A Panel Data Analysis of Code Sharing, Antitrust Immunity and Open Skies Treaties in International Aviation Markets

by

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Abstract

This paper estimates the effects of code sharing, antitrust immunity and Open Skies treaties on prices, output and capacity using an eleven-year panel of U.S.-Europe data. Code sharing and immunized alliances are found to have significantly lower prices than traditional interline (multi-carrier) service, but the effects are smaller in magnitude than previous results that rely on cross sectional data. Statistical tests that prices for immunized alliance service are equal to online (single carrier) service often cannot be rejected, providing additional evidence that immunity grants allow immunized carriers to internalize a double marginalization problem. Estimated output effects, consistent with the price effects, show that alliances are associated with large increases in passenger volumes. Lastly, the relationship between immunity grants and Open Skies treaties is explored. Estimates suggest that capacity expansions associated with Open Skies are due entirely to expansion by immunized carriers on routes between their hubs. The results are robust to attempts to control for potential bias from changes in the mix of business and leisure passengers.

Keywords: Airline Alliances, Antitrust Immunity, Code Sharing, Open Skies Treaties

JEL Codes: L11, L24, L40, L93

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I. Introduction

In reaction to significant increases in demand for international air travel over the last decade, U.S. airlines have forged strategic alliances with their overseas counterparts to extend the reach of their hub-and-spoke networks. Because of scope and scale economies and the thinness of international routes, carriers generally only provide nonstop service on overseas routes between their hubs and the largest international cities.[2] Thus, service to any destination beyond these large hub cities requires that the carrier put passengers on foreign carriers for part of their itineraries. With an alliance, multiple carrier or "interline" service mimics single carrier or "online" service, and the alliance partners claim consumers can reap all of the scope and scale benefits associated with online service. Those benefits include integrated frequent flier programs, coordinated schedules to reduce layovers, increased frequencies and the ability to check luggage through to the final destination.[3]

These alliances can take many different forms depending on the degree of integration between the carriers, but there are two prevalent types: code sharing alliances and antitrust immunized alliances. Code sharing allows the partners to put their carrier designator code on each other's flights, which facilitates marketing tickets where at least a portion of the flight is operated by the partner. The most common form of code sharing allows a carrier relatively open access his partner's capacity at a fixed price per passenger (conditional on ticket restrictions) that is

2 Even with liberalized aviation treaties, so called Open Skies, prohibitions on cabotage would prevent the foreign carrier from operating a segment within another country and insufficient demand will prevent a carrier from operating nonstop service from his home country to many moderate or small sized international cities.
3 While the networks of carriers in an international alliance are generally complementary, there are usually several, often densely traveled, routes where the carriers provide substitute service. Competition on these routes could be reduced by alliances, particular ones immunized from the antitrust laws. The focus of this paper is on effects on the complementary routes. Any welfare analysis would need to evaluate the potential harms as well.

negotiated in advance (called a "prorate"). Thus, when a carrier sells a ticket where part of the itinerary is on a foreign carrier, it pays the prorate to that carrier. Code sharing alliances are sometimes associated with other cooperative behavior as well. For example, the carriers are likely to coordinate their flight schedules to facilitate connections (much like a single carrier schedules banks at its hubs to minimize layover times).

In the absence of a code sharing agreement, when a passenger must be put on a foreign carrier to reach his final destination, the prorate paid to the foreign carrier is determined at International Air Transport Association (IATA) tariff conferences and subject to approval of the respective governments. At the tariff conferences, which are immunized from antitrust laws, carriers collectively set interline fares for thousands of markets. Carriers are not required to charge the conference price but are required to pay the other carriers a prorate as if the conference price was charged.[4] For a more detailed description of IATA and its rate making role see O'Connor (2000).

Because international treaties limit foreign ownership in airlines and prevent mergers, the most integrated relationships possible occur when two carriers are granted antitrust immunity from the relevant government agencies. With immunity, carriers can integrate their scheduling, pricing and yield management systems and share revenues from the alliance. In the U.S., the Department of Transportation (DOT) has the authority to grant antitrust immunity and has done so frequently, often in conjunction with more liberalized aviation bilateral agreements ("Open Skies" treaties). These treaties replaced more restrictive bilaterals and allowed carriers to set schedules, capacity and prices free of government regulation. Although termed Open Skies, these treaties do not allow

4 In practice, some evidence suggests that carriers do not deviate from the conference price very often when they do not have an alliance. See DG Competition Consultation Paper (2001).

entry by a foreign carrier into the domestic market (cabotage) nor do they lift the cross ownership restrictions that prevent mergers between carriers from different countries. Immunity grants, though, allow carriers to behave as if they were merged and thus, allows them to jointly price routes and share revenue.

Brueckner (2001) and Brueckner and Whalen (2000) (hereafter B&W) argue that pricing without an alliance is similar to carriers independently choosing “subfares” for their respective portion of the itinerary, taking as given the subfare charged by the other carrier. If the carriers have market power over their portions of the itinerary, this non-cooperative pricing generates a double marginalization problem because neither carrier considers what effect setting a high subfare has on the revenue of the other carrier. In other words, a carrier sets the subfares that all other carriers pay for booking a passenger on his flights at too high a level. Joint profits would rise and prices would fall if the carriers would lower their subfares. The efficient outcome would have one carrier charge marginal cost for its portion of the itinerary to lower the overall price and stimulate additional demand, but without some mechanism for compensating the carrier who charges marginal cost, it has no incentive to do so.

Moreover, B&W and Brueckner argue that when these carriers have an alliance (not differentiating between code sharing and immunized alliances), they jointly set price and share revenues. The ability to share revenues allows the carriers to internalize the double marginalization problem and results in lower prices. In empirical tests using a cross section of data from 1997, B&W find that interline fares on carriers with alliances (code sharing or immunity) are on average 25% below fares charged by non-alliance interline pairs.

Brueckner (2003) expands this analysis and finds, using a cross section of data from 1999, that carriers with code sharing agreements charge fares 8 to 17% below traditional interline pairs and that fares on carrier with antitrust immunity are 17 to 30% lower. Brueckner argues that, while code sharing resembles the non-cooperative fare setting in the model, it should result in lower fares than the IATA process because the negotiations are bilateral and not multilateral in nature. Thus, carriers with preferences for lower prices may lose out to carriers who prefer higher ones in IATA negotiations but could obtain lower prices in a bilateral negotiation.

This paper expands on the previous empirical results in several ways. First, it makes use of a large data set that covers 11 years of international traffic between the U.S. and Europe. Previous research has relied on cross sectional variation, measuring the price effect relative to non-alliance carriers for a given quarter, while this data set covers the formation and, in some cases, termination of most major U.S.-European carrier alliances to date. In general, the alliance price effects estimated in previous work are robust to the better data, though the effects in this paper are somewhat smaller. Immunity grants are associated with fares 14 to 22% lower than traditional interline and code sharing fares are 5 to 10% lower. In addition, all else equal, immunized alliance fares are often statistically identical to online fares. Because online fares cannot be affected by double marginalization, this result is consistent with the hypothesis that the primary effect of the alliance is an internalization of this demand externality.

In addition, this paper estimates the effect these alliances have on output and, consistent with the price effects, finds that output rises significantly. Immunized alliances are associated with output 51-88% higher than traditional interline service while code sharing is 22-45% higher. Both the price and output results are robust to different data sets that attempt to control for so called "mix effects," that changes in the mix of business and leisure traffic could explain some of the observed effects from alliances. This paper does not find that mix effects consistently under or over state the effect of alliances. Lastly, this paper investigates the proposition that the benefits from immunized alliances are simply a byproduct of Open Skies treaties, which often occur in conjunction with grants of immunity. The results are inconsistent with this hypothesis, but regressions suggest that capacity increases between countries with Open Skies treaties are due entirely to expansion of immunized alliances on routes between their hubs.

