

A discusión

STRATEGIC EFFECTS OF INTERNATIONAL AIRLINE ALLIANCES*

Ricardo Flores-Fillol and Rafael Moner-Colonques**

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Corresponding author: R. Moner-Colonques. Universitat de València, Department of Economics, Campus dels Tarongers, 46022 Valencia (Spain). Tel.: 96 382 87 84 / Fax: 96 382 82 49 / E-mail: Rafael.Moner@uv.es

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** R. Flores-Fillol: Universidad Autónoma de Barcelona, Spain. R. Moner-Colonques: Universitat de València, Spain.

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ABSTRACT

The present paper develops a simple model of a network structure to analyze the profitability and the strategic effects of airline alliances in which two complementary alliances, following different paths, may be formed to serve a certain city-pair market. We examine whether airlines that employ the same hub have an incentive to create an alliance, analyze the effects on carriers outside the alliance and study how fares are affected. We conclude that complementary alliances are profitable for a sufficient degree of product differentiation, which implies that competition intensity is low; that an alliance hurts the outsiders; and that fares will decrease. These findings remain valid to the introduction of more competition in the form of a direct non-stop flight. Our results provide a very simple testable implication that relies on demand parameters that measure the degree of product differentiation, and our findings are consistent with some of the observed facts in the industry.

Keywords: complementary airline alliances, substitute trips, product differentiation.

1 Introduction

The air transportation sector has witnessed a number of changes since the deregulation processes of the US industry (in the 1980s) and of the European industry (in the 1990s). These changes include the substantial decline in the number of major carriers, the intensified reorganization of routes into hub-and-spoke networks and, still taking place, the formation of strategic alliances among international carriers.¹ The present paper develops a simple model of a network structure where passengers in a given city-pair market use two carriers connecting through a hub airport. Passengers can fly via different hubs to reach their destination. We examine whether airlines that employ the same hub have an incentive to create an alliance, analyze the effects on carriers outside the alliance and study how fares are affected.

Airline alliances are designed to offer passengers a seamless service in order to minimize some of the inconveniences of interline multicarrier trips. They allow the carriers to rely on a partner to provide flight to destinations where they lack route authority. Cooperation adopts several forms -which in many instances come close to effective merger- and includes code-sharing agreements, the coordination of flight schedules and the joint use of frequent flyer programs. To illustrate our analysis let us consider the following simple network structure. Suppose that a passenger wishes to travel from Madrid to Washington. He can fly via Chicago O'Hare International or via London Heathrow. In the former case, Madrid-Chicago is provided by Iberia

¹See Morrison and Winston (1995) for an overview of developments in the industry.

(e.g. IB6275) and Chicago-Washington R.Reagan National is operated by American Airlines (e.g. IB7063). In the latter, the passenger can fly with British Midland from Madrid to London (e.g. BD482) and then make the trip between London and Washington Dulles International with United Airlines (e.g. UA925). As it turns out, Iberia and American Airlines belong to the Oneworld alliance - in fact, our example is one of a codesharing agreement. On the other hand, British Midland and United Airlines are partners in the Star Alliance.² It is our purpose to characterize the pre-alliance and alliance situations when there is competition between routes through different hubs and each trip requires travelling with two carriers, which are viewed by passengers as complementary products.

The existing literature on airline alliances is sparse. Theoretical hub-and spoke network models include Brueckner and Spiller (1991), Oum et al. (1995), Park (1997), Berechman et al (1998), Hendricks et al (1999), Barla and Constantatos (2000), Brueckner (2001), Lin (2004) and Hassin and Shy (2004). The papers by Oum et al. (1995), Berechman et al (1998), Hendricks et al (1999) and Barla and Constantatos (2000) provide reasons and conditions under which hub-and-spoke networks are equilibrium structures. Brueckner and Spiller (1991) first developed a hub-and-spoke model where an airline is considered as a multiproduct firm with cost complementarities. They assume a cost function with increasing returns to traffic density and

²The reader can access www.airwise.com and find plenty of examples where a passenger must change planes on their way to final destination where carriers belong to the same alliance; trips can be made through different hubs.

