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The effects of airline alliances: What do the aggregate data say?[1]

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Abstract:

We consider an empirical model of worldwide airline alliances that we apply to a large set of companies for the period 1995-2000. Using observations at the companies level, we estimate a cost, capacity, and demand system that accounts for cross-price elasticities. From the estimates, we shed light on the fact that many airlines involved in the same alliances are potential substitutes. We also test for the effects of alliances on airlines' fares and suggest that airlines inside alliances cut prices by 5% on average compared to airlines outside alliances. Finally, we construct price-cost margins for each airlines and suggest that current pricing habits are not uniform and vary from one alliance to another.

Keywords: Alliances, airline, cross-price elasticities, Nash behavior.

JEL: L11, L13, L41, L93

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1 Introduction

Using aggregate data at the airline level, we analyze worldwide airline alliances. We suggest that airlines inside alliances cut prices by 5% on average. We also propose an empirical model that allows us to evaluate to which extend two airlines' networks are substitutes. We suggest that a significant number of airlines enrolled in the same alliances offer services which can be considered as substitutes, which could lead to anti-competitive practices. We also evaluate price cost margins for each alliance and shed light on whether these margins obey to some Nash pricing behavior.

There is increasing evidence suggesting that strategic alliances between otherwise independent firms have become commonplace in a wide variety of industries. According to Oster (1994), a strategic alliance could be defined as an arrangement in which two or more firms combine resources outside the market in order to accomplish a particular task or set of tasks. In the airline industry, deregulation has triggered several waves of alliances between worldwide airlines. Alliances between airlines are mainly designed to achieve fleet rationalization, expansion and rationalization of network structure as well as greater exploitation of cost economies. In particular, international airlines have the opportunity to extend their networks to foreign countries by entering an alliance agreement with a foreign airline. By coordinating their services or production processes, alliance partners can offer greater convenience to consumers, including access to connecting services, greater efficiencies and procedural operations in ticketing, ground handling and baggage handling, expanded route networks and connecting options.

Airlines can engage as well in cooperative pricing, while enjoying antitrust immunity. Strategic alliances in the airline industry have attracted more antitrust attention than any others.[1] Many types of alliances have been adopted by airlines, ranging from agreements that involve relatively little cooperation such as frequent flyer programs to agreements commonly known as code sharing practices that involve the sharing of costly assets such as planes, terminals, counters, crews and more (see Oum and Park, 1997, for more details on the forms of alliances in the airline industry). Code sharing arrangements have been until very recently the most popular form of alliance adopted by airlines. In this case, two companies operating two connecting routes offer an interline trip that is ticketed as

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[1] The European Commission Article 81 and 82 Treaty states that the Commission can exempt an alliance if it considers that the economic efficiencies and overall benefits of the transaction outweigh the anti-competitive effects.

if the two components were served by one single airline.

Economic studies focusing on the effect of airline alliances on welfare have identified various counter powered effects. Oum, Park, and Zhang (1996), Brueckner and Whalen (2000), Brueckner (2001 and 2003), and Whalen (2007) among others have focused on the competitive effects of international alliances. Bamberger, Carlton and Neumann (2004) among others have investigated domestic alliances. These authors suggest that, if the corresponding networks of the alliance members offer the possibility of connecting many routes, they can be regarded as complements. In this case, firms cooperate on routes that were not individually served before, but are created by connecting networks. Accordingly, after the alliance, both prices and costs will fall and both buyers and sellers will be better off. In contrast, if the corresponding networks of alliance members used to overlap for a large number of routes, they can be regarded as substitutes (parallel alliances). In this case, the firms share planes on routes that they both used to served individually. This results in softer competition, and therefore, higher prices.

We aim at considering all the international alliances that were operating between 1995 and 2000, using annual aggregate data on firms' balance sheets, capacity and demand levels. We empirically analyze whether the network of individual alliance members is a substitute or a complement for the other alliance member's network. To do so, we estimate a cost, capacity, and demand system for airline companies, accounting for cross-price elasticities. Estimating demand entails proposing a original procedure in the specific context of the airline industry that allows reducing the number of cross price elasticity parameters to be estimated. In particular, we account for connecting and overlapping route between airlines' networks.

We also test for the effects of alliances on airlines' aggregate prices and costs. We confirm that being a member of an alliance entails cutting prices significantly with respect to airlines from outside alliances. However, we do not find any significant effect of the alliances on airlines' operating costs. Finally, we retrieve cost and demand parameters, construct marginal costs, and derive price-cost margins for each airline and alliance. We want to test whether some general pricing behavior can be observed at the airline level, i.e., we test whether pricing policies by airlines correspond to Nash pricing. Our results suggest that companies outside the alliances suffer from lower price-costs margins than those within alliances, even if, on average, they set higher prices.

The rest of the paper is organized as follows: The next section presents a discussion of the data we use and the associated methodology. Section 3 proposes to construct airlines' networks substitution indexes. Section 4 presents the basic capacity, demand and cost ingredients which are inherent to our airline model. Section 5 focuses on the empirical implementation of the model. In particular, functional forms and the estimation procedure are presented. We develop in this section the procedure we use in order to model the price demand interactions between the different companies' networks of our dataset. Section 6 discusses our estimation procedure. In particular, we present the instruments we use to proxy airlines' fares in the demand equation. Section 7 is dedicated to the description of the dataset and the construction of the variables. Section 8 presents the estimation results. Section 9 proposes an evaluation of competitive forces in the industry.

2 Discussing the data and the model

In what follows we specify a model of airlines' behavior that entails estimating the international demand faced by each airline as well as its technology. The ideal modelling approach consists in working at the airline-route level. This approach has been followed by Borenstein (1989), Oum, Park, and Zhang (1996), Brueckner and Whalen (2000), Brueckner (2001 and 2003), or Whalen (2007), where a specific market is an origin destination pair. Given that airlines take different price and capacity decisions on each market they operate, working at the airline-route level allows the researcher to observe and account for each market characteristics such as the number and identity of the competitors, the length of the route, or the prices of each product available.

In this paper, we are interested in shedding light on alliance effects on airlines' behavior at a more aggregate level, i.e., at the airline level. Our motivation is twofold: First, the researcher focusing on non-U.S. airlines is usually constrained by the quality of the data available, which makes any work at the airline-route level unfeasible.[2] Second, we aim at advocating the idea that airlines may take corporate and strategical decisions at the

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[2] Data at the airline-route level are provided by the U.S. Department of Transportation. The database allows observing only interline trips where at least one route segment is flown on a U.S. airline. This implies for instance that it contains information on the United-Lufthansa or United-SAS pairs, but it does not on the routes jointly operated by Lufthansa and SAS. Data at the airline-route level for airlines outside the U.S. are in general very limited. For instance, the world air transport statistics published by the International Civil Aviation Organization (ICAO) and the Air Transport Association (IATA) do not contain observations on ticket prices at the route level.

entire network level. An airline enters an alliance in order to expend its network overseas to destinations points that it could not reach otherwise, because of the high fixed costs induced, or because most countries do not permit cabotage by foreign companies. The decision of an airline to join an alliance and eventually find appropriate solutions to reorganize its productive structure affects its operating costs and the demand it faces at the network level. Airlines serve a large number of interconnected routes that form a network. Sometimes consumers buy a company's service in one single route (what is known as a direct flight) but very often they buy sets of (normally two or three) interconnected routes (indirect flights through one or two hubs). Additionally, when buying a ticket in an individual route, frequent consumers take into account the company's network size and characteristics, since this affects the flexibility to make further interconnections if needed, exchange tickets, take alternative routes and even enjoy frequent flyer prizes and discounts. Scope economies among routes and network effects (almost) impose a common policy to all the routes served by a given airline.[3]

In other words, we aim at proposing a different approach based on aggregate data which attempts to derive lessons at the airlines' network level rather than the route level. We propose two main contributions: First, we test for the impact of the formation of alliances on airlines annual prices and costs. We suggest that price reductions due to alliances are strong enough so that they can be identified through annual prices. We find no empirical evidence however on the effect of alliances on airlines' operating costs. Second, we propose an original demand framework that accounts for the intensity of competition in each airline's main hub. In particular, we account for the proportions of overlapping and connecting route kilometers between two airlines' main hub. We identify a substitution index cut-off above which two airlines' networks can be considered as substitutes.