Although the literature on international airline alliances is sparse, a review of work not mentioned previously is worthwhile. A theoretical model by Park (1997) predicted that competition in some markets produced an externality in other markets for alliance partners, which led to an increase in welfare for alliances with complementary route structures but a decrease for alliances whose route structures overlapped. Park and Zhang (1998) developed a theoretical model that suggests alliances increase traffic on gateway-to-gateway routes and found empirical support for the hypothesis using data on transatlantic traffic. Oum, Park and Zhang (1996) estimated the effects of code sharing agreements between non-market leaders on the price and output of the market leader and found using published prices that code sharing on non-market leaders caused the leader's price to fall and output to rise. Similarly, Park and Zhang (2000) investigated effects on fares and output for four transatlantic alliances using published fare data and segment passengers, finding that prices fell and output rose. Hassin and Shy (2004) modeled the effects of code sharing in markets where one carrier can offer online service but the other must code share on the competitor. They found that the code sharing agreement is Pareto improving. Hassin and Shy (2000) modeled the effects of code sharing in markets where the alliance partners compete, endogenizing the choice of flight frequency. This model predicts that while the alliance raises flight frequency, it raises prices and lowers passenger welfare. Finally, Bilotkach (2004) developed a differentiated Bertrand model of alliances where consumers have preferences for fewer stops. The model predicts that alliances without immunity produce the same benefits to interline passengers as those with it and that the addition of immunity serves only to raise fares in the hub-to-hub markets where alliance partners previously competed.

There is also a growing literature on the effects of domestic code sharing alliances. Bamberger, Carlton and Neumann (2004) and Ito and Lee (2004) found that domestic alliances generally benefited consumers. Armantier and Richard (2005b) found heterogeneous effects across different types of markets in the Northwest-Continental alliance. Whalen (2005) found heterogeneous effects across different domestic alliances. Armantier and Richard (2005a) used a discrete choice model to estimate the effects of the Northwest-Continental alliance and found that per passenger consumer surplus fell. Whalen (1999) found that the potential benefits from converting interline passengers to online were small relative to the potential anticompetitive effects of domestic alliances.

This paper is organized as follows. Section two discusses international airline alliance pricing theory. Section three discusses the construction of the data set and provides background on existing alliances. Section four presents some summary statistics and regression results. Sections five presents some additional analysis of immunity grants and Open Skies treaties. And the final section offers some concluding remarks.

II. Alliance Pricing Theory

B&W and Brueckner present models of the effect of international alliances. These models are structured with a set of routes in one country that are served by carriers in that country and a set in another country served by different carriers. Passengers wishing to travel from destinations in one country to those in the other are forced to use the services of two carriers. The prices for these itineraries in the absence of an alliance are set in a non-cooperative fashion. Each carrier chooses a subfare for the portion of the itinerary it operates taking as given the subfare chosen by the other carrier. The passenger then pays the sum of the subfares for the entire itinerary. To the extent that carriers in each country have some market power, both carriers will markup their subfares above marginal cost, and because each carrier takes the other's subfare as given in its optimization problem, the carriers essentially apply their markup on top of the markup applied by the other carrier. This introduces a double marginalization problem and results in prices that are inefficiently too high.

It is straightforward to see how this problem arises. Suppose for simplicity that there is a monopolist for service in each country. Demand for itineraries requiring both carriers is a function of the sum of the subfares, i.e. $Q = D(s_1 + s_2)$ where s_1 and s_2 are the subfares for carriers 1 and 2 respectively. Each carrier then maximizes the profit function, $p_i = (s_i - c)D(s_1 + s_2)$, where c is a constant marginal cost and i takes the values 1 and 2 to represent the two carriers.[5] The price paid by the passenger is $P = s_1 + s_2$. The first order condition for carrier i is

$$s_i + Q\frac{dP}{dQ} = c. \tag{1}$$

Assuming symmetry between carrier 1 and carrier 2, the price paid by the passenger is found by multiplying equation (1) by 2 and replacing $2s_i$ with P. Specifically,

$$2s_i + 2Q\frac{dP}{dQ} = 2c \quad \Leftrightarrow \quad \frac{1}{2}P + Q\frac{dP}{dQ} = c. \tag{2}$$

If, on the other hand, the route was served by a single carrier (online service) or carriers with an

5 Constant marginal cost is assumed for simplicity. Brueckner and B&W incorporate economies of density into the cost function.

immunized alliance who can jointly set price and share profits, the carrier(s) would maximize the profit function $p = (P - c)Q(P)$, which is the standard monopolist's problem. The first order condition of that maximization is

$$P + Q\frac{dP}{dQ} = c. \quad (3)$$

Equations (2) and (3) differ only in the ½ that appears before price in the non-alliance equation (2). Notice that because $Q\frac{dP}{dQ}$ is negative, the price that satisfies equation (2) is larger than the price that satisfies (3) for any given Q. Furthermore, because the price that satisfies equation (3) maximizes profits without the additional constraint of the other carrier's subfare, the higher non-alliance price not only makes passengers worse off, but also results in lower profits for the carriers.[6]

These models imply that, all else equal, there is an efficient price setting mechanism in online or immunized pricing, and an inefficient mechanism in non-alliance interline pricing, but these model do not given much guidance for the pricing behavior of code sharing agreements. Because non-alliance interlining relies on prices set at multilateral IATA negotiations, Doganis and Brueckner suggest that code sharing may result in lower fares simply because it allows carriers with preferences for lower prices to break out of the multilateral negotiations and set individualized prices. Thus while their prices are still inefficient from the double marginalization problem, they are lower than traditional interlining because they arises from bilateral and not multilateral negotiations.

6 Nonlinear contracting could also solve the double marginalization problem, but airlines generally seem unwilling to enter contracts that might resemble profit sharing. Because the networks of these airlines are complementary on some routes and substitutes on others, they may fear antitrust action from such contracts.

III. The Data

The data used for the empirical analysis come in part from the DOT's quarterly Origin and Destination Survey, DB1A and DB1B, (henceforth called the "O&D data"). These data are a 10% sample of all traffic either ticketed by U.S. carriers or where a U.S. carrier operated at least one of the segments. Each observation in the O&D data contains the fare, the origin, destination and connecting airports, the carrier operating each segment and the number of sampled passengers traveling the itinerary at a particular fare.

This analysis uses data for the third quarter of every year from 1990 through 2000.[7] Because most of the alliances--particularly those with antitrust immunity--were formed between U.S. and European carriers, the data are restricted to U.S.-Europe traffic. Several adjustments were made to the data to correct for data problems and allow for regression analysis. The majority of these changes are detailed in appendix A, but the creation of the data set is outlined here to give the reader a sense for what the data look like.

First, the raw data are a mix of round trip and one-way observations. Round trip itineraries were broken into their one-way components and one half of the fare was applied to each direction. Second, in order to facilitate comparing fares for carriers with alliances to fares of either non-alliance partners or single carrier itineraries, itineraries with more than two carriers were eliminated. A relatively small number of passengers travel on itineraries with three or more carriers and a visual inspection of the data suggests many of those likely involve reporting errors.

7 Airline data are extremely seasonal. Rather than try to control for that seasonality in the regression analysis, this paper relies only on third quarter data. This quarter is the peak travel season, so the data are rich with business and leisure traffic.

The data were then aggregated in two different ways to create the regression data sets used in the analysis. The first approach aggregated the data to the route-carrier level. Each observation in this data set is unique to the origin-destination pair and the carrier or carrier pair. Thus, each origin-destination pair will have multiple observations if more than one carrier or carrier pair offered service on that route. For example, there may be multiple observations for passengers traveling from Milwaukee to Berlin (for a given quarter): one for passengers traveling on United Airlines online service, another for those traveling on United and Lufthansa interline service, and yet another for those traveling on American and Swiss Air.[8] The second method aggregated the data to the origin-destination level (the route data set). Continuing with the same example, in this data set, there is only one observation (for a given quarter) for the Milwaukee-Berlin route that is aggregated across all carriers. Beyond just a check on robustness in general, estimating the model for both data sets provides a test for whether the fare effects from alliances are due at least partly to changes in the passenger mix between carriers within a route. For example, if there is a disproportionate shift of low fare passengers to alliance carriers relative to high fare passengers, average fares on non-alliance carriers in the route-carrier data set would rise while average fares on alliance carriers would fall. These effects would not reflect a change in pricing by the carriers, only a change in the mix of high and low fare passengers. Thus, regression results using the route-carrier data set could overstate the effect of the alliance. Conversely, a disproportionate shift of high fare passengers could lead to an understatement of the alliance effects. Because the route data set aggregates across all carriers on a route, the average fare is invariant to changes in passenger

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8 A carrier can appear in several observations in the route-carrier data set: once by itself for online service and then a number of times as a part of different pairs. For example, on a particular route, United could appear in an observation for online service and then appear in additional observations as a United-Lufthansa pair, a United-SAS pair, etc.

