Domestic Code Sharing, Alliances, and Airfares in the U.S. Airline Industry

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Abstract

This paper examines the impact of domestic code-sharing alliances on airfares. Our analysis yields two novel and somewhat surprising findings that have yet to be documented in the literature. First, unlike with international code sharing, we find that the overwhelming majority of domestic code-share itineraries involve a single operating carrier, a phenomenon that we refer to as virtual code sharing. Second, we find that these virtual code-sharing itineraries are priced lower than itineraries operated and marketed by a single carrier in the same market. We suggest that carriers may be using virtual code sharing—in large part—as a generic product to compete for the most price-sensitive passengers.

1. Introduction

The impact of cooperative marketing agreements—in particular alliances and code sharing—has been a dominant theme of international aviation over the past decade (Brueckner 2001, 2003; Brueckner and Whalen 2000; Park and Zhang 2000). Recently, the same trend has also taken hold in the U.S. domestic airline industry. Over the past few years, for example, virtually all of the largest U.S. hub-and-spoke carriers have entered into broad domestic code-sharing partnerships, including the United/US Airways alliance that began in January 2003 and, even more recently, the three-way alliance among Northwest, Continental, and Delta that was initiated in June 2003.[1] In light of this recent trend toward increased code sharing (the number of domestic code-share passengers grew over 13-fold between 1998 and 2003 to roughly 2 million domestic passengers) and the fact that carriers making up the three largest U.S. alliances (Continental/Northwest/Delta, United/US Airways, and American/Alaska) account for nearly

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[1] It is important to note that code sharing between mainline and regional carriers (American/American Eagle, Northwest/Mesaba, Delta/Comair, and so forth) has been an integral part of the U.S. airline industry for several decades.

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two-thirds of all domestic origin and destination (O&D) passenger traffic, there are legitimate policy concerns regarding the impact of these cooperative marketing agreements on fares and service levels (Transportation Research Board 1999; see also U.S. Senate 1999).

Simply stated, code sharing is an agreement between two carriers whereby one carrier (the operating carrier) allows another carrier (its code-share partner) to market and sell seats on some of the operating carrier's flights. For example, the code-share agreement between United and US Airways allows United to market and sell seats on thousands of flights operated by US Airways and vice versa. In international markets, the popularity of cooperative marketing agreements arises from the fact that they enable airlines to extend the scope of their networks by offering relatively seamless travel to destinations they otherwise would be unable to serve, owing to either cost or regulatory (that is, route authority) factors. For example, while no carrier currently carries passengers between Providence, Rhode Island, and Warsaw solely on its own network, numerous U.S. carriers and their international alliance partners such as Delta/Air France, American/British Airways, United/Lufthansa, and Northwest/KLM are able to offer passengers convenient, well-integrated, connecting service in this market. Consequently, numerous government and academic studies have concluded that cooperation among international carriers has resulted in lower fares and higher traffic in literally thousands of international aviation markets (Brueckner 2003; U.S. Department of Transportation 2000; Park and Zhang 2000; Brueckner and Whalen 2000).

While the effects of code sharing and alliances have been well studied in the context of international air travel (Brueckner 2003; Oum, Park, and Zhang 1996; Brueckner and Whalen 2000), code sharing and alliances among domestic carriers are a relatively new phenomenon and therefore have received only limited attention. Using data from 1994–96, Bamberger, Carlton, and Neumann (2004) found that average fares fell by 7.5 percent in markets where code sharing was introduced by Continental/America West (relative to non-code-share markets) and by 3.9 percent in markets where code sharing was introduced by Northwest/Alaska. Whalen (1999), however, predicted that there could be substantial losses in consumer welfare from the Northwest/Continental, American/US Air, and United/Delta alliances because the increase in online fares (mainly in hub-to-hub markets) more than offsets the impact of lower fares for the relatively small number of passengers who had previously purchased interline tickets on the alliance partners.[2] Using a discrete-choice model based on flight characteristics, Armantier and Richard (2005) also attempted to measure the change in consumer welfare associated with the Continental/Northwest alliance. Finally, Clougherty (2000) studied the welfare benefits of domestic alliances, taking into account their international effects.

[2] It should be noted that neither the American/US Air nor the United/Delta code-sharing alliances ever materialized.

This paper assesses the impact of domestic code sharing and alliances on airfares in the U.S. airline industry. Following Brueckner and Whalen (2000) and Brueckner (2003), we estimate cross-section and market fixed-effects fare equations using a broad set of city-pair markets. Although our methodological framework is quite similar to that found in the international code-sharing literature (Brueckner 2003; Brueckner and Whalen 2000), we find that domestic and international code-sharing practices differ significantly. In particular, while international code sharing typically combines the networks of two different operating carriers in order to create a convenient connecting itinerary—a practice we refer to as traditional code sharing—the overwhelming majority (85 percent) of domestic code-sharing itineraries involve a single operating carrier, a practice we refer to as virtual code sharing. For example, a typical traditional code-sharing itinerary might involve a connection between a Northwest flight and a Continental flight, where the entire ticket is marketed by Northwest, while a virtual code-share itinerary could consist of a connection between two United Airlines flights, where the entire ticket is marketed and sold by US Airways. Our analysis demonstrates that the distinction between traditional and virtual code sharing is critical to understanding the effects of domestic code sharing because the economic incentives—as well as the implications on airfares—behind these practices may differ substantially from those documented in international code-sharing literature. Our paper also differs from the existing domestic code-sharing literature (Bamberger, Carlton, and Neumann 2004) in that we focus on the price effects of virtual—rather than traditional—code-sharing practices.

Although our paper is the first of its kind to distinguish between traditional and virtual code sharing, the notion of virtual code sharing has not escaped the scrutiny of policy makers. For example, in its study of competition issues in the U.S. airline industry, the Transportation Research Board (1999, pp. 141–42) questioned the potential benefits of such arrangements: "Less plausible, however, are the consumer benefits from codesharing that major carriers have claimed for single-connect or nonstop markets in which one or both of the partners already operates through-service. The concern is that such arrangements will reduce competition in these markets, because it is likely that the partners have—or had—competing flights in the market, or that they had the potential to become rivals in the market. . . . These arrangements also might aim at increasing market shares by diverting traffic from competitors through the preferential listing of online itineraries in CRSs [computer reservation systems]." In light of concerns such as those cited above and to demonstrate why it is important to distinguish between traditional and virtual code sharing, we first estimate our models without pooling different types of code sharing and then reestimate the same models disaggregating generic code sharing into its traditional and virtual subcategories.

Consistent with the existing literature, we find that code-sharing itineraries are priced lower than their corresponding benchmarks. As expected, traditional code-share itineraries are roughly 11.6 percent less expensive than nonallied interline itineraries but 6.4 percent more expensive than pure online itineraries (those operated and marketed by a single carrier) in the same markets. Somewhat surprisingly, however, we find that virtual code-share itineraries are 5–6 percent less expensive than pure online itineraries. This latter finding is particularly interesting since the common explanations of code-sharing incentives (network expansion, reduction of the double-marginalization externality, and so forth) do not predict that code sharing should lower fares below those offered by a single carrier. In light of this surprising and somewhat counterintuitive empirical finding, we conclude that another factor is at work. In particular, we argue that for at least some travelers, virtual code-share itineraries are perceived as imperfect substitutes to otherwise identical, non-code-share itineraries operated by the same carrier since virtual tickets are typically not bundled with all of the same attributes—many of which are highly valued by some travelers—as non-code-share tickets. For example, most airlines do not permit passengers holding virtual code-share tickets to upgrade to first class and/or may offer fewer frequent-flyer miles on virtual tickets. Thus, while the pure online itineraries offered by a carrier can be thought of as that carrier's brand-name product (that is, one bundled with all of the benefits of the fully branded product), its code-share itineraries can be thought of as its less desirable generic product, which is used to attract more price-sensitive travelers. Thus, we conclude that domestic virtual code sharing represents—in large part—another means of product differentiation beyond those that are typically associated with the industry such as advance purchase restrictions.

