to differ across airlines. The estimation results for the simple version are representative, and allowing for the coefficients on the product variables to differ across airlines does not affect the net effect of the code-share variables. Accordingly, we discuss the estimation results for the simple version. The prediction results, listed in Table 3, are computed from the full version, which includes an additional 168 parameters.

[25] See, e.g., Berry 1990, Borenstein 1989, 1991, Evans and Kessides 1993.

[26] Nonstop flights are factored in each of the variables *nonstop* and *online_in*. An additional nonstop flight from A to B in airport-pair A-B increases the number of products proportionately to the number

94% of an airline's passengers fly nonstop, on average, when the airline has nonstop products in a market.

When CO-NW code-share *in* a market, we find that, all else equal, the CO-NW code-share variables are not associated with statistically significant changes in prices and quantities. Indeed, the number of CO-NW code-share products *in* a market (*csconw_in*), and the related dummy variable (*dum_csconw_in*), are not statistically significant in the price and passenger regressions. In contrast, CO's and HP's mean prices and passenger volume in a market are found to be higher the greater the number of their code-share products (*cscohp_in*, *dum_cscohp_in*).[27] In the DOT data, we observe that CO-HP ultimately code-shared more nonstop products than CO-NW did, as 8.2% of the itineraries that CO-HP code-shared in the DOT data were nonstop compared to only 0.7% for CO-NW.

To determine the net effect of the CO-NW agreement on prices and passenger volumes, we compute the mean prices and passenger volumes that obtain from the model at the estimated coefficient values and the observed values for the right-hand side variables. Within an airport-pair, these predicted values are compared across a pre-agreement and a post-agreement period, where the pre-agreement (post-agreement, respectively) spans all quarters preceding (following, respectively) the start of the code share agreement in that airport-pair.[28] In airport-pairs where CO-NW do not code-share, predictions for 1998 are compared to those for the period 1999 to 2001. Results are listed in Table 3.

Across airport-pairs *in* which CO-NW code-shared, we predict that CO-NW's mean prices were lower by 3.2%, and CO-NW's passenger volumes were higher by 12.3%, in the

of nonstop and connecting flights from B to A. The negative sign on *nonstop* in the price regression may indicate, in this reduced form analysis, that airlines price lower on their demand curve when they have nonstop flights in a market.

[27] The net effect of the *cscohp_in* and *dum_cscohp_in* is a statistically significant increase in passenger volume, in that should either of these variables be removed then the remaining variable becomes significant. The same is not true for the CO-NW code-share variables.

[28] Mean values are computed net of fixed-effects for the quarters and of the *strike* terms, as to control for exogenous variations over time. In the period following the start of the agreement in a market, we only take into consideration the quarters during which CO-NW code-share. A before/after comparison is informative in this paper as at least one of CO or NW is present in 1998 in 97.5% of the airport-pairs *in* which and *through* which they code-share following their agreement.

post-agreement period. For reference, across airport-pairs where CO-NW *never* code-shared, we predict that CO-NW's mean prices were lower by 1.1% during the period 1999 to 2001 relative to 1998, and CO-NW's passenger volumes also were lower by 6.2%. Hence, the prediction results indicate lower prices and higher passenger volumes for CO-NW when they code-shared *in* a market. These results are consistent with Ito and Lee (2005a,b). Interestingly, this increase in passenger volume across airport-pairs *in* which CO-NW code-shared may mostly be traced, not to the CO-NW code-share products in the market (see the previous paragraph), but to an increase in the number of times CO and NW were both present in a market in the post-agreement period. In particular, the number of times that both CO and NW were present in a market increased by 25% following their agreement across airport-pairs *in* which they code-shared, whereas it was unchanged across airport-pairs where they *never* code-shared. Hence, the total number of online products supplied by CO-NW, as a group, increased by 27% in the post-agreement period across airport-pairs *in* which they code-shared, whereas it increased by 16% across all other airport-pairs where they were present.

In the price regression, the coefficient values on the dummy variables *dum_conw_expost* and *dum_csconw_thru* are statistically significant. This means that, across airport-pairs where CO-NW had nonstop flights, we estimate a fixed, statistically significant increase in prices in the post-agreement period, and this increase was relatively larger across airport-pairs *through* which CO-NW code-shared.[29] The sum of the coefficient values on *dum_csconw_thru* and *dum_conw_expost* in the passenger regression is not statistically significant, however (p-value=0.11). This means that we estimate that there was no statistically significant fixed change in passenger volume across the pre-agreement and post-agreement periods in airport-pairs *through* which CO-NW code-shared.