mix between carriers and thus, should correct for this potential problem.[9]

International routes fall into four basic categories. The first category is gateway-to-gateway routes. These are routes between U.S. and foreign gateway airports. Typically, these routes connect the hub of a U.S. carrier with the hub of a European carrier, and thus, the carriers potentially offer overlapping nonstop service. Because the purpose of this paper is to focuses on alliance effects in markets where domestic and foreign carriers can provide complementary service, gateway-to-gateway markets were eliminated. The second category is gateway-to-beyond routes. These are routes between a U.S. gateway airport and a non-gateway foreign airport. A foreign carrier can offer online service on these routes, but a U.S. carrier can only offer service by interlining with a foreign carrier. These routes were also eliminated. Only U.S. carriers file data with DOT, reporting their online service as well as interline service they provide jointly with a foreign carrier. Because foreign carriers can serve gateway-to-beyond routes on an online basis, this online service will not appear in the data and could bias the results of the estimation. The third category is behind-to-gateway routes. These are routes between a non-gateway U.S. airport and a foreign gateway airport. In these markets, a U.S. carrier may offer online service, but foreign carriers can only serve the route in conjunction with a U.S. carrier. Because all the service on these routes is sampled by the DOT data, these routes were kept. Finally, there are behind-to-beyond routes. These are routes between two non-gateway airports where only interline service (either alliance or non-alliance) is possible. Because all the service is sampled by the DOT data, these routes are also kept. Thus the data set contains two categories of routes: behind-to-beyond routes where only interline service is possible and behind-to-gateway

9 The O&D contain no reliable information on ticket restrictions. Thus, controlling for passenger mix explicitly in the regression analysis is impossible.

routes where interline service or U.S. carrier online service is possible.

DOT T-100 Service Segment data were used to identify these categories of markets. The T-100 data reports the number of operations, available seats and onboard passengers for each segment, including international segments that include a U.S. endpoint. Both foreign and U.S. carriers report these data.[10] To guarantee that both gateway-to-gateway and gateway-to-beyond itineraries were eliminated, all markets with a U.S. gateway endpoint were dropped. U.S. gateway airports were defined as those airports with at least one nonstop flight per business day to a European airport. This restriction guarantees that markets that could be served solely by foreign carriers (and thus are not observable in the O&D data) are eliminated.[11]

Data on alliances came primarily from Airline Business magazine's annual alliance survey, which identifies when carriers entered into code sharing agreements or immunized alliances. This information was supplemented in some instances with other media sources and DOT press releases. The agreements and their effective dates are listed in Table 1. There were 30 code sharing agreements that appeared in the data over this eleven year period and eight grants of antitrust immunity. The first major alliance was between Northwest Airlines and KLM and began in 1989. The airlines began code sharing in 1991 and were the first immunized alliance in 1993. While most of the agreements, once started, continued throughout the entire sample period, six of the code sharing agreements were terminated during the sample period and three of the immunities. The most notable code share that was terminated was between USAir and British Airways, which lasted from 1993 to 1996. The alliances with antitrust immunity that were terminated were Delta-

10 Prior to 1998, foreign carriers only reported on-board passengers to the DOT who then used OAG scheduling data to estimate the available seats and frequencies of the foreign carriers.

11 The T-100 data were also used to calculate number of operations and available seats on gateway-to-gateway markets for the

Swiss Air, Delta-Sabena and Delta-Austrian Air, which Delta terminated to pursue an alliance with Air France (which was immunized in 2001).

Lastly, some exogenous demand side characteristics were added to the data. U.S. Metropolitan Statistical Area populations and per capita income were added based on the location of the U.S. airport. These data come from the Bureau of Economic Analysis. European country populations and gross domestic product were also added based on the location of the European airport. GDP was normalized by the country population. Those data come from the OECD.

IV. Estimation Strategy and Regression Results

Summary Statistics

The summary statistics for both data sets are presented in Table 2. Not surprisingly, they are similar between the data sets. Differences are largely due to the fact that the route-carrier data set will give more weight to larger routes (because it tends to have multiple observations for larger routes) while the route data set gives more weight to smaller routes. In the route-carrier data, the average one-way fare (Avg Fare) is $697 and an itinerary has on average 2.6 coupon segments (Avg Coup). The average number of sampled passengers in a quarter on each route (Mkt Pax) is 30.7, which corresponds to 307 actual passengers (because the data are a 10% sample). Each carrier or carrier-pair on a route carries 6.4 sampled or 64 actual passengers (Carrier Pax) on average. Dummy variables indicate whether service was single carrier service (Online), code share alliance service (CS) or immunized service (Immunity).[12] In the data set, 42% of the service

analysis of the capacity effects of Open Skies agreements. This is described in more detail in Section V.

12 Carriers with code sharing alliance do not code share on every route, but prior to 1998, the DOT O&D data did not differentiate between passengers traveling on code share itineraries and those not. Therefore, in this work, the dummy for code

is online, 14% is immunized and 6% is code sharing. The excluded category in the regressions to which the effects are measured is non-alliance interline service, which constitutes the remaining 38%.

Competition in the markets is measured using a Herfindahl-Hirschman index (HHI). Separate HHI's were calculated for carriers offering online or alliance service (HHI_Oa) from those offering just non-alliance interline service (HHI_Int). The HHI_Oa is calculated based on the share of passengers carried by each carrier offering online or alliance service on the route. For the purpose of calculating shares, carriers with immunized alliances were considered the same carrier while passengers traveling on code sharing alliances were divided equally between the two carriers. For example, suppose in a particular market, United carries five passengers on an online basis, the United-Lufthansa immunized alliance carries two, and the Delta-Air France code sharing alliance carries three.[13] Because United and Lufthansa have an immunized alliance, they are counted as a single carrier with 70% of the market (seven of the ten passengers). Because Delta and Air France have only a code sharing alliance, they are counted separately, and their passengers are split between them. Thus, each is counted as having 15% of the market (1.5 passengers each). HHI_Int is calculated using carriers who do not otherwise offer online or alliance service in the market. For those carriers, the passengers are divided equally between them to calculate shares. In general, the routes are highly concentrated with an average HHI_Oa of 0.56 and HHI_Int of 0.28.

A dummy variable was constructed to control for the effects of Open Skies treaties

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sharing indicates whether the two carriers operating the itinerary had a code sharing alliance.

13 Although Delta and Air France have an immunized alliance today, that alliance was not immunized until 2001, after the sample period.

(Opensky). It takes a value of one when the European destination was in a country with which the U.S. had an Open Skies treaty. 31% of the itineraries in the route-carrier data set traveled to countries with Open Skies agreements.

Summary statistics for the route data set are very similar. The average fare is slightly lower at $679. The number of sampled passengers in a market is 14, roughly half the number in the route-carrier data. Because the route-carrier data has multiple observations on many dense routes, this simply reflects a kind of double counting of denser routes. The measures of concentration are also similar between the data sets. In the route data set, the HHI_Oa is 0.60 while the HHI_Int is 0.25.

Because the route data is aggregated across carriers (or carrier-pairs), it is no longer possible to use dummy variables to indicate the type of service. Instead, these variables are converted to the percentage of passengers traveling on each type of service on the route. The summary statistics for these variables are similar to those for the route-carrier data set with 48% of the traffic traveling on online service (Pct Online), 14% traveling on immunized alliances (Pct Immune), and 6% traveling on code sharing alliances (Pct CS).

Table 3 contains selected means by type of service from the route-carrier data set for just the third quarter of 1996. These summary statistics offer more insight into the relationship between prices and the various types of service and are consistent with many of the expectations. First, the highest average fare is for non-alliance interline itineraries at $923. This is substantially higher than the average fare for online service, which is $669. The average immunized fare at $722 is considerably lower than the non-alliance fare but also somewhat higher than the average online fare. The average code sharing fare is even higher at $763, but still significantly lower than the non-alliance fare. Output follows a similar pattern. Online service, which has the lowest average fare, has the highest output with 40 sampled passengers in the quarter. Immunized alliances are second with 32 sampled passengers. Code sharing alliances and non-alliance interline are roughly equivalent with 18 sampled passengers. Other characteristics like average coupon segments and HHI's also differ between the types. While those effects will be accounted for in the regression analysis, the summary statistics are generally consistent with the expectations about fares and service.