The remainder of this paper is organized as follows. Section 2 presents some notation and definitions used throughout the paper. Section 3 discusses the economic incentives behind domestic code sharing and explores how the various incentives might be expected to impact airfares. Section 4 presents our data and empirical model. Estimation results are summarized in Section 5. Section 6 provides brief concluding remarks.

2. Definitions and Notation

2.1. Preliminary Definitions

In order to understand the effects of domestic code sharing, it is important to distinguish among three related but different concepts in airline marketing: code sharing, interlining, and alliances.

A flight itinerary or ticket consists of one or more flight coupons, each coupon typically representing travel on a particular flight segment between two airports.[3] While every flight segment has, by definition, a single operating carrier (the airline whose aircraft is used to operate the flight), it can have one or more marketing carriers (airlines that have the ability to list the flight as part of their flight schedule, set its fares, and, in turn, market seats on the flight to travelers).

[3] The one exception is on so-called direct flights, which involve an en route stop without a change of flight number.

Definition 1. A flight is said to be code shared when the operating and marketing carrier for that flight differs.

For example, Alaska Airlines operates nonstop flights between Seattle and Chicago O'Hare. However, the Seattle-Chicago flights operated by Alaska are listed in the CRSs and flight schedules of both Alaska Airlines and American Airlines. Thus, because seats on a flight between Seattle and Chicago operated by Alaska Airlines can be marketed and sold by American Airlines, the flight is said to be code shared.

From an institutional standpoint, all domestic code-sharing agreements use what is known in the industry as the free-sale model. Under a free-sale agreement, the operating carrier maintains and controls the seat inventory but allows its code-share partner(s) to market and sell seats on designated code-share flights under their own marketing code.[4] Hence, both the operating and code-share carriers sell seats out of the same general inventory, and the operating carrier receives all of the ticket revenue, regardless of which carrier actually sells the seat.[5] In return for selling a seat on a code-share flight, the operating carrier usually pays the marketing carrier a nominal commission to cover costs (for example, the cost to the marketing carrier of issuing its frequent-flyer miles). Since virtually all of the revenue from a code-share flight accrues to the operating carrier, code-share agreements are carefully negotiated so that they are balanced in the sense that partners exchange their operating and marketing roles across different routes so as to roughly equalize the benefits from the agreement.[6] Finally, federal regulations require the code-share carrier to indicate that the flight is actually being operated by a partner airline. In flight guides or computer reservation listings, this is commonly done by placing a symbol (an asterisk or a cross) next to the flight number.

A related but different concept in airline marketing is whether or not an
q1 itinerary is online or interline .

Definition 2. An itinerary is said to be online when the operating carrier for each flight coupon of the itinerary remains the same. In contrast, an itinerary is said to be interline when there are two or more operating carriers.

For example, a ticket that is operated by Delta Air Lines for both of its segments

[4] A carrier's marketing code is its two-letter designator in computer reservation systems, for example, AA for American, WN for Southwest, and UA for United.

[5] In practice, there may be technological differences between the seat inventories available to the operating and code-share carriers. For example, while the operating carrier will have real-time access to its seat inventory, the code-share partner's inventory may be delayed if the particular agreement calls for its inventory to be updated only periodically throughout the day.

[6] A less common type of institutional agreement is the so-called block-space agreement. Under this form of code-share arrangement, the operating carrier sells a block of its seats on a given flight to another carrier (the code-share partner), which then assumes the sole responsibility for marketing and selling the inventory of seats it has purchased, which it does under its own marketing code. Since the code-share carrier purchases the inventory from the operating carrier, it keeps all of the revenue associated with the code-share seats it sells.

is said to be online, while a ticket for which the first segment is operated by Delta and the second segment is operated by American would be considered interline. It is important to emphasize that a ticket's status as online versus interline depends only on that ticket's operating carrier(s). Thus, while a ticket may consist of flights with multiple marketing carriers as a result of a code-sharing agreement, it can still be online. Likewise, an interline ticket can have the same marketing carrier throughout as a result of a code-share agreement. Finally, note that all single-coupon itineraries are online by definition, since it is impossible for the operating carrier to change.

Carriers can form cooperative marketing alliances that may cover a wide array of joint activities, up to—but not necessarily including—code sharing. In general, a typical domestic alliance may include cost-reduction initiatives (sharing or consolidating airport facilities such as gates, lounges, and so forth), schedule and gate coordination to provide more convenient connections between flights of alliance partners, and frequent-flyer program and/or airport lounge reciprocity.[7] Unlike many international alliances, no domestic alliance currently has antitrust immunity that would allow it to jointly determine pricing on domestic code-share flights. Since alliance partners strive to provide passengers with an experience comparable (in terms of both convenience and other nonflight benefits) to that of a single carrier, alliance partners also benefit from expanded network scope. It is important to note, however, that alliances can differ significantly in their degree of integration. Thus, for the purposes of our analysis, we use the following definition:

Definition 3. Carriers are alliance partners if passengers on one of the alliance carriers can earn elite-qualifying frequent-flyer miles on flights marketed or operated by the other alliance partner(s) and vice versa.

Elite-qualifying miles are those frequent-flyer miles that passengers accrue toward a carrier's status tiers in their frequent-flyer programs, such as American's AAdvantage Gold/Platinum/Executive Platinum status or United's Premier/Premier Exec/Premier 1K status. Frequent fliers who achieve elite status on an airline are entitled to additional benefits such as automatic bonus miles for every flight, complimentary upgrades, preferred seat assignments, and priority boarding. During the period of our analysis, the alliances we consider are Northwest/Continental/Delta, United/US Airways, Northwest/Alaska, Continental/Alaska, American/Alaska, American/Hawaiian, Northwest/Hawaiian, and Continental/Hawaiian.[8]

[7] While most alliances currently do not allow passengers to pool miles from different programs for award redemption, they do allow passengers to choose which of the alliance partners' miles they will earn on any given alliance flight, regardless of either the operating or marketing carrier. Thus, a Continental OnePass member can earn OnePass miles on flights operated and marketed by either Delta or Northwest.

[8] Note that for the purposes of our analysis, United/Delta does not qualify as an alliance even though their joint marketing agreement was still in effect during the period of our data, since Delta SkyMiles members did not earn elite qualifying miles on United flights and vice versa.

Table 1

Current Domestic Alliances and Code-Share Agreements

Carriers	Combined Domestic Share (%)	Notes
Continental/Delta/Northwest	30.4	Three-way code sharing began in June 2003; excludes local hub markets
United/US Airways	17.6	Commenced January 2003
American/Alaska	16.2	Commenced 1999; code share on select flights to and from Los Angeles/Portland/ San Francisco/Seattle; excludes reciprocal lounge access
American/Hawaiian	13.9	Commenced March 1998; American code shares on Hawaiian Airlines services within Hawaii; Hawaiian code shares on American Eagle services at Los Angeles
Northwest/Alaska	11.4	Commenced August 1999; systemwide code sharing except select flights to and from Mexico and transcontinental flights; excludes reciprocal lounge access
Continental/Alaska	10.5	Commenced March 1999
Northwest/Hawaiian	9.2	Commenced 1995; code shares on intra-Hawaii flights and trans-Pacific flights; excludes reciprocal lounge access
Continental/Hawaiian	8.3	Commenced August 1999; code shares on interisland flights; excludes reciprocal lounge access

Note. Share is of domestic origin and destination passengers for the third quarter of 2003 based on the U.S. Department of Transportation OD1A database. Effective dates are from *Airline Business* (2003). Airline lounge reciprocity information is from carrier Web sites. The United/Delta alliance is excluded from our analysis since passengers were not eligible for elite-qualifying miles on partner flights.

q2 Table 1 summarizes the current domestic alliances and code-sharing agreements in the United States. As of the third quarter of 2003, the three-way alliance among Continental, Delta, and Northwest was the largest domestic alliance, accounting for slightly more than 30 percent of domestic O&D passengers. The next largest alliance was United/US Airways, accounting for 17.6 percent of domestic O&D passengers.[9]

2.2. A Taxonomy of Cooperation and Integration

In order to better understand how the concepts of code sharing, interlining, and alliances are related to one another, Figure 1 depicts the six types of itineraries that we will focus on for the remainder of our analysis. In the examples below, we use the conventional operating carrier code or marketing carrier code and denote a code-share carrier with an asterisk. Moreover, we denote a connection between two flights with an arrow. For example, AA/AA → AA/AA denotes a connecting itinerary between two flights in which both the operating and mar-

[9] Note that many airlines do not form exclusive partnerships. For example, both Alaska Airlines and Hawaiian Airlines have bilateral alliances with three different partners. This should come as no surprise, however, since both of these carriers' networks are fairly concentrated geographically.

