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SOME WORLDWIDE EVIDENCE

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ABSTRACT

Alliances in the Air: Some Worldwide Evidence*

We consider an empirical model of worldwide airlines' alliances that we apply to a large set of companies for the period 1995-2000, with special attention to US and EU carriers. From the estimation of a cost, capacity and demand system that accounts for cross-price elasticities, we attempt to shed light on several interesting issues: First, we analyse whether alliance members' networks are complements or substitutes. Second, we construct price-cost margins and test several hypothesis of non-cooperative behaviour such as individual Nash and joint price setting within the alliance. We suggest that current alliances' pricing habits are not uniform and range from individual Nash to more competitive behaviours.

JEL Classification: L11, L13, L41 and L93
Keywords: airline, alliances, cross-price elasticities and Nash behaviour

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1 Introduction

We analyze worldwide airline alliances and propose an empirical model that allows us to evaluate cross price demand elasticities for all pairs of airline carriers. We determine whether alliances partners can be regarded as complements or substitutes. 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. By coordinating their services or production processes, alliance partners can offer greater convenience to consumers, as well as engage in cooperative pricing, while enjoying antitrust immunity.

Strategic alliances in the airline industry have attracted more antitrust attention than any others. 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 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. 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. (see Brueckner, 2001, and Chen and Ross, 2000).

In this paper, we focus on the five major alliances that were operating between 1995 and 2000. Our aim is twofold. First, we empirically analyze whether the network of individual alliance members is a substitute or a complement for the other alliance member's network. This is an interesting issue, since it allows appraising the social relevance of existing alliances. To do so, we estimate a cost, capacity, and demand system for airline companies, accounting for cross-price elasticities. The latter 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 airline carriers' networks.

Second, we retrieve cost and demand parameters, construct marginal costs, and derive price-cost margins for each carrier and alliance. We want to test whether they correspond to a non-cooperative behavior under alternative hypothesis, e.g., companies act individually, or there is joint price setting within the alliance. We use data for a large set of world-wide companies for the period

1995-2000, with special attention to US and E.U. carriers, which normally constitute the main alliance partners. The data are mainly retrieved from IATA and ICAO official statistics as well as the carriers annual reports.

The rest of the paper is organized as follows: The next section presents the cost, capacity, and demand system under consideration. Section 3 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 4 is dedicated to the description of the dataset and the construction of the variables. Section 5 presents the estimation results. Section 6 proposes an evaluation of competitive forces in the industry, which entails determining the pricing rules set by the different airline alliances. Section 7 concludes.

2 Determining the ingredients of the model

In what follows we specify a model of airlines' behavior that entails estimating the demand faced by each carrier as well as its technology. A modelling approach followed by several authors consists in assuming that firms make individual decisions for each route they serve.[1] This approach allows for route specific policies. The advantage of this is that it takes into account route characteristics that may affect firms' behavior, such as the number and identity of the competitors or the length and density of the route. An alternative approach followed in previous contributions assumes that companies take corporate decisions that affect their

[1] See Borenstein (1989) for the American domestic market, among others, and Marín (1995) for the European international market.

entire network.[2]

Leaving aside reasons related to data availability, we believe that the second approach is more appropriate for the purpose of this paper. 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. In other words, scope economies among routes and network effects (almost) impose a common policy to all the routes served by a given carrier. We thus assume that the decision of an airline carrier 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.

Costs

In the short run, firms are endowed with a given technology that is determined by the quantity and quality of capital installed, as well as a network, determined by the previous history. In order to provide a given amount of service, Q_i, a carrier must buy variable inputs, namely, labor, L_i and materials, M_i, which productivity depends on installed capital, K_i, and network exogenous characteristics, z_i. The production process and its underlying technology can

[2] See Röller and Sickles (2000), Neven et al. (1996 and 2001), Marín (1998), and Gagnepain and Marin (2004), among others.

be implemented through a short-run dual cost function. Denoting by w_L and w_M the price of labor and materials, the program of the firm can be translated into the following terms:

$$\min_{L,M} \; C_i = w_L L_i + w_M M_i$$

$$\text{subject to}$$

$$Q_i = Q(L_i, M_i, K_i, z_i, t; \rho),$$

where t is a trend, and ρ is a vector of parameters denoting technology.

