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ORIGINAL ARTICLE

A panel data analysis of code-sharing, antitrust immunity, and open skies treaties in international aviation markets

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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 does traditional interline (multi-carrier) service, but the effects are smaller in magnitude than those found in 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, estimates suggest that capacity expansions associated with "Open Skies" treaties are due entirely to expansion by immunized carriers on routes between their hubs.

Keywords Airline Alliances · Antitrust Immunity · Code-Sharing · Open Skies Treaties

1 Introduction

Increasing demand for international air travel since the early 1990's has led U.S. airlines to forge strategic alliances with their overseas counterparts to extend

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the reach of their hub-and-spoke networks. Because of scope and scale economies and the thinness of international routes, it is generally inefficient for carriers to serve a vast majority of overseas destinations using their own aircraft. Instead, they offer service primarily on routes between their hubs and the largest international cities and transfer passengers to foreign carriers if those passengers' ultimate destination is beyond these large hub cities.[1]

With an alliance, these multiple carrier or "interline" itineraries mimic single carrier or "online" service, and the alliance partners can reap some 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. These alliances can take many different forms depending on the degree of integration between the carriers, but the two most prevalent types are code-sharing alliances and antitrust-immunized alliances.

Previous research, primarily Brueckner and Whalen (2000) (hereafter B&W) and Brueckner (2003), suggests that non-alliance interline pricing suffers from a double marginalization problem that is internalized in alliances, and the empirical analyses in these works show that alliances are associated with fares that are significantly lower than traditional non-alliance interlining.

This paper extends that research in several ways. Previous research has relied on cross-sectional variation in a given quarter to measure alliance effects, while this analysis makes use of an 11-year panel of international traffic between the U.S. and Europe. This approach is likely to be more robust because it covers the formation and, in some cases, termination of the major U.S.-European alliances to date. Generally, the more robust data produce somewhat smaller price effects than the previous research, though the results are qualitatively similar. Alliances that are granted antitrust immunity are associated with fares that are 13 to 20% lower than traditional interline fares, and code-sharing fares are 5 to 9% lower. This paper also estimates output effects from alliances and finds, consistent with the price effects, that immunized alliances are associated with 51–77% higher output while code-sharing output is 29–41% higher.

This paper also more directly tests the double marginalization hypothesis by comparing immunized-alliance fares to online fares and generally finds that immunized-alliance fares are statistically identical to online fares. Because online fares cannot be affected by double marginalization, this finding is consistent with the hypothesis that the primary effect of immunized alliances is an internalization of this demand externality. The results are also shown to be robust to different data sets that attempt to control for so called "mix effects," where changes in the mix of business and leisure traffic could explain some of the observed effects of alliances.

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[1] Even with liberalized aviation treaties, so-called "Open Skies", prohibitions on cabotage would prevent a foreign carrier from operating a segment within another country, and insufficient demand will prevent a carrier from operating nonstop service from its home country to many moderate- or small-sized international cities.

Lastly, this paper investigates the proposition that the benefits from immunized alliances are simply a byproduct of more liberalized aviation treaties (so-called "Open Skies"), which often occur in conjunction with grants of immunity. The results are inconsistent with this hypothesis, but regressions suggest that capacity increases between countries signing Open Skies treaties are due entirely to the expansion of immunized alliances on routes between their hubs.

This paper is organized as follows. Section two discusses airline pricing in international markets and provides a brief literature review. Section three discusses the construction of the data sets and provides some background on existing alliances. Section four presents summary statistics and the estimation strategy. Section five contains the regression results, and section six presents some additional analysis of immunity grants and Open Skies treaties. Section seven concludes.

2 Airline pricing in international markets

When carriers interline, the carrier marketing the ticket pays the foreign carrier a prorate (conditional on ticket restrictions) for each passenger transferring to that carrier to reach his final destination. For traditional, non-alliance interlining, prorates are determined at International Air Transport Association (IATA) tariff conferences and are often subject to the approval of the respective governments. At the conferences, which are immunized from antitrust laws, carriers collectively set interline fares and prorates for thousands of markets. Carriers are not required to charge the conference price but are required to compensate other carriers as if the conference price was charged.[2] For a more detailed description of IATA and its rate making role, see O'Connor (2000).

Brueckner (2003) and B&W (2000) argue that this pricing 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.[3]

When carriers enter a code-sharing agreement, they put their carrier designator code on each other's flights, which facilitates the marketing of interline tickets. The most common form of code-sharing allows a carrier relatively open access to its partner's capacity at a prorate determined by bilateral negotiations. Doganis (1991) and Brueckner (2003) suggest that code-sharing may result in lower fares because it allows carriers with preferences for lower prices to opt out of the IATA multilateral negotiations and set individualized prices. Thus while their prices are still inefficient (because of the double marginalization

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[2] 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).