The dataset has been constructed for the period 1995-2000 from raw data included in *Digest of Statistics* published by International Civil Aviation Organization (ICAO), *World Air Transport Statistics* published by International Air Transport Association (IATA), and *Economic Outlook* published by the Economics and Statistics Department of the Organization for Economic Cooperation and Development (OECD) as well as airlines annual

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[3] This type of aggregate approach has been mostly used by authors measuring the effects of the European airline deregulation on airlines' costs reductions. This is the case for instance in Good et al. (1993), Neven et al. (1996 and 2001), Röller and Sickles (2000), Marín (1998), and Gagnepain and Marin (2006).

reports. The companies under study are worldwide airlines with special attention to the U.S. and the E.U. airlines, which usually constitute the main alliance partners. Some of the airlines belong to international alliances and some others operate as independent airlines. The dataset includes observations for a total of 55 airline airlines, as shown in table 1. Table 2 presents a list of the different alliances members.

3 A measure of network substitution

We propose a methodology based on airlines' total networks. We define first in this section a measure of substitution between two airlines' networks. To illustrate our aim, we present an example in Figure 1, where five airlines operate services on five networks. Some networks have no overlapping routes: This is the case for instance of network 1 and 2, which have a city (I) in common, but no overlapping routes. These two networks are said to be complements. As the number of overlapping route kilometers between two networks increases, so does the degree of substitutability between them. Networks 1 and 3 have one route in common; in particular, they share two cities, B and I. Networks 1 and 4 have two routes in common, given that they both operate at cities B, I, and H. Finally, networks 1 and 5 share all routes (cities A, B, I, and H), which makes them perfect substitutes.

Hence, counting the number of route kilometers that two networks have in common allows us to derive a substitutability index between two networks. This in turn enables us to shed light on the degree of substitutability between two (average products of) airlines. Note however that, due to data restriction, we do not have detailed information on the activity of airlines on each route they operate. We are nevertheless able to observe airlines' operations in their respective hub. This is a potential drawback, since we do not observe the entire activity of an airline, but we are confident that the observation of airlines' activity through their hubs provides a fair instrument, as the hub is the center of gravity of airlines' operations.[4]

In figure 2, we illustrate how the measure of the airlines' network substitutability can be translated at the level of airlines' hubs. Consider two airlines 1 and 2 with respective

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[4] If a carrier has several hubs (which is the case of many American carriers), the most important hub in terms of supply is accounted for. A detailed description of all companies' hubs as well as the level of supply operated from each of them is available upon request.

hubs H_1 and H_2, from which they operate their services. In 2.a., the number of overlapping routes between 1 and 2 is at its minimum level, i.e., airline 1 (2 resp.) does not propose any service in 2's (1's resp.) network besides the route that links H_1 and H_2. The two airlines' services are said to be complementary in this case, and it is very much alike the case of networks 1 and 2 in Figure 1. In 2.b., Airline 1 (2 resp.) may decentralize a share of its operations to H_2 (H_1), increasing thus the degree of substitutability between 1 and 2's operations. This situation is similar to the networks pairs 1-3 and 1-4 above. Finally, in 2.c., both companies' hubs coincide, setting the degree of substitutability of both activities at the maximum level, as in the case of the network pair 1-5 above.

We construct our substitution index as follows: Consider two airlines i and j. We suggest that the degree of substitutability (complementarity resp.) between the total operations of two airline airlines i and j increases (decreases resp.) with the share of route kilometers departing from i and j's hubs and that i and j have in common. Define O_{ij} as airline i's share of hub route kilometers also served by airline j. Likewise, define O_{ji} as airline j's share of hub route kilometers also served by airline i. Moreover, denote as T_i (T_j) the total hub route kilometers for airline i (j). Hence, the substitution index is defined as $O_{i-j} = \frac{(O_{ij}+O_{ji})}{(T_i+T_j)}$. Note that a higher degree of substitution between i and j implies therefore that O_{i-j} increases.

We proceed in a similar fashion to construct a complementarity index between both airlines i and j. Define as C_{ij} the quantity of airline i's hub route kilometers not served by airline j, and C_{ji} the quantity of airline j's hub route kilometers not served by airline i. Provided with these components it is possible to define $C_{i-j} = \frac{(C_{ij}+C_{ji})}{(T_i+T_j)}$. Hence, a higher degree of complementarity between i and j implies therefore an increase of C_{i-j}. Moreover, $C_{i-j} = 1 - O_{i-j}$.

From our 55 airlines, we determine all the possible airline pairs. Out of the 1485 possibilities, 444 pairs are characterized by overlapping activities. We calculate the substitution index O_{i-j} for each of them. Table 3 presents a list of the 87 airline pairs with the highest indexes. Some of these airline pairs present high substitution indexes because they operate from the same hub. This is the case for instance of All Nippon and Japan airlines (Hub: Tokyo), British Airways and Virgin Atlantic (Hub: London), Aeromexico and Mexicana (Hub: Mexico City), or Air Europa and Spanair (Hub: Madrid). Other pairs operate from distinct hubs located in the same domestic markets: Delta and TWA

(Hubs: Atlanta and St Louis), and Air Canada and Canadian Airlines (Toronto and Calgary) for instance. Finally, one observes pairs of airlines with distinct hubs located in different countries. High substitution indexes in this case implies that these airlines operate a significant share of their total activity in their competitor's hub. Examples are Qantas and Thai (Hubs: Sydney and Bangkok), and British Airways and United (Hubs: London and Chicago).

Determining whether two airlines' operations can actually be considered as substitutes or complements requires the definition of a substitution index cut-off. This can be achieved through the estimation of a demand function for world airlines' operations, which constitutes the core of the analysis presented in this paper.

4 Cost, capacity, and demand

An airline offers a specific capacity determined by the total number of seats available in the airplanes, and the total mileage performed. Based on this supply and prices, consumers make optimizing travel decisions that consist of a particular number of trips. Hence, as already suggested by numerous authors, passenger-trips are not as much under the control of operators, and airlines are concerned by the capacity to produce a potential for trips (See Berechman, 1993.). In other words, costs and revenues are driven by two different variables that are closely related. It is thus crucial to disentangle the capacity supplied, Q, and the level of transport services requested by the customers, q.

Since the capacity supplied must at least meet the highest peaks of traffic, demand never saturates the network capacity on average. On the other hand, the capacity must be adjusted to the level of demand, so the former is endogenous to the latter. Here we do not present a complete model of optimal provision of transport services. Instead, we simply introduce a reduced form of a technical adjustment process between capacity and demand according to the relation that we specify as follows:

$$Q_i = \Phi(q_i, \lambda), \tag{1}$$

where λ is a vector of parameters to be estimated. This equation just approximates how engineers adjust the network size and structure to the demand level on annual basis.