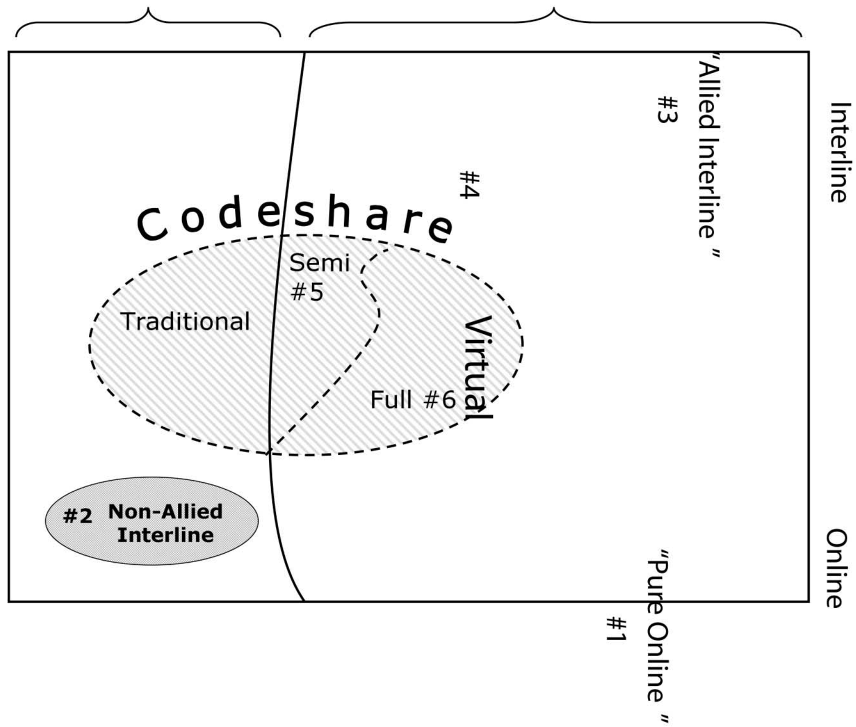

Figure 1. Taxonomy of airline cooperative agreements

keting carrier is American Airlines. Likewise, NW/CO* → CO/CO denotes a connecting itinerary where the first segment is operated by Northwest but is marketed by Continental as a code-share flight and the second segment is both operated and marketed by Continental. For clarity of explanation (and to match our empirical analysis that follows), we assume that all itineraries are made up of either one or two coupons per directional leg.[10]

We start by describing two benchmark cases for our analysis.

Case 1: Pure Online. We say that an itinerary is pure online if it is both online and has no code-share segments, for example, a two-segment ticket with both segments operated and marketed by Continental Airlines (CO/CO → CO/CO) or a single-coupon ticket operated and marketed by Southwest Airlines (WN/WN).

Case 2: Nonallied Interline. A nonallied interline itinerary is a connecting ticket between two carriers that are not part of an alliance, for example, con-

[10] It is important that neither the distribution of itineraries nor our empirical results change if we include three-coupon itineraries.

necting itineraries between Delta and American (DL/DL → AA/AA) or Alaska and United (AS/AS → UA/UA).[11] Cases 1 and 2 are the two extreme cases on the spectrum of integration and cooperation. While case 1 represents a fully integrated (and presumably most desirable from the point of view of the traveler) itinerary, case 2 is the least integrated, potentially most inconvenient, and the most costly type of itinerary to provide. Next we consider two commonly studied types of cooperative itineraries.

Case 3: Allied Interline. We say that an itinerary is allied interline if it consists of an interline transfer between two carriers that are alliance partners, for example, a two-segment ticket between United and US Airways, with each segment marketed by the operating carrier (US/US → UA/UA). Other examples would include NW/NW → DL/DL and AS/AS → AA/AA.

Case 4: Traditional Code Share. We define an itinerary as a traditional code-share itinerary when it (1) has two segments, (2) is interline, and (3) has one code-share segment, for example, a connecting itinerary between Continental and Northwest, marketed solely by Northwest (CO/NW* → NW/NW) or a connecting itinerary between United and US Airways, marketed solely by United (UA/UA → US/UA*).

It is important to note that traditional code sharing involves two distinct operating carriers. Finally, we consider two additional types of code sharing, which we refer to as the virtual code-sharing cases.

Case 5: Semivirtual Code Share. A semivirtual code-share itinerary is defined as a two-coupon itinerary that (1) has the same operating carrier throughout and (2) has one code-share segment, for example, a connecting itinerary operated solely by Northwest but marketed partly by Continental and partly by Northwest (NW/NW → NW/CO*).

Case 6: Fully Virtual Code Share. Finally, a fully virtual code-share itinerary is defined as an itinerary that (1) has the same marketing carrier throughout, (2) is online, and (3) shares codes on all of its segments. Thus, a fully virtual code-share itinerary has the potential to create an entirely new online competitor, for example, a connecting itinerary operated entirely by United but marketed solely by US Airways (UA/US* → UA/US*) or a nonstop itinerary operated by Alaska but marketed by American (AS/AA*).

The key distinction between traditional (case 4) and virtual (cases 5 and 6) code sharing is that in the virtual cases, the operating carrier remains the same across all coupons of the ticket. We refer to code-share itineraries of these types as virtual rather than traditional since pure online service is already being offered by one (and perhaps both) of the carriers in the market. Thus, code sharing of this type creates an additional virtual competitor in the market. Put differently, what makes virtual code-sharing arrangements unique is that the operating car-

[11] While it is possible that one or both of the segments in a nonallied interline ticket could also be code share (for example, NW/CO* → UA/US*), we abstract from this possibility, as these instances are exceedingly rare. We have also dropped such itineraries, of which there were eight, from our data set.

rier (and in 70 percent of the cases in our data, the marketing carrier as well) will always offer its own pure online service in the same market. Indeed, in some markets, seats on the same flights may be marketed as pure online (case 1, that is, NW/NW → NW/NW), semivirtual code share (case 5, that is, NW/NW → NW/CO*), and fully virtual code share (case 6, that is, NW/CO* → NW/CO*), potentially all at different prices.

At this point, it is worth pausing to understand how cases 1–6 fit into the existing literature on code sharing. Thus far, most of the existing literature on code sharing—both international and domestic—has considered only connecting itineraries involving two distinct operating carriers (Brueckner 2003; Brueckner and Whalen 2000; Bamberger, Carlton, and Neumann 2004). Thus, for all intents and purposes, the term "code sharing" used in the previous literature refers to our traditional code-share case, 4. Moreover, since prior to the proliferation of international alliances, the majority of international itineraries involved nonallied interline connections, the benchmark of comparison in the international literature (Brueckner 2003; Park and Zhang 2000; Brueckner and Whalen 2000) has been equivalent to our case 2.

Furthermore, unlike the previous literature, we include nonstop itineraries as part of our analysis because nearly 20 percent of code-sharing passengers in our data travel nonstop. By definition, the single-coupon code-share itineraries are included as part of our fully virtual code-share case, 6. Thus, while the literature has focused primarily on comparing type 4 itineraries (traditional code share) to type 2 itineraries (nonallied interline), we believe that some of the most interesting economic and policy questions surrounding cooperative marketing agreements in the domestic airline industry arise from the differences among the code-sharing variations (cases 4–6). And since nonallied interline itineraries (case 2) are exceedingly rare in the U.S. domestic market, our benchmarks are the set of pure online itineraries (case 1).