[3] 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.

problem), they are lower than traditional interlining. Consistent with this belief, Brueckner (2003) finds that carriers with code-sharing agreements charge fares 8 to 17% lower than do traditional interline pairs.

Because national laws often limit foreign ownership in airlines and prevent mergers, the most integrated relationships occur when two carriers are granted antitrust immunity by 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). Prior to Open Skies treaties, air transport between two countries was often governed by complex agreements that regulated scheduling, capacity, and prices. Replacing these treaties with Open Skies allowed carriers to compete free of most government regulation. However, the term "Open Skies" is something of a misnomer as these treaties do not allow entry by foreign carriers into the domestic markets (cabotage) nor do they lift the cross-ownership restrictions that prevent cross-border mergers.

Because immunity grants allow carriers to behave as if they were merged, price setting on routes where their networks are complementary should mimic online pricing and allow carriers to internalize the double marginalization problem. This suggests that immunized-alliance prices should be even lower than are code-sharing prices and identical to online prices. Brueckner (2003) finds evidence consistent with the former, estimating that antitrust immunity is associated with fares 17 to 30% lower than traditional interlining, almost twice the effect of code-sharing. This paper additionally looks for evidence of the latter by testing for the equality of immunized and online fares.

While this research focuses primarily on the routes where the networks of the alliance partners are complementary, there are usually several, often densely traveled routes where alliance carriers provide substitute service. Competition on these routes could be reduced by alliances, particularly ones immunized from the antitrust laws. Any alliance welfare analysis would need to evaluate these potential harms as well, which is beyond the scope of this work.

A brief review of the remaining body of literature on international airline alliances is worthwhile. Park (1997) developed a Cournot game that generally predicted increased welfare from alliances with complementary route structures and decreased welfare when their route structures overlapped. Park and Zhang (1998) developed a model that predicted increased traffic on gateway routes from alliances and found empirical support for the hypothesis using data on transatlantic traffic. Oum et al. (1996) and Park and Zhang (2000) estimated the effects of code-sharing agreements using published prices. Hassin and Shy (2004) modeled the effects of code-sharing in markets where one carrier offers online service but the other must code-share with the competitor. Heimer and Shy (2006) modeled the effects in markets where the alliance partners compete, endogenizing the choice of flight frequency. Finally, Bilotkach (2004) developed a differentiated Bertrand model of alliances where consumers have preferences for fewer stops.

There is also a growing literature on the effects of domestic code-sharing alliances. Bamberger et al. (2004) and Ito and Lee (2004) found that domestic alliances generally lowered fares. Armantier and Richard (2005b) found heterogeneous effects across different types of markets from the Northwest-Continental alliance. Whalen (2005) found heterogeneous effects across different domestic alliances. Armantier and Richard (2005a) found that per passenger consumer surplus fell from the Northwest-Continental alliance using a discrete choice framework. Whalen (1999) found that potential benefits from converting interline traffic to online were small relative to the potential anticompetitive effects of domestic alliances.

3 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.[4]

This analysis uses data for the third quarter of every year from 1990 through 2000.[5] Because most 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 the appendix, but the creation of the data set is outlined here to give the reader a sense for what the data look like.

First, 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 alliances to fares of either traditional interlining or online, 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 that many of those likely involve reporting errors.

The data were then aggregated in two different ways to create two regression data sets. 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

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[4] Carriers are required by DOT to report fare data in U.S. dollars.

[5] 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 price effects from online, immunity, and code-sharing are generally larger (more negative) when the analysis uses first quarter data instead, but qualitatively the same. Output effects are nearly identical.

route. The second method aggregated the data to the origin-destination level (the route data set).

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 among the carriers on a route. For example, if alliances caused a disproportionate shift of low fare passengers to the alliance carriers, 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 mix between carriers and thus should correct for this potential problem.[6]

International routes fall into four basic categories, two of which are used in the empirical analysis and two excluded. Excluding some routes is necessary because an itinerary has to have a segment on a U.S. carrier to be reportable to DOT, and thus a substantial amount of traffic on routes where foreign carriers can offer online service can go unobserved. The included categories are behind-to-gateway routes and behind-to-beyond routes. The former are routes between a non-gateway U.S. airport and a foreign gateway airport. On these routes, a U.S. carrier can offer online service, but foreign carriers can only serve the route in conjunction with a U.S. carrier. Behind-to-beyond routes are between two non-gateway airports and thus only interline service (either alliance or non-alliance) is possible. Because foreign carriers cannot serve either type of route on an online basis, all the service is sampled by the DOT, giving a complete picture of service on the routes (within the sampling limitations).[7]

The excluded categories are gateway-to-gateway routes and gateway-to-beyond routes. The former are routes between U.S. and foreign gateway airports, typically hubs, where the U.S. and European hub carriers potentially offer overlapping nonstop service. These markets were excluded because this paper's focus is on alliance effects in markets where domestic and foreign service is complementary. Gateway-to-beyond routes, where service is between a U.S. gateway airport and a non-gateway foreign airport, were also excluded. Foreign carriers can offer online service on these routes, but because only U.S. carriers report data to the DOT, that service would go unobserved and potentially bias the empirical results.