Note that we are assuming additive costs and C_i are observed operating costs. The associated short-run cost function, conditional on capital installed is

$$C_i = C(Q_i, \omega_i, K_i, z_i, \beta), \tag{1}$$

where β is a vector of parameters to be estimated.

Capacity

Before moving on to the demand side, we should notice that in transit industries, costs and revenues are driven by two different measures of output. Costs are determined by capacity supplied, i.e., available seat-kilometers, that in turn, depends on fleet capacity (measured by the number of seats available), and total mileage performed by the airplanes. However, available seat-kilometers are only an intermediate output that is used by consumers to produce the final output, revenue passenger-kilometers (see Berechman, 1993). This final output, q_i, determines carriers' revenues. Still, capacity and demand are closely related by a function that may change with time, t, with the technology available,

$$Q_i = \Phi(q_i, t; \lambda), \tag{2}$$

where λ is a vector of parameters to be estimated.

Demand

On the demand side, 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 carriers. 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. Accordingly, each carrier faces a demand of the form,

$$q_i(p_i, p_j, m_i, t; \alpha), \qquad i = 1, ..., N, \quad j \neq i \tag{3}$$

where α is a vector of parameters. Next, we need to define the structure of the system made of Equations (1)-(3).

3 Empirical implementation

The next step consists in proposing specific functional forms for the cost and demand functions, as well as the relationship between demand and capacity, in order to derive a set of structural equations to be estimated.

We assume a Cobb-Douglas specification for the cost function in (1). 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.[3] The cost function is then specified as

$$C_i = \beta_0 \; \omega_{Li}^{\beta_1} \omega_{Mi}^{\beta_2} Q_i^{\beta_3} K_i^{\beta_4} z_i \exp(\beta_t \; t + u_{ci}) \tag{4}$$

where ω_{Li}, ω_{Mi}, K_i and z_i denote wages, price of materials, capital installed and network exogenous characteristics that affect the cost function, t is a trend, and u_{ci} is an error term. Homogeneity of degree one in input prices is imposed, i.e., $\beta_1 + \beta_2 = 1$.

For our empirical specification we assume that z_i includes measures of airlines' network size, NET_i, and average stage length, ASL_i,[4] and has the following shape:

$$z_i = NET_i^{\beta_5} \; ASL_i^{\beta_6}. \tag{5}$$

With respect to the relationship between demand, q_i, and supply, Q_i, represented in (2), we assume the following functional form,

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

[4] 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.

$$Q_i = \lambda_0 \; q_i^{\lambda_1} \; \exp(\lambda_t \; t + u_{Qi}), \tag{6}$$

where u_{Qi} is an error term.

The demand equation corresponding to (3) is specified in linear form as follows

$$q_i = \alpha_{1i} + \alpha_{2i} p_i + \sum_{j \neq i} \alpha_{i-j} p_j + \alpha_m \; m_i + \alpha_t \; t + u_{qi}, \; i, j = 1, ..., N, \tag{7}$$

where p_i and m_i are firm i's average price and home country exogenous characteristics, t is a time trend and u_{qi} is an error term. Notice that we allow the intercept α_{1i} and the own-price effects α_{2i} to vary across carriers. Moreover, we account for firms' cross-price specific effects α_{i-j}. These two 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 (2000), 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 carrier are proportional to the size of its own network. Accordingly, we define $\alpha_{1i} = \alpha_0 + \alpha_1 NET_i$ and $\alpha_{2i} = \alpha_2 NET_i$.

Second, the total cross-price effect of a rival j is related to the share of i's network in which j is encountered as either a substitute or a complement. We therefore weight carriers' coincidences and potential connections with all their rivals. In particular, we define $\alpha_{i-j} = g(O_{i-j}, C_{i-j}) = \alpha_3 \; O_{i-j} + \alpha_4 \; C_{i-j}$, where α_3 and α_4 are the common cross-price effects and O_{i-j} and C_{i-j} are two variables that represent two components specific to each pair of carriers.