3. Economic Incentives for Domestic Code Sharing

In this section, we discuss alternative hypotheses about carriers' incentives to code share and explore their potential pricing implications.

The Impact of Double Marginalization. In the context of international aviation, interline itineraries are known to be more expensive than otherwise comparable online itineraries because of the double-marginalization problem. Double marginalization occurs because each carrier of an interline itinerary tries to maximize the profit from its own segment independently from the other carrier. Consequently, interlining carriers typically charge segment fares higher than a single decision maker who controls prices over the joint itinerary would. Thus, in international aviation, it is well understood that a code-share itinerary should result in a lower fare than an otherwise comparable interline itinerary, since cooperative pricing enables carriers to internalize part of the double-marginalization externality associated with joint pricing on interline tickets (Brueckner

2003; Brueckner and Whalen 2000).[12] Likewise, eliminating double marginalization raises the joint profits of the carriers, which provides inventive for code sharing. If the same logic applies to domestic itineraries, we would expect—in general—that both traditional (case 4) and fully virtual (case 6) code-share itineraries will also be priced less expensively than nonallied interline itineraries (case 2). However, the double-marginalization hypothesis does not predict code-share fares to be below those of pure online itineraries (case 1). Rather, it predicts that code-share fares will tend to fall between those of case 1 and case 2 (nonallied interline).

Crowding Out. Since code-share flights appear multiple times in CRSs, they can potentially crowd out itineraries of other carriers on the computer screens of travel agents or travelers trying to book tickets (Bamberger, Carlton, and Neumann 2004; Transportation Research Board 1999). This has led to a concern that code-share partners may generate an unfair advantage relative to non-code-sharing carriers, potentially resulting in less competition and higher fares. Likewise, if alliance partners chose to compete less vigorously than they otherwise would on overlapping markets but for the cooperative agreement, fares offered by code-share partners in these markets could increase (Whalen 1999; Transportation Research Board 1999).

Network and Frequency Expansion. Under traditional code sharing, the networks of two partner carriers are linked to provide highly coordinated service, often where one (and sometimes both) of the partner carriers does not offer online service of its own. Since the operating carrier receives all of the revenue from the segment(s) it operates (under free-sale agreements) and since passengers using traditional code-share tickets by definition travel on both partner carriers, carriers' incentives to engage in traditional code sharing are fairly straightforward.[13]

Virtual code sharing, on the other hand, entails a single operating carrier that allows its code-share partner to market and sell tickets using its own marketing code. For example, for the virtual itinerary UA/US* → UA/US*, US Airways markets the ticket, but the passenger flies entirely on flights operated by United. At first glance, the incentives to engage in virtual code sharing are not at all obvious. In the above itinerary, for example, US Airways receives none of the ticket revenue despite the fact that it sold the ticket, and United could simply

[12] As noted by Brueckner (2003), depending on the specific details of the revenue pro-rate agreement between code-share partners (that is, the formula used by carriers to divide ticket revenue) and absent antitrust immunity, it is unlikely that traditional code sharing could allow carriers to fully internalize the double-marginalization externality. This same argument applies to the traditional code-share itineraries in our domestic sample and is consistent with our empirical results.

[13] For example, on the traditional code-share ticket NW/NW → CO/NW*, Northwest receives the revenue from the first segment and Continental receives the revenue from the second segment. Despite the fact that Northwest markets the entire ticket, both carriers benefit from the code-share agreement since the passenger may not have flown on either carrier but for the ability of a single marketing carrier to set the price of the ticket, especially in markets where there is competition from other carriers offering pure online service.

sell the same ticket as UA/UA → UA/UA. Unlike traditional code sharing, therefore, virtual code-sharing incentives are more subtle.

In order to understand virtual code-sharing incentives, it is important to emphasize that while the virtual marketing partner does not realize any ticket revenue (other than a nominal commission) for the virtual code-sharing tickets it sells, it does benefit from expanded network scope and schedule frequency. For example, while US Airways does not operate nonstop service between Boston and San Francisco, it can sell nonstop service in this market to its Boston-based customers (where it has a substantial base of frequent flyers) via its code-share partnership with United. Customers of US Airways purchasing the nonstop UA/US* virtual ticket from Boston to San Francisco still receive elite-qualifying frequent-flyer mileage and other benefits, such as access to United's lounges. Thus, virtual code sharing enables US Airways to compete more effectively for local customers in Boston, many of whom will value the larger virtual network. And despite the fact that US Airways does not receive any revenue on the virtual tickets it sells, code-share agreements between major carriers are carefully negotiated so that they are balanced in the sense that the sets of markets where partners offer virtual code sharing on each other's networks are more or less equivalent. Thus, while US Airways benefits from expanded network scope from Boston to parts of the country where it does not offer service (or does so with less convenient schedules and routings) such as San Francisco or Los Angeles, United benefits from US Airways' network coverage from Boston to destinations in the eastern part of the country such as US Airways' shuttle routes to New York's LaGuardia Airport and Washington's National Airport.

Likewise, in many markets (indeed, 70 percent in our data set), the virtual carrier also offers its own pure online service. Consequently, virtual code sharing enables both alliance partners to augment their schedule frequency, which is also valued by most passengers. For example, while Alaska Airlines and American Airlines both offer nonstop flights between Seattle and Chicago, virtual code sharing on each other's flights enables both carriers to increase their nonstop flight frequency in the market, which in turn should allow the carriers to collectively capture a greater share of the Boston-Chicago traffic, where they compete with other carriers offering nonstop flights such as United and Southwest.

Service Quality and Product Differentiation. Thus, while the basic incentive for offering virtual code sharing (expanded network scope and frequency) appears to be consistent with that for traditional code sharing, the fare implications have the potential to be quite different. This is because there are small—but often significant—differences in the benefits offered to elite frequent flyers purchasing virtual code-share tickets. For example, while American's elite frequent flyers are able to upgrade to first class on flights operated and marketed by American, they are not eligible for upgrades when purchasing either virtual tickets operated by Alaska (AS/AA* → AS/AA*) or virtual tickets operated by American but marketed by Alaska (AA/AS* → AA/AS*).[14] Consequently, a virtual ticket operated by American but sold by Alaska (AA/AS* → AA/AS*) is likely to be perceived by some passengers—in particular, American's elite frequent flyers—as an imperfect substitute. We would expect therefore, that in markets where American offers both pure online service and virtual service, its virtual service will be sold at a discount to its pure online service.

Thus, it is possible that beyond expanding frequency and network scope, virtual code sharing can be used as a customer segmentation device by airlines. It is well known that airlines have long used various ticket restrictions (Saturday night stay requirements, refundability, change fees, and so on) to differentiate between business and leisure passengers. Virtual code sharing may provide yet another mechanism by which carriers can further differentiate between passengers who value all of the product characteristics that are bundled with the pure online product (that is, upgradeability) and those passengers who may not (nonelite passengers seeking the lowest possible fare). In some sense, the pure online service represents a carrier's brand-name premium product, whereas the virtual code-share service represents its generic product. In the absence of the virtual code-share product, a carrier may not want to offer prices that are sufficiently low to attract extremely low-willingness-to-pay customers, since some of its customers with higher willingness to pay (such as elite passengers hoping to upgrade) would also buy these tickets. However, by offering the virtual code-share product, a carrier is able to serve these low-willingness-to-pay consumers while its elite passengers will continue to choose the relatively more expensive—but upgradeable—pure online product.

To summarize, there appear to be at least four possible incentives for carriers to engage in code sharing: (1) to internalize the externality associated with double marginalization, (2) to increase the number of listings in the CRS (that is, crowding out), (3) to expand network scope and schedule frequency, and
q3 (4) to achieve product differentiation. While the network scope, frequency, and crowding-out hypotheses imply that code sharing should result in higher fares, the reduction of double marginalization and product differentiation hypotheses imply that code-share fares should be lower than otherwise similar, non-code-share fares. We now turn our attention to studying how these competing incentives interact in the data.