DOT T-100 Service Segment data were used to identify these categories of markets. The T-100 data report, among other things, the number of operations by carrier between every airport pair so long as one of the airports is in the U.S.

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

[7] The empirical analysis pools both categories of routes. Estimating separate models for behind-beyond and behind-gateway routes produces qualitatively similar results.

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	

Both foreign and U.S. carriers report these data.[8] In order 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.

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

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[8] Prior to 1998, foreign carriers only reported on-board passengers to the DOT, which then used the Official Airline Guide's scheduling data to estimate the available seats and frequencies of the foreign carriers.

agreements that appeared in the data over this eleven-year period and eight grants of antitrust immunity.[9]

The first major alliance was between Northwest Airlines and KLM, which began in 1989. The two airlines began code-sharing in 1991 and, in 1993, became the first immunized alliance. While most of the agreements, once started, continued throughout the entire sample period, six of the code-sharing agreements and three of the immunities were terminated during the sample period. The most notable terminated code-share was between USAir and British Airways, which lasted from 1993 to 1996. The terminated immunized alliances were Delta Air Lines-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 Annual National Account database.[10]

4 Estimation strategy

4.1 Summary statistics

The summary statistics for both data sets are presented in Table 2. Not surprisingly, they are quite similar. In the route-carrier data, the average fare (Avg Fare) is $697, itineraries have an average of 2.6 coupon segments (Avg Coup), and 12% of the itineraries are for one-way travel (Pct OW). The average number of sampled passengers in a quarter on each route (Mkt Pax) is 30.7, which corresponds to 307 actual passengers. 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 (Online), code-share alliance (CS), or immunized alliance (Immunity).[11] In the data set, 42% of the service is online, 14% is immunized, and 6% is code-sharing. The excluded

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[9] American Airlines and British Airways do not appear in this table. While the two airlines have a joint marketing agreement and founded the “oneworld” alliance, regulatory barriers prevented them from code-sharing until 2003. The results in this paper, however, are virtually unchanged if American and British Airways are counted as code-sharing partners.

[10] The GDP data were convert to U.S. dollars by the OECD using constant 2000 exchange rates.

[11] Carriers with code-sharing alliances 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 variable for code-sharing indicates whether the two carriers operating the itinerary had a code-sharing alliance.

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
Pct OW	0.118	0.280	Pct OW	0.116	0.254
Avg Dist	5098.6	765.1	Avg Dist	5063.3	734.0
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			

category in the regressions is non-alliance interline service, which constitutes the remaining 38%.[12]

Competition in the markets is measured using a Herfindahl-Hirschman index (HHI). The most significant source of competition comes from carriers offering online or alliance service. Competition could also come from non-alliance interline service, but one could argue that because the pricing of this type of service is so heavily dependent on IATA tariff conference negotiations, its pricing may just reflect some kind of cartel behavior. So, similar to B&W (2000) and Brueckner (2003), separate HHIs were calculated for carriers offering online or alliance service (HHI_Oa) from those offering just non-alliance interline service (HHI_Int).[13]

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 Airlines carried five passengers on an online basis, the United-Lufthansa immunized alliance carried two, and the Delta-Air

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[12] Table 2 shows a sizeable difference in the average number of market passengers between the data sets. Because the route-carrier data set has an observation for each carrier or carrier-pair with traffic on the route, routes with a large number of passengers tend to have more observations than do routes with a small number of passengers. Table 2 presents simple averages; thus in the route-carrier data, large routes are weighted more heavily by virtue of having more observations in the data.

[13] B&W (2000) and Brueckner (2003) use the number of firms rather than HHIs, but otherwise the construction is similar.

France code-sharing alliance carried three.[14] 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). Delta and Air France are counted separately, and the 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 were 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 (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 average number of coupon segments and the percentage one-way remain the same at 2.6 and 12%, respectively. The HHI_Oa is slightly higher at 0.60, while the HHI_Int is slightly lower at 0.25. The number of sampled passengers in a market is 14, roughly half the number in the route-carrier data.

Because the route data are 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 also 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).