The results also indicate that an airline's prices and quantities in a market where it has nonstop flights vary with the set of products that sell seats on these aircraft. In

[29] The estimated increases are on the order of (i) $23.6 across airport-pairs where they never code-shared *through* (see *dum_conw_expost*), and (ii) $41.0 (i.e. $41=$23.6+$17.4) across airport-pairs *through* which CO-NW code-shared (see *dum_conw_expost*+*dum_csconw_thru*).

particular, we find that the coefficient on the variable $flight\_online\_thru$ is statistically significant and positive (negative, respectively) in the price (passenger, respectively) regression. This means that prices and passenger volumes *in* a market are, all else equal, adversely affected by an increase in the average number of online connecting products that may be used to sell seats on an aircraft in the market. In other words, this suggests that passengers who buy nonstop products and passengers who buy connecting products may, at the margin, be substitute passengers for the same seat on an aircraft. Likewise, in markets *through* which CO-NW code-shared, we find that an increase in the average number of CO-NW code-share products that market seats on a CO-NW aircraft ($flight\_csconw\_thru$) is associated with higher prices and lower passenger volumes for CO and NW *in* the market. These findings therefore indicate that, as the set of products that may be used to sell seats on an aircraft in a market increases, the airline may ask for higher prices from its passengers *in* the market, as we might expect under effective yield management practices.

We estimate that the effects associated with the level of code-sharing *through* a market are non-trivial. Indeed, at sample mean values, we find that, all else equal, the effect of the variable $flight\_csconw\_thru$ represents i) a 4.4% increase in CO-NW's mean prices, and ii) a 6.2% decrease in passenger volume across airport-pairs *through* which CO-NW code-shared. Hence, in the case of the CO-NW agreement, the level of code-sharing *through* a market is associated with significant price increases and, at the margin, passenger decreases in that market.

Turning more generally to price and passenger predictions, we predict that, following the implementation of the code-share agreement, CO-NW's mean prices were higher by 13.6%, which represents a significant increase over predicted changes across other airport-pairs (see Table 3). We also predict that CO-NW's passenger volume was higher by 6.7% following their agreement across airport-pairs *through* which they code-shared. This increase is lower than that across airport-pairs *in* which they code-shared, but greater than that across airport-pairs where they *never* code-shared. Interestingly, we predict that the code-share *through* variables (i.e. $flight\_csconw\_thru$ and dum_csconw_thru)

are associated, all else equal, with i) a net 10.6% increase in CO-NW's mean prices and ii) a net 0.6% decrease in CO-NW's passenger volume.[30] In particular, the increase in passenger volume across airport-pairs *through* which CO-NW code-shared may mostly be traced to an increase in the post-agreement period in the number of nonstop flights supplied by CO-NW across these airport-pairs. Indeed, in the OAG data, we observe that CO-NW increased their number of nonstop flights in the post agreement period by 8.8% across airport-pairs *through* which they code-shared, and by 5.3% only across all other airport-pairs.

Aggregating across all airlines in a market, we predict prices that were higher by 10.7%, on average, in the post-agreement period across airport-pairs *through* which CO-NW code-shared. We also predict a mean increase of 10.3% in the total passenger volume, which is comparable to the increase across airport-pairs *in* which CO-NW code-shared. Hence, as CO-NW raised their prices in airport-pairs *through* which they code-shared, other airlines gained in passenger volumes.

Finally, our results on code-sharing *through* a market are robust to alternative specifications. For instance, consider the following model. The dependent variable is $\ln(price_{i,t})$ for the price regression and $\ln(pass_{i,t})$ for the passenger regression. The right-hand side variables include the previously defined (see Section 4.2) dummy variables $dum\_nonstop_{i,t}$, $dum\_csconw_{i,t}$, $dum\_csconw\_thru_{i,t}$, as well as airport-pair, airline, and quarter fixed effects. We also include a new variable: $csconw\_thru\_share_{i,t}$, which is defined for each of CO and NW as the fraction of all products that market CO-NW's nonstop flights that are CO-NW code-share products.[31] This variable

[30] Under our interpretation that the changes associated with code-sharing *through* a market result from more effective yield management following the code-share agreement, there is no reason to necessarily expect a net decline in passenger volumes, since net changes in volumes also depend on capacity adjustments. We found evidence of a general increase in products supplied following the agreement and of a decrease, at the margin, in volume associated with the level of code-sharing *through* the market. Such changes are consistent with our interpretation of the findings. Note that in 1999, Continental Chairman and CEO Gordon Bethune stated that the CO-NW alliance had been "hugely beneficial" bringing $80 million revenues in 1999, $20 million more than expected (source: Aviation Week and Space Technology, 01/24/00).