4. The Data and Model

Data for our analysis were drawn from the U.S. Department of Transportation's (DOT's) domestic origin and destination Databank 1B, a 10 percent sample of passengers traveling on U.S.-certified carriers. The period of time covered in our study is the third quarter of 2003. Each observation in the raw DOT data consists

[14] Likewise, while Northwest's elite frequent flyers are eligible to receive free upgrades on flights operated by Northwest, they do not qualify for upgrades on virtual tickets operated by Delta (that is, DL/NW* → DL/NW*).

of a unique airline itinerary, including the starting and ending airports of each flight coupon, the operating and marketing carrier for each flight coupon, the price paid, class of service, and (among other things) the number of passengers traveling on that particular itinerary. The raw DOT data set for the third quarter of 2003 consists of roughly 2.4 million observations representing over 55 million directional trips. In order to focus our analysis on common types of trips, we place the following restrictions on raw data. First, we restrict our analysis to passengers purchasing round-trip, coach class (both restricted and unrestricted) tickets in which the passenger started and ended at the same airport (that is, we exclude "open-jaw" tickets). Second, we limited our analysis to tickets with either one or two coupons per directional trip leg. Third, we excluded tickets with reported one-way fares less than $25 or greater than $1,500, since these might represent incorrectly coded nonrevenue tickets (for example, employee travel or frequent-flyer tickets) or first-class or business-class tickets. Fourth, we excluded itineraries where the marketing carrier of either segment was a non-U.S. carrier. Finally, we limited our analysis to directional city-pair markets generating, on average, at least one passenger per day.

Since the purpose of our analysis is to study the fare implications of code sharing between large carriers, we took care to ensure that we appropriately accounted for itineraries involving the regional code-sharing partners of the larger hub-and-spoke carriers. Since the marketing carrier code for a flight segment operated by a regional affiliate (that is, American Eagle [MQ]) will be that of its mainline partner (that is, American [AA]), we recoded the operating carrier code for each coupon operated by a code-sharing regional carrier with the code of its mainline partner. Although this is a rather tedious endeavor, failing to do so would substantially overcount the number of code-share itineraries, since a flight segment is defined as being code shared when its operating and marketing codes differ.

Our unit of observation is a directional, carrier-specific itinerary.[15] Since we are ultimately interested in studying the effect of code-share agreements on fares in city-pair markets, we group itineraries with originating and terminating airports in the same metropolitan area.[16] Likewise, since there are often numerous records for itineraries with different prices that are otherwise identical, we collapsed the data by itinerary, retaining the passenger-weighted average fare and total number of passengers for that itinerary. Our final data set includes 73,379 observations, representing slightly over 37.5 million passengers traveling on over 14,470 different city-pair markets.

[15] We consider passengers traveling between Boston and San Francisco to be in different markets than those traveling between San Francisco and Boston.

[16] For the purposes of our analysis, we group airports in the following metropolitan area: Washington, D.C. (BWI, DCA, IAD), San Francisco Bay area (SFO, SJC, OAK), Los Angeles (LAX, BUR, LGB, SNA, ONT), Houston (IAH, HOU), Dallas (DAL, DFW), Chicago (ORD, MDW), New York City (LGA, JFK, EWR, HPN), and Miami (MIA, FLL).

Table 2

Classification of Cooperative Agreements in Data Set

Case Number and Classification	Example	Observations Frequency	Observations Percent	Passengers Frequency	Passengers Percent
1. Pure online	AA/AA → AA/AA	58,901	80.27	36,973,270	98.43
2. Nonallied interline	AA/AA → CO/CO	3,369	4.59	54,530	.15
3. Allied interline	NW/NW → CO/CO	1,295	1.76	28,190	.08
4. Traditional code share	NW/NW → CO/NW*	1,865	2.54	77,850	.20
5. Semivirtual code share	DL/DL → DL/NW*	4,703	6.41	171,320	.46
6. Fully virtual code share	UA/US* → UA/US*	3,246	4.42	258,860	.69
Total		73,379	100.00	37,564,020	100.00

Note. Data are from the third quarter of 2003, U.S. Department of Transportation OD1B domestic database. Data include round-trip, coach-class tickets with less than three coupons per directional trip leg. Examples represent connecting itineraries between operating carrier and marketing carrier flight segments, with code-share segments denoted by an asterisk.

4.1. Code Sharing in Practice

This section presents some stylized facts regarding the various cooperative practices—as outlined in Section 2.2—seen in our data. Of the 73,379 itineraries in our sample, slightly more than 13 percent (accounting for .5 million passengers) involve at least one code-share segment. Table 2 summarizes our data
q4 according to the six types of itinerary groupings described in Section 2.2.

As expected, the overwhelming majority of passengers (over 98 percent) in our sample travel on pure online (case 1) itineraries. In contrast, and also as expected, only a small fraction of passengers (.15 percent) use nonallied interline itineraries. The fact that allied interline (case 3) itineraries are the least frequent type in our sample reflects the fact that code sharing among alliance partners has become the preferred type of cooperative marketing arrangement.

A key observation from Table 2 is that among code-sharing itineraries, virtual code sharing (cases 5 and 6) is five times more common than traditional code sharing (case 4). While virtual code sharing is also seen in some international markets (for example, Northwest and KLM sell seats on each other's flights between Boston and Amsterdam), the proclivity of such code sharing (either in domestic or international markets) has not yet been documented in the literature. Among the two types of virtual code sharing, fully virtual is more prevalent (in terms of passengers) than semivirtual.

4.2. The Models

Our empirical goal is to analyze fare differentials among the different categories of cooperative itineraries relative to the predominant type of domestic itinerary, that is, pure online itineraries. We denote itineraries with index i where an itinerary is defined as a unique combination of market and operating/marketing carriers (for example, CO/CO → NW/NW between Memphis and El Paso). We denote the market of an itinerary i with index j_i, or j for brevity.

Our dependent variable is the natural log of the passenger-weighted average fare on a given itinerary, denoted $\ln(\text{Fare})_i$. We regress these average fares on itinerary characteristics, including the code-share and alliance status, while controlling for market fixed effects. For comparative purposes, we also present results from a pooled cross-section regression in which we also include a vector of market characteristics (our baseline model). All regression estimations are analytically weighted according to the number of passengers traveling on each itinerary.

Baseline Model. In our baseline model, we regress $\ln(\text{Fare})_i$ on a vector of itinerary characteristics $\boldsymbol{X}_i$, a market characteristic vector $\boldsymbol{Z}_j$, and a vector of dummy variables $\boldsymbol{W}_i$ that represent the code-sharing and alliance status of each itinerary:

$$\ln(\text{Fare})_i = \alpha + \boldsymbol{X}_i'\beta + \boldsymbol{Z}_j'\gamma + \boldsymbol{W}_i'\boldsymbol{\delta} + \varepsilon_i. \quad (1)$$

The key parameters of interest are the vector $\boldsymbol{\delta}$, which indicates how code-share fares rank relative to other types of otherwise similar itineraries. We also show how traditional code-share fares differ from virtual code-share fares using these parameter estimates.

Market Fixed-Effects Model. Since unobserved market heterogeneity may influence the estimates in the baseline model, our primary interest is a model with market fixed effects. Using ϕ_j to control for market heterogeneity, we regress $\ln(\text{Fare})_i$ on the itinerary characteristics $\boldsymbol{X}_i$ and code-share status dummies $\boldsymbol{W}_i$:

$$\ln(\text{Fare})_i = \tilde{\alpha} + \boldsymbol{X}_i'\tilde{\beta} + \boldsymbol{W}_i'\tilde{\boldsymbol{\delta}} + \phi_j + \tilde{\varepsilon}_i. \quad (2)$$

The advantage of the fixed-effects model is that $\tilde{\boldsymbol{\delta}}$ estimates represent purely within-market variations, independent of market heterogeneity. Controlling for market heterogeneity is important for two reasons. First, code-sharing decisions may raise some market selection issues (Brueckner 2003). For example, if alliances choose to code share in markets where they face relatively greater competition, the code-share variables are likely to pick up this market selection bias. Second, the presence of code-share itineraries may influence the prices of other itineraries in the same markets, contributing further to market heterogeneity. Since we would like to separate those factors from our estimates as much as possible, our analysis focuses on the fixed-effect estimates.[17]

4.3. Independent Variables

q5 Descriptions of our independent variables are detailed below. Itinerary-specific variables are indexed by *i*, and market-specific variables are indexed by *j*. We

[17] Since code sharing takes place in only 36.46 percent of all the markets in our sample, the fare differential calculated in the fixed-effects model between the code-share and non-code-share itineraries is essentially based on that subsample of markets. Consequently, to compare how code-share fares compare to itineraries outside the subsample, we also need to use the baseline model.

start by describing the itinerary-specific variables included in the market fixed-effects regression.