4.2 Estimation strategy

Fixed effects regressions were estimated to measure the price and output effects of different types of service.[15] The basic forms of the regression equations are listed below where *DepVar* is the log transformation of average fare in the price regressions and the log of the number of passengers in the output regressions. The first equation is for the route-carrier data set. 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

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

[15] This paper estimates reduced form regressions of price and output. Estimating a structural model requires specifying an equation for marginal cost, which in this context is unrealistic. While marginal cost is not a well defined concept for airlines to begin with, it is particularly problematic in the case of international service because traditional measures of cost such as cost-per-available-seat-mile are not available for just the international service of domestic carriers nor at all for foreign carriers. Furthermore, other measure such as fuel costs tend to be very poor predictors of price.

above. The route effects in both equations are differenced out using fixed effects. Carrier dummy variables are included to control for carrier-specific effects, and year dummy variables capture period-specific effects.[16]

$$\begin{aligned} DepVar_{i,m,t} = f(&Online_{i,m,t}, Immunity_{i,t}, CS_{i,t}, Avg\,Coup_{i,m,t}, AvgDist_{i,m,t},\\ &PctOW_{i,m,t}, HHI\_OA_{m,t}, HHI\_INT_{m,t}, Opensky_{m,t}, US\,Pop_{m,t},\\ &US\,Inc_{m,t}, EU\,Pop_{m,t}, EU\,GDP/Pop_{m,t}, YearEffects_{t},\\ &Carrier\,Effects_{i}, Route\,Effects_{m}) \end{aligned} \tag{4}$$

$$\begin{aligned} Dep\,Var_{m,t} = g(&Pct\,Online_{m,t}, Pct\,Immune_{m,t}, Pct\,CS_{m,t}, Avg\,Coup_{m,t},\\ &Avg\,Dist_{m,t}, Pct\,OW_{m,t}, HHI\_OA_{m,t}, HHI\_INT_{m,t}, Opensky_{m,t},\\ &US\,Pop_{m,t}, US\,Inc_{m,t}, EU\,Pop_{m,t}, EU\,GDP/Pop_{m,t},\\ &Year\,Dummies_{t}, Carrier\,Shares_{m,t}, Route\,Effects_{m}) \end{aligned} \tag{5}$$

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 is fare setting through the IATA process.

In some specifications of the regression analysis, the HHIs will be treated as endogenous. As instruments, the regressions include lagged HHIs for all service, online and alliance service, and interline service (and their squares). They also include the lagged number of carriers offering any service, the lagged number offering online service, and the lagged number offering immunized or code-share services (and their squares). In addition, one specification will also treat code-sharing as endogenous. Those details are discussed below.

5 Regression results

Tables 3 and 4 contain the results of the fixed-effects estimations on price. Table 3 has the results for the route-carrier data set, and Table 4 has the route data results.[17] The first specification in each table, OLS (1), includes route- and time-

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[16] The coefficients on the year and carrier dummy variables are omitted from the tables but are available from the author on request.

[17] All of the regressions use White's robust variance estimator to correct for potential heteroscedasticity. Because the measure of price is the average fare, it is quite likely that the variance differs across observations depending on the number of itineraries that factor into the average fare.

Table 3 Price regression results—route-carrier data set

	OLS (1)	OLS (2)	IV (1)	IV (2)	Endog CS
Online	−0.2683***	−0.1911***	−0.2570***	−0.1760***	−0.1812***
	−63.01	−8.55	−13.73	−5.59	−7.50
Immunity	−0.2318***	−0.1886***	−0.2212***	−0.1837***	−0.1817***
	−43.28	−26.12	−9.30	−7.28	−24.14
CS	−0.0934***	−0.0987***	−0.0675***	−0.0785***	−0.0414***
	−13.82	−13.03	−5.22	−5.84	−4.83
Open Sky	0.0491***	0.0429***	0.0416***	0.0387***	0.0400***
	8.90	7.76	6.50	6.14	6.86
Avg Coup	−0.0611***	−0.0462***	−0.0690***	−0.0533***	−0.0490***
	−15.64	−11.24	−16.10	−12.64	−11.36
Pct OW	0.4409***	0.4468***	0.4534***	0.4597***	0.4578***
	65.10	66.90	76.20	77.54	65.04
Avg Dist	0.4637***	0.1801***	0.4628***	0.1696***	0.1800***
	16.71	6.01	17.50	5.52	5.78
EU Pop	0.2370***	0.2857***	1.6188***	1.2796***	1.3042***
	4.22	5.12	4.63	3.65	4.58
EU Gdp/Pop	0.3752***	0.3904***	0.2997***	0.3701***	0.3350***
	11.31	11.95	3.54	4.45	7.67
US Pop	−0.3966***	−0.3969***	−0.4316***	−0.4143***	−0.4916***
	−9.66	−9.74	−6.73	−6.36	−10.55
US Inc	0.3812***	0.3450***	0.3990***	0.3583***	0.2494***
	6.20	5.66	5.32	4.79	3.71
HHI_Oa	0.0141**	0.0071	0.1238	0.1392	0.0088
	2.40	1.22	0.79	0.88	1.41
HHI_Int	0.0149*	0.0134*	0.2295**	0.1950*	0.0286***
	1.83	1.66	2.22	1.91	3.46
Constant	−3.5208**	−2.5018*	−26.3139***	−19.2695***	−17.1980***
	−2.56	−1.80	−4.96	−3.66	4.77
Time effects	Yes	Yes	Yes	Yes	Yes
Carrier effects	No	Yes	No	Yes	Yes
Route effects	Yes	Yes	Yes	Yes	Yes
P-value: Onl=Imm	0.00	0.912	0.00	0.742	0.982
R^2	0.131	0.151	0.127	0.149	0.152
Observations	120,758	120,758	104,867	104,867	113,295