The graph in Figure 1 makes the same point in a different way. It shows the average fares over time for each category of service: online, immunized, code sharing, and non-alliance interline. The average fares for non-alliance interline service are consistently the highest while online service is consistently the lowest. The gap between these prices is roughly $150-$200. Immunized itineraries, which begin in 1993, track very closely to the online fares, which is consistent with the belief that immunized alliance pricing is identical to online pricing. Code sharing fares are generally below the non-alliance fares but higher than immunized fares. The regression analysis will hold other factors constant and test whether these relationships continue to hold.

Estimation Strategy

Several fixed effects regressions were estimated to measure the price and output effects of different types of service. The basic forms of the regression equations are listed below where *DepVar* is the average fare in the price regressions and the number of passengers in the output regressions. The first equation is for the route-carrier data set where the subscript i refers to the carrier, m to the route and t to the year. The second equation is for the route data set where, because the data are aggregated to the route level, the subscript i is dropped and several variables are transformed to percentages as described above. The route effects in both equations are differenced out using fixed effects; thus, invariant route characteristics over the sample period will be captured by these fixed effects. Carrier dummies are included to control for carrier-specific effects and year dummies capture period-specific effects. [14]

$$
\begin{aligned}
\ln(DepVar_{i,m,t}) = {} & a_1 + a_2\,Online_{i,t} + a_3\,Immunity_{i,t} + a_4\,CS_{i,t} + a_5\,Avg\ Coup_{i,m,t} \\
& + a_6\,HHI\_OA_{m,t} + a_7\,HHI\_INT_{m,t} + a_8\,Opensky_{m,t} + a_9\,US\ Pop_{m,t} + a_{10}\,US\ Inc_{m,t} \\
& + a_{11}\,EU\ Pop_{m,t} + a_{12}\,EU\ gdp_{m,t} + b\ Year\ Dummies_t + g\ Carrier\ Dummies_i \\
& + h\ Route\ Effects_m + e_{i,m,t}
\end{aligned} \tag{4}
$$

$$
\begin{aligned}
\ln(DepVar_{m,t}) = {} & a_1 + a_2\,Pct\ Online_{m,t} + a_3\,Pct\ Immune_{m,t} + a_4\,Pct\ CS_{m,t} \\
& + a_5\,Avg\ Coup_{m,t} + a_6\,HHI\_OA_{m,t} + a_7\,HHI\_INT_{m,t} + a_8\,Opensky_{m,t} + a_9\,US\ Pop_{m,t} \\
& + a_{10}\,US\ Inc_{m,t} + a_{11}\,EU\ Pop_{m,t} + a_{12}\,EU\ gdp_{m,t} + b\ Year\ Dummies_t \\
& + g\ Carrier\ Shares_{m,t} + h\ Route\ Effects_m + e_{m,t}
\end{aligned} \tag{5}
$$

In the price regressions, the signs of the coefficients on the variables measuring online and immunized alliance service (Online/Pct Online and Immunity/Pct Immune) are expected to be negative. Theory suggests that these types of service internalize the double marginalization problem and should have lower fares than non-alliance interline itineraries (the base case). Furthermore, the coefficient on the online service variable is expected to be identical to the coefficient on the immunity variable to the extent that immunized alliances can price like a single firm. The coefficients on the variables measuring code sharing (CS/Pct CS) are also expected to be negative to the extent that bilateral prorate negotiations are more efficient than fare setting through the IATA process.

14 The coefficients on the year and carrier dummies are omitted from the tables but available from the author on request.

The coefficient on the average number of coupon segments is likely to be negative because passengers have strong preferences for fewer stops. The HHI coefficients are expected to have positive signs although to the extent that non-alliance interline service fares are dictated by IATA negotiations, it is not clear that competition from this type of service (HHI_Int) would have an effect on fares. The coefficients on the proxies for demand (US Pop, EU Pop, US Inc, and EU Gdp) are expected to have positive coefficients.[15] Finally, if Open Skies treaties have a measurable effect on interlining passengers, perhaps because they generally allow for more capacity between the gateways, the coefficient on the Open Skies variable should be negative.

Regression Results

Tables 4 and 5 contain the results of the fixed effects estimations on price. Table 4 has the results for the route-carrier data set and Table 5, the route data set. There are four specifications for each data set. The first specification includes route and time-specific effects, while the second adds carrier-specific effects. The third and fourth repeat these specifications using instrumental variables to control for the potential endogeneity of the HHI's. Lagged HHI's for all service, online and alliance service, and interline service as well as the lagged number of carriers offering online service (and its square) and the number offering immunized or code share services (and its square) were used as instruments.

For the coefficients of particular interest, all the regressions produce similar results that are mostly consistent with the expectations. Focusing first on the route-carrier data in Table 4, the effect of online service on average fares is qualitatively similar across all of the specifications and highly statistically significant. In the first specification, online service is associated with 22.7%

15 In the regressions, the log transformation of these characteristics is used.

lower fares than non-alliance interline service. [16] When carrier-specific effects are included in the second specification, the effect of online service drops to 17.0%. This generally suggests that more efficient carriers on a particular route are more likely to offer online service. The effects are similar, though slightly smaller, in the IV estimates in columns three and four. Without carrier-effects, online service is associated with 20.9% lower fares and with carrier-effects, 14.1%. All of these results are consistent with the hypothesis that carriers are not able to price non-alliance interline service efficiently, but the externality is internalized in single carrier service.

For immunized alliances, the results are similar. In the absence of carrier-specific effects, immunized alliance fares are 20.5% lower than non-alliance interline fares. When carrier effects are included, the effect shrinks to 17.6%. As with online service, this suggests that more efficient carriers enter into immunized alliances. The IV estimates produce similar but slightly smaller effects. Without carrier effects, immunized service is associated with 18.0% lower fares and with carrier effects, 15.1%. All of these results are also highly significant and suggest that immunized alliances, like single carrier service, can internalize the demand externality associated with non-alliance interlining. Moreover, tests were constructed for the equality of the online and immunity coefficients to test whether the pricing behavior of immunized alliances is identical to that of the single firm. In the regressions without carrier-specific effects, the hypothesis that the coefficients are equal is rejected, but when carrier-specific effects are included, equality cannot be rejected. Because the preferred specifications include carrier-specific effects, the results are consistent with the prediction that immunized alliances can fully internalize the demand externality.

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16 Because the dependent variable in the these regressions is the log of average fare, the marginal effect of changing a variable X is calculated as $\exp(\alpha\ \Delta X)-1$, where α is the coefficient and ΔX is the change in the independent variable. The text reports these transformations of the coefficients in the tables.

The results on code sharing suggest it has roughly half of the effect of online or immunity pricing. In the non-IV regressions, code sharing is associated with 9.4% and 10.0% lower fares than non-alliance interlining without and with carrier effects, respectively. In the IV regressions, the effects are generally smaller where code sharing is associated with 7.6% and 8.6% lower fares when carrier effects are omitted and included, respectively. All these results are highly significant, but, unlike the online and immunity results, the inclusion of carrier-specific effects does not have much impact on the results. This is surprising given the expectation that more efficient or lower cost carriers were generally entering into code sharing agreements to escape the IATA process. Thus, the code sharing coefficient should have shrunk when carrier-specific effects were included.

Because the observations in the route-carrier data set are by carrier, these fare effects could be explained in part by mix effects, but the route data set does not suffer from this problem because it is invariant to changes in the mix of business and leisure passengers between carriers on a particular route. However, because the service type variables in this data set are converted to the percentage of traffic traveling on a type of service, comparability of the coefficients between the route and route-carrier regressions is not obvious.[17] For the route-carrier data set, a change in the number of passengers traveling online, for example, changes the average fare on the *route* by $(e^{b} - 1)RS$ where b is the coefficient for online service in the route-carrier regression and RS is the revenue share of the passengers switching to online service. In the route data set, a change in the percentage of passengers traveling online changes the average fare on the route by $e^{dMS} - 1$ where d is the coefficient for online service in the route regressions and MS is the passenger

17 Appendix B shows the derivation of these formulas.

share of switching passengers. The coefficients are directly compatible when the revenue share and market share of the switching passengers equal one (i.e. all passengers on the route switch to online service). As the revenue and market share of switching passengers deviate from one, these expressions will only be approximately equal (so long as the exponent is "small"). Similarly, differences between the revenue share and market share of the switching passengers will also cause these expressions to differ. This paper is concerned with whether the results of the route data set differ qualitatively from the route-carrier data set, and thus, for simplicity the results are treated as if directly compatible, recognizing that they are generally only approximately equal.