[31] $csconw\_thru\_share = flight\_thru\_csconw \; / \; (flight\_online\_in + flight\_online\_thru + flight\_csconw\_thru + flight\_cscohp\_thru + flight\_interline\_thru)$.

proxies for the level of code-sharing *through* the market. Results are in Table 4. In the log-price (log-passenger, respectively) regression, the estimated coefficient value on *csconw_thru_share* is positive (negative, respectively) and statistically significant. In other words, we again estimate that the level of code-sharing *through* a market increased, at the margin, CO-NW's mean prices and lowered their passenger volumes. At the sample value for *thru_csconw_share* (i.e. 0.48, when positive), we estimate that the effect of the variable *csconw_thru_share* represents a 5.1% increase in CO-NW's mean prices in airport-pairs *through* which they code-shared, which is comparable to the 4.4% increase estimated from our results in Table 3. Computing predictions from the alternative model, we predict that, across airport-pairs *through* which CO-NW code-shared, mean prices for CO-NW were higher by 11.2% in the post-agreement period, and their passenger volume was also higher by 9.5%. These prediction results are in line with those obtained from our model in Table 3, and they attest to the robustness of our findings.

6. Conclusion

When Continental Airlines and Northwest Airlines announced in 1998 that they were forming the most significant code-share alliance in the US, expectations among analysts were that the alliance would lead to lower prices and higher traffic volumes. Such a development would have been consistent with the evidence on other code-share agreements at the time. Using a comprehensive and original panel data set, we provided mixed evidence on this matter. We found that passenger volumes were higher across markets affected by the CO-NW code-share agreement, and that CO-NW's mean prices were lower across markets *in* which they code-shared following their agreement. However, we also found evidence of significant price increases across markets with nonstop flights from CO and NW, with prices rising by an average of 13.6%.

The literature on international alliances highlights as well some evidence of higher prices in markets with nonstop flights from both alliance airlines (see Brueckner and Whalen 2000). The suggestion in that literature is that, as international airlines are granted some partial antitrust exemptions on prices, they may collude more generally. The CO-NW alliance, however, has been granted no antitrust exemptions. In fact, not only do CO and NW both offer nonstop flights in just a handful of the same markets, but also our estimation results put forth evidence of lower prices across markets *in* which they code-share. In this paper, we made no claims of collusion. Instead, we provided evidence that CO and NW used their code-share agreement to increase the demand for seats in their aircraft. In conjunction with this increase, then, and consistent with yield management practices, our results suggested that CO-NW maximized revenues, thereby increasing prices.

These findings therefore suggest that greater emphasis be placed on identifying how changes in product offerings in markets *in* which the alliance airlines code-share may in turn adversely affect prices in markets in which the alliance airlines do not code-share. This suggestion is particularly relevant in that policy reviews of the recent domestic code-share agreements, such as the 1999 CO-NW, the 2003 Delta-CO-NW, and the 2003 United-US Airways agreements, focused on the overlap in markets served by the alliance partners, and on the potential for collusion in prices in markets *in* which the alliance airlines code-share. It remains that the reduced-form analysis in the present paper does not allow us to draw unambiguous conclusions on changes in consumer welfare following the CO-NW code-share agreement. To address adequately welfare issues, we need a structural model of demand that accounts for the multi-dimensional effects of the CO-NW agreement on consumer choices. The model in Armantier and Richard (2005a) may offer a blueprint for such an analysis.

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8. Tables

Table 1.
Descriptive Sample Statistics.

Aggregates per Market (12,538 markets)					
Variables	*Mean (Standard dev.)*	*Minimum Maximum*	*Variables*	*Mean (Standard dev.)*	*Minimum Maximum*
Number of Passengers *	13,853.3 (17,905.5)	18 16,358	Number of Airlines	3.74 (1.96)	1 10
Mean Price per Passenger ($)	336.81 (130.82)	66.33 1104.05	Number of Products	288.61 (347.17)	1 4,588
Level Variables in the Model (46,679 observations)					
Variable	*Mean (Standard dev.)*	*Minimum Maximum*	*Variable*	*Mean (Standard dev.)*	*Minimum Maximum*
price ($)	342.88 (129.81)	75.36 1231.79	flights	2.27 (5.13)	0 65
pass	367.83 (780.63)	18 13262	flight_online_in	2.38 (5.24)	0 47.53
online_in	68.17 (113.69)	0 2256	flight_online_thru	16.08 (45.70)	0 523.75
csconw_in	6.64 (54.51)	0 1447	flight_csconw_thru	2.22 (22.47)	0 755.3
cscohp_in	2.07 (22.98)	0 981	flight_cscohp_thru	0.83 (12.11)	0 627.4
interline_in	0.65 (19.01)	0 1578	flight_interline_thru	0.18 (2.01)	0 136.5
traveltime_in	602.13 (213.62)	80 1156.1	share	0.16 (0.13)	0 0.91
			herf	0.44 (0.21)	0.12 1

* Predicted quarterly average from DB1B (i.e. value observed in Databank 1B multiplied by 10).