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

specific effects, while the second, OLS (2), adds carrier-specific effects.[18] The third and fourth, IV (1) and IV (2), repeat these specifications using instrumental variables to control for the potential endogeneity of the HHIs. The route-carrier results contain an additional specification, Endog CS, that endogenizes the decision on which routes to code-share.

For the coefficients of particular interest, all of the regressions produce similar results that are mostly consistent with expectations. Focusing first on the route-carrier data in Table 3, we find that the effect of online service on average fares is qualitatively similar across all of the specifications and highly

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[18] Separate regressions allowing for an AR(1) process were estimated using the route data set to test the sensitivity of the results to potential autocorrelation. Price effects were unaffected while output effects were slightly smaller.

Table 4 Price regression results—route data set

	OLS (1)	OLS (2)	IV (1)	IV (2)
Pct Online	−0.2283***	−0.1903***	−0.3124***	−0.2467**
	−20.55	−3.91	−3.41	−2.07
Pct Immune	−0.1849***	−0.1429***	−0.2687***	−0.2201**
	−15.11	−9.21	−2.82	−2.19
Pct CS	−0.0556***	−0.0477***	−0.0484	−0.0456
	−3.94	−3.10	−0.78	−0.70
Open Sky	0.0414***	0.0324***	0.0390***	0.0331***
	5.96	4.59	4.89	4.08
Avg Coup	−0.0412***	−0.0376***	−0.0480***	−0.0470***
	−5.53	−4.87	−5.82	−5.79
Pct OW	0.4598***	0.4623***	0.4864***	0.4894***
	44.01	44.53	50.42	50.75
Avg Dist	0.4580***	0.2746***	0.4170***	0.2466***
	8.61	4.80	8.14	4.49
EU Pop	0.3459***	0.3696***	1.6180***	1.0966***
	4.80	5.09	4.30	2.87
EU Gdp/Pop	0.3562***	0.3580***	0.2563***	0.3233***
	8.58	8.53	4.11	5.13
US Pop	−0.4053***	−0.4404***	−0.3479***	−0.3686***
	−7.74	−8.41	−5.02	−5.17
US Inc	0.2500***	0.1948**	0.2801***	0.2075**
	3.25	2.53	3.11	2.31
HHI_Oa	0.0013	0.0023	0.1742*	0.1589
	0.16	0.29	1.81	1.58
HHI_Int	0.0619***	0.0621***	0.1623	0.1457
	5.84	5.89	1.29	1.17
Constant	−3.9088**	−0.9584	−25.4958***	−14.1059**
	−2.18	−0.46	−4.04	−2.02
Time effects	Yes	Yes	Yes	Yes
Carrier effects	No	Yes	No	Yes
Route effects	Yes	Yes	Yes	Yes
P-value: Onl = Imm	0.00	0.33	0.00	0.60
R^2	0.130	0.143	0.127	0.142
Observations	54,893	54,893	45,510	45,510

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

statistically significant. In the first specification, online service is associated with 23.5% lower fares as compared to non-alliance interline service.[19] When carrier-specific effects are included in OLS (2), the effect of online service drops to 17.4%. This generally suggests that carriers with lower prices on a particular route are more likely to offer online service. The effects are similar, though slightly smaller, in the IV estimates. Without carrier-specific effects, online service is associated with 22.7% lower fares; with carrier-specific effects, online service has fares that are 16.1% lower. All of these results are consistent with

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[19] Because the dependent variable in the 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 hypothesis that carriers are not able to price non-alliance interline service efficiently.

For immunized alliances, the results are strikingly similar. In the absence of carrier-specific effects, immunized alliance fares are 20.7% lower than non-alliance interline fares. When carrier effects are included, the effect shrinks to 17.2%. As with online service, this suggests that carriers with lower prices enter into immunized alliances. The IV estimates are similar. Without carrier effects, immunized service is associated with 18.8% lower fares; with carrier effects, immunized service brings fares that are 16.8% lower. 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 conducted for the equality of the online and immunity coefficients to determine 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.