The results from the route data set are very similar to the route-carrier data. This suggests that mix effects are not significantly distorting the results, but the direction of the effect varies depending on the specification. The text focuses on the IV and non-IV results with carrier effects included (columns two and four). The analysis of the specifications without carrier effects is identical. In the non-IV regression, the results for online and immunized service are slightly smaller in the route data set. Online service is associated with 14.9% lower fares compared to 17.0% in the route-carrier data. Immunized alliance fares are 13.7% lower compared to 17.6% in the route-carrier data. In the IV regression, however, the relationship flips and the effects in the route data are larger than in the route-carrier data. For online service, the fares are 18.2% lower compared to 14.1% in the route-carrier data. For immunity, the fares are 18.8% lower compared to 15.1% in the route-carrier data. All of the non-IV results from the route data set are statistically significant. In the IV specification, however, the coefficient on online service is not significant when carrier effects are included, and the coefficient on immunize service is significant only at a 10% level.

For code sharing, the effects in the route data are consistently smaller than those in the route-carrier data, suggesting that code sharing might attract a disproportionate share of leisure traffic. In the non-IV regression using the route data, code sharing is associated with 5.3% lower fares compared to 10.0% in the route-carrier data. In the IV regression, code sharing fares are 4.6% lower compared to 8.6% in the route-carrier data. While the non-IV results are statistically significant in the route data, the code sharing coefficients in the IV specification, while similar in magnitude, are not.

In both data sets, the other control variables produce results mostly consistent with the expectations. The average number of coupon segments has a negative coefficient in all specifications and is statistically significant in most, suggesting that consumers view additional coupon segments as an inferior product. The coefficients on U.S. MSA per capita income and European country GDP per population are positive and significant in every specification, indicating that average fares are higher in places with greater wealth. European country population, however, tends to have a negative and significant coefficient in the non-IV regressions, contrary to the expectation that higher populations should be associated with higher demand. These coefficients are positive and significant in all of the IV regressions. U.S. MSA population is negative and significant in every specification.

The measures of concentration produce unusual and varied results. HHI_Oa is statistically insignificant in all specification including the IV estimates. HHI_Int, though it was not expected to have much power in explaining competition, has a positive coefficient in all specifications and is significant in several. It is possible that this variable is not so much measuring the effects of competition as it is measuring something unobserved about the bilateral treaties between countries (this issue is discussed further in the output regression section below). Finally, the coefficient on the Open Skies variable has a positive and significant coefficient, suggesting the average fares for itineraries terminating in countries with which the U.S. has a more liberalized bilateral treaty are higher than those without such a treaty. The effect is roughly 3-5% higher fares. This result is unexpected and discussed in more detail in the section below on Open Skies.

Output Regressions

Table 6 contains the results of the fixed effects estimations on output. In the route-carrier data, the dependent variable in these regressions is the natural log of passengers for a carrier on a route, while in the route data, it is the natural log of total passengers on the route. These regressions measure the response of output to immunized and code sharing alliance service. Generally, because prices for these services are significantly lower than non-alliance interline service, the coefficients are expected to be positive, but if consumers view these products as inferior in some ways, those output effects might be small or non-existent.

The results suggest that, consistent with the price effects, code sharing and immunized alliances are associated with large and significant increases in output. The first two columns of table 6 present results using the route-carrier data without and with carrier-specific effects. All else equal, switching a carrier pair in the data from non-alliance to immunized is associated with a increase in output of 61.9% in the regression without carrier effects and 51.1% with them. In the route data, switching a route from entirely non-alliance service to entirely immunized service is associated with an 87.7% or 78.0% increase in output without and with carrier effects, respectively. Because the average number of sampled passengers in the route data is 14, this effect is roughly an increase of 11 sample passengers. Code sharing has a similar effect on output though with roughly half the magnitude. The effect of code sharing on output ranges from 22.0-45.2% across the four specifications. All these results are highly significant and are consistent with the large price effects found in the price regressions.

The other coefficients are generally consistent with expectations. An increase in the average number of coupon segments is associated with fewer passengers because passengers dislike stopovers. Increases in demand as measured by the U.S. MSA population and per capita income are associated with higher output. However, the European country population and GDP produce mixed results, often having negative and significant coefficients. Because the data are predominately U.S. originations, higher EU country GDP may be correlated with a higher cost for Americans to travel to those countries and thus lower demand. The coefficient on the Open Skies variable is small and insignificant in every specification, suggesting that Open Skies did not have much effect on output in markets beyond the gateway airports.

HHI_Oa, the measure of concentration for carriers offering online or alliance service, has a negative and significant sign, suggesting that increases in concentration are associated with lower output. Although this is the expected sign, it is somewhat surprising because the price regressions did not produce positive and significant effects. The coefficient on HHI_Int, the measure of concentration for non-alliance interline service, is positive and significant, suggesting that an increase in concentration of interlining carriers is associated with higher output. The price regressions frequently found that increases in HHI_Int were associated with higher prices. These unusual results could be due to correlation between HHI_Int and something unobserved about the bilateral. Without more information about the bilaterals and how they were enforced over the years, it is not possible to test this theory.

V. Open Skies Agreements and Antitrust Immunity

One anomalous result in the regressions is the coefficient on the Open Skies variable. The result indicates that average fares were between 3-5% higher if the itinerary terminated in a European country with which the U.S. had an Open Skies treaty. Because Open Skies treaties relax restrictive bilateral agreements, it is likely that these were beneficial to consumers. In fact, DOT analysis suggests traffic expanded between countries that signed Open Skies agreements.[18] There are several possibilities for why this seemingly anomalous result appears in the regression. First, Open Skies treaties could be highly correlated with grants of immunity and induce a multicolinearity problem. While Open Skies treaties are a necessary condition for an immunity grant, the variables are not particularly highly correlated because plenty of non-immunized carriers continue to carry passengers to countries with Open Skies treaties. Moreover, the U.S. has Open Skies treaties with several countries where no carriers where granted antitrust immunity.[19] Finally, if the Open Skies variable is removed from the regressions, the results are largely unchanged. Another possibility is that Open Skies may have shifted out the demand curve for service between U.S. and European gateway airports. Because that capacity is shared with connecting passengers, carriers may have increased capacity less than what was necessary to meet all the new demand. Thus while capacity increased, the opportunity cost of carrying a connecting passenger rose. Hence the price also rose.

First, to get a sense for whether the regressions are “confusing” the effects of immunity with those of Open Skies, a subset of the data was extracted from before and after the U.S.-

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18 See DOT report, Deregulation Takes Off.

19 For example, the U.S. has Open Skies treaties with Finland, Denmark and Norway but there are no immunized alliances with hubs in those countries.

Germany Open Skies treaty and the United-Lufthansa immunity grant. United and Lufthansa began code sharing in 1994 while immunity and Open Skies with Germany went into effect in 1996. The subset includes itineraries from the third quarter of 1995 and 1997 for passengers who traveled between the U.S. and Germany. In practical terms, this means the data were restricted to interline itineraries on a U.S. carrier and Lufthansa that connected in Germany. The change in average fares over this time period for United-Lufthansa itineraries was affected by both Open Skies and immunity but not by the code share, which went into effect in 1994. The change in average fares for other-U.S. carrier-Lufthansa itineraries was affected only by Open Skies. Thus, if the Open Skies agreement alone were responsible for the fare decreases, one should observe similar effects for United-Lufthansa observations and other-U.S. carrier-Lufthansa observations. If there are differences between United-Lufthansa and other U.S.-Lufthansa observations, because the United-Lufthansa code share was in effect over the whole period, those differences might be attributed to the immunity.

Table 7 shows the average fares for both types of observations. Over the period when immunity and Open Skies were enacted, fares on United-Lufthansa itineraries fell 7.7% while fares on other-U.S.-Lufthansa observations rose by 14.8%**.** Recognizing that other factors have not been controlled for, these results are consistent with the regression results, suggesting that the large price decreases are associated with immunized carriers and not just a byproduct of Open Skies treaties.

