Did the entry of low cost companies foster the growth of strategic alliances in the airline industry?*

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Abstract

In this paper we adopt a vertical differentiation model to study the effect of deregulation in the airline industry. In particular, we focus on the entry of low cost companies, which succeed in providing essential flight services at relatively cheap prices. We argue that the entry of very aggressive rivals pushed traditional carriers to react by forming strategic alliances and exploit economies of densities through hub-and-spoke systems. We verify that a strategic alliance is profitable if the gain in terms of economies of density is sufficiently high and consumers' utility is not significantly decreased by the indirect connection.

JEL classification: L29, L93.

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1 Introduction

The entry of low cost companies in the airline industry is a recent phenomenon which has attracted the interest of many economists and policy-makers. Low cost companies appeared as a consequence of the deregulation of the air transport system which took place at the end of 1970's in the US and during the 1990's in Europe.

The deregulation of an industrial sector which was previously dominated by a limited number of flag carriers profoundly modified not only the provision, but also the concept of the flight service itself. It implied more freedom for airline companies in terms of deciding about routes, tariffs and flight frequency. Furthermore, and even more relevant, it removed many restrictions on entry and exit, encouraging in this way fierce competition between 'traditional' incumbents and new entrants, especially low cost companies (Franke, 2004).[1] These companies, using a combination of managerial strategies and entrepreneurial talent, turned out to be particularly efficient in offering essential but cheap air transport services.[2] They succeeded in reducing significantly the cost of operating the flight and gained growing market shares even at the expenses of existing carriers (Boguslaski et al., 2004; Piga and Filippi, 2002).

As a consequence of the deregulation process, hence, traditional flag carriers were forced to face the entrance of aggressive and more efficient rivals. They adopted different measures in order to survive, but the most significant was the creation of *strategic alliances*. By developing synergies and intertwining their services, a strategic alliance allows to expand the network of routes served by the partner companies.[3] Moreover, it manages to decrease the cost of production, without altering the quality of the service, by taking advantage

[1] Notable examples of low cost companies are Southwest Airline in the U.S. and Ryanair and Easyjet in Europe.

[2] Low cost companies are often referred as 'no frills', as they tend to eliminate additional services previously offered in combination with the transport service (e.g. food, beverage and newspapers). Moreover, they make use of less expensive secondary airports (see Bardot, 2006) and reduce the booking price with on-line reservation systems.

[3] While at the very begininng of U.S. deregulation the concentration rate of the air transport market decreased, and the degree of differentiation among flight services increased significantly, since 1985 this concentration rate rose again as a consequence of alliances between flag carriers (Tucci, 1998).

of both economies of scale and economies of scope or density. As Oum et al. (2000) pointed out:[4]

> "Economies of scale can be achieved if, holding network size constant, a partner is able to serve the same amount of traffic at a lower cost. Shared use of airport facilities and ground staff, cooperative advertising and promotional campaigns, joint procurement of fuel and amenities, combined development of computer systems and software, and mutual handling of baggage transfers and passengers check-in are some ways that alliances will result in economies of scale [...]. Economies of scope can, also, be exploited if alliance carriers join their existing networks and by that provide efficient connecting service to new origin-destination markets" (page. 13).

A crucial element is the use of the *hub-and-spoke* system instead of the previously adopted *fully connected* system. By conveying all passengers into the hub, an hub-and-spoke network generates high traffic densities on the spoke routes, yielding lower cost per passenger (Brueckner et al., 1992; Morrison and Winston, 1986 and 1995, Brueckner and Pels, 2005).

Notwithstanding the relevance of the issue, scanty attention has been paid by the literature. The goal of this paper is then to provide a theoretical model which explains the stylized facts summarized above. To this aim, we start by considering as a benchmark case a pre-deregulation scenario where two traditional carriers act as monopolists on their respective routes in a tri-city environment. Given the particular nature of the 'good' under consideration, we introduce vertical differentiation as the main theoretical feature of the model. To our knowledge, only Barbot (2006) applies a vertical differentiation setting to the study of the airline industry. We verify that, in absence of competitive pressures, traditional flag carriers provide only one type of service for consumers, thus explaining the relative scarcity of vertical differentiation prior to the deregulation.