The results on code-sharing suggest that it has roughly half of the effect of online or immunity pricing. In the OLS regressions, code-sharing is associated with 8.9% and 9.4% lower fares as compared to non-alliance interlining without and with carrier effects, respectively. In the IV regressions, the effects are generally smaller as code-sharing is associated with 6.5% and 7.5% lower fares. All of these results are significant at a 1% level, but, unlike the online and immunity results, the inclusion of carrier-specific effects does not have much impact on the coefficients. This is surprising given the expectation that low-price carriers would be more likely to enter into code-sharing agreements to escape the IATA process.

Because carriers do not code-share over their entire network, the decision to code-share on a route could be affected by unobserved route characteristics that also affect prices. The fixed-effect estimates reduce this endogeneity concern by controlling for invariant route characteristics, but it remains possible that carriers choose to code-share on routes where prices are otherwise higher or lower, biasing the econometric estimates. In the last column of the route-carrier table, results are presented allowing for the endogeneity of code-sharing. In the first stage estimate, the probability of code-sharing is predicted using a fixed effects logit model. The instrumental variables omitted from the second stage are the number of interline passengers carried by each airline on the itinerary lagged by one year and their product. The second stage uses the probability of code-sharing in place of the dummy variable. The results show little change for the online and immunity coefficients. The coefficient on code-sharing, however, is smaller but still statistically significant, suggesting that while code-sharing is associated with lower fares than is traditional interlining, carriers may code-share on routes where prices are otherwise lower.

Table 4 contains the results using the route data set. Because this data set is invariant to changes in the mix of business and leisure passengers among carriers on a particular route, these results provide some insight into passenger mix effects. 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. 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 $(e^{\beta} - 1)RS$ where β is the coefficient for online service and RS is the revenue share of the passengers switching to online service. In the route data set, the change in the average fare is $e^{\delta MS} - 1$ where δ is the coefficient for online service and MS is the passenger share of switching passengers.[20]

The coefficients are directly comparable 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 comparable, with the recognition that they are generally only approximately equal.

The results are very similar to the route-carrier results, suggesting that mix effects are not significantly distorting the results. For exposition, the text focuses on the specifications that include carrier effects, OLS (2), and IV (2). In OLS (2), the results for online and immunized service are slightly smaller in the route data set. Online service is associated with 17.3% lower fares compared to 17.4% in the route-carrier data. Immunized alliance fares are 13.3% lower compared to 17.2% 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 21.9% lower compared to 16.1% in the route-carrier data. For immunity, the fares are 19.8% lower compared to 16.8% in the route-carrier data. As in the route-carrier results, immunized fares are statistically identical to online fares in the specifications that include carrier effects.

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 4.7% lower fares compared to 9.4% in the route-carrier data. In the IV regression, code-sharing fares are 4.5% lower compared to 7.5% in the route-carrier data. While the non-IV results are highly significant, the code-sharing coefficients in the IV specifications are not.

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[20] These derivations are available from the author on request.

In both data sets, the other variables produce results mostly consistent with expectations. The average number of coupon segments has a negative coefficient in all specifications, suggesting that consumers view additional coupon segments as an inferior product. The percentage of passengers traveling on a one-way basis has a positive coefficient, which is consistent with the belief that business travelers are more likely to purchase one-way tickets. The coefficients on U.S. MSA per capita income and European country GDP per population are positive in every specification, indicating that average fares are higher in places with greater income. European country population has a positive effect on average fares, suggesting that higher populations are associated with higher demand and prices. However, the coefficient on U.S. MSA population is negative and significant in every specification. Places with greater populations may have more competition, the effect of which may be partially captured by this population variable.[21]

The measure of concentration for online and alliance service, while correctly signed, is small in magnitude and generally insignificant in the OLS specifications. In the IV specifications, its magnitude rises substantially, but it remains insignificant in all but one specification. These small effects from concentration are unusual but consistent with B&W (2000) and Bruecker (2003) who also found small effects. The HHI constructed from carriers providing only non-alliance interline service has a positive and generally significant effect in the non-IV specifications. Like HHI_OA, the coefficients increase in magnitude in the IV specifications but generally become less significant. 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.

Finally, the coefficient on the Open Skies variable is positive and significant, 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.

5.1 Output regressions

Table 5 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

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[21] One substantive difference when carrier fixed-effects are included in the regressions is that the coefficient measuring the average distance of the itineraries shrinks considerably. Four carriers seem completely to drive this change. Three of them, Continental Airlines, US Airways, and Northwest Airlines, tend to have both low average distance and low average fares. The fourth, Delta Air Lines, tends to have high average distance and high average fares. Because US Airways, Continental, and Northwest have smaller networks, they may be less attractive to the higher yielding transatlantic traffic, resulting in lower average fares. It is not surprising that this effect is correlated with average distance because Continental and US Airways have well-positioned international hubs in Newark and Philadelphia, respectively, while Delta connects many of its European passengers through Atlanta.