compare the monopoly solution with other solutions involving various types of competition. Competition transmits across routes because of returns to traffic density and suggest that antitrust treatment on this issue should be more carefully looked at. Brueckner (2001) adapts the former model to an international setting. His analysis emphasizes the beneficial impact for passengers derived from complementary alliances, since they put a downward pressure on fares in the interline city-pair markets: "a couple of studies showed that tickets booked through allied airlines on two-stage flights were 18-28% cheaper than separate flights on the same route with non-allied airlines".³ Hassin and Shy (2004) also examine codesharing agreements among airlines competing on international routes and show that codesharing including all carriers are welfare improving. On the other hand, Park (1997) classifies alliances in two categories: parallel and complementary. A parallel alliance refers to collaboration between two firms competing on the same route and the complementary one refers to the case where two firms link up their existent networks and build a new network providing an interlining service to their passengers. Park (1997) shows that each type of alliance has a different impact on economic welfare; complementary alliances are likely to increase it. Finally, Lin (2004) proposes a game where airlines can choose the roles of fare-leader and fare-follower in the allied markets.⁴

³Economist (10/04/2003).

⁴The effect of airline alliances has been empirically investigated by Oum et al. (1996), Park and Zhang (1998), Brueckner and Whalen (2000), Brueckner (2003), among many others. These studies provide evidence that international alliances lead to lower fares, increases in the number of passengers on the relevant routes and that airline cooperation

The network structure is typically assumed exogenous and although earlier analyses have looked at several structures, none of them has considered the one proposed in the present study. It is conveniently constructed to take into account the type of collaboration among partners in the same alliance, contemplates the use of different hub airports and allows us to model competition between substitute routes when each route is composed of complementary trips. We will assume that every alliance enjoys antitrust immunity, which allows the partners to collaborate in pricing decisions. Thus, we will suppose that cooperation is full, which implies that the alliance will behave as a single carrier in the market for which it is formed at the eyes of the passengers.

Specifically, the aim of our paper is to analyze the profitability and the strategic effects of airline alliances in a simple setting in which two complementary alliances, following different paths, may be formed to serve a certain city-pair market. We wish to answer the following questions: when are alliances profitable for the potential partners?, what are the "collateral effects" of an alliance for the outsiders? what is the outsiders' optimal response? and how are fares affected? We conclude that complementary alliances are profitable for a sufficient degree of product differentiation; that an alliance hurts the outsiders; and that fares will decrease. These findings remain valid to the introduction of more competition in the form of a direct non-stop flight. The

generates important benefits for interline passengers. See also Lee (2003) for a criticism on some evaluations of the US airline industry.

paper is structured as follows. Section 2 introduces the model presenting the pre-alliance equilibrium and the equilibria arising from the situations with a single and a double alliance, respectively. A simultaneous game of airline alliances is then presented. Section 3 proposes a modification of the model where there is a new airline operating. A brief concluding section closes the paper.

2 The Model

Basic assumptions.

The model's network structure is shown in Figure 1. Airline 1 operates route AH , airline 2 serves route HB , airline 3 provides the flight AK and airline 4 operates route KB . Travellers wish to fly from city A to city B through airport H or through airport K . Thus, travellers must fly by either combining airlines 1 and 2 or by combining airlines 3 and 4 so that routes AH and HB are regarded as complementary products (just as routes AK and KB together). However, the trips through airport H and airport K are viewed by travellers as substitute trips. There is no direct flight connecting cities A and B so that passengers have to interline at the hubs H and K . The proposed network structure is meant as a first approximation to the above example and aims at capturing the particular aspect of alliances where carriers cooperate to offer trips in which passengers need to travel with two different airlines. Thus, city A would be Madrid and city B Washington and the hubs H and K would be Chicago and London, respectively; airlines 1 through 4

are Iberia, American Airlines, British Midland and United Airlines.⁵

We will assume that demand functions for air travel between cities A and B are linear as follows,

$$\begin{aligned} Q_{12} &= \alpha - b(p_1 + p_2) + d(p_3 + p_4) \\ Q_{34} &= \beta - b(p_3 + p_4) + d(p_1 + p_2) \end{aligned}$$

where Q_{12} and Q_{34} represent the travel volumes on the two interline flights in the market; p_i denotes the fare charged by airline i , for $i = 1, 2, 3, 4$; α, β are positive parameters that measure market size and the quality of the services provided; b, d are positive and $b > d$. This demand system for differentiated products follows from solving the optimization problem of a representative passenger with a quasi-linear utility function a la Dixit (1979); it reflects that composite products are substitutes for one another and products are less differentiated as d tends to b . Marginal costs per passenger are assumed zero. Economides and Salop (1992) illustrate their results on complementary goods with the above linear demand system.