[4] For other theoretical contributions on strategic alliances in the airline industry, see Oum and Park (1997), Pels (2001), Park et al. (2001). Empirical investigation includes Brueckner and Whalen (1998) and Park and Zhang (2000), *inter alii*.

The second part of the paper introduces the effects of deregulation. We allow for the entrance of a low cost company in one route; it provides relatively cheap flights for price sensitive travellers, thus leading to a proper vertical differentiation in the transport sector, which presents now both a high and a low 'quality' service. As for the incumbent, first we demonstrate that it still prefers to offer only one quality variant. Second, we highlight the profit loss that it suffers on that particular route and ask whether it has an incentive to form with the other existing firm a strategic alliance by operating a hub-and-spoke system.

We assume that members of the alliance exploit economies of scope/density that arise from funnelling passengers through the hub and benefit from a re-shaping of the cost structure. We then verify that it is profitable to form such alliance in presence of relatively strong economies of density and when passengers are not excessively inconvenienced by the indirect connection. It follows that the incumbent may recover the profit in a segment which otherwise could have been lost.

The paper is laid out as follows. The next section presents the basic model while Section 3 introduces the benchmark case where traditional flag carriers are monopolists in their respective routes. Section 4 considers the entry of the low cost company in one segment and the following profit loss for the incumbent carrier. Section 5 analyses the incentive for the existing carriers to form a strategic alliance by implementing a hub-and-spoke system. Section 6 concludes the paper.

2 The model

We consider an airline industry which consists of three gateway cities labeled as *A, B* and *C.* A and B are located in Europe, while C is located in the US. Routes between these gateways are operated by an European carrier and an US carrier, say 1 and 2 respectively. We assume that the European carrier 1 serves the routes AB and AC, while the US carrier 2 serves the route BC.

The network is represented in Figure 1:

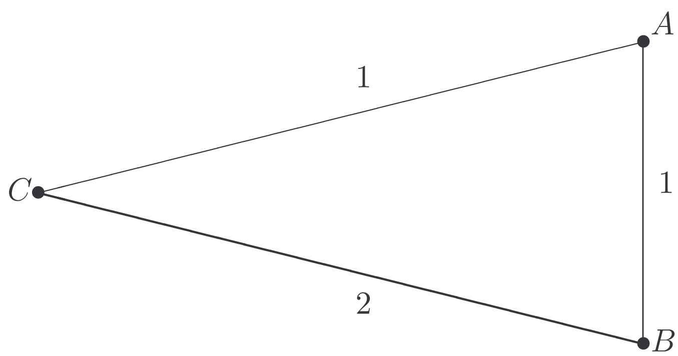

Figure 1 : Initial Network Structure

In each route they serve, these carriers are allowed to provide travellers with two variants of the service - say *high-quality* variant h and *low-quality* variant l. What we mean by difference in quality in the airline sector is the provision of different flight services. It follows that the distinction between economy and business class is not taken into account, as it represents an attempt to price discriminate within the same flight service.

Qualities are set previously to the game, and so they are exogenous variables. The cost of providing the two variants is fixed and denoted by K_h and K_l respectively, with $K_h > K_l$. We assume then that the cost of offering a flight service is only linked to the quality while it does not depend on the number of seats. Although this assumption is not entirely realistic, it allows us to focus on strategic considerations and to capture the essential difference between the two types of service available.[5]

The demand model is directly inspired by traditional models of vertical product differentiation (see Mussa and Rosen, 1978; Gabszewicz and Thisse, 1979; Shaked and Sutton, 1982). Travellers are uniformly distributed with density equal to 1 over the interval $[0, 1]$. The utility traveller θ, $\theta \in [0, 1]$,