For the specification of the demand function, we follow the classical guidelines. Assume that from consumer n's indirect utility associated with the consumption of air transportation we can derive the individual demand function. This function is interpreted as a short-run demand since it takes the capacity Q as given. By replacing Q in this demand function by its expression in (1), we obtain a reduced form interpreted as the long-run demand function which is defined as

$$q_i(p_i, p_j, m_i, \alpha), \qquad i = 1, ..., N, \quad j \neq i, \tag{2}$$

where α is a vector of parameters. Firm i's aggregate demand q_i depends on its own price, p_i, competitors' prices p_j, as well as market exogenous characteristics m_i. A limited number of competitors meets in each route, with the combination of competitors changing from one route to another. Different competitors supply alternative products which differ in time schedule, number of stops, availability of interconnections with other flights, etc. In addition, at the two ends of each route start other routes that can be served by the same or a different set of airlines. Accordingly, the services offered by different airlines can be regarded either as imperfect substitutes or complements. By assuming the same pricing policy for all the routes served by one company, we are implicitly saying that p_j represents the price asked by the different firms in the market, and this price accounts for the fact that the routes served by firms are complements or substitutes of those served by firm i.

The price elasticity associated with this reduced-form demand corresponds to an estimate of the long-run elasticity, when capacity has been fully adjusted. Estimating Equations (1) and (2) avoids the simultaneity problem that exists between supply and demand.

Moreover, airlines are endowed with a given technology. In order to provide a given amount of service, Q_i, an airline must buy variable inputs, namely, labor, L_i and materials, M_i, which productivity depends on network exogenous characteristics, z_i. The production process and its underlying technology can be implemented through a long-run dual cost function. Denoting by w_L and w_M the price of labor and materials, the cost function is:

$$C_i = C(Q_i, \omega_i, z_i, t, A_i, \beta), \tag{3}$$

where t is a trend, and β is a vector of parameters denoting technology. Note moreover that we test for the alliance's effect on the company's costs. A_i is a dummy variable that takes value 1 if the observe airline is part of an alliance, and 0 otherwise.

Our econometric model comprises three equations in a block-recursive structure, so that each equation can be estimated separately. The lower level provides the demand of transport that explains the demand (usage) of transport in terms of the transportation price, which is endogenous, and needs to be proxied. We will go back to this point below. The middle level is constituted by Equation (1) that provides a relationship between demand and capacity (or supply). This equation just says that, at each period, one can identify the engineering function that has been used to set up the network structure in terms of size. The upper level is made of the cost function, which relates cost to capacity and to other elements like the inputs prices and the effect of alliances.

Note that we do not attempt to estimate firms' pricing strategy simultaneously with our Aforementioned equations. The reason is that, since we work at the aggregate level, making any assumption on the "average" pricing conduct of airlines would not help to improve the quality of our estimates. We will provide further discussion on this aspect in Section 9.

5 Empirical implementation

The next step consists in proposing specific functional forms for our three equations. In particular, we explain how our demand function identifies the cross price effects between each pair of airlines observed in our database.

The demand equation corresponding to (2) is specified in linear form as follows

$$q_i = \alpha_{1i} + \alpha_{2i} p_i + \sum_{j \neq i} \alpha_{i-j} p_j + \alpha_m \, m_i + u_{qi}, \, i, j = 1, ..., N, \tag{4}$$

where u_{qi} is an error term. Notice that we allow the intercept α_{1i} and the own-price effects α_{2i} to vary across airlines. Moreover, we account for firms' cross-price specific effects α_{i-j}. These characteristics imply a matrix of own and cross-price effects $\frac{\partial q_i}{\partial p_j}$ that can only be estimated imposing some constraints. Following the approach suggested by Jaumandreu and Lorences (2002), we assume that own-price and cross-price effects must follow some pattern.

First, we assume that the intercept and the total own-price effect of each airline are proportional to the size of its own network. Accordingly, we define $\alpha_{1i} = \alpha_0 + \alpha_1 NET_i$ and $\alpha_{2i} = \alpha_2 NET_i$, i.e., we assume that the own rate effect of an airline depends on the size of its operations.

Second, the total cross-price effect of a rival j depends on the extend to which j's network is a substitute or a complement to i's network. We therefore weight airlines' coincidences and potential connections with all their rivals. In particular, we define $\alpha_{i-j} = \alpha_3\ O_{i-j} + \alpha_4\ C_{i-j}$, where α_3 and α_4 are the common cross-price effects and O_{i-j} and C_{i-j} are the two overlapping and connecting indexes defined above. We expect α_3 and α_4 to be positive and negative respectively, i.e., a higher proportion of overlapping route kilometers O_{i-j} (connecting route kilometers C_{i-j} resp.) between two airlines i and j makes it more likely for these airlines to be substitutes (complements resp.).

Defining $p^o_{ij} = O_{i-j}\ p_j$, and $p^c_{ij} = C_{i-j}\ p_j$, expression (4) can be transformed into an equation with only two cross-price parameters α_3 and α_4 to be estimated,

$$\begin{aligned} q_i &= \alpha_0 + \alpha_1 NET_i + \alpha_2 NET_i p_i + \alpha_3 \sum_{j \neq i} p^o_{ij} + \alpha_4 \sum_{j \neq i} p^c_{ij} + \\ & \alpha_m\ m_i + u_{qi},\ i,\ j = 1, ..., N. \end{aligned} \tag{5}$$

Note that the whole matrix of own and cross-price effects can be recovered from this estimation for a given set of values of NET_i, the O_{i-j} and C_{i-j} variables, and the α coefficients. Moreover, we define the minimum value of the substitution coefficient O_{i-j} from which two airline i and airline j can be considered as substitutes: We need $\alpha_{i-j} > 0$, i.e., $O_{i-j} > -\frac{\alpha_4}{\alpha_3 - \alpha_4}$. Likewise, two airlines are complements when $O_{i-j} < -\frac{\alpha_4}{\alpha_3 - \alpha_4}$.

We turn now to the two other equations. We assume a Cobb-Douglas specification for the cost function in (3). This specification retains the main properties desirable for a cost function and provides a sufficiently precise description of the technology, while remaining tractable for our purpose.[5] The cost function is then specified as

$$C_i = \beta_0\ \omega_{Li}^{\beta_1} \omega_{Mi}^{\beta_2} Q_i^{\beta_3} z_i \exp(\beta_t\ t + u_{ci}) \tag{6}$$

where u_{ci} is an error term. Homogeneity of degree one in input prices is imposed, i.e., $\beta_1 + \beta_2 = 1$. We assume that z_i includes measures of airlines' network size, NET_i, and

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[5] See Marín (1998) for details on the same choice for the airline industry

average stage length, ASL_i,[6] and has the following shape:

$$z_i = NET_i^{\beta_4}\ ASL_i^{\beta_5}. \tag{7}$$

Note that the average stage length measures the length of the average route operated by an airline while the network size adds the lenghts of all routes of the airline's network. With respect to the relationship between demand, $q_{i,}$ and supply, Q_i, represented in (1), we assume the following functional form,

$$Q_i = \lambda_0\ q_i^{\lambda_1}\ \exp(u_{Qi}), \tag{8}$$

where u_{Qi} is an error term.

6 Estimation

We estimate the sequential system of equations (5), (6) and (8). Since prices p_i in the demand equation (5) are endogenous, we need to find some instruments. We use as instruments for p_i a trend t, the national private consumption in the airline's country of origin, $PRIV_i$, the size of population of the airline's country of origin, POP_i, wages, ω_{Li}, a measure of competition $COMP_i$, and a dummy indicating whether the airline belongs to an alliance or not, A_i (All these variables are discussed in more details in the next section). Hence, we estimate the following additional equation:

$$p_i = p\left(A_i, PRIV_i, POP_i, \omega_{Li}, COMP_i, t, \delta\right),\ i = 1, ..., N, \tag{9}$$

where δ is a vector of parameters. Several comments are worth emphasizing: First, note that we test whether alliances have any impact on the global average price set by airlines using a simple dummy, in a similar fashion as in the cost equation. This procedure is similar to the one used by Brueckner and Whalen (2001) and Whalen (2007) with two differences: They measure the effects of codesharing and immunity agreements on prices while we rather focus on the effect of being a member of an alliance without specifying

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[6] See Marín (1998) and Neven *et al.* (2001) for discussions on the introduction of these two variables in the cost function and for evidence on their effects on airlines' productivity. A measure of airport concentration was included in an alternative specification but it turned out to be highly correlated with the size of the network.

with precision the nature of the agreement. Moreover, as already mentioned, these authors work at the route (market) level while we focus on economic indicators aggregated at the network level. Note however that they consider that the codesharing and immunity agreements apply to all the products offered by airlines while in practice these agreements are effective in some specific markets only. In a sense, this “generalization” of airlines’ cooperative behaviors generates an average effect on prices that is similar to our measures to some extent.