We begin by characterizing the *pre-alliance* solution. Airlines choose simultaneously and non-cooperatively their respective profit-maximizing fares. The profit functions are $\pi_1 = p_1 Q_{12}$, $\pi_2 = p_2 Q_{12}$, $\pi_3 = p_3 Q_{34}$, and $\pi_4 = p_4 Q_{34}$. Superscript *na* denotes the no-alliances scenario. The equilibrium prices are

⁵Note that, in the European Economic Area, the proportion of monopoly routes account for about 75%.

given by,

$$p_1^{na} = p_2^{na} = \frac{3b\alpha + 2d\beta}{9b^2 - 4d^2}; \quad p_3^{na} = p_4^{na} = \frac{3b\beta + 2d\alpha}{9b^2 - 4d^2}$$

Equilibrium travel volumes, profits and consumer surplus are the following,

$$Q_{12}^{na} = \frac{b(3b\alpha + 2d\beta)}{9b^2 - 4d^2} = bp_1^{na}; \quad Q_{34}^{na} = \frac{b(3b\beta + 2d\alpha)}{9b^2 - 4d^2} = p_3^{na}$$

$$\pi_1^{na} = \pi_2^{na} = \frac{b(3b\alpha + 2d\beta)^2}{(9b^2 - 4d^2)^2} = b(p_1^{na})^2; \quad \pi_3^{na} = \pi_4^{na} = \frac{b(3b\beta + 2d\alpha)^2}{(9b^2 - 4d^2)^2} = b(p_3^{na})^2$$

$$CS^{na} = \frac{b[(9b^2 + 4d^2)(\alpha^2 + \beta^2) + 24bd\alpha\beta]}{2(9b^2 - 4d^2)^2}$$

2.1 Alliance equilibrium between airlines 1 and 2.

With an alliance, the airlines 1 and 2 set the fare for flight through hub H cooperatively while competition with flight through hub K remains. Denote by p_{12} the fare of the interline flight. Demand functions take now the form: $Q_{12} = \alpha - bp_{12} + d(p_3 + p_4)$ and $Q_{34} = \beta - b(p_3 + p_4) + dp_{12}$. Thus, the profit functions are given by $\pi_{12} = p_{12}Q_{12}$, $\pi_3 = p_3Q_{34}$, and $\pi_4 = p_4Q_{34}$. Solving the system formed by $\partial\pi_{12}/\partial p_{12} = 0$, $\partial\pi_3/\partial p_3 = 0$ and $\partial\pi_4/\partial p_4 = 0$ yields the following equilibrium prices,

$$p_{12}^a = \frac{3b\alpha + 2d\beta}{2(3b^2 - d^2)}; \quad p_3^a = p_4^a = \frac{2b\beta + d\alpha}{2(3b^2 - d^2)}$$

where superscript a identifies the airline alliance between 1 and 2. The remaining equilibrium variables are,

$$Q_{12}^a = \frac{b(3b\alpha + 2d\beta)}{2(3b^2 - d^2)} = bp_{12}^a; \quad Q_{34}^a = \frac{b(2b\beta + d\alpha)}{2(3b^2 - d^2)} = bp_3^a$$

$$\pi_{12}^a = \frac{b(3b\alpha + 2d\beta)^2}{4(3b^2 - d^2)^2} = b(p_{12}^a)^2; \quad \pi_3^a = \pi_4^a = \frac{b(2b\beta + d\alpha)^2}{4(3b^2 - d^2)^2} = b(p_3^a)^2$$

$$CS^a = \frac{b[(9b^2 + d^2)\alpha^2 + 16bd\alpha\beta + 4(b^2 + d^2)\beta^2]}{8(3b^2 - d^2)^2}$$

The next result follows directly by comparing the situation with an airline alliance vis a vis the pre-alliance solution.⁶

Proposition 1 *i) The fare p_{12}^a is lower than the pre-alliance fare $p_1^{na} + p_2^{na}$.
ii) Airline profits with the alliance are higher than before for $0 < d/b < 0.66$.
iii) The fares set by airlines 3 and 4 are lower and so are their equilibrium profits.*