Let O_{i-j} refer to the share of route kilometers of i's network also served by carrier j and vice versa (share of overlapping route kilometers), and C_{i-j} refers to the share of route kilometers of i's network not served by carrier j and vice versa (share of connecting route kilometers). Notice that the cross-price effects of any two rivals will be symmetric, since they depend on the degree of overlapping and potential connecting routes across networks, i.e., $O_{i-j} = O_{j-i}$ and $C_{i-j} = C_{j-i}$. 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 carriers i and j makes it more likely for these carriers to be substitutes (complements resp.). Defining $p_{ij}^o = O_{i-j}\ p_j$, and $p_{ij}^c = C_{i-j}\ p_j$, expression (7) can be transformed into an equation with only two cross-price parameters α_3 and α_4 to be estimated,

$$\begin{aligned} q_i = {} & \alpha_0 + \alpha_1 NET_i + \alpha_2 NET_i p_i + \alpha_3 \sum_{j \neq i} p_{ij}^o + \alpha_4 \sum_{j \neq i} p_{ij}^c + \\ & \alpha_m\ m_i + \alpha_t\ t + u_{qi},\ i, j = 1, ..., N. \end{aligned} \tag{8}$$

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, $g(O_{i-j}, C_{i-j})$, and the α coefficients.

The system of equations formed by (4), (6) and (8) is determined simultaneously. Accordingly and in order to avoid endogeneity problems, these equations are estimated by the Instrumental Variables Estimation Method. The system is identified and all parameters can be recovered.

4 Data and variables definition

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 carriers annual reports. The companies under study are worldwide carriers with special attention to the U.S. and the E.U. carriers, which usually constitute the main alliance partners. Some of the carriers belong to international alliances and some others operate as independent airlines (see table 1 for a brief description of the major alliances). The dataset includes observations for a total of 55 airline carriers.

The variables have been constructed as follows. In the cost function, total costs (C_i), production (Q_i), wages (ω_{Li}), capital (K_i) and average stage length (ASL_i) correspond to total operating expenses (ICAO), seat-kilometers available, flight crew salaries and maintenance and overhaul expenses over number of employees, fleet total number of seats, and total aircraft kilometers over total aircraft departures, 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 data needed to construct these variables have been retrieved from different issues of *Digest of Statistics* published by ICAO, apart from number of employees that are published by IATA. The variable NET_i is the total number of route kilometers an airline operates on (published by IATA). Finally, the price of materials (ω_{Mi}) has been constructed as the average fuel prices at the carrier's home country and at the OECD (published by OECD), weighted by the company's domestic and international operations respectively (published by ICAO).

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. All of them with raw data provided by ICAO. The home country exogenous characteristic m_i is consumption growth ($GCONS_i$), which corresponds to domestic private consumption (OECD). Finally, t the time trend, is equal to one in 1995 and incremented by one each year.

We turn now to the construction of the function $g(O_{i-j}, C_{i-j})$, following our previous definition, $\alpha_{i-j} = g(O_{i-j}, C_{i-j}) = \alpha_3 \; O_{i-j} + \alpha_4 \; C_{i-j}$, where O_{i-j} refers to the share of route kilometers of i's network also served by carrier j and vice versa, and C_{i-j} refers to the share of route kilometers of i's network not served by carrier j and vice versa. In practice, observing all the routes of the 55 companies and identifying the kilometers that two companies i and j have in common is a difficult and endless task. To make the construction of our variables O_{i-j} and C_{i-j} feasible, we assume that most of the activity of an airline carrier is operated from its hub.[5] It is thus suggested that the degree of substitutability (complementarity resp.) between the total operations of two airline carriers i

[5]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.

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. Hence, define O_{ij} (O_{ji}) as carrier i (j)'s share of hub route kilometers also served by carrier j (i), C_{ij} (C_{ji}) as carrier i (j)'s share of hub route kilometers not served by carrier j (i) and T_i (T_j) as total hub route kilometers for carrier i (j). Provided with these components it is possible to define $O_{i-j} = \frac{(O_{ij}+O_{ji})}{(T_i+T_j)}$, $C_{i-j} = \frac{(C_{ij}+C_{ji})}{(T_i+T_j)}$, and

$$\alpha_{i-j} = g(O_{i-j}, C_{i-j}) = \frac{\alpha_3\ (O_{ij} + O_{ji}) + \alpha_4\ (C_{ij} + C_{ji})}{(T_i + T_j)}$$

Notice that we expect $g'_O > 0$, and $g'_C < 0$. Moreover, $C_{i-j} = 1 - O_{i-j}$, which implies that carrier i and carrier j can be considered as substitutes (complements resp.) when $\alpha_{i-j} > 0$ ($\alpha_{i-j} < 0$ resp.), i.e., when $O_{i-j} > -\frac{\alpha_4}{\alpha_3-\alpha_4}$ ($O_{i-j} < -\frac{\alpha_4}{\alpha_3-\alpha_4}$ resp.).