Second, data on transatlantic capacities was assembled to understand more systematically how Open Skies treaties affected the capacity decision of carriers in different types of agreements (code sharing and immunized alliances). Because airlines are a network industry, there is no meaningful way to measure capacity on routes requiring connections, and the transatlantic capacity is shared between the connecting passengers and those traveling in the gateway-to-gateway market. Because transatlantic capacity is an important component of capacity in the connecting markets, understanding how Open Skies affected it may be useful in understanding the price effects.

Transatlantic capacities as measured by number of departures and total available seats in the quarter were calculated using the T-100 data for each carrier offering U.S.-Europe service for the same 11 year period covered by the price and output analyses. Like the prior analysis, the data was aggregated to the route-carrier level where an observation is a carrier operating service on a gateway route, and it was aggregated to the route level where an observation is total capacity of all carriers on the gateway route. This allows for four separate specifications: two using the number of departures as the capacity measure (one for the route-carrier data set and one for the route data set) and two using total available seats as the capacity measure. Dummy variables were used to categorize the observations by Open Skies and types of service. The categories are as follows for the route-carrier data.

1. Base case: no Open Skies treaty between the U.S. and the destination country, and the carrier operating the service does not have an immunized alliance or code sharing agreement with a carrier based in the foreign country.
2. Cld-CS: no Open Skies treaty and the carrier has a code sharing agreement with a carrier based in that country.
3. Open-Int: an Open Skies treaty exists between the U.S. and the destination country, and the carrier has no code sharing or immunized alliance with a carrier from that country.
4. Open-CS: an Open Skies treaty exists, and the carrier has a code sharing agreement with a carrier from that country.

5. Open-Immune: an Open Skies treaty exists, and the carrier has an immunized alliance with a carrier from that country. This last category is further broken down by whether the route is between hubs of the immunized carriers (Hub-Hub) or not (Other).

The categories are the same for the route data set, but because the observations are aggregated to the route level, the code sharing and immunity categories are turned on if any carrier on the route has a code sharing or immunized alliance, respectively. In these regressions, the population, GDP (normalized by population) and per capita income measures used in the alliance analysis were included, as well as time and route-specific effects. In the route-carrier data, carrier-specific effects were also included.

The results of the capacity regressions are presented in Table 8. The first two columns use the route data set and the dependent variables are the natural log of the number of operations and the natural log of the number of seats, respectively. The second two columns repeat these regressions using the route-carrier data. All four specifications produce similar results, namely, that all of the capacity effects associated with Open Skies treaties are due to expansion by immunized alliances on the trunk routes between their hubs. This expansion involved both an increase in the number of departures and an increase in the size of the aircraft, and all the results are highly statistically significant. In the route data, the number of operations on hub-hub routes with immunized carriers rose 20% while the number of seats rose by 30%. In the route-carrier data, the number of operations rose by 19% and the number of seats by 36%. There was no statistically significant change in capacity after Open Skies for carriers with immunized alliances to cities other than between the partners' hubs. There was also no statistically significant effect for code sharing alliances or for non-alliance carriers. However, carriers with code sharing alliances to countries without Open Skies treaties had a positive and significant effect on capacity. In the route data, capacity rose by approximated 10%. In the route-carrier data, the effects were smaller, roughly 4%, and the results are less statistically significant.

It seems likely that the large capacity expansions on trunk routes are to facilitate connections between the carriers as immunized alliances shift their non-alliance interline traffic on to their partner. The expectation in the price regressions was that Open Skies would lead to a general increase in service from a variety of carriers on a variety of routes and thus price would fall. The capacity regressions suggest that this general increase in capacity did not occur. Still, this does not explain the observed price increases. Although it cannot be tested from these data, it remains possible that carriers expanded capacity by less than what was necessary to meet the increased demand in both the gateway markets and the connecting markets. This raised the opportunity cost of carrying a connecting passenger and resulted in higher fares.

VI. Conclusion

This paper uses the most extensive data set assembled to assess the effects of airline alliances on prices and output. Like the previous literature, the results suggest that code sharing and antitrust immunity are associated with significantly lower fares than non-alliance interline service. However, the price effects found here using an 11 year panel of data are somewhat smaller than those found in the cross sectional analysis of previous work. These results suggest that immunized fares are 14-22% lower than traditional interline and code sharing 5-10% lower.

This paper also finds that online service is associated with fares 14-23% lower than traditional interline fares. Tests of the hypothesis that the online price effect is identical to the immunity price effect cannot be rejected in many specifications. Because online service does not suffer from double marginalization problems, this result is consistent with the hypothesis that non-alliance pricing is subject to this externality but that it is completely internalized in immunized alliances. Because fares for code sharing alliances lie roughly halfway between the immunized/online fares and the non-alliance fares, it seems likely that code sharing is insufficient to eliminate the externality but still has some benefits for consumers. This paper also finds little evidence that changes in the business/leisure passenger mix leads to a significant over or under estimate of the effect of alliances.

This paper also estimates the output effects associated with these alliances. Consistent with the price effects, immunized alliances are associated with large increases in output, between 51-88%. Similarly, code sharing is associated with 22-45% increases in output.

Lastly, the price regressions find, somewhat surprisingly, that Open Skies treaties are associated with 3-5% higher fares on these connecting routes. An analysis of capacity changes on the transatlantic segments before and after Open Skies suggests that all of the capacity expansion associated with Open Skies treaties is due to expansion by carriers with immunized alliances on routes between their hubs. Because Open Skies did not lead to capacity increases from a variety of carriers, the expectation that Open Skies should have resulted in lower prices on the connecting routes may have been incorrect.

Appendix A

This appendix provides details about the treatment of the O&D data. First, open jaw itineraries, those with surface segments, and itineraries that failed the DOT's Dollar Credibility Indicator, a measure of whether the reported fare is likely in error, were deleted. Also deleted were one-way itineraries with more than 4 coupon segments and roundtrips where either portion exceeded 4 coupons. These itineraries are rare but frequently obviously in error. Because this paper focuses on U.S.-Europe traffic, itineraries with origins, destinations or stops outside of the continental U.S. and Europe were deleted. Itineraries with the "unknown" carrier code, UK and YY, were also deleted.[20] Whenever possible commuter carriers that report separately to the DOT from their major carrier partner were recoded to that major carrier. Those recodes are Continental Express (RU) to Continental (CO); Eurowings (EW) and Air Dolomiti (EN) to Lufthansa (LH); Mesaba (XJ) and Express Air (9E) to Northwest (NW); Atlantic Southeast (EV) and Comair (OH) to Delta (DL); Atlantic Coast (DH), Air Wisconsin (ZW), UFS (U2) and Great Lakes Aviation (ZK) to United (UA); Simmons (MQ) to American (AA); KLM Cityhopper (WA) to KLM (KL); Air Inter (IT) to Air France (AF); GB Airways (GT) to British Airways (BA); USAir Shuttle (TB), Air Midwest (ZV), CC Air (ED), Alleghency (12), Chautaqua (13), Commutair (14), PSA (16) and Piedmont (17) to USAir (US). After these recodings, itineraries with more than 2 carriers were deleted. These itineraries are rare and beyond the scope of the analysis. Some airport codes were also recoded when the metro area code was used instead of the airport code.

Itineraries were also screened for misreported fare data. In particular, itineraries were deleted if the fare was equal to or greater than $9999 or equal to $4999.5. While fare in excess of

20 Unfortunately, prior to 1999 DOT used carrier code UK for both unknown carrier and Air UK. Because there is no

$9999 are rare, the small mass of fare at exactly $9999 were likely intended as a flag in the computer system for "not available." Fares below $100 were also deleted.

After calculating the HHI indices, several other adjustments to the data were made. Itineraries involving carriers that carry 10 or fewer sampled passengers over the entire 11 year sample were deleted. Because these carriers appear in the data only a couple of times each, they likely were not significant enough players in the market, and if they are the least efficient firms, may bias the non-alliance interline fares upward. Itineraries with two U.S. carriers were also deleted. The focus of this paper is on the price effects of international alliances relative to non-alliance interlining between carriers in separate countries. Domestic interlining may function differently, and so these itineraries were excluded from the pricing and output studies (though they were counted in measuring competition). Finally, carrier specific effects were only included for carriers with at least 500 sampled passengers over the 11 years. Carriers that failed this screen were counted in a single "other" carrier category. 35 carriers met this criteria, so the carrier-specific effects include effects for the 35 largest carriers and one "other" category. In the route-carrier data, for online service, the carrier effect variable for that particular itinerary is set to 1. For interline, code sharing and immunized service, both carriers have their carrier effect variable set to ½. In the route data set, these carrier effects variables are aggregate to shares.

reasonable way to sort out these codes, Air UK is removed from the analysis.