The above results partially confirm Cournot's (1838) model of complementary duopoly. Cournot considered the merger of two monopolists that produce complementary goods (zinc and copper) into a single (fused) monopolist that produces the combination of them (brass). The price of the composite good is lower than under independent ownership. The alliance between airlines that offer complementary services internalizes the externality that arises when they set fares independently thus ignoring the effects on their individual markups. If there were no competition from a substitute flight, then the alliance would always turn out profitable - as in Cournot's example. However, the presence of airlines 3 and 4 unveils that the alliance will

⁶The difference $p_1^{na} + p_2^{na} - p_{12}^a$ yields $3b^2(3b\alpha + 2d\beta)/(54b^4 - 42b^2d^2 + 8d^4)$, which is clearly positive provided $b > d$. Since prices are strategic complements it follows that p_3^a and p_4^a are now lower, and so are profits to airlines 3 and 4 by the way equilibrium profits are written. Finally, the difference $\pi_{12}^a/2 - \pi_1^{na}$ yields $(b/4)(3b\alpha + 2d\beta)^2(9b^4 - 24b^2d^2 + 8d^4)/(9b^2 - 4d^2)^2(3b^2 - d^2)^2$. The sign of the difference is given by the sign of $9b^4 - 24b^2d^2 + 8d^4$. The difference is positive for $(d/b) < 0.66$.

be profitable if competition is not too intense. Values of b far from values of d imply that product differentiation is strong and hence competition intensity is low; the difference in fares is smaller for smaller values of d . Then, although prices go down the increase in travel volumes is such that profits under the alliance situation are higher. Strategic complementary pushes prices of rival airlines down and consequently their profits.

Our findings can also be related with the literature on mergers with complementary products. Thus, Gaudet and Salant (1992) consider the case of n firms producing perfect complements and competing in price. They suggest that a merger of a subset $s \leq n$ of the firms may be unprofitable to the parties. Such a conclusion remains true, as we have just seen, in the presence of substitute products or systems (two possible trips) where each system is composed of two complementary components (interline flights).

2.2 Is an alliance between airlines 3 and 4 a best response to an alliance between airlines 1 and 2?

This subsection addresses whether it is always strategically optimal for the airlines outside the alliance to cooperate in setting the fare, p_{34} , for flight through hub K . Demands are now $Q_{12} = \alpha - bp_{12} + dp_{34}$ and $Q_{34} = \beta - bp_{34} + dp_{12}$. Superscripts aa stand for the case where both alliances occur. The corresponding equilibrium prices are given by,

$$p_{12}^{aa} = \frac{2b\alpha + d\beta}{4b^2 - d^2}; \quad p_{34}^{aa} = \frac{2b\beta + d\alpha}{4b^2 - d^2}$$

which yield the following travel volumes and profits,

$$Q_{12}^{aa} = \frac{b(2b\alpha + d\beta)}{4b^2 - d^2} = bp_{12}^{aa}; \quad Q_{34}^{aa} = \frac{b(2b\beta + d\alpha)}{4b^2 - d^2} = bp_{34}^{aa}$$

$$\pi_{12}^{aa} = \frac{b(2b\alpha + d\beta)^2}{(4b^2 - d^2)^2} = b(p_{12}^{aa})^2; \quad \pi_{34}^{aa} = \frac{b(2b\beta + d\alpha)^2}{(4b^2 - d^2)^2} = b(p_{34}^{aa})^2$$

$$CS^{aa} = \frac{b[(4b^2 + d^2)(\alpha^2 + \beta^2) + 8bd\alpha\beta]}{2(4b^2 - d^2)^2}$$

Comparison with the equilibrium variables in the previous subsection leads to the next result.⁷

Proposition 2 *i) The fare p_{34}^{aa} is lower than $p_3^a + p_4^a$ when airlines 1 and 2 form an alliance. Furthermore, p_{12}^{aa} is also lower than p_{12}^a .*

ii) Airlines 3 and 4 profits with the alliance are higher than before for $0 < d/b < 0.77$. Furthermore, profits of alliance between 1 and 2 decrease.