Note also that α_{i-j} varies over time and both O_{ij} and O_{ji} may be decision variables for carriers i and j. In order to avoid endogeneity problems, we keep O_{i-j} fixed over time, i.e., we use the 1995 value of O_{i-j} to proxy the degree of substitution between carriers over the whole period of observation.

5 Evaluating demand elasticities and costs

Tables 2 to 5 provide the results for the econometric model. We recover in this section the two main sets of ingredients that are required to evaluate competition in the industry: First, own and cross price elasticities are obtained trough the estimation of the airline demand function. Second, individual marginal cost values are recovered from the estimation of the cost function.

Table 2 presents the results for the demand equation. All the coefficients have the expected signs. As expected, demand increases significantly with the size of the network. Likewise, private consumption growth affects positively demand, although the parameter is not significant. The own price parameter α_2 is negative and significant, and implies a value for the own price elasticity of $\theta_{ii} = -3.817$ for the average airline carrier over the period considered.[6] 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 carriers i and j makes it more likely for these carriers to be substitutes. Likewise, a higher proportion of connecting route kilometers between two carriers i and j makes it more likely for these carriers to be complements. Our estimation shows that two carriers i and j are substitutes when $O_{i-j} > 0.169$, i.e., when at least 16.9% of the total route kilometers departing from the hubs of carriers i and j are operated by both i and j. Note that, among the 1485 possible carriers pairs from our sample, only 12 are made of carriers that are substitutes. This clearly suggests that services operated by airline carriers are generally complements. Table 3 identifies the pairs of carriers whose services are substitutes. Interestingly, only one of these pairs of carriers belongs to the same alliance, namely, *SAS* and *Thaï,* which belong to *Star Alliance.* Otherwise, alliances gather companies whose services can be considered as complements.

Cross price elasticity θ_{ij} between carrier i and carrier j is given by $(\alpha_2 O_{i-j}+$

[6] 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.

$\alpha_3 C_{i-j})\frac{p_j}{q_i}$. Considering two average firms in the sample, say *Alitalia* and *Thai* for instance, cross price elasticities are $\theta_{TA} = -0.01$ and $\theta_{AT} = -0.005$. These elasticities show small complementarity between these two carriers.

Table 4 presents the demand-capacity relationship. Again, the coefficients are significant and have the expected sign. The main interest of this equation is to provide instruments for supply in the cost function. Table 5 presents the estimates for the cost function. The variable capital has been dropped from the regressions because of multicollinearity problems.[7] Additionally, running a maximum likelihood test, it was not possible to reject the model without capital against a model including it at any sensible confidence level.[8]. 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 time trend is negatively signed, suggesting the presence of technological progress. Finally, airlines' network size and average stage length have a negative impact on operating cost. Thus, companies with higher networks and/or longer routes enjoy a significant cost advantage.

[7]This correlation problem is common to most empirical studies dealing with the estimation of short run costs functions.

[8]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.

6 Evaluating competition

Provided with the demand and cost estimates, we are capable of providing measures that characterize the degree of competition in the industry after the introduction of alliances.

We define the pricing program of each alliance. Denote by A_s the set of companies belonging to alliance s, $\{1s, ..., is, ...Is\}$. Notice that, under this notation, one alliance may have one or more members.

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

$$\max_{p_{is}} \pi_{is} = \sum_{\forall is \in A_s} q_{is}(\cdot) p_{is} - \sum_{\forall is \in A_s} C(\Phi(q_i(\cdot), \cdot), \omega_i, K_i, z_i), \tag{9}$$

where p_{is} is a vector of optimal prices to be chosen. Thus, each company i of the set A_s defines the optimal price that maximizes the sum of all A_s's members profits. Accordingly, the first order conditions for firm i that belong to alliance s are given by

$$\frac{p_{is} - \Phi'(q_{is}(\cdot)) \; MC_{is}(\Phi(q_{is}(\cdot)))}{p_{is}} = -\frac{q_{is}}{p_{is}} \Delta_{is}, \tag{10}$$

where

$$MC_{is}(\cdot) = \frac{\partial C_{is}}{\partial Q_{is}} \quad \text{and} \quad \Phi'(q_{is}(\cdot)) = \frac{\partial Q_{is}}{\partial q_{is}}.$$