Itinerary-Specific Variables. Even within the same market, itineraries can differ in their routing choice and carrier. For example, for the same origin and destination, some itineraries represent nonstop service, while others are connecting. Thus, we include a dummy variable D(Nonstop) that takes the value one if itinerary i consists of a single coupon (that is, nonstop or direct itineraries) and takes the value zero otherwise. We also include Distdif_{ij}, which is computed as itinerary i's actual distance divided by the nonstop distance of market j. While longer itineraries are more expensive to operate (all things equal), travelers are likely to prefer shorter itineraries. Consequently, the sign on Distdif_{ij} is ambiguous a priori.

The variable Orgshare_{ij} measures carrier i's share of O&D passengers at the origin of market j. We also include two dummy variables to identify itineraries operated by low-cost carriers (LCCs). The term $D(\text{LCConline})_i$ is a dummy variable that takes the value one if itinerary i is a pure online LCC itinerary and zero otherwise. Similarly, $D(\text{LCCinterline})_i$ is a dummy variable that takes the value one if itinerary i in an interline itinerary involving an LCC and zero otherwise.[18]

Carrier-Specific Effects. Following Brueckner and Whalen (2000) and Brueckner (2003), we measure airline-specific cost effects by creating carrier variables generated by interacting airline dummies with the distance flown.[19] While we control for these carrier-specific effects in both models, we suppress the estimates in our tables for brevity.

Cooperation Variables. The existing literature on cooperative airline agreements (both international and domestic) typically distinguishes between code-share and non-code-share itineraries, alliance and nonalliance itineraries, and online and interline itineraries. Thus, our first set of regressions follows this tradition by including three dummy variables representing an itinerary's code-share, alliance, and online status. The variable $D(\text{Online})_i$ is a dummy that takes
q6 the value one if itinerary i is online and takes the value one if the itinerary includes an interline connection (that is, change in operating carrier). The term $D(\text{Codeshare})_i$ is a dummy variable that takes the value one if, for any coupon
q7 on itinerary i, the operating and marketing carriers differ and zero otherwise. Finally, Ally_i is a dummy variable that takes the value one if itinerary i involves two allied carriers (based on our set of alliances from Table 1) and zero otherwise.

Our main empirical goal is to determine the effect of various cooperative

[18] The low-cost carriers (LCCs) we include in these variables as well as LCCshare are Southwest, JetBlue, Frontier, AirTran, ATA, America West, Spirit, and Sun Country. Moreover, when constructing our share variables such as Orgshare, we included first- and business-class passengers as well as those purchasing one-way tickets and tickets with more than two coupons per directional leg.

[19] For example, if the two operating carriers on an itinerary are Northwest and Continental, Northwest's variable equals the natural log of the distance flown on the Northwest-operated segment and Continental's variable is equal to the natural log of the distance flown on the Continental-operated segment; the carrier variables for all other carriers would equal zero.

Table 3

Our Six Itinerary Classifications and Traditional Code-Sharing Treatments

Case Number and Classification	Online_i	Ally_i	Codeshare_i
1. Pure online	1	0	0
2. Nonallied interline	0	0	0
3. Allied interline	0	1	0
4. Traditional code share	0	1	1
5. Semivirtual code share	1	1	1
6. Fully virtual code share	1	1	1

Note. Semivirtual code share (case 5) and fully virtual code share (case 6) are differentiated by the fact that all segments on a fully virtual code-share ticket are code shared.

arrangements on domestic airfares. These cooperative variables, represented by the vector $\boldsymbol{W}_i$ in our model, measure the code-sharing and alliance status of each itinerary.

In our second set of regressions, we fully disaggregate our sample into each of our six, mutually exclusive cases, using pure online itineraries (case 1) as the base case. Thus, coefficients on the dummies representing all other cases measure the fare differentials from the base case.

Table 3 summarizes how our 6 degrees of integration and cooperation outlined
q8 in Section 2.2 are related to the traditional treatment of Online, Codeshare, and Ally. The reader should be aware that in our data, code sharing need not imply an online itinerary and vice versa. Likewise, while Codeshare implies Ally, the reverse relationship does not necessarily hold. Finally, there is one additional combination not covered by the six cases enumerated above: $\text{Online}_i = 0$, $\text{Ally}_i = 0$, $\text{Codeshare}_i = 1$, for example, the itinerary NW/CO* → UA/US*. In our data set, there were eight such observations, which were dropped.

q9 *Market-Specific Variables.* In the baseline model, we include market-specific variables to control for market heterogeneity. The term Dist_j is the natural logarithm of the nonstop distance for market j. The term Poporig_j and Popdest_j are the populations at the origin and destination cities of market j, respectively, in natural logarithm. Large cities often generate proportionally more business travelers and thus may tend to have higher average fares. Likewise, since markets
q10 with a high proportion of vacation travelers tend to have lower average fares, we follow Morrison (2001) by including Sunbelt dest_j, a dummy variable that takes the value one if the destination of market j is in one of the following states or territories: California, Nevada, Arizona, New Mexico, Texas, Louisiana, Mississippi, Alabama, Florida, Hawaii, Puerto Rico, and the U.S. Virgin Islands.

We also include three variables that measure the overall competitiveness of markets. First, we include mkthhi_j, the Herfindahl index for market j based on O&D passengers. We also include LCCshare_j, the collective share of LCCs in market j. Finally, we include No. of itineraries_j, the number of different pure online itineraries in the markets j.

Table 4

Variable Descriptions

Variable	Definition
ln (Fare)$_i$	Natural log of average fare for itinerary j
Orgshare$_i$	O&D passenger share of the carrier at the originating airport
No. of itineraries$_j$	Number of pure online itineraries available at market i
ln (Poporig)$_j$	Natural log of the population at the originating city
ln (Popdest)$_j$	Natural log of the population at the destination city
D(Sunbelt)$_j$	Dummy for the sunbelt destination
mkthhi$_j$	Herfindahl-Hirschman index in the market
LCCshare$_j$	Collective share of O&D passengers held by LCCs in the market
ln (Dist)$_j$	Natural log of direct distance
Distdif$_i$	Itinerary's travel distance divided by the direct distance
D(Nonstop)$_i$	Dummy for nonstop itineraries
D(LCConline)$_i$	Dummy for LCC carriers' pure online itineraries
D(LCCinterline)$_i$	Dummy for LCC carriers' interline itineraries
D(Codeshare)$_i$	Dummy for code-sharing itineraries
D(Traditional CS)$_i$	Dummy for traditional code-sharing itineraries (case 4)
D(Virtual CS)$_i$	Dummy for virtual code-sharing itineraries (case 5 and 6)
D(Allied)$_i$	Dummy for itineraries between allied carriers
D(Online)$_i$	Dummy for online itineraries
D(Case 1)$_i$	Pure online
D(Case 2)$_i$	Nonallied interline
D(Case 3)$_i$	Allied interline
D(Case 4)$_i$	Traditional code sharing
D(Case 5)$_i$	Semivirtual code sharing
D(Case 6)$_i$	Fully virtual code sharing

Note. O&D = origin and destination; LCC = low-cost carrier.