Again, the alliance (or integration) of companies providing complementary products drives prices down. Not only the fare of the new alliance decreases but also that of the rival; this happens because prices are strategic complements. It then follows that, as illustrated in proposition 1, the formation of an alliance is disadvantageous for rivals no matter they set fares cooperatively (as in this subsection) or non-cooperatively (as in the previous subsection). The intuition for airlines 3 and 4 to strategically form an alliance is the same as before. The price decrease is lower the higher the degree

⁷The difference $p_3^a + p_4^a - p_{34}^{aa}$ results in $b^2(2b\beta + d\alpha)/(12b^4 - 7b^2d^2 + d^4)$, which is positive provided $b > d$. The difference $\pi_{34}^{aa}/2 - \pi_3^a$ yields $(b/2)(2b\beta + d\alpha)^2(2b^4 - 4b^2d^2 + d^4)/(4b^2 - d^2)^2(3b^2 - d^2)^2$. The sign of the difference is given by the sign of $2b^4 - 4b^2d^2 + d^4$. The difference is positive for values of d/b below 0.77.

of product differentiation. Consequently, low values of the ratio d/b make it such that the alliance is profitable despite the loss associated with lower prices. It is also worth mentioning that a setting with two alliances leads to lower fares and higher total travel volumes. These theoretical findings coincide with some observed facts in the airline industry.

As for consumer surplus, $CS^a > CS^{na}$ unless d/b is very high (above 0.943). Put differently, when products are very weakly differentiated an alliance will damage consumers. It is well known that with homogeneous products, mergers reduce consumer surplus. The difference $CS^{aa} - CS^a$ has an ambiguous sign. As expected, the sign depends on the size of the demand parameters α and β .⁸ In particular, if the market of the new allied airlines, β , is sufficiently large relative to the one of the already allied airlines, α , then the setting with two alliances will result in higher consumer surplus for every $d/b \in (0, 1)$.

2.3 A simultaneous game of airline alliances.

The foregoing analysis suggests that airline alliances are profitable only under some circumstances. Let us then propose the following two-stage game. In the first stage airlines 1 and 2 and airlines 3 and 4 decide simultaneously and independently whether to form an alliance. In stage two, given the inherited outcome from the first stage, airlines set fares. From our previous

⁸The precise condition is $\frac{\beta}{\alpha} > \frac{d(4b^4+9b^2d^2-3d^4)}{2(20b^5-23b^3d^2+5bd^4)}$. The r.h.s. is increasing with d so that the higher value it can take is $10/4$. Hence, it is sufficient that $\beta > 2.5\alpha$ to have that consumers are better off with both alliances.

analysis the subgame perfect equilibrium amounts to characterizing the Nash equilibrium of the following normal-form game, where each cell shows profit per airline:

<i>Airlines 1 or 2 // 3 or 4</i>	<i>Alliance</i>	<i>No Alliance</i>
<i>Alliance</i>	$\left(\frac{b(2b\alpha+d\beta)^2}{2(4b^2-d^2)^2}, \frac{b(2b\beta+d\alpha)^2}{2(4b^2-d^2)^2} \right)$	$\left(\frac{b(3b\alpha+2d\beta)^2}{8(3b^2-d^2)^2}, \frac{b(2b\beta+d\alpha)^2}{4(3b^2-d^2)^2} \right)$
<i>No Alliance</i>	$\left(\frac{b(2b\alpha+d\beta)^2}{4(3b^2-d^2)^2}, \frac{b(3b\beta+2d\alpha)^2}{8(3b^2-d^2)^2} \right)$	$\left(\frac{b(3b\alpha+2d\beta)^2}{(9b^2-4d^2)^2}, \frac{b(3b\beta+2d\alpha)^2}{(9b^2-4d^2)^2} \right)$

We may use the above results to solve for the Nash equilibrium. Suppose that airlines 3 and 4 do not form an alliance. Then, airlines 1 and 2 will if $0 \leq \frac{d}{b} \leq 0.66$ and will not if $0.66 < \frac{d}{b} < 1$. Now suppose that airlines 3 and 4 form an alliance. Then, airlines 1 and 2 will if $0 < \frac{d}{b} \leq 0.77$ and will not if $0.77 < \frac{d}{b} < 1$. The analysis is symmetric to study the best response for airlines 3 and 4. Thus, the next proposition follows in a straightforward manner.