Table 2.

Estimation Results.

Regression for:	**Price**	**Pass**		**Price**	**Pass**
Variables	*Estimate (Standard error)*	*Estimate (Standard error)*	*Variables (continued)*	*Estimate (Standard error)*	*Estimate (Standard error)*
online_in	0.126 (0.007)*	0.412 (0.028)*	dum_cscohp_thru	-14.521 (3.771)*	51.184 (15.844)*
csconw_in	0.015 (0.008)	0.035 (0.035)	dum_nonstop	2.060 (2.681)	-120.299 (11.266)*
cscohp_in	0.145 (0.024)*	0.095 (0.100)	dum_connect	26.237 (2.541)*	274.064 (10.679)*
interline_in	0.012 (0.017)	0.041 (0.072)	share	190.281 (5.742)*	28.762 (24.127)
dum_csconw_in	-4.689 (2.397)	-7.206 (10.072)	herf	253.403 (14.460)*	-142.404 (60.761)
dum_cscohp_in	6.560 (4.245)	30.067 (17.838)	strike	-18.933 (5.797)*	-20.746 (24.361)
traveltime_in	-0.149 (0.008)*	-0.689 (0.034)*	strike*online_in	0.302 (0.082)*	-0.335 (0.344)
flights	-1.068 (0.207)*	119.917 (0.869)*	strike*flights	3.174 (0.946)*	-30.938 (3.974)*
flight_online_in	-0.707 (0.279)	14.946 (1.171)*	1998 quarter 1	9.443 (1.315)*	-14.445 (5.524)*
flight_online_thru	0.120 (0.015)*	-0.749 (0.064)*	1998 quarter 3	-10.274 (1.251)*	13.604 (5.258)*
flight_csconw_thru	0.150 (0.023)*	-0.579 (0.095)*	1998 quarter 1	2.657 (1.243)	-12.857 (5.222)
flight_cscohp_thru	0.013 (0.042)	-0.390 (0.175)	1998 quarter 3	-14.454 (1.219)*	10.144 (5.122)
flight_interline_thru	0.069 (0.173)	-0.856 (0.726)	2000 quarter 1	8.025 (1.216)*	-4.179 (5.111)
dum_conw	-15.979 (8.817)	-135.865 (37.051)*	2000 quarter 3	-4.026 (1.217)*	15.537 (5.113)*
dum_conw_expost	23.551 (5.484)*	-59.025 (23.043)			
dum_csconw	-0.316 (8.580)	261.401 (36.055)*			
dum_csconw_thru	17.450 (5.497)*	91.194 (23.099)*	R^2	0.73	0.87

* indicates statistical significance at a 1% level.

Table 3.
Prediction Results.

	Airport-pairs where CO-NW never code-shared	Airport-pairs *in* which CO-NW code-shared	Airport-pairs *through* which CO-NW code-shared
	Post-agreement change (% of pairs with change>0)	*Post-agreement change (% of pairs with change>0)*	*Post-agreement change (% of pairs with change>0)*
CO-NW's mean prices	-1.1% (31.5%)	-3.2% (10.5%)	13.6% (94.0%)
CO-NW's passenger volume	-6.2% (36.5%)	12.3% (68.3%)	6.7% (61.6%)
Mean prices across all airlines in airport-pair	-0.5% (41.9%)	-2.8% (16.6%)	10.7% (89.8%)
Passenger volume across all airlines in airport-pair	5.4% (56.8%)	10.5% (73.0%)	10.3% (65.9%)

* Change = (post-agreement mean value – pre-agreement mean value)/pre-agreement mean value.

Table 4.
Estimation Results for The Alternative Model.

Regression for:	**ln(price)**	**ln(pass)**		**ln(price)**	**ln(pass)**
Variables	*Estimate (Standard error)*	*Estimate (Standard error)*	*Variables (continued)*	*Estimate (Standard error)*	*Estimate (Standard error)*
dum_nonstop	0.105 (0.003)*	2.234 (0.011)*	1998 quarter 1	0.015 (0.003)*	-0.064 (0.012)*
csconw_thru_share	0.106 (0.031)*	-0.612 (0.115)*	1998 quarter 3	-0.041 (0.003)*	0.050 (0.012)*
dum_csconw	0.056 (0.009)*	0.653 (0.032)*	2000 quarter 1	0.013 (0.003)*	-0.039 (0.012)*
dum_csconw_thru	0.056 (0.017)*	0.329 (0.065)*	2000 quarter 3	-0.025 (0.003)*	0.069 (0.011)*
1998 quarter 1	0.023 (0.003)*	-0.100 (0.012)*			
1998 quarter 3	-0.028 (0.003)*	0.030 (0.012)*	R^2	0.70	0.76

* indicates statistical significance at a 1% level.