Variable definitions are summarized in Table 4. Summary statistics (both raw and passenger weighted) for our independent variables are presented in Table 5.

5. Estimation Results

Estimation results from our fixed-effects model are summarized in Table 6, and results from our baseline model are summarized in Table 7. In both tables, columns 1 and 2 differ in their treatment of the cooperation and integration variables. We focus our analysis on the fixed-effects results in Table 6 because they better control for the effects of market heterogeneity.

5.1. Fixed-Effects Results

Column 1 in Table 6 replicates the conventional treatment of code sharing and alliances on domestic itineraries by including three dummy variables *D*(Allied), *D*(Online), and *D*(Codeshare). Our *D*(Codeshare) variable aggregates the traditional case (4) and virtual code-sharing cases (5 and 6) into one group. The results show that code-share itineraries—defined generically—are 3.2 percent less expensive than otherwise similar non-code-share itineraries in the same market. Although the magnitude is relatively small and not statistically significant, the coefficient sign is consistent with the literature. Likewise, online itineraries

Table 5

Summary Statistics

Variable	Raw Data	Passenger-Weighted Data
ln (Fare)$_i$	5.174 (.399)	4.988 (.397)
Orgshare$_i$	.178 (.183)	.250 (.197)
No. of itineraries$_j$	7.243 (4.690)	10.610 (5.943)
ln (Poporig)$_j$	14.187 (1.226)	15.008 (1.193)
ln (Popdest)$_j$	14.075 (1.333)	14.756 (1.338)
D(Sunbelt)$_j$	.343 (.475)	.476 (.499)
mkthhi$_j$	.427 (.193)	.431 (.199)
LCCshare$_j$	.160 (.226)	.335 (.292)
ln (Dist)$_i$	7.082 (.585)	6.807 (.722)
Distdif$_i$	1.198 (.264)	1.048 (.126)
D(Nonstop)$_i$	.119 (.324)	.665 (.472)
D(LCConline)$_i$	.112 (.316)	.312 (.463)
D(LCCinterline)$_i$	.012 (.109)	.000 (.020)
D(Allied)$_i$	.151 (.358)	.014 (.119)
D(Online)$_i$	.911 (.285)	.996 (.065)
D(Codeshare)$_i$	.134 (.340)	.014 (.116)
D(Case 1)$_i$	.803 (.398)	.984 (.124)
D(Case 2)$_i$	.046 (.209)	.001 (.038)
D(Case 3)$_i$	.018 (.132)	.001 (.027)
D(Case 4)$_i$	.025 (.157)	.002 (.045)
D(Case 5)$_i$	.064 (.245)	.005 (.067)
D(Case 6)$_i$	.044 (.206)	.007 (.083)
N	73,379	37,564,020

Note. Data are mean (SD).

are 14.1 percent less expensive than otherwise similar interline itineraries in the same markets, whereas alliance itineraries are 2.4 percent lower than otherwise similar itineraries.

The fairly large (14.1 percent) gap between online and interline fares is consistent with the presence of double marginalization for interline itineraries, a result widely discussed in the literature. The relatively small price impacts of alliances and code sharing are, at first glance, somewhat surprising because these cooperative marketing agreements are intended to reduce fares by alleviating some of the double-marginalization externality. However, we suspect that the aggregation of traditional and virtual code sharing may be masking a number of competing effects that are taking place at the same time.

To investigate further, column 2 in Table 6 disaggregates our sample by employing the six classifications outlined in Section 2.2. Using pure online itineraries (case 1) as our base case, column 2 includes five different dummy variables for the remaining cases. As expected, the most expensive itinerary type is nonallied interline (case 2), which is 18.0 percent more expensive than the pure online itinerary, a result of double marginalization. Allied interline (case 3) and traditional code-share (case 4) itineraries fall between pure online (case 1) and nonallied interline itineraries. In particular, allied interline itineraries are 11.6 percent more expensive than pure online itineraries, while traditional code-share

Table 6

Model with Market Fixed Effects

	(1)	(2)
Itinerary-specific variables:		
Orgshare$_i$	.304** (.013)	.304** (.013)
Distdif$_i$	−.032** (.011)	−.033** (.011)
D(Nonstop)$_i$	−.128** (.029)	−.128** (.029)
D(LCConline)$_i$	−.295** (.064)	−.295** (.064)
D(LCCinterline)$_i$	−.165** (.033)	−.204** (.034)
Cooperation and integration variables ($\boldsymbol{W}_i$):		
D(Codeshare)$_i$	−.032 (.021)	
D(Allied)$_i$	−.024 (.021)	
D(Online)$_i$	−.141** (.011)	
D(Case 1)$_i$		Base case
D(Case 2)$_i$		.180**
D(Case 3)$_i$		.116**
D(Case 4)$_i$		.064**
D(Case 5)$_i$		−.046**
D(Case 6)$_i$		−.056**

Note. The dependent variable is ln (Fare)$_i$. Standard errors are in parentheses. Carrier-specific effects are controlled for, but estimates have been suppressed. $N = 73{,}379$; $R^2 = .910$.

** Significant at the 1% level.

itineraries are 6.4 percent more expensive than otherwise similar pure online itineraries in the same market.

The results of the first three categories relative to those of the pure online case are consistent with the double-marginalization story argued by Brueckner (2003). Alliance and traditional code-share itineraries both lower fares relative to the nonallied interline level. As expected, code sharing is more effective at reducing the double-marginalization externality than alliances absent code sharing since the code-share fare is set by a single carrier. Both cooperative arrangements, however, still result in fares that are above pure online fares, the benchmark that perfect cooperation or integration would have achieved.

While traditional code sharing is more expensive than the pure online base case, both types of virtual code sharing are less expensive than pure online itineraries. While semivirtual code sharing (case 5) is 4.6 percent less expensive than the pure online itinerary, fully virtual code sharing (case 6) is 5.6 percent less expensive.[20] This result, which has not yet been documented in the literature, is both novel and quite surprising.[21] Although the double-marginalization hypothesis implies that code-share fares could approach pure online fares, it does

[20] We also estimated the same models with nonstop itineraries excluded from the data. Relative rankings and fare differentials remain the same.

[21] We have tested whether the coefficients on cases 5 and 6 are significantly different. The result rejects the null hypothesis that these coefficients are the same at 1 percent significance. We revisit the difference between these two cases later in our discussion.

Table 7

Baseline Model without Market Fixed Effects

	(1)	(2)
Itinerary-specific variables:		
Orgshare$_i$	.151** (.005)	.150** (.005)
Distdif$_i$	.065** (.009)	.065** (.009)
D(nonstop)$_i$	−.126** (.018)	−.127** (.018)
D(LCConline)$_i$	−.517** (.019)	−.517** (.019)
D(LCCinterline)$_i$	−.274** (.045)	−.325** (.049)
Market-specific variables:		
No. of itineraries$_j$	−.006** (.000)	−.006** (.000)
ln (Poporig)$_j$	.025** (.001)	.025** (.001)
ln (Popdest)$_j$	.006** (.001)	.006** (.001)
D(Sunbelt)$_j$	−.069** (.002)	−.069** (.002)
mkthhi$_j$	.262** (.006)	.262** (.006)
LCCshare$_j$	−.472** (.004)	−.472** (.004)
ln (Dist)$_i$	.334** (.005)	.334** (.005)
Cooperation and integration variables ($\boldsymbol{W}_i$):		
D(Allied)$_i$	−.023 (.034)	
D(Online)$_i$	−.210** (.016)	
D(Codeshare)$_i$	−.068* (.034)	
D(Case 1)$_i$		Base case
D(Case 2)$_i$		.260** (.026)
D(Case 3)$_i$		.187** (.031)
D(Case 4)$_i$		.094** (.019)
D(Case 5)$_i$		−.054** (.013)
D(Case 6)$_i$		−.109**

Note. The dependent variable is ln (Fare)$_i$. Standard errors are in parentheses. Carrier-specific effects are controlled for, but estimates have been suppressed. $N = 73{,}379$; $R^2 = .680$.

* Significant at the 5% level.