- Proposition 3** *i) No alliances will occur in equilibrium for $\frac{d}{b} \in (0.77, 1)$.
ii) Both alliances take place in equilibrium for $\frac{d}{b} \in (0, 0.66]$.
iii) No alliances and both alliances are equilibria for $\frac{d}{b} \in (0.66, 0.77]$.*

The degree of product differentiation indicates how intense competition is in the market. We conclude that a setting with alliances arises when competition intensity is low whereas alliances will not take place in equilibrium when competition intensity is tough. It must be noted that asymmetric equilibria in which only an alliance occurs is not possible in our demand-based setting. This suggests that some cost structure (e.g. returns to traffic density,

fixed costs and the like) should be introduced in the model if we searched for a theoretical explanation to some observed behaviour in the airline industry. Furthermore, part ii) of the above proposition can result in a prisoners' dilemma situation, that is, $\pi_{12}^{aa}/2$ (resp. $\pi_{34}^{aa}/2$) can be lower than π_1^{na} (resp. π_3^{na}). It is sufficient that d/b exceeds 0.52 to have that $\pi_1^{na} > \pi_{12}^{aa}/2$, regardless of the values of α and β .

3 Direct Non-stop Competition.

We wish to examine whether the previous results are modified in the presence of another carrier offering non-stop flights. Thus suppose that there is another airline, denoted 5, which provides direct service between cities A and B (see Figure 2). Symmetric demand functions are the following,

$$\begin{aligned} Q_{12} &= \alpha - b(p_1 + p_2) + d(p_3 + p_4) + ep_5 \\ Q_{34} &= \beta - b(p_3 + p_4) + d(p_1 + p_2) + ep_5 \\ Q_5 &= \gamma - bp_5 + e(p_1 + p_2 + p_3 + p_4) \end{aligned}$$

where $\gamma > 0$, and $b > d + e$, because the products are gross substitutes. We will employ tildes to distinguish the different equilibrium variables from those in the previous section. The *pre-alliance* equilibrium is characterized by the following prices, travel volumes and profits:

$$\begin{aligned} \tilde{p}_1^{na} &= \tilde{p}_2^{na} = \frac{1}{2} \left(\frac{\alpha - \beta}{3b + 2d} + \frac{b(\alpha + \beta) + e\gamma}{3b^2 - 2bd - 2e^2} \right) \\ \tilde{p}_3^{na} &= \tilde{p}_4^{na} = \frac{1}{2} \left(\frac{\beta - \alpha}{3b + 2d} + \frac{b(\alpha + \beta) + e\gamma}{3b^2 - 2bd - 2e^2} \right) \quad \tilde{p}_5^{na} = \frac{2e(\alpha + \beta) + (3b - 2d)\gamma}{2(3b^2 - 2bd - 2e^2)} \end{aligned}$$

$$\tilde{Q}_{12}^{na} = b\tilde{p}_1^{na}; \quad \tilde{Q}_{34}^{na} = b\tilde{p}_3^{na}; \quad \tilde{Q}_5^{na} = b\tilde{p}_5^{na}$$

$$\tilde{\pi}_1^{na} = \tilde{\pi}_2^{na} = b(\tilde{p}_1^{na})^2; \quad \tilde{\pi}_3^{na} = \tilde{\pi}_4^{na} = b(\tilde{p}_3^{na})^2; \quad \tilde{\pi}_5^{na} = b(\tilde{p}_5^{na})^2$$

We next compute the equilibrium when *airlines 1 and 2 form an alliance*. Demands now take the form $Q_{12} = \alpha - bp_{12} + d(p_3 + p_4) + ep_5$, $Q_{34} = \beta - b(p_3 + p_4) + dp_{12} + ep_5$ and $Q_5 = \gamma - bp_5 + e(p_{12} + p_3 + p_4)$. Maximization of $\pi_{12} = p_{12}Q_{12}$, $\pi_3 = p_3Q_{34}$, $\pi_4 = p_4Q_{34}$ and $\pi_5 = p_5Q_5$ with respect to prices yields,

$$\begin{aligned} \tilde{p}_{12}^a &= \frac{(6b^2 - 2e^2)\alpha + (4bd + 2e^2)\beta + e(3b + 2d)\gamma}{12b^3 - 4bd^2 - 7be^2 - 4de^2} \\ \tilde{p}_3^a &= \tilde{p}_4^a = \frac{(2bd + e^2)\alpha + (4b^2 - e^2)\beta + e(2b + d)\gamma}{12b^3 - 4bd^2 - 7be^2 - 4de^2} \\ \tilde{p}_5^a &= \frac{e(3b + 2d)\alpha + e(4b + 2d)\beta + 2(3b^2 - d^2)\gamma}{12b^3 - 4bd^2 - 7be^2 - 4de^2} \end{aligned}$$

Travel volumes and profits are obtained as above. The next result follows by comparing the situation with alliance 1 and 2 vis a vis the pre-alliance solution.⁹

⁹It is straightforward to check that the price of flight through hub H decreases, provided that $b > d + e$. As for the difference in profits, we have quadratic terms in the denominator and a quadratic term in α, β and γ in the numerator. The sign is then given by the sign of the polynomial in part ii) of the proposition.