Second, entering an alliance is a decision of the airline and this has several consequences in our model: We should proxy the alliance variable A_i since it is most probably endogenous. This is however a difficult task due to the fact that very few instruments are left in our database. We run several logit estimations on the choice of entering an alliance or not and obtained results where a trend, airlines’ wages, and the (1995) airlines’ network size significantly affect the probability to enter an alliance. Note however that these instruments (which are plugged in the price equation) create important collinearity problems once prices are proxied in the demand equation. We therefore decided to discard the idea of proxying the decision to enter an alliance. Further comments on the logit estimation results are provided in section 8.

Another consequence is that the overlapping and connection indexes O_{i-j} and C_{i-j} may themselves be decision variables of airlines. In order to avoid endogeneity problems at this level, we keep both O_{i-j} and C_{i-j} fixed over time, i.e., we use the initial 1995 indexes to proxy the degree of substitution and connection between airlines over the whole period of observation.

Finally, we compute several robustness checks to test the validity of our estimates of own and cross price elasticities. We show that the own elasticities do not vary much when prices are proxied or not. We also try other specifications of the demand equation. In particular, we replace NET_i in the expression of the constant and the own price parameter by the number of airline’s flights departures DEP_i and the number of routes $ROUTES_i$. We suggest that these changes entail minor variation in the results.

7 Variables definition

The variables have been constructed as follows. In the cost function, total costs (C_i), production (Q_i), wages (ω_{Li}), and average stage length (ASL_i) correspond to total operating expenses, seat-kilometers available, flight crew salaries and maintenance and overhaul expenses over number of employees, and total aircraft kilometers over total aircraft departures (DEP_i), respectively. With respect to total costs, companies report one single figure that corresponds to passengers, freight and mail activities. The distribution of operations among these three activities can vary significantly among companies. However, it is easy to obtain information on the total number of tonne-Kilometers performed that correspond to passengers (including baggage), freight and mail, respectively. We multiply total costs reported by each company by the share of tones-kilometers performed corresponding to passengers in order to compute our cost variable (C_i).

The variable NET_i is the total number of route kilometers an airline operates on all its different routes ($ROUTES_i$). Finally, the price of materials (ω_{Mi}) has been constructed as the average fuel prices at the airline's home country and at the OECD, weighted by the company's domestic and international operations respectively.

On the demand side, demand (q_i) corresponds to passenger-kilometers performed, and prices (p_i) are measured as passenger revenues over passenger-kilometers performed. The home country exogenous characteristic m_i is domestic private consumption $PRIV_i$. Finally, t the time trend, is equal to one in 1995 and incremented by one each year.

We also construct a competition index $COMP_i$ for each airline i, which accounts for the number and the intensities of coincidences of i's network with other airlines' networks. We have defined previously the substitution index $O_{i-j} = \frac{(O_{ij}+O_{ji})}{(T_i+T_j)}$ as the share of route kilometers departing from two airlines i and j's hubs and that i and j have in common. Summing O_{i-j} over all airlines j which coincide with i, we obtain a measure of the competition index, $COMP_i = \sum_j O_{i-j}$ for airline i. Thus, airline i faces a higher competitive pressure if $COMP_i$ increases, i.e., if i shares a higher quantity of route kilometers with its competitors.

Finally, we need to construct a variable to account for the alliances effects in the price and cost equations. Airlines cooperate with partners which are the members of the same alliance, i.e., ONE, SKY, STAR, WINGS, and QUAL. We construct a dummy

$ALLI_i$ which takes value one if the observed airline is a member of any of these alliances, and zero otherwise. Note that it is implicitly assumed that being a member of one of these alliances entails that an airline sets cooperative prices in all the markets where it is present.

Table 4 presents descriptive statistics.

8 Demand elasticity and costs

Tables 5 to 11 provide the results for the econometric model. Prior to estimating the demand function (5), we need to obtain estimated prices $\hat{p}_i$ through the price equation (9). As a by-product, we test several price determinants, as presented in Table (5). We obtain price outcomes that are similar to the empirical results obtained by Brueckner and Whalen (2000) and Whalen (2007), although these authors work at a more disaggregated level, i.e., on a market (route) basis. First, note that prices decrease at an annual rate of 4 to 7% as suggested by the trend. Second, prices are higher, on average, if the domestic private consumption inside the home country of the observed airline is more important. Third, the size of the population of the home country of the observed airline and the price are inversely related, which suggests that this variable is a potential proxy for the quantity of passengers-kilometers carried.

Note that the average wage paid to the employees of the airline is not a relevant determinant of the price, suggesting that a direct connection between airlines' prices and costs is potentially loose. Whether or not an airline is a member of an alliance has a significant impact. On average, prices are 5 to 6% lower under alliances. This is an interesting result, given the highly aggregated nature of the data. Although airlines establish strategic price interactions on a market to market basis, prices reductions are important enough so that this reductions can be identified in annual average prices at the airline level. Interacting the alliance variable with our measure of competition yields the expected negative results, i.e., prices are lower for alliance members facing a higher competitive pressure.

As suggested previously, we also estimate the decision of airlines to enter an alliance.[7]

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[7] The estimated probability to enter an alliance is $\Pr = \underset{(1.59)}{-30.62} + \underset{(1.33)}{6.91}\ TREND + \underset{(0.30)}{1.59}\ NET - \underset{(0.31)}{0.61}\ WAGES$. Standard errors are in parenthesis.

Replacing $ALLI_i$ in the price equation by this estimated probability reduces significantly the magnitude of the alliance effect (-1% instead of -5%), although the alliance outcome remains negative and highly significant. This suggests a potential endogeneity bias: Airlines entering alliances may enjoy lower marginal costs than those not entering. Not accounting for this issue may lead to an overstatement of the alliance effects on prices.

From the different price specifications in Table 5, we derive measures $\hat{p}_i$ which are introduced in our demand equation. Tables 6-8 present the results for the demand equation. Table 6 shows the results of the demand equation (5). In Tables 7 and 8, we produce alternative estimates obtained from the estimation of (5) where NET_i is replaced by the number of routes, $ROUTES_i$, and the number of departures DEP_i, respectively. All the coefficients have the expected signs. As expected, demand increases significantly with the size of the network, the number of aircraft departures, or the number of routes operated. Likewise, private consumption growth affects positively demand. The own price parameter α_2 is negative and significant, and do not vary much depending on whether the size of the network, the number of routes, or the number of departures enter the specification of the own price demand elasticity. Note moreover that, from Table 6, plugging into the demand function the real observed price p_i (Column A) or the estimated $\hat{p}_i$ (Columns I to V) do not affect much α_2. With respect to cross price estimates, it appears that α_3 (α_4 resp.) is positive (negative resp.) and significant. This result suggests that a higher proportion of overlapping route kilometers between two airlines i and j makes it more likely for these airlines to be substitutes. Likewise, a higher proportion of connecting route kilometers between two airlines i and j makes it more likely for these airlines to be complements.