** Significant at the 1% level.

not predict code-share fares to be lower than pure online fares. Thus, this outcome necessitates an alternative explanation.

Of the remaining hypotheses discussed earlier, we believe that the most compelling explanation as to why virtual code-share fares are lower than pure online fares is product differentiation. Recall the example of the ticket AA/AS* → AA/AS* discussed in Section 3. For an American Airlines' elite frequent flyer, this is an imperfect substitute for American's pure online itinerary (that is, AA/AA → AA/AA) since the virtual ticket does not allow the traveler to upgrade to first class, even though the flights on the two itineraries are the same. Since frequent flyers do not typically enjoy all of the same benefits when purchasing virtual tickets, we should expect virtual tickets—on average—to be priced lower, reflecting the vertically differentiated nature of these products.[22]

[22] Likewise, the semivirtual ticket, AA/AA → AA/AS* (case 5), is slightly more desirable than the fully virtual ticket, AA/AS* → AA/AS* (case 6), to an American frequent flyer since the traveler would be able to enjoy his or her full elite privileges (that is, upgrade) on the first segment of the trip marketed (and operated) by American. In both our fixed-effects and baseline models, case 6 fares are lower (and statistically different) than case 5 fares. Thus, the results support our hypothesis on the difference between semivirtual and fully virtual code sharing.

It is well known that airlines use a wide variety of ticket restrictions to segment passengers based on their willingness to pay. However, the widespread proliferation of LCCs in recent years has forced many carriers to relax certain restrictions; consequently, the restrictions have become somewhat less effective.[23] The effectiveness of differential pricing is limited by a carrier's ability to separate consumers by their different willingnesses to pay. Our results suggest that virtual code sharing may help carriers segment customers even further than they could otherwise do using only their pure online service. In particular, virtual code sharing appears to be a tool that carriers can use to further differentiate between customers seeking the branded product from those who are willing to purchase the nonbranded virtual product in exchange for a lower fare.[24]

In contrast, both CRS crowding out as well as increased network and frequency expansion should—all other things equal—lead to a higher share of passengers at key airports for the alliance carriers, which in turn should lead to higher fares on flights to and from those airports (Evans and Kessides 1993; Lee and Luengo-Prado 2005). This, however, is the opposite of what we find.

Turning our attention to the other independent variables in Table 6, we find that most coefficients have the expected sign and are significant at the 1 percent level. The carrier's share of local passengers at the origin has a large positive effect on fares, a result commonly found in the literature (Evans and Kessides 1993). For example, a 1 percent increase in the carrier's market share at the origin raises fares by .304 percent. For a given a market, longer itineraries—relative to the nonstop distance—tend to have lower fares, which reflects travelers' preferences for shorter (and often more convenient) itineraries within the same market. However, nonstop itineraries are 12.8 percent less expensive than otherwise similar connecting itineraries, which is possibly a reflection of the lower operating costs, all things equal, that are associated with providing nonstop service. As expected, itineraries provided by LCCs are much less expensive than the otherwise similar itineraries. Also as expected, the impact of LCCs is stronger for online than for interline itineraries.[25]

Finally, we stress that our results control for carrier-specific effects by including the interaction variables between carrier dummies and the distances they fly in each itinerary (these coefficients are have been suppressed in Tables 6 and 7). Thus, even if code-sharing carriers consistently price differently than other carriers, those effects are already controlled for in our estimated coefficients.

[23] For example, in markets where full-service hub-and-spoke carriers compete head-to-head with an LLC, Saturday night stay requirements are often not required to qualify for the lowest fare.

[24] Moreover, we found that the average share of LCCs in markets where fully virtual code sharing was offered was roughly 24.4 percent, compared with 12.6 percent in markets where only traditional code sharing was offered. This tends to reinforce the notion that carriers use virtual code sharing as a means to segment passengers with extremely low willingness to pay.

[25] We refrain from interpreting the coefficients on *D*(LCConline) and *D*(LLCinterline) . Since our regressions control for carrier-specific effects by interacting carrier dummies and coupon distance (their coefficients are also suppressed in the table), these coefficients are the intercept differences at zero distance, which is devoid of meaningful interpretation.

5.2. Baseline Model Results

Table 7 presents the results of our baseline model where market heterogeneity is controlled for using a set of independent variables without market fixed effects. Most itinerary-specific variables have the same signs as in Table 6. As expected, the coefficients' magnitudes are different, as they are influenced by unobserved market heterogeneity.

The signs and relative ranking of all the cooperation and integration categories remain the same as those in Table 6. However, the magnitudes of coefficients are often larger because of unobserved market heterogeneity. For example, in column 1, the estimated coefficient for $D(\text{Online})_i$ shows a 21 percent gap between online and interline itineraries (compared with a 14 percent gap in the fixed-effects model). Both alliances and code sharing appear to reduce fares. In column 2, nonallied interline itineraries (case 2) are 26 percent more expensive than pure online itineraries (case 1), and, as before, the allied interline (case 3) and traditional code-share (case 4) cases lie between these two benchmark cases.

The relative rankings of virtual code-share cases remain the same. Semivirtual and fully virtual code-share itineraries are 5.4 percent and 10 percent less expensive, respectively, than pure online itineraries. And while the presence of market heterogeneity prevents us from interpreting these numbers solely as the impact of code sharing, it is nevertheless interesting to note that code-share itineraries, when compared with pure online itineraries with similar characteristics across markets, have much lower fares than when we compare them solely within the same markets.

The coefficients on market-specific variables are statistically significant at 1 percent and have the expected signs. More pure online itineraries in a market result in lower fares in that market owing to added effective competition. Higher population, both at the origin and destination, increases fares, as large metropolitan areas tend to generate proportionally more business travelers. In contrast, the higher the proportion of leisure travelers, as indicated by $D(\text{Sunbelt})_j$, the lower the fares. Higher market concentration, measured by the Herfindahl index of O&D passengers, increases fares, while—unsurprisingly—higher market shares by LCCs result in lowers fares. Finally, longer markets have higher fares because q11 of their higher costs, all other things equal.

6. Conclusions

This paper investigates the price implications of alliances and code sharing in the U.S. domestic airline industry. While our results are fully consistent with the existing literature on international code sharing (Brueckner 2003; Brueckner and Whalen 2000), we find that internalization of the double-marginalization externality plays only a limited role in shaping today's domestic airfares. This is because the overwhelming majority of passengers traveling in domestic markets already use online service.

We find that only 15 percent of code-share tickets in our sample link the networks of two carriers (a practice we refer to as traditional code sharing). Instead, roughly 85 percent of domestic code sharing is virtual in nature, whereby a carrier markets tickets entirely on flights operated by another carrier. From a policy standpoint, this distinction is very important since in these virtual code-share markets, at least one (and often both) of the partner carriers already offers pure online service.

Surprisingly, our fixed-effects results find that virtual code-sharing itineraries are 5–6 percent less expensive than single-carrier online service in the same markets. We believe that increased product differentiation may—in large part—be driving this somewhat surprising result. Under this hypothesis, a carrier uses virtual code sharing as a generic or qualitatively inferior product to further segment its customers between those who are willing to purchase the branded premium product (that is, pure online) and those who are not.

Despite what is an admittedly focused analysis of one particular aspect of domestic airline pricing, we believe that the findings documented in this paper are part of a growing and important trend for travelers. Indeed, the same trend of alliances that dominated international aviation throughout the 1990s and during the early part of this decade appear to be spilling over into the domestic arena.[26] Consequently, the number of passengers traveling on domestic code-share itineraries—which had already reached roughly 2 million passengers in 2003—is likely to continue growing rapidly.[27]

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[26] Indeed, in 2005, even Southwest Airlines and ATA—two LCCs—formed a domestic code-share agreement.

[27] Finally, while the current number of passengers traveling on virtual code-share tickets is small relative to all passengers, a recent related panel data analysis conducted by the authors (Ito and Lee 2006) suggests that the presence of virtual code-share tickets also appears to have a negative, albeit small, effect on the prices of other carriers serving the market.

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