Proposition 4 *i) The fare \tilde{p}_{12}^a is lower than the pre-alliance fare $\tilde{p}_1^{na} + \tilde{p}_2^{na}$.
ii) Airline profits with the alliance are higher than before if $18b^6 - 48b^4d^2 + 16b^2d^4 - 8be^2(6b^3 + 6b^2d - 5bd^2 - 4d^3) + e^4(23b^2 + 40bd + 16d^2) > 0$.
iii) The fares set by airlines 3, 4 and 5 are lower and so are their equilibrium profits.*

It can be observed that the result on fares stated in proposition 1 above remains true in the presence of an airline offering direct non-stop services. The difference $\tilde{\pi}_{12}^a/2 - \tilde{\pi}_1^{na}$ is positive when the above polynomial in b, d and e is positive. It will be the case for low and equal values of d and e provided that $b > d + e$. It becomes negative for sufficiently large values of d and e , although they are equal, or for high values of d (low e) and low values of e (high d). It is easy to check that as $e \rightarrow 0$, the condition in proposition 1 part ii) is recovered. Hence, the intuition is that the alliance between airlines 1 and 2 is profitable as long as there is enough product differentiation. Just note that the fact that there is now more competition in the market because there is another carrier makes the condition on "enough" product differentiation milder.¹⁰

We now characterize the equilibrium when *both alliances* occur to identify whether airlines 3 and 4 find it strategically optimal to cooperate in setting the fare p_{34} this meaning there will be three competitors offering flights between cities A and B . The equilibrium prices are given by,

¹⁰For example, take $b = 1$. The polynomial is positive for $d = e = 0.4$ so that $1 > 0.8$ and the alliance is profitable. In proposition 1 above, the alliance is profitable for values of the cross-effect below 0.66.

$$\begin{aligned}\tilde{p}_{12}^{aa} &= \frac{1}{2} \left(\frac{\alpha - \beta}{2b + d} + \frac{b(\alpha + \beta) + e\gamma}{2b^2 - bd - e^2} \right) \\ \tilde{p}_{34}^{aa} &= \frac{1}{2} \left(\frac{\beta - \alpha}{2b + d} + \frac{b(\alpha + \beta) + e\gamma}{2b^2 - bd - e^2} \right); \quad \tilde{p}_5^{aa} = \frac{e(\alpha + \beta) + (2b - d)\gamma}{2(2b^2 - bd - e^2)}\end{aligned}$$

Equilibrium travel volumes and profits are obtained as above. We next present the analogous to proposition 2 above in the presence of competition from a non-stop carrier.

Proposition 5 *i) The fare \tilde{p}_{34}^{aa} is lower than $\tilde{p}_3^a + \tilde{p}_4^a$ when airlines 1 and 2 form an alliance. Furthermore, \tilde{p}_{12}^{aa} is also lower than \tilde{p}_{12}^a .*

ii) Airlines 3 and 4 profits with the alliance are lower than before if $8b^2(2b^4 - 4b^2d^2 + d^4) + 8b(b + d)(-5b^2 + bd + 2d^2)e^2 + (17b^2 + 24bd + 8d^2)e^4 > 0$. Furthermore, profits of alliance between 1 and 2 decrease.

iii) The fare \tilde{p}_5^{aa} is now lower than \tilde{p}_5^a and so are profits to airline 5.

The combination of propositions 4 and 5 imply that we may characterize the (subgame perfect) Nash equilibria of the simultaneous game of airline alliances above presented. As already argued, demand intercepts α, β and γ , do not play any role in determining a company's best response. To clarify the intuition, suppose that $b = 1$. Then it must be the case that $1 > d + e$. The polynomial in proposition 4 part ii) is positive for values of $d = e$ between 0 and 0.434 this meaning that, provided the other two airlines do not form an alliance, it is a best response to create an alliance between the other two. The best response is not to form an alliance for $d = e$ between 0.434 and 0.5. On the other hand, the polynomial in proposition 5 part ii) is positive for

values of $d = e$ between 0 and 0.472 this meaning that, provided that there is an alliance, the rivals' best response is to form an alliance. There are other combinations of values but the next proposition just collects the cases when $d = e$.