From the estimation of the own price parameter α_2 obtained in Tables 6-8, we evaluate the own price demand elasticity as $\theta_{ii} = \alpha_2 NET_i \times \left(\frac{p_i}{q_i}\right)$. We obtain estimates between -1.51 and -1.99 for the average airline airline over the period considered.[8] More interestingly, using the cross price demand parameters α_3 and α_4, we derive the substitution index cut-off $O^*_{i-j} = -\frac{\alpha_4}{\alpha_3 - \alpha_4}$ above which two airlines can be considered as substitutes. From Table 6 (7 and 8 resp.), the cut-off is equal to 0.180 (0.077 and 0.113 resp.)[9] Hence,

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[8] A survey by Oum et al. (1992) on price elasticities of air transport demand suggests that empirical findings obtained during the 80s usually lie between -4.51 and -0.4. The fact that our estimate gets closer to the lower bound should not be surprising given that our database mostly consider long-distance routes where price-sensitive holiday-makers form the majority of travellers.

[9] We keep the worst case scenario from each table.

the number of substitute airlines is 12, 31, or 57, which represents respectively 2.7, 6.9, and 12.8% of the airline pairs characterized by overlapping activities.

Table 9 identifies the pairs of airlines whose services are substitutes, depending on each cut-off value O^*_{i-j}. Airlines pairs which are members of the same alliances over 1995-2000 are underlined. Airline pairs which become members of the same alliance after our period of observation are underlined and in italic. Interestingly, a significant number of pairs of substitute airlines belongs to the same alliance, which may lead to softer competition and higher prices. Among the pairs with the highest substitution index are SAS and Thai, (Star Alliance from 1997), Continental and Delta (Skyteam from 2004), or Canadian Airlines and Cathay (OneWorld from 1999). Note also the presence of the pair American Airlines-British airways (OneWorld since 1998) which required antitrust immunity on transatlantic routes in 1997 and 2001 without success, or the pair Lufthansa-United which got granted antitrust immunity in 1997 under very specific restrictions on some particular routes such as Washington/Frankfurt and Chicago/Frankfurt.[10] More recently, the European Commission opened two antitrust proceedings against these four airlines together with other members of Star Alliance (Air Canada and Continental) and OneWorld (Iberia) in relation to cooperation on transatlantic routes.[11] The Commission is willing to assess whether cooperation among these airlines may lead to restrictions of competition on certain routes. These cases illustrate that a methodology based on network substitution such as the one presented in this paper may be a relevant tool for regulators when deciding whether or not two airlines should not allowed to implement cooperative arrangements. We will propose in a last section alternative alliance compositions which do not include substitute airlines. Before doing so we turn to the capacity and cost side of our results.

Table 10 presents the demand-capacity relationship. Again, the coefficients are significant and have the expected sign. Table 11 presents the estimates for the cost function.[12] All the parameters are significant and have the expected sign. Costs increase with wages and production. The production process is characterized by increasing returns to scale since the production parameter β_3 is significantly lower than 1. The coefficient of the

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[10] Note issued by the U.S. Department of Transportation on the 20th May 1996.

[11] European Commission MEMO/09/168. 20th April 2009.

[12] We also estimated a long run cost function where capital was regarded as a variable input. Accordingly, a measure for the price of capital was computed from the companies' accounting data and included in the cost function. This variable was not significant at any confidence level.

time trend is negatively signed, suggesting the presence of technological progress. Airlines' network size and average stage length have a negative impact on operating cost. Thus, companies with larger networks and/or longer routes enjoy a significant cost advantage. Finally, we also introduce in the cost function our alliance ($ALLI$) dummy variable to test whether airlines' operating costs are reduced if airlines enter into cooperative agreements. The results suggest that alliances have no direct effect on cost since the $ALLI$ effect is not significant.

Hence, it seems that alliances between airlines reduce prices significantly but they have no direct effect on costs. We expect however alliances to have a positive impact on the quantity of passengers kilometers carried (Whalen, 2007), which in turn leads to a decrease of airlines' average costs due to the presence of economies of density. Thus, alliances mostly increase the flow of passengers inside the existing network, and thus reduce airlines' costs, but it does not affect their cost technology.

9 The competition effect of alliances

We propose now to discuss further our previous findings in light of the *average* competitive behaviour of each airline. Provided with the demand, capacity, and cost estimates, we measure the degree of competition in the industry after the introduction of alliances. We evaluate alliances' marginal costs and margins and shed light on whether the pricing behavior of airlines which are members of alliances is similar to an hypothetical Nash pricing behavior.

Provided with the cost and demand ingredients, each airline solves the following program,

$$\max_{p_i} \ \pi_i = q_i(\cdot)p_i - C(\Phi(q_i(\cdot), \cdot), \omega_i, z_i), \tag{10}$$

where p_i is the optimal price to be chosen. The first order conditions for firm i, which entails Nash pricing, is given by

$$\frac{p_i - \Phi'(q_i(\cdot)) \ MC_i(\Phi(q_i(\cdot)))}{p_i} = -\frac{q_i}{p_i}\frac{\partial p_i}{\partial q_i}, \tag{11}$$

where

$$MC_i(\cdot) = \frac{\partial C_i}{\partial Q_i} \quad \text{and} \quad \Phi'(q_i(\cdot)) = \frac{\partial Q_i}{\partial q_i}.$$

Using the estimates of the cost, capacity and demand system obtained in the previous section, we can evaluate the observed price-cost margins $M_i = \frac{p_i - \Phi'(q_i(\cdot))\ MC_i(\Phi(q_i(\cdot)))}{p_i}$, and test these margins against those that could be obtained if airlines obeyed to Nash behavior, where firms set prices independently, since each firm i only cares for its own demand q_i.[13]

From the expressions of demand (5), capacity (8) and costs (6), the price first-order condition under Nash behavior can be rewritten as

$$\frac{p_i - \frac{\lambda_1 Q_i}{q_i} MC_i(\cdot)}{p_i} = -\frac{q_i}{p_i}\frac{1}{\alpha_1}. \tag{12}$$

Through the estimation of the cost function, the marginal costs MC_i can be easily recovered. Putting them together with our estimate of the capacity-demand elasticity λ_1, as well as the observed values for supply, demand and prices, we are able to evaluate the weighted price-marginal cost margin M_i set by each airline. Then, we can compare these values with those predicted by the Nash scenario proposed above.

Table 12 presents the estimated values for marginal costs MC_i, and margins M_i, for all firms and alliances. Several results are worth emphasizing. First, the average airline enjoys a positive margin. Second, distinguishing companies belonging to alliances from companies outside alliances, it seems that companies within alliances obtain higher margins. These companies face however lower marginal costs and set lower prices. Third, note that prices, marginal costs, and margins vary significantly across alliances. A striking result is the average margin of Qualiflyer which is close to 0. This could be related to the negative profit obtained by some of its airlines for several years, illustrating the financial difficulties of the alliance, which stopped its operations in 2001 after the bankruptcies of Swissair and Sabena.

Using our estimates for the demand equation, note that, as suggested by the right-hand side of Equation (11), Nash behavior would entail an average margin M_N^T for all the

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[13] By estimating cost and demand functions, we are able to generate direct measures of the price-cost margins. This approach follows the spirit of Genesove and Mullin (1998), which shows that direct estimations of the conduct parameter through the pricing rule may lead to significant underestimation of market power. Similarly, imposing a specific conduct and estimating costs may lead to over or underestimation of costs when perfect competition or monopoly are assumed respectively. On the contrary, estimates are quite insensitive to the assumed demand functional form.

airlines in the sample equal to 0.707. On average, the industry's real margin $M^T = 0.122$ does not entail pure Nash behavior. It is also worth distinguishing airlines that belong to alliances and those that do not. We have suggested that companies within alliances were setting the highest margins. We also calculate an average individual Nash margin for each group. Note that, from the ratio q_i/p_i, evaluated at the average observation of the sample, it can be seen that the airlines within alliances meet demand on a more inelastic portion of the curve than other companies. Hence, pure Nash behavior for companies inside alliances entails a margin M_N^A equal to 0.950, while for other companies the margin, M_N^{NA}, is equal to 0.677. Hence, the values of these actual margins lie below the individual Nash behavior margins. Hence, individual Nash behavior is not met for any set of companies. However, the companies within alliances are closer to individual Nash behavior than the other airlines, suggesting that they are more likely to survive in the long run. Finally, we can evaluate an average Nash margin for each alliance. Airlines inside these alliances show a behavior that is different from individual Nash. According to our results, Airlines in SkyTeam and Star Alliance are those characterized by the less competitive behavior. Note that Star Alliance includes six airlines, namely United, Lufthansa, all Nippon, SAS, Thai, and Mexicana, whose networks are substitutes to other airlines' networks inside the same alliance.