Table 5 Output regressions results

	Rt-Car (1)	Rt-Car (2)	Rt (1)	Rt (2)
Online	1.0186***	0.7698***	0.7516***	0.6229***
	144.22	26.98	34.70	8.78
Immunity	0.4866***	0.4152***	0.6288***	0.5719***
	62.64	41.31	29.51	23.34
CS	0.1967***	0.2539***	0.3628***	0.3421***
	21.18	24.90	17.19	15.23
Open Sky	−0.0130	−0.0039	−0.0077	0.0023
	−1.42	−0.43	−0.68	0.20
Avg Coup	−0.4179***	−0.3820***	−0.2043***	−0.1901***
	−68.95	−60.42	−17.31	−15.62
Pct OW	−0.4546***	−0.4557***	−0.6035***	−0.6022***
	−60.49	−60.86	−49.39	−49.32
Avg Dist	−1.3840***	−1.7126***	−0.7178***	−0.6414***
	−33.24	−37.66	−9.11	−7.58
EU Pop	−0.4883***	−0.2921***	−0.5484***	−0.5452***
	−4.59	−2.75	−4.25	−4.22
EU Gdp/Pop	−0.1745***	−0.0837	0.1332*	0.1012
	−2.88	−1.39	1.79	1.35
US Pop	0.9687***	0.9223***	1.3475***	1.2994***
	12.83	12.28	13.80	13.31
US Inc	0.2144**	0.2189**	1.0197***	0.9387***
	2.05	2.12	7.66	7.08
HHI_Oa	−0.1801***	−0.1857***	−0.2573***	−0.2440***
	−22.06	−22.74	−17.78	−16.79
HHI_Int	0.2453***	0.2436***	0.6755***	0.6704***
	17.44	17.56	33.81	33.76
Constant	8.3555***	6.5782***	−12.1353***	−5.7043
	3.35	2.63	−3.84	−1.45
Time effects	Yes	Yes	Yes	Yes
Carrier effects	No	Yes	No	Yes
Route effects	Yes	Yes	Yes	Yes
R^2	0.310	0.329	0.208	0.215
Observations	120,758	120,758	54,893	54,893

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

log of total passengers on the route. 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 5 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 an increase in output of 62.7% without carrier effects and 51.5% with them. In the route data, switching a route from entirely non-alliance service to entirely immunized service is associated with an 87.5% or 77.2% increase in output without and with carrier effects, respectively. Code-sharing has a similar effect on output, though with roughly half the magnitude. The effect of code-sharing on output ranges from 21.7–43.7% 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 additional connections. 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 a majority of the data are 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. In addition, if an interaction term between European population and per capita GDP is included, the marginal effect on output of increasing population is positive for all but the poorest countries in the data. Similarly, the marginal effect of increasing per capita GDP is positive for all but the least populated countries. Thus, the counterintuitive signs on GDP and population appear to be driven by the poorest and least populated countries in the data. 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 competition for carriers offering online or alliance service, has a negative and significant coefficient, suggesting that increases in concentration are associated with lower output. Although this is the expected result, it is somewhat surprising because the price regressions did not produce 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 are likely due to correlation between HHI_Int and something unobserved about bilateral treaties. A detailed study of the effects of bilateral treaties is beyond the scope of this work, but is a potentially interesting area of study.

6 Open Skies Agreements and Antitrust Immunity

One anomalous result in the regressions is that Open Skies treaties are associated with 3–5% higher average fares. Because Open Skies treaties relax restrictive bilateral agreements, it is likely that these were beneficial to consumers. In fact, DOT analysis suggests that traffic expanded between countries that signed Open Skies agreements.[22] This section explores some possible explanations for this result.

One potential explanation is that Open Skies treaties are highly correlated with grants of immunity and induce a multicolinearity problem. However, while Open Skies treaties are a necessary condition for immunity grants, the variables are not particularly highly correlated. Many non-immunized carriers continue to carry passengers to countries with Open Skies treaties, and, moreover, the

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[22] See U.S. DOT (1999)

Table 6 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%

U.S. has Open Skies treaties with several countries where no carriers were granted antitrust immunity.[23] Finally, if the Open Skies variable is removed from the regressions, the results are largely unchanged.

Another possibility is that Open Skies shifted out the demand curve for service between U.S. and European gateway airports. Transatlantic capacity is shared between gateway-to-gateway and beyond passengers, so if carriers increased capacity by less than what was necessary to meet all the new demand, the opportunity cost of carrying a connecting passenger would rise. Hence the price would also rise.[24]

In order 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.-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 U.S.-Germany itineraries from the third quarter of 1995 and 1997 for passengers who traveled on a U.S. carrier and connected in Germany to a Lufthansa flight. 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.

Table 6 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%. Though 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.