[5]One can alternatively think of $K_h = \overline{k} + k_h$ and $K_l = \overline{k} + k_l$, where the total cost includes a fixed cost of operating the flight, $\overline{k}$, plus an additional component representing the additional services which are provided, with $k_h > k_l$. The cost formulation that we adopt, although very simple, is widely used. Barla and Constantatos (2000) and (2005a) assume that all airlines face a similar cost structure and that the cost of offering one seat does not depend on the number of seats carried on a route.

derives from buying at price p_i the variant i, $i \in \{h, l\}$, writes as follows

$$U = \theta\beta u_i - p_i \tag{1}$$

where u_i and p_i refer to the quality and the price of the service i, respectively. The additional parameter β introduces the difference in quality between fully connected and hub-and-spoke services. When $\beta = 1$ passengers are served by a fully connection, while $\beta < 1$ indicates the presence of a hub-and-spoke service which entails a loss of utility for consumers. So, if $\beta < 1$ the attractiveness of flying in terms of travel time lost for reaching the ending-point decreases.[6] Furthermore, when the hub-and-spoke system requires the combination of different carriers to connect spokes through the hub, it is likely that consumers experience a higher loss of time and suffer from additional inconveniences, such as an increased probability of lost baggage, transfer delay at the connection point, etc.

3 The air transport market before the deregulation

We start by analyzing the air transport market before the deregulation process. This will serve as a benchmark case. Consider the two flag carriers which act as monopolists in their respective routes. They provide only fully connected services, as they are not allowed to establish inter-continental service networks.

We assume that passengers wishing to travel in the route AC (resp. BC) always choose the direct connection offered by carrier 1 (resp. 2). Accordingly, the profit accruing to carrier 1 is the sum of the monopoly profits of routes AB and AC, while the profit accruing to carrier 2 consists only of the monopoly profit of route BC.

[6] Traditionally, it is assumed that the full price paid by travellers consists of the ticket price and the non-ticket cost. The non-ticket cost derives from the difference between the desired time and the actual time of departure, and the total time of flight including stops at hubs and s.o. In our vertically differentiated model, we depart from using the full price and introduce the parameter β. While it does not affect consumers' attitude toward flying in the case of fully connected flights (as for fully connection $\beta = 1$), it has a strong impact on travellers' willingness to pay for flying in case of a hub-and-spoke system.

As we introduced before, in every route the carrier has to decide whether to provide only a single variant or both. Given that we limit the analysis to fully connected flights, we can normalize β to 1. We consider generic carrier 1 but the corresponding analysis for carrier 2 can be easily derived by symmetry. The options available for the monopolist are: *(a)* to supply the market with both flight services h and l; *(b)* to supply the market with the high quality h; *(c)* to supply the market with the low quality l.

When only a variant i is marketed, the demand function is:

$$D_i(p_i) = (1 - \frac{p_i}{u_i}). \tag{2}$$

The profit $\pi_i(p_i)$ accruing to the monopolist which supplies this flight service is given by:

$$\pi_i(p_i) = (1 - \frac{p_i}{u_i})p_i - K_i. \tag{3}$$

Maximizing with respect to p_i, we get the optimal monopoly price, $p_i^M = u_i/2$. By substitution, one can easily verify that the demand for variety i is always positive. The optimal profit is:

$$\pi_i^M = \frac{u_i}{4} - K_i. \tag{4}$$

Non-negativity of the above profit implies $K_i \leq u_i/4$. For future reference, $\overline{K}_i = u_i/4$ denotes the threshold value above which the carrier does not provide the service of quality i.

When both variants h and l are available for consumption at some instant, demand functions are given by:

$$D_h(p_h, p_l) = (1 - \frac{p_h - p_l}{u_h - u_l}),\ D_l(p_h, p_l) = (\frac{p_h - p_l}{u_h - u_l} - \frac{p_l}{u_l}), \tag{5}$$

where p_h and p_l are the market prices for variant h and variant l, respectively, on the route that we consider.