Finally, we can play the role of the benevolent regulator and propose alternative alliance formations in order to avoid substituting networks inside the same alliance. We adopt the following rules: (*i*) If two airlines are substitutes inside the same alliance, the smaller airline (in terms of seats-kilometers, see Table 1) must switch alliance. (*ii*) A switching airline cannot join an alliance if it is a substitute to any member of the alliance it joins. (*iii*) We attempt to keep alliances balanced from a geographical point of view. (*iv*) We exclude Qualiflyer from this reconstructing process.

The results would be as follows: British Airways must leave OneWorld but cannot join any other alliance; it may therefore create a new alliance with, say, U.S. Airways, which is not a member of any alliance during this period. British Airways could be replaced in OneWorld by Lufthansa, which has to exit Star Alliance. Moreover, Cathay (OneWorld) could be replaced by Japan Air System, which is not a member of any alliance, All Nippon (Star Alliance) by Cathay (OneWorld), and Mexicana (Star Alliance) would exchange seat with Aeromexico (SkyTeam).

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Table 1: List of airlines included in the Dataset

Airline	Seats-kil.	Airline	Seats-kil.
United Airlines	272,380,784	Aeromexico	16,770,044
American Airlines	250,920,342	Mexicana	15,942,627
Delta Airlines	224,202,461	Finnair	13,409,143
Northwest	153,461,676	Olympic	13,157,697
British Airways	144,535,575	TAP	12,837,742
Japan Airlines	112,853,559	Continental Micronesia	9,200,909
Continental Airlines	108,316,288	Aer Lingus	8,662,699
Lufthansa	103,576,477	Avianca	7,275,610
U.S. Air	95,375,781	LOT	6,707,159
Air France	94,723,686	Air Lanka	6,628,365
All Nippon Airways	79,336,012	Air Europa	4,987,922
Qantas	78,106,832	British Midland	4,819,388
KLM	70,075,874	Spanair	4,682,385
TWA	59,716,643	Braathens	4,536,869
Cathay Pacific	56,506,464	Malev	4,029,375
Air Canada	51,470,679	Cyprus Airways	3,889,153
Alitalia	51,433,485	Air UK	3,393,372
Thai Airways	47,788,381	Meridiana	3,316,857
Iberia	43,128,693	Mea Air Liban	3,233,606
Swissair	38,245,227	Gb Airways	1,770,826
America West	37,929,149	Jersey European	1,228,033
Canadian Airlines	35,288,169	Croatia Airlines	1,020,691
Varig	35,199,155	Maersk Air	727,783
SAS	31,500,448	Lithuanian Airlines	623,836
Virgin Atlantic	26,642,135	Estonian Air	408,050
Alaska Airlines	25,589,388	Air Baltic	268,564
Japan Air system	22,201,996	Air Botswana	109,663
Sabena	20,714,658		

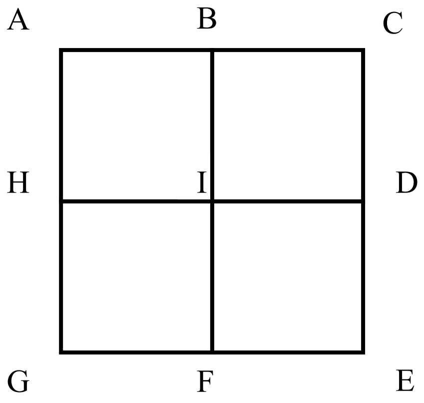
Note. Seats-kilometers supplied: Average between 1995 and 2000.

Table 2: Alliances

Alliance	Carrier	Date of entry
OneWorld	American Airlines	Sep. 98
	British Airways	Sep. 98
	Qantas	Sep. 98
	Cathay	Sep. 98
	Iberia	Sep. 99
	Finnair	Sep. 99
	Canadian	Feb 99
	Aer Lingus	Jun. 00
SkyTeam	Delta	Sep. 99
	Air France	Sep. 99
	Alitalia	Jul. 01
	Aeromexico	Sep. 99
Star Alliance	United	May. 97
	Lufthansa	May. 97
	All Nippon	Oct. 99
	Air Canada	May. 97
	Thai	May. 97
	Varig	Oct. 97
	SAS	May. 97
	Mexicana	Jul. 99
	LOT	Jun. 03
	British Midland	Jul. 00
	Spanair	Jun. 03
Wings	Northwest	89
	KLM	89
	Continental	89
Qualiflyer	Swissair	Mar. 98
	Sabena	Mar. 98
	TAP	Mar. 98
	LOT	Jan. 00
	Air Europa	Mar. 99

Note:“Date of entry” refers to the date at which the carrier joins the alliance.

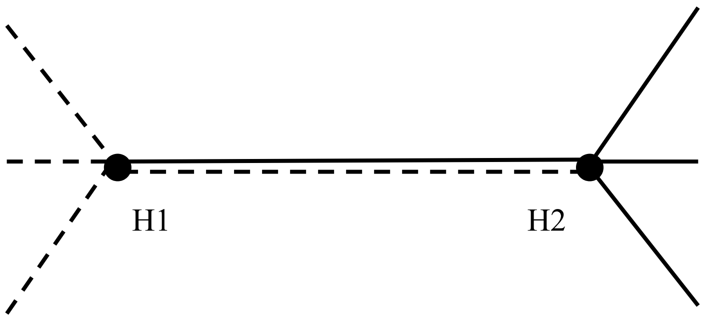
Figure 1: Network overlapping



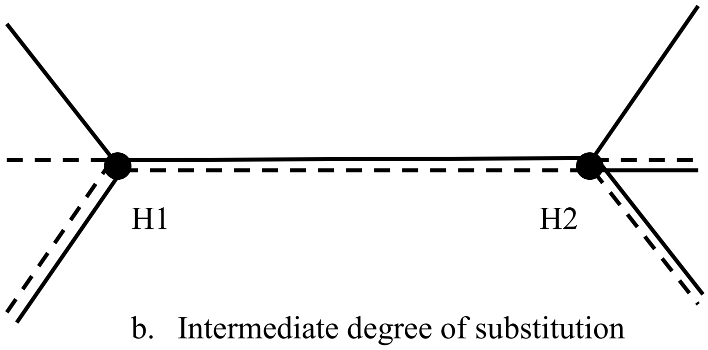
Networks:

#1: ABIH
#2: IDEF
#3: BCDI
#4: BCEGHI
#5: ABIH

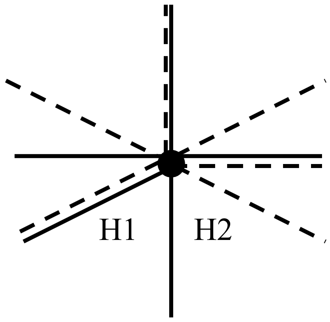
Figure 2: Hub overlapping



a. Complementary networks



b. Intermediate degree of substitution



c. High degree of substitution

Hubs:

H1: Airline 1
H2: Airline 2

Routes:

— Airline 1
- - - Airline 2

Table 3: Overlapping pairs

Airline Pair	Index	Airline Pair	Index
All Nippon – Japan Airlines	0.5641	Air France – Japan Airlines	0.0907
Delta – TWA	0.3860	British Airways - United	0.0859
Aeromexico – America West	0.3484	Lufthansa – Thai	0.0854
SAS – Thai	0.3358	All Nippon – Sabena	0.0834
Continental - TWA	0.3118	Japan Air System - Northwest	0.0827
Air UK – Spanair	0.3063	United – Virgin	0.0827
Continental - Delta	0.2670	Delta – Swissair	0.0826
British Airways - Virgin	0.2400	British Airways - Delta	0.0825
Aeromexico – Mexicana	0.2383	British Airways - Qantas	0.0812
Continental Micro. – Japan Air Sys.	0.1858	Qantas – United	0.0799
Air Europa – Spanair	0.1829	Alitalia – TWA	0.0786
Japan Airlines - United	0.1812	Air France – Thai Airways	0.0779
Olympic - TWA	0.1795	Continental - Mexicana	0.0773
Mexicana - USAIR	0.1539	Continental – Virgin	0.0757
Air UK – British Midland	0.1536	Delta – Virgin	0.0752
Qantas - Thai	0.1522	Japan Airlines - Virgin	0.0752
British Airways - Continental	0.1518	Air Europa – Iberia	0.0735
American – Delta	0.1501	Japan Airlines - Lufthansa	0.0734
Canadian Airlines – Cathay	0.1413	Delta – SAS	0.0713
Japan Airlines - Northwest	0.1374	Air Canada – British Airways	0.0698
Delta - Lufthansa	0.1364	Continental – Japan Air sys.	0.0698
Air Canada – Canadian Airlines	0.1355	Air UK – KLM	0.0693
Aeromexico – Iberia	0.1314	Air Europa – TWA	0.0689
Olympic - Thai	0.1307	Swissair – Varig	0.0686
All Nippon – Northwest	0.1288	British Airways - USAIR	0.0680
Continental - SAS	0.1263	Delta – Sabena	0.0669
Alitalia – Thai	0.1261	TAP – TWA	0.0660
TAP - Varig	0.1242	Delta – United	0.0656
Japan Airlines – Japan Air System	0.1191	Air France – TWA	0.0647
American – Continental	0.1178	Air France – All Nippon Airw	0.0641
Mexicana - United	0.1173	Continental - Lufthansa	0.0640
American – British Airways	0.1126	Japan Air System – United	0.0637
British Airways - Thai	0.1116	Air France – United	0.0636
Lufthansa - United	0.1101	Cont. Micro. – Japan Airl.	0.0631
American – United	0.1066	Iberia – Varig	0.0630
Northwest - Qantas	0.1049	Japan Airlines - Thai	0.0626
All Nippon – Qantas	0.1046	Cathay – Swissair	0.0624
All Nippon – Virgin	0.1028	Air Canada – Iberia	0.0620
Japan Airlines - Qantas	0.0988	Olympic – Qantas	0.0619
Continental Micronesia – Northwest	0.0987	All Nippon – Cont. Micro.	0.0618
All Nippon – United	0.0980	Delta – Varig	0.0614
Aeromexico – Continental	0.0948	American – Lufthansa	0.0613
Cathay – Qantas	0.0930	Iberia – TWA	0.0613
Air UK – Cathay	0.0922	…	

Note: Only the first 87 over a total of 444 overlapping airline pairs are presented here.

Table 4: Descriptive statistics
(Annual data, 1995-2000, 55 airlines)

Variable	Mean	Stand. Dev.	Min	Max
Costs (10^3 $)	2,465,913	172,663	11,820	14,901,114
Wages ($)	14,969	510	773	59,094
Price Fuel (index)	162.68	1.94	88.21	283.76
Price ticket ($/Pass.kil)	0.117	0.003	0.032	0.303
Production (Seats-kil)	45,906,516	3,450,119	96,609	284,044,940
Demand (Pass-kil)	32,439,265	2,469,556	50,994	204,149,480
Network size (kil)	271,083	14,508	1,467	1,075,683
Av. Stage Length (kil)	1,385	57	277	8,978
# Routes	193.58	9.56	1.52	809.57
# Departures	177,587	12,315	4,029	968,893
Priv. Cons. (index)	1443.70	117.44	1.29	6683.8
Competition (index)	0.619	0.029	0.001	1.964
Alliance	0.118			
OneWorld	0.027			
Star Alliance	0.060			
Wings	0.061			
SkyTeam	0.009			
Qualiflyer	0.021			

Table 5: Prices

Variable	I	II	III	IV	V
CONST	-4.70***	-1.01	-2.65***	-4.65***	-4.69***
	(0.26)	(2.19)	(0.07)	(0.25)	(0.29)
TREND	-0.07***	-0.06***	-0.04***	-0.06***	-0.06***
	(0.01))	(0.01)	(0.01)	(0.01)	(0.01)
PRIV	0.41***	0.41***		0.39***	0.40***
	(0.05)	(0.04)		(0.04)	(0.05)
POP		-0.22*			
		(0.13)			
WAGES			0.04		
			(0.03)		
ALL				-0.05**	-0.06***
				(0.02)	(0.02)
ALL×COMP					-0.06*
					(0.03)
Error Dev.	0.09***	0.09***	0.09***	0.09***	0.09***
	(0.003)	(0.003)	(0.003)	(0.02)	(0.003)
R Squared	0.96				
Mean Log-likelihood	1.92				
# of observations	330	330	330	330	330

Note: Standard errors are in parenthesis.
*** Significant at the 1% level; **significant at the 5% level; *significant at the 10% level.

Table 6: Demand I (Network)

Variable	Par	A	I	II	III	IV	V
CONST		0.97^{**}	1.04^{**}	1.03^{**}	1.09^{**}	0.99^{**}	0.98^{**}
		(0.47)	(0.47)	(0.47)	(0.47)	(0.47)	(0.48)
NET		0.21^{***}	0.22^{***}	0.22^{***}	0.22^{***}	0.22^{***}	0.22^{***}
		(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)
NET×OWN PRICE		-0.88^{***}					
		(0.15)					
NET×OWN PRICE 2			-0.95^{***}	-0.96^{***}	-0.98^{***}	-0.94^{***}	-0.94^{***}
			(0.16)	(0.16)	(0.17)	(0.16)	(0.16)
PRICE_O		0.77^{**}	0.73^{**}	0.73^{**}	0.72^{**}	0.75^{**}	0.75^{**}
		(0.32)	(0.35)	(0.32)	(0.33)	(0.32)	(0.32)
PRICE_C		-0.17^{**}	-0.18^{**}	-0.18^{**}	-0.18^{**}	-0.17^{**}	-0.17^{**}
		(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)
PRIV		0.25^{**}	0.28^{**}	0.28^{**}	0.25^{**}	0.28^{**}	0.28^{**}
		(0.11)	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)
Error Dev.		0.22^{***}	0.22^{***}	0.22^{***}	0.22^{***}	0.22^{***}	0.22^{***}
		(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
R^2		0.76					
Own Price Elasticity		-1.73	-1.77	-1.77	-1.78	-1.79	-1.78
		(0.11)	(0.11)	(0.11)	(0.10)	(0.11)	(0.11)

Note: Standard errors are in parenthesis.
*** Significant at the 1% level; **significant at the 5% level; *significant at the 10% level.