- Proposition 6** *i) No alliances will occur in equilibrium for $d = e \in (0.472, 0.5)$.
ii) Both alliances take place in equilibrium for $d = e \in (0, 0.434]$.
iii) No alliances and both alliances are equilibria for $d = e \in (0.434, 0.472]$.*

We conclude that our main result that alliances arise in equilibrium for sufficient product differentiation holds true, but needs some qualification. It must be noted that alliances will not occur for values of d and e far from each other. Hence, it suffices that competition with one competitor, either from connecting flights or from direct flights, be strong to make alliances unprofitable. Furthermore, the equilibrium in part ii) above can give rise to a prisoners' dilemma situation, that is, the setting without alliances may yield higher profits than the equilibrium with both alliances.

4 Concluding Remarks.

The airline sector is characterized by its dynamism and transformation over the last decades. In the 1980s, all major carriers started to organize their networks in a hub-and-spoke manner and, at the beginning of the 1990s, a revolution shook the industry: the proliferation of airline alliances. International alliances were viewed as the key element for airlines to extend their networks without investing new resources, being clearly beneficial for

its members. As a consequence, every major airline in the world belongs nowadays to one of the three large international alliances (Oneworld, Star Alliance and Sky Team). There are of course many other features that help characterize the current and future status of the air transportation landscape such as the surge of low-cost passenger carriers, the closing of old hubs and the development of new ones, the expected evolution of regional operators to join networks, etc. Despite its simplicity, our model identifies the effects of airline alliances on fares, travel volumes and consumer surplus. Our results provide a very simple testable implication to establish whether the formation of an alliance on routes involving several airlines' flights that are complementary is profitable. The rule relies on demand parameters that measure the degree of product differentiation, and our findings are consistent with some of the observed facts in the industry. The interesting results obtained are an invitation to pursue research along these lines.

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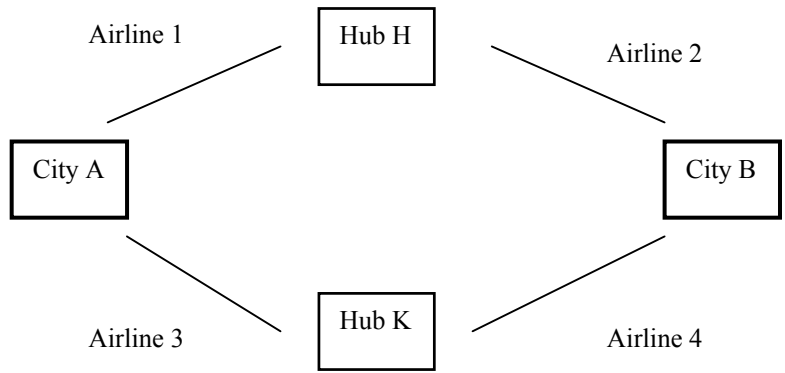


Figure 1. Network structure

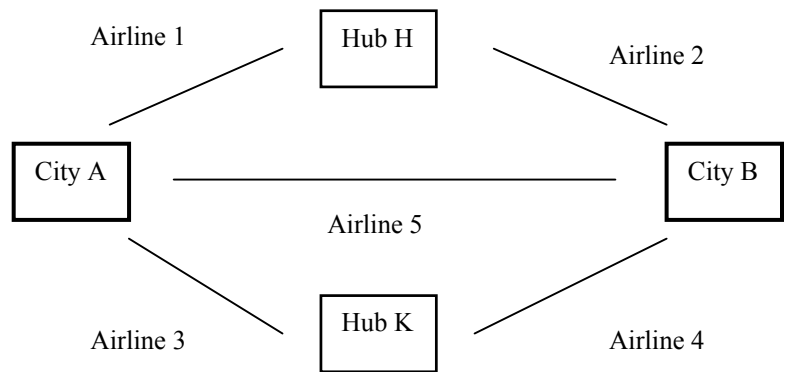


Figure 2. Network structure with direct non-stop competition