Profit function $\pi_{h,l}(p_h, p_l)$ is then given by:

$$\pi_{h,l}(p_h, p_l) = (1 - \frac{p_h - p_l}{u_h - u_l})p_h + (\frac{p_h - p_l}{u_h - u_l} - \frac{p_l}{u_l})p_l - (K_h + K_l). \tag{6}$$

From the joint maximization of (6) with respect to p_h and p_l, we obtain the equilibrium prices $p_h^M = u_h/2$ and $p_l^M = u_l/2$. Replacing these prices in expression (5) we find that the demand for variety h is always positive, while the one for variety l is equal to zero. This anticipates the result of the comparison, indicating that the firm will provide only one type of service. In fact, substituting p_h^M and p_l^M in (6) yields the optimal profit:

$$\pi_{h,l}^M = \frac{u_h}{4} - (K_h + K_l), \tag{7}$$

which is non-negative iff $(K_h + K_l) \leq u_h/4$.

We compare π_i^M and $\pi_{h,l}^M$ to prove that:

Proposition 1 *It is never profitable for the monopolist to provide both the high and the low quality flight service. Moreover, when*

$$\frac{u_h - u_l}{4} \geq K_h - K_l,$$

the optimal strategy for the monopolist is to supply the high quality variant, and viceversa.

Proof. See Appendix. ■

Two main indications derive from the above result. Firstly, in each route, *AB, BC* and *AC,* a carrier acting as a monopolist prefers to supply only one type of service. This provides a rationale for the relative scarcity of vertical segmentation prior to the deregulation of the sector. Secondly, the carrier opts for the high quality variant if the quality difference $(u_h - u_l)/4$ is large enough to cover the cost gap $(K_h - K_l)$. This happens when travellers enjoy such a high utility that the monopolist is able to charge a price that overcompensates the additional cost required to operate the high quality flight.

For future reference, we write the overall profit functions for carrier 1 and carrier 2:

$$\Pi_1^M = \pi_{1_{AC}}^M + \pi_{1_{AB}}^M = \frac{u_{AC} + u_{AB}}{4} - (K_{AC} + K_{AB}), \tag{8}$$

$$\Pi_2^M = \pi_{2_{BC}}^M = \frac{u_{BC}}{4} - K_{BC}. \tag{9}$$

As it is immaterial to the aim of our analysis which variety they provide in their respective route, we indicate the utility of each segment without specifying if it is of high or low quality.

4 The Entry of the Low Cost Company

The airline industry has been strongly affected by the deregulation process. As we highlighted in the Introduction, one of the major effect has been the removal of many restrictions on entry and exit in an industry which was previously dominated by a limited number of flag carriers. This opened the door to the invasion of low-cost companies, which completely reshaped the airline industry by providing essential services at relatively cheap prices.

On the basis of these stylized facts, we assume that a low cost company enters into the segment AB and starts competing against carrier 1, the incumbent. In terms of our model, the main advantage for the newcomer is represented by a very low cost of operating the flight.

The new scenario entails for competition in AB between carrier 1 and the low-cost company, indicated by L. Remind that carrier 1 can provide either a high quality or a low quality service, or both simultaneously. However, the quality of both services offered by the incumbent is always higher than the one offered by the low-cost carrier.

Figure 2 represents the airline network after the entry of the low-cost company:

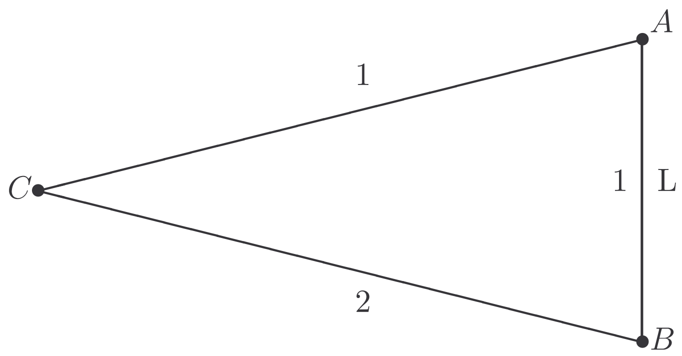

Figure 2 : The