Table 7: Demand II (Departures)

Variable	Par	I	II	III	IV	V
CONST		1.06^{***}	1.05^{***}	1.06^{***}	1.02^{***}	1.00^{***}
		(0.34)	(0.34)	(0.33)	(0.34)	(0.34)
DEP		0.29^{***}	0.29^{***}	0.29^{***}	0.29^{***}	0.29^{***}
		(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
DEP×OWN PRICE		-1.48^{***}	-1.49^{***}	-1.53^{***}	-1.48^{***}	-1.48^{***}
		(0.14)	(0.14)	(0.14)	(0.14)	(0.14)
PRICE_O		2.02^{***}	2.02^{***}	2.01^{***}	2.03^{***}	2.03^{***}
		(0.19)	(0.19)	(0.19)	(0.19)	(0.19)
PRICE_C		-0.17^{***}	-0.17^{***}	-0.17^{***}	-0.17^{***}	-0.16^{***}
		(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
PRIV		-0.02^{***}	-0.01^{***}	-0.02^{***}	-0.02^{***}	-0.02^{***}
		(0.005)	(0.005)	(0.005)	(0.006)	(0.005)
Error Dev.		0.15^{***}	0.15^{***}	0.15^{***}	0.15^{***}	0.15^{***}
		(0.006)	(0.005)	(0.006)	(0.06)	(0.005)
R^2		0.88				
Own Price Elasticity		-1.53	-1.53	-1.51	-1.53	-1.54
		(0.11)	(0.11)	(0.10)	(0.11)	(0.11)

Note: Standard errors are in parenthesis.
*** Significant at the 1% level; **significant at the 5% level; *significant at the 10% level

Table 8: Demand III (Routes)

Variable	Par	I	II	III	IV	V
CONST		1.06^{**}	1.05^{**}	1.14^{**}	1.02^{**}	1.01^{**}
		(0.47)	(0.47)	(0.47)	(0.47)	(0.47)
ROUTES		0.26^{***}	0.26^{***}	0.27^{***}	0.26^{***}	0.26^{***}
		(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
ROUTES×OWN PRICE		-1.35^{***}	-1.35^{***}	-1.41^{***}	-1.33^{***}	-1.33^{***}
		(0.19)	(0.19)	(0.20)	(0.19)	(0.19)
PRICE_O		1.39^{***}	1.39^{***}	1.37^{***}	1.41^{***}	1.41^{***}
		(0.30)	(0.30)	(0.30)	(0.30)	(0.30)
PRICE_C		-0.19^{***}	-0.18^{**}	-0.20^{***}	-0.18^{**}	-0.18^{**}
		(0.07)	(0.07)	(0.07)	(0.07)	(0.07)
PRIV		0.07^{***}	0.07^{***}	0.07^{***}	0.07^{***}	0.07^{***}
		(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Error Dev.		0.21^{***}	0.21^{***}	0.21^{***}	0.21^{***}	0.21^{***}
		(0.008)	(0.008)	(0.008)	(0.01)	(0.01)
R^2		0.77				
Own Price Elasticity		-1.99	-1.98	-1.99	-1.99	-1.98
		(0.12)	(0.12)	(0.12)	(0.12)	(0.12)

Note: Standard errors are in parenthesis.
*** Significant at the 1% level; **significant at the 5% level; *significant at the 10% level.

Table 9: Pairs of substitute carriers

Airline Pair	Index	Airline Pair	Index
All Nippon – Japan Airlines	0.5641	American – Continental	0.1178
Delta – TWA	0.3860	Mexicana – United	0.1173
Aeromexico – America West	0.3484	American – British Airways	0.1126
SAS – Thai	0.3358	British Airways – Thai	0.1116
Continental – TWA	0.3118	Lufthansa – United	0.1101
Air UK – Spanair	0.3063	American – United	0.1066
Continental – Delta	0.2670	Northwest – Qantas	0.1049
British Airways – Virgin	0.2400	All Nippon – Qantas	0.1046
Aeromexico – Mexicana	0.2383	All Nippon – Virgin	0.1028
Continental Micro. – Japan Air Sys.	0.1858	*Japan Airlines – Qantas*	0.0988
Air Europa – Spanair	0.1829	Continental Micro – Northwest	0.0987
Japan Airlines – United	0.1812	All Nippon – United	0.0980
Olympic – TWA	0.1795	*Aeromexico – Continental*	0.0948
Mexicana – USAIR	0.1539	Cathay – Qantas	0.0930
Air UK – British Midland	0.1536	Air UK – Cathay	0.0922
Qantas – Thai	0.1522	Air France – Japan Airlines	0.0907
British Airways - Continental	0.1518	British Airways - United	0.0859
American – Delta	0.1501	Lufthansa – Thai	0.0854
Canadian Airlines – Cathay	0.1413	All Nippon – Sabena	0.0834
Japan Airlines – Northwest	0.1374	Japan Air System - Northwest	0.0827
Delta – Lufthansa	0.1364	United – Virgin	0.0827
Air Canada – Canadian Airlines	0.1355	Delta – Swissair	0.0826
Aeromexico – Iberia	0.1314	British Airways – Delta	0.0825
Olympic – Thai	0.1307	British Airways – Qantas	0.0812
All Nippon – Northwest	0.1288	Qantas – United	0.0799
Continental – SAS	0.1263	Alitalia – TWA	0.0786
Alitalia – Thai	0.1261	Air France – Thai Airways	0.0779
TAP – Varig	0.1242	Continental – Mexicana	0.0773
Japan Airlines – Japan Air System	0.1191		

Table 10: Demand-Capacity relationship

Variable	Parameter
CONST	1.58*** (0.28)
q	0.92*** (0.01)
Error Dev.	0.05*** (0.002)
R^2	0.99

Note: Standard errors are in parenthesis.
*** Significant at the 1% level; **significant at the 5% level; *significant at the 10% level.

Table 11: Cost function

Variable	A	A2
CONSTANT	-4.95*** (0.24)	-4.99*** (0.25)
WAGE	0.24*** (0.02)	0.24*** (0.02)
Q	0.93*** (0.02)	0.93*** (0.02)
NET	-0.07** (0.03)	-0.07** (0.03)
ASL	-0.38*** (0.04)	-0.38*** (0.04)
TREND	-0.15*** (0.03)	-0.15*** (0.03)
ALL		-0.03 (0.06)
Error Dev.	0.30*** (0.01)	0.30*** (0.01)
R^2	0.97	

Note: Standard errors are in parenthesis.
*** Significant at the 1% level; **significant at the 5% level; *significant at the 10% level.

Table 12. Marginal costs, prices, and margins.

Alliance	Price	Marginal cost	Real Margin	Nash Margin
All carriers	0.129^{**}	0.074^{**}	0.122	0.707
	(0.061)	(0.035))	(0.349)	(0.499)
Carriers within alliances	0.099^{***}	0.056^{***}	0.234	0.950^{***}
	(0.029)	(0.018)	(0.199)	(0.342)
Carriers outside alliances	0.132^{**}	0.076^{**}	0.108	0.677
	(0.063)	(0.036))	(0.360)	(0.507)
OneWorld	0.102^{***}	0.056^{***}	0.244^{***}	1.487^{***}
	(0.025)	(0.011)	(0.080)	(0.246)
SkyTeam	0.095^{***}	0.049^{***}	0.328^{***}	1.011^{***}
	(0.003)	(0.008)	(0.121)	(0.007)
Qualiflyer	0.095^{***}	0.067^{***}	0.022	0.751^{***}
	(0.016)	(0.013)	(0.266)	(0.211)
Star Alliance	0.101^{***}	0.053^{**}	0.308^{***}	0.930^{***}
	(0.035)	(0.021)	(0.103)	(0.317)
Wings	0.148^{**}	0.087^{**}	0.192	0.959
	(0.061)	(0.041)	(0.175)	(0.587)

Notes: Price: One passenger-kilometer in Dollars. *MC*: One seat-kilometer in Dollars.
Standard errors are in parenthesis.
*** Significant at the 1% level; **significant at the 5% level; *significant at the 10% level.