Appendix B

For exposition, the price equation can be simplified as $P = e^{bD+gX}$ where D is the percentage of passengers traveling on a particular type of service (online, code sharing or immunized) in the route data set and a dummy for type of service in the route-carrier data set. X represents the other characteristics of the observation. For the route data set, the change in the average price on a route resulting from a change in the percentage of passengers traveling on a particular type of service, holding all else constant, is

$$\frac{P_2}{P_1} - 1 = \frac{e^{bD_2+gX}}{e^{bD_1+gX}} - 1 = e^{b(D_2-D_1)} - 1 = e^{bMS} - 1$$

where MS is the share of passengers switching from non-alliance interline service to online, code share or immunized service.

In the route-carrier data set, because there are multiple observations for each route, calculating the average change in price on the *route* is more difficult. Suppose there are n observations for a particular route. The average fare on the route when all the observations are non-alliance interline is

$$P_1 = \frac{1}{Q}\sum_{i=1}^{n} P_i q_i = \frac{1}{Q}\sum_{i=1}^{n} e^{gX_i} q_i \, .$$

The average fare when one observation (for example, $i=1$) is for a different type of service is

$$P_2 = \frac{1}{Q}\sum_{i=1}^{n} P_i q_i = \frac{1}{Q}\left(e^{b+gX_1} q_1 + \sum_{i=2}^{n} e^{gX_i} q_i \right).$$

The effect on price at the route level from a change in service type for one observation on the route is therefore

$$\frac{P_2}{P_1}-1=\frac{\frac{1}{Q}\left(e^{b+gX_1}q_1+\sum_{i=2}^{n}e^{gX_i}q_i\right)}{\frac{1}{Q}\left(\sum_{i=1}^{n}e^{gX_i}q_i\right)}-1=\frac{e^{b+gX_1}q_1}{\sum_{i=1}^{n}e^{gX_i}q_i}+\frac{e^{gX_2}q_2}{\sum_{i=1}^{n}e^{gX_i}q_i}+\ldots+\frac{e^{gX_n}q_n}{\sum_{i=1}^{n}e^{gX_i}q_i}-1$$

$$=\frac{e^{b+gX_1}q_1}{\sum_{i=1}^{n}e^{gX_i}q_i}+RS_2+\ldots+RS_n-1=\frac{e^{b+gX_1}q_1}{\sum_{i=1}^{n}e^{gX_i}q_i}-RS_1=\frac{e^{b}e^{gX_1}q_1}{\sum_{i=1}^{n}e^{gX_i}q_i}-RS_1=e^{b}RS_1-RS_1=\left(e^{b}-1\right)RS_1.$$

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Table 1. Codesharing and Antitrust Immunities

U.S. Carrier	European Carrier	Codesharing	Antitrust Immunity
American	British Midland	1994-1999	
	Finnair	Mar 1999	
	Iberia Airlines	May 1998	
	LOT Polish Air	Sept 1996	
	Sabena	Nov 1999	Nov 1999
	Swiss Air	Nov 1999	Nov 1999
America West	British Airways	Apr 1996	
Continental	Air France	Apr 1997	
	Alitalia	May 1994	
	British Midland	Aug 1998	
	CSA Czech Air	Apr 1996	
	Virgin Atlantic	Feb 1998	
Delta	Air France	1996	
	Austrian Air	1994-1999	1996-1999
	Malev	May 1994	
	Sabena	1993-1999	1996-1999
	Swiss Air	1993-1999	1996-1999
	Virgin Atlantic	1995-1997	
Midwest Express	Virgin Atlantic	1997	
Northwest	Alitalia	May 1999	
	Braathens	1998	
	KLM	1991	1993
TWA	Air Malta	May 2000	
United	Austrian Air	Apr 2000	
	British Midland	Apr 1992	
	Lufthansa	Jun 1994	1996
	Scandinavian Air	Apr 1995	1996
	Spanair	Oct 1999	
USAir	British Airways	1993-1996	
	Deutsche BA	1996	

Table 2. Summary Statistics

Route-Carrier Data (120,758 obs.)			Route Data (54,893 obs.)		
Variable	Mean	Std Dev	Variable	Mean	Std Dev
Avg Fare	696.66	490.16	Avg Fare	678.62	403.04
Online	0.424	0.494	Pct Onl	0.477	0.450
Immune	0.137	0.344	Pct Immune	0.141	0.305
CS	0.064	0.246	Pct CS	0.055	0.194
Open Sky	0.308	0.462	Open Sky	0.283	0.451
Avg Coup	2.620	0.545	Avg Coup	2.638	0.502
HHI_Oa	0.564	0.343	HHI_Oa	0.599	0.403
HHI_Int	0.280	0.198	HHI_Int	0.251	0.226
US Pop (000)	1,143	1,639	US Pop	999	1,691
US Inc	24,067	4,860	US Inc	23,408	4,783
EU Pop (000)	43,399	28,758	EU Pop	43,059	28,504
EU Gdp/Pop	20,338	6,004	EU Gdp/Pop	20,135	6,141
Mkt Pax	30.68	63.42	Mkt Pax	13.97	38.54
Car Pax	6.36	15.34			

Table 3. Means by Type of Service for 1996 (Route-Carrier Data)

	Online	Immunity	Code Share	Non-Alliance
Avg Fare	669.11	722.45	762.99	923.06
Avg Coup	2.30	2.93	2.78	2.86
HHI_Oa	0.652	0.733	0.471	0.429
HHI_Int	0.207	0.207	0.231	0.399
Mkt Pax	40.02	17.56	32.07	18.30