The term Δ_{is} accounts for differences in price elasticities under different competitive situations. Using the estimates of the cost, capacity and demand system obtained in the previous section, we can evaluate the price-cost margins M_{it} (expressed in the left-hand side of Equation 10), and test these margins against those that could be obtained if carriers obeyed to alternative Nash behaviors. In particular, we define the following values for Δ_{is}:

$$\Delta_{is1} = \frac{\partial p_{is}}{\partial q_{is}}, \tag{11}$$

and

$$\Delta_{is2} = \frac{\partial p_{is}}{\partial q_{is}} \left[1 + \frac{1}{q_{is}} \sum_{\forall js \in A_s,\ j \neq i} (p_{js} - \Phi'(q_{js}(\cdot))\ MC_{js}(\Phi(q_{js}(\cdot)))) \frac{\partial q_{js}}{\partial p_{is}} \right]. \tag{12}$$

The first term Δ_{is1} indicates that firms in the alliance s set prices independently, since each firm i only cares for its own demand q_{is}. The second term entails that firms in the same alliance s set prices jointly. If two firms i and j of A_s are complements ($\frac{\partial q_{js}}{\partial p_{is}} < 0$), their corresponding networks offer the possibility of connecting many routes. Thus, firm i internalizes the positive effect on j's demand q_{js} of a decrease of its own price p_{is}. Hence, we expect $\Delta_{is2} < \Delta_{is1}$. From the estimation of the real margins, we can figure out what carriers' behavior fits the data better.

From the expressions of demand (8), capacity (6) and costs (4), the price first-order condition (under Nash behavior) can be rewritten as

$$\frac{p_{is} - \frac{\lambda_1\ Q_{is}}{q_{is}} MC_{is}(\cdot)}{p_{is}} = -\frac{q_{is}}{p_{is}} \Delta_{is}. \tag{13}$$

where our alternative expression for Δ_{is} corresponds to either

$$\Delta_{is1} = \frac{1}{\alpha_1} \tag{14}$$

or

$$\Delta_{is2} = \frac{1}{\alpha_1}\left[1 + \frac{1}{q_{is}} \sum_{\forall js \in A_s,\ j \neq i} \left(p_{js} - \frac{\lambda_1\ Q_{js}}{q_{js}} MC_{js}(\cdot)\right)(\alpha_2\ O_{is-js} + \alpha_3\ C_{is-js}))\right] \tag{15}$$

respectively for the two cases referred above.

Through the estimation of the cost function, the marginal costs MC 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 set by each carrier, defined as the left-hand side of Equation (13). Then, we can compare these values with those predicted by the two alternative behavioral scenarios proposed above.

Table 6 presents the estimated values for marginal costs MC, and margins M, for all firms and alliances. Several results are worth emphasizing. First, the average carrier 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 carriers 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 (13), Nash behavior that involves individual price setting ($\Delta_{is} = \Delta_{is1}$) would entail an average margin M_I^T for all the carriers in the sample equal to 0.317. A t-test ($H_0 : M^T - M_I^T = 0$) presented in Table (7) shows that, on average, the industry's real margin M^T does not entail pure Nash behavior. It is also worth distinguishing carriers that belong to alliances and those that do not. Table (6) has suggested that companies within alliances were setting the highest margins. To test whether these companies do actually have a less competitive behavior than those outside alliances, we need to 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 carriers within alliances meet demand on a more inelastic portion of the curve than other companies. Hence, pure individual Nash behavior for companies inside alliances entails a margin M_I^A equal to 0.404, while for other companies the margin, M_I^{NA}, is equal to 0.298. Table (7) shows that the values of these actual margins lie below the individual Nash behavior margins M_I^A and M_I^{NA}. A t-test ($H_0^A : M^A - M_I^A = 0$ and $H_0^{NA} : M^{NA} - M_I^{NA} = 0$) suggests that 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 carriers, suggesting that they are more likely to survive in the long run. Finally, we can evaluate an individual Nash margin for each alliance. A t-test ($H_0 : M^s - M_I^s = 0$, $s = one, sky, qua, sta, win$) presented in Table (7) shows that three alliances, namely SkyTeam, Qualiflyer, and Star Alliance, show a behavior that is not significantly different from individual Nash, while OneWorld and Wings do not. According to our results, OneWorld is the alliance characterized by the most competitive behavior, while SkyTeam is the alliance with the less competitive behavior.