In order to understand more systematically how Open Skies treaties affected capacity decisions, regressions were estimated using data sets of transatlantic gateway-to-gateway capacities. Capacities, as measured by number of

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[23] For example, the U.S. has Open Skies treaties with Finland, Denmark, and Norway, but there are no immunized alliances with carriers based in those countries.

[24] Airlines might respond with less than the necessary capacity if operating costs are rising–perhaps, for example, if the increase in capacity increases airport congestion or results in higher airport usage fees. I thank an anonymous referee for this observation.

departures and also by 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 were aggregated into a route data set and a route-carrier data set. This allows for four separate specifications using departures and seats as the capacity measures for each data set. 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, and no immunized or code-share alliance between the carrier operating the service and a carrier based in the destination country.
2. Cld-CS: no Open Skies, and the carrier has a code-sharing agreement with a carrier based in the destination country.
3. Open-Int: Open Skies, and the carrier has no alliances with carriers from the destination country.
4. Open-CS: Open Skies, and the carrier has a code-sharing agreement with a carrier from the destination country.
5. Open-Immune: Open Skies, and the carrier has an immunized alliance with a carrier from the destination country. This last category is further classified 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 dummy variables are set equal to one if any carrier on the route has a code-sharing or immunized alliance, respectively. These regressions also include the population and income measures used previously, 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 7. The first two columns present results for the number of operations and the number of seats using the route data set while the second two use the route-carrier data. All four specifications produce similar results: 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 departures on hub-hub routes with immunized carriers rose 20.1%, while the number of seats rose by 29.8%. In the route-carrier data, the number of operations rose by 19.1%, and the number of seats rose by 36.5%. 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 approximately

Table 7 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
Open-Immune: Other	−0.0328	0.0176	−0.0007	0.0325
	−0.87	0.43	−0.02	0.81
EU Pop	−0.0054	0.1195	−0.0983	0.0112
	−0.02	0.41	−0.46	0.04
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 effects	Yes	Yes	Yes	Yes
Carrier effects	No	No	Yes	Yes
Route effects	Yes	Yes	Yes	Yes
R^2	0.135	0.097	0.483	0.393
Observations	1704	1704	2563	2563

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

10%. In the route-carrier data, the effects were smaller, roughly 4%, and less 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 with other carriers to their alliance 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 the theory cannot be directly 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, thus raising the opportunity cost of carrying a connecting passenger.

7 Conclusion

This paper uses an extensive 11-year panel of data 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 as compared to non-alliance interline service. However, the price effects found here are somewhat smaller than those found in the cross sectional analysis of previous work. These results suggest that immunized fares are 13–20% lower than traditional interline fares and code-sharing fares are 5–9% lower.

This paper also finds that online service is associated with fares that are 16–22% 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 immunized alliances are internalizing this demand externality. 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. Consistent with the price effects, immunized alliances are also associated with large increases in output, between 52–88%. Similarly, code-sharing is associated with 22–44% increases in output. 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.

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 these 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

This appendix provides details about the treatment of the O&D data. Itineraries with open jaws, surface segments, or that failed the DOT's Dollar Credibility Indicator, suggesting that the reported fare was likely in error, were deleted. Also deleted were itineraries in which either the outbound or return portions exceeded 4 coupon segments. These itineraries are rare but frequently in error. Itineraries with origins, destinations, or stops outside of the continental U.S. and Europe were deleted. Itineraries with the "unknown" carrier codes, UK and YY, were also deleted.[25] Commuter carriers that reported independently from their major carrier partner were recoded to the major wherever possible.[26] Itineraries with more than two carriers were deleted. Some airport codes were also recoded when the metro area code was used instead of the airport code.

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[25] Unfortunately, prior to 1999 DOT used carrier code UK for both unknown carrier and Air UK. Because there is no reasonable way to sort out these codes, Air UK is removed from the analysis.

[26] They are RU to CO; EW, EN to LH; XJ, 9E to NW; EV, OH to DL; DH, ZW, U2, ZK to UA; MQ to AA; WA to KL; IT to AF; GT to BA; TB, ZV, ED, 12, 13, 14, 16, 17 to US.

Itineraries were deleted if the fare was equal to or greater than \$9999 or equal to \$4999.5. Fares in excess of \$9999 are rare, and the small mass of fares at exactly \$9999 were likely intended as "not available." Fares below \$100 were also deleted.

Itineraries involving carriers with ten or fewer sampled passengers over the entire 11 year sample were deleted. Itineraries with two U.S. carriers were also deleted. Finally, carrier-specific effects were included for the 35 carriers with at least 500 sampled passengers over the 11 years. Carriers that failed this screen were counted in a single "other" carrier category. In the route-carrier data, the carrier effect variable is set to 1 for online service and 1/2 for each carrier providing interline service. In the route data set, the carrier effects are aggregated to shares.

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