Figure 1. Average Fare by Category of Service

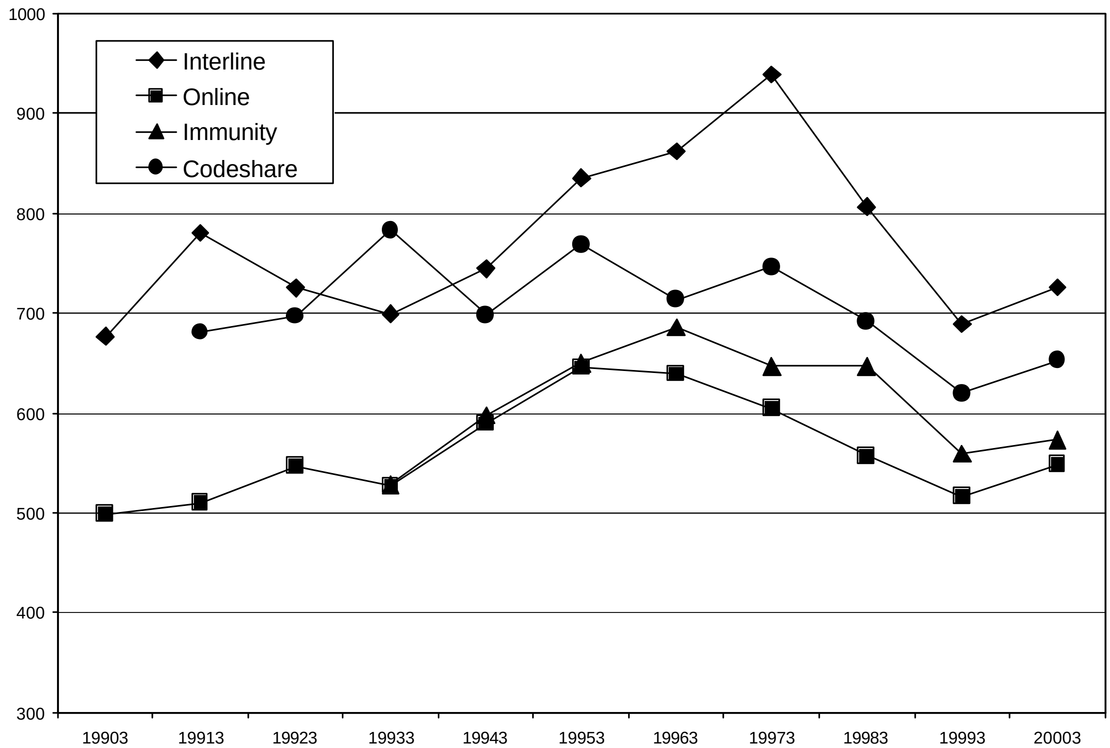

Table 4. Price Regression Results---Route-Carrier Data Set

	OLS (1)	OLS (2)	IV (1)	IV (2)
Online	-0.2581 ***	-0.1868 ***	-0.2339 ***	-0.1518 ***
	-63.76	-9.17	-14.31	-5.06
Immunity	-0.2299 ***	-0.1933 ***	-0.1988 ***	-0.1636 ***
	-44.88	-29.56	-9.84	-7.56
CS	-0.0991 ***	-0.1054 ***	-0.0790 ***	-0.0901 ***
	-15.69	-15.03	-6.02	-6.60
Open Sky	0.0484 ***	0.0428 ***	0.0369 ***	0.0348 ***
	8.47	7.52	5.67	5.40
Avg Coup	-0.0251 ***	-0.0221 ***	-0.0355 ***	-0.0327 ***
	-7.13	-6.11	-8.63	-7.78
EU Pop	0.1878 ***	0.2483 ***	2.1271 ***	1.8131 ***
	2.94	3.92	6.24	5.32
EU Gdp/Pop	0.4193 ***	0.4330 ***	0.2317 ***	0.2948 ***
	11.26	11.69	3.18	4.10
US Pop	-0.4301 ***	-0.4311 ***	-0.5086 ***	-0.5061 ***
	-10.12	-10.23	-8.53	-8.43
US Inc	0.3608 ***	0.3291 ***	0.3581 ***	0.3138 ***
	5.93	5.47	4.76	4.19
HHI_Oa	0.0084	0.0003	-0.0932	-0.1132
	1.49	0.05	-0.79	-0.95
HHI_Int	0.0161 *	0.0137	0.1714 *	0.1424
	1.88	1.61	1.64	1.38
Constant	8.3163 ***	7.7782 ***	-11.2288 ***	-7.6443 **
	8.65	8.14	-3.13	-2.14
Time Effects	Yes	Yes	Yes	Yes
Carrier Effects	No	Yes	No	Yes
Route Effects	Yes	Yes	Yes	Yes
P-value: Onl=Imm	0.00	0.75	0.00	0.62
Observations	120,758	120,758	104,867	104,867

*** Significant at 1% level, ** at a 5% level, * at a 10% level.

Table 5. Price Regression Results---Route Data Set

	OLS (1)	OLS (2)	IV (1)	IV (2)
Pct Online	-0.2193 ***	-0.1613 ***	-0.2858 ***	-0.2009
	-18.41	-3.86	-2.76	-1.49
Pct Immune	-0.1855 ***	-0.1468 ***	-0.2486 **	-0.2077 *
	-14.51	-9.77	-2.31	-1.81
Pct CS	-0.0635 ***	-0.0548 ***	-0.0508	-0.0467
	-4.86	-3.93	-0.75	-0.65
Open Sky	0.0385 ***	0.0312 ***	0.0325 ***	0.0290 ***
	5.35	4.28	3.90	3.41
Avg Coup	-0.0030	-0.0065	-0.0132	-0.0187 **
	-0.46	-0.97	-1.59	-2.26
EU Pop	0.2990 ***	0.3484 ***	1.9944 ***	1.4377 ***
	3.71	4.29	5.11	3.62
EU Gdp/Pop	0.4014 ***	0.4069 ***	0.2707 ***	0.3549 ***
	8.79	8.82	4.14	5.37
US Pop	-0.4365 ***	-0.4748 ***	-0.3749 ***	-0.4008 ***
	-7.68	-8.34	-5.17	-5.32
US Inc	0.2274 ***	0.1780 **	0.2685 ***	0.2044 **
	2.90	2.27	2.86	2.18
HHI_Oa	-0.0088	-0.0098	0.1297	0.1201
	-1.02	-1.14	1.17	1.02
HHI_Int	0.0517 ***	0.0529 ***	0.1441	0.1371
	4.28	4.40	1.08	1.03
Constant	8.4303 ***	8.7364 ***	-10.7458 **	-3.9737
	6.73	6.95	-2.50	-0.91
Time Effects	Yes	Yes	Yes	Yes
Carrier Effects	No	Yes	No	Yes
Route Effects	Yes	Yes	Yes	Yes
P-value: Onl=Imm	0.00	0.73	0.00	0.90
Observations	54,893	54,893	45,510	45,510

*** Significant at 1% level, ** at a 5% level, * at a 10% level.

Table 6. Output Regressions Results

	Rt-Car (1)		Rt-Car (2)		Rt (1)		Rt (2)	
Online	0.9947	***	0.8005	***	0.7385	***	0.5918	***
	151.56		24.25		39.97		9.10	
Immunity	0.4820	***	0.4127	***	0.6296	***	0.5764	***
	58.04		38.92		31.76		24.66	
CS	0.1985	***	0.2545	***	0.3727	***	0.3502	***
	19.39		22.39		18.40		16.16	
Open Sky	-0.0143		-0.0083		-0.0043		0.0030	
	-1.54		-0.90		-0.38		0.26	
Avg Coup	-0.4953	***	-0.4821	***	-0.2599	***	-0.2442	***
	-86.70		-82.36		-25.60		-23.44	
EU Pop	-0.4110	***	-0.2479	**	-0.4834	***	-0.5170	***
	-3.97		-2.41		-3.86		-4.09	
EU Gdp/Pop	-0.2297	***	-0.1545	***	0.0730		0.0340	
	-3.80		-2.57		1.03		0.47	
US Pop	1.0093	***	0.9607	***	1.3886	***	1.3471	***
	14.64		14.05		15.75		15.22	
US Inc	0.2569	***	0.2668	***	1.0519	***	0.9652	***
	2.61		2.73		8.64		7.92	
HHI_Oa	-0.1735	***	-0.1731	***	-0.2442	***	-0.2276	***
	-19.01		-19.11		-18.31		-17.00	
HHI_Int	0.2413	***	0.2382	***	0.6889	***	0.6823	***
	17.32		17.28		36.76		36.50	
Constant	-8.6369	***	-9.3689	***	-19.6558	***	-17.9232	***
	-5.54		-6.05		-10.12		-9.17	
Time Effects	Yes		Yes		Yes		Yes	
Carrier Effects	No		Yes		No		Yes	
Route Effects	Yes		Yes		Yes		Yes	

*** Significant at 1% level, ** at a 5% level, * at a 10% level.

Table 7. Change in Fares Before and After Germany Open Skies

	Average Fare 1995	Average Fare 1997	Change
United-Lufthansa	730.29	674.11	-7.7%
Other US-Lufthansa	893.53	1025.75	14.8%

Table 8. Capacity Effects of Open Skies Agreements

	Route Data Set		Route-Carrier Data Set	
	Ln Dep	Ln Seat	Ln Dep	Ln Seat
Cld-CS	0.0901 ***	0.1083 ***	0.0380 *	0.0459 *
	3.57	3.99	1.87	1.86
Open-Int	-0.0535	-0.0367	-0.0270	0.0053
	-1.31	-0.84	-0.94	0.15
Open-CS	0.0017	0.0273	-0.0216	0.0275
	0.03	0.48	-0.44	0.46
Open-Immune				
Hub-Hub	0.1830 ***	0.2610 ***	0.1752 ***	0.3112 ***
	2.84	3.77	3.51	5.13
Other	-0.0328	0.0176	-0.0007	0.0325
	-0.87	0.43	-0.02	0.81
EU Pop	-0.0987	-0.2708	-0.6688 ***	-0.6210 **
	-0.32	-1.30	-2.68	-2.05
EU Gdp/Pop	-0.0933	-0.2708	-0.5705 ***	-0.6322 ***
	-0.48	-1.30	-3.36	-3.06
US Pop	-0.5495 **	-0.1702	-0.2443	0.0738
	-2.04	-0.59	-1.10	0.27
US Inc	0.1166	0.2547	-0.2649	-0.0468
	0.32	0.66	-0.91	-0.13
Constant	13.3948 **	11.5102 *	16.1147 ***	13.9427 **
	2.34	1.87	3.47	2.47
Year Eff	Yes	Yes	Yes	Yes
Car Eff	No	No	Yes	Yes
Rt Eff	Yes	Yes	Yes	Yes
Observations	1704	1704	2563	2563

*** Significant at 1% level, ** at a 5% level, * at a 10% level.