Using our estimates for the demand equation, and in particular the evaluation of the cross price elasticities $\frac{\partial q_{js}}{\partial p_{is}}$ between two members i and j of the same alliance s, we can also compute estimates of joint Nash margin M_J^s for each alliance, as suggested by the right-hand side of Equation (13). Joint Nash behavior involves joint price setting ($\Delta_{is} = \Delta_{is2}$) by all the members of the same alliance s. Again, since carriers' networks are usually complement goods, we expect $\frac{\partial q_{js}}{\partial p_{is}} < 0$ in Equation (15), and joint Nash margins M_J^s to be lower than individual Nash margins M_I^s. As shown by Table 7, joint Nash margins are actually lower than individual Nash margins, and get closer to the observed margins M^s. A t-test ($H_0 : M^s - M_J^s = 0$, $s = one, sky, qua, sta, win$) shows that joint Nash margins explain better the behavior of the alliances than individual Nash margins. Note however that the differences between individual and joint Nash margins are small, which suggests that joint price setting may not be the only criterion accounted by firms. This is especially true for OneWorld and Wings, since joint Nash margins are statistically different from actual margins for these two alliances.

7 Conclusion

After worldwide liberalization of the airline market, competition has led firms to start forming alliances that allow them to share operating costs, as illustrated by our data. In terms of prices, economic studies have proposed that alliances between carriers whose networks can be regarded as substitutes should result in softer competition and higher prices. At the same time, alliances between carriers whose networks can be regarded as complements should result in lower prices due to cost reductions. In both cases, price cost margins and carriers' viability increase in the mid run. However, the former type of alliance should be avoided, but the latter should be promoted.

This study sheds light on these issues. First, it suggests that most of the companies that were allied between 1995 and 2000 could cooperate on routes that were not individually served before and could connect their networks so that prices and marginal costs went down, the joint effect of these two forces leading to greater price cost margins. Second, companies outside the alliances suffer from lower price costs margins than those within alliances, even if, on average, they set higher prices, and the difference between the observed and the predicted Nash equilibrium prices is much greater for the former than for the latter.

From the methodological point of view, in order to estimate cross-price elasticities for all the networks of our database, we follow an original approach that considers carriers' networks coincidences and potential connections with all their rivals. The results allow us to classify all company pairs as either complements or substitutes, predict equilibrium prices and price cost margins and show how alliances do not have uniform pricing habits, since only some of them follow a behavior that is consistent with our predictions.

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Table 1: Alliances

Alliance	Carrier	Date of entry	Passengers-kilometers	Seats-kilometers
OneWorld	American Airlines	Sep. 98	165,194,000	249,425,000
	British Airways	Sep. 98	90,944,000	122,958,000
	Qantas	Sep. 98	48,861,238	71,632,829
	Cathay	Sep. 98	34,767,329	48,731,677
	Iberia	Sep. 99	23,804,031	34,008,114
	Finnair	Sep. 99	8,340,120	12,582,169
	Air Lingus	Jun. 00	4,660,790	6,460,729
SkyTeam	Delta	Sep. 99	136,940,000	209,297,000
	Air France	Sep. 99	49,519,667	69,785,887
	Alitalia	Jul. 01	31,747,753	45,697,720
	Aeromexico	Sep. 99	8,511,541	14,239,969
Star Alliance	United	May. 97	179,466,000	254,606,000
	Lufthansa	May. 97	61,600,009	88,221,964
	All Nippon	Oct. 99	42,854,773	67,273,587
	Air Canada	May. 97	26,314,335	41,863,124
	Thai	May. 97	27,053,463	40,298,160
	Varig	Oct. 97	20,877,027	31,626,415
	SAS	May. 97	18,509,619	28,449,076
	Mexicana	Jul. 99	8,326,962	13,744,500
	LOT	Jun. 03	4,241,765	6,412,989
	British Midland	Jul. 00	2,435,369	3,994,240
	Spanair	Jun. 03	983,847	1,594,978
Wings	Northwest	Jan. 93	100,567,000	140,713,000
	KLM	Jan. 93	44,674,126	59,921,960
Qualiflyer	Swissair	Mar. 98	19,724,661	30,587,416
	Sabena	Mar. 98	8,620,068	13,685,377
	TAP	Mar. 98	7,715,318	11,193,321
	LOT	Jan. 00	4,241,765	6,412,989
	Air Europa	Mar. 99	1,992,799	2,727,027

Note: “Date of entry” refers to the date at which the carrier joins the alliance.
“Passengers-kilometers” and “Seats-kilometers” are total demand and supply, 1995.

Table 2: Demand function

Dependent variable: q_i

Variable	Coefficient	Estimate
Constant	α_0	0.491 (0.264)
$\boldsymbol{NET_i}$	α_1	0.496 (0.013)
$\boldsymbol{P_i}$	α_2	-3.354 (0.115)
$\boldsymbol{P_{jo}}$	α_3	0.407 (0.181)
$\boldsymbol{P_{jc}}$	α_4	-0.083 (0.042)
$\boldsymbol{GCONS_i}$	α_5	0.079 (0.063)
Standard Deviation of the error term		0.121 (0.005)

Note: Standard deviations in parentheses.

Table 3: Pairs of substitute carriers

Carrier *i*	**Carrier *j***	O_{i-j}
All Nippon	Japan Airlines	0.564
Delta	TWA	0.386
Aeromexico	America West	0.348
SAS	Thaï	0.335
Continental	TWA	0.311
Air U.K.	Spanair	0.306
Continental	Delta	0.267
British Airways	Virgin Atlantic	0.240
Aeromexico	Mexicana	0.238
Air Europa	Spanair	0.183
Japan Airlines	United	0.181
Olympic	TWA	0.179

Note: O_{i-j} is defined as $(O_{ij}+O_{ji})/(T_i+T_j)$, where O_{ij} (O_{ji}) is defined as carrier *i* (*j*)'s share of hub route kilometers also served by carrier *j* (*i*), and T_i (T_j) is the total hub route kilometers for carrier *i* (*j*).

Table 4: Demand-Capacity relationship
Dependent variable: $\ln(Q_i)$

Variable	Coefficient	Estimate
Constant	λ_0	1.947 (0.456)
Ln(q)	λ_1	0.896 (0.028)
Standard Deviation of the error term		0.908 (0.035)

Note: Standard deviations in parentheses.

Table 5. Cost function
Dependent variable: $\ln(C_i)$

Variable	Coefficient.	Estimate
Constant	β_0	-4.933 (0.240)
$\boldsymbol{w_{Li}}$	β_1	0.238 (0.023)
$\boldsymbol{Q_i}$	β_3	0.937 (0.025)
$\boldsymbol{NET_i}$	β_5	-0.079 (0.034)
$\boldsymbol{ASL_i}$	β_6	-0.379 (0.038)
$\boldsymbol{T}$	β_t	-0.059 (0.010)
Standard Deviation of the error term		0.303 (0.011)

Notes: Standard deviations in parentheses.

Table 6. Marginal costs, prices, and margins.

	Price	*MC*	*M*
All carriers	0.117	0.068	0.157
Carriers within alliances	0.103	0.059	0.259
Carriers outside alliances	0.120	0.070	0.135
OneWorld	0.080	0.045	0.299
SkyTeam	0.090	0.048	0.327
Qualiflyer	0.094	0.068	0.043
Star Alliance	0.098	0.052	0.315
Wings	0.122	0.071	0.251

Notes: Price: One passenger-kilometer in Dollars.
Marginal cost *MC*: One seat-kilometer in Dollars.
All values for marginal costs, *MC*, and margins, *M*, are significantly different from zero at the 1% level.

Table 7. Comparing estimated margins with Nash and Joint Profit behaviors.

Companies	Individual Nash M_I	Alliance Nash M_J	Real Margin M	Test $M_I - M$	Test $M_J - M$
All carriers	0.317	-	0.157	5.686	
Carriers within alliances	0.404	-	0.259	2.878	
Carriers outside alliances	0.298	-	0.135	6.053	
OneWorld	0.574	0.564	0.299	4.656	4.333
SkyTeam	0.452	0.448	0.327	1.176	1.042
Qualiflyer	0.209	0.204	0.043	1.512	1.480
Star Alliance	0.363	0.355	0.315	0.784	0.651
Wings	0.430	0.419	0.251	2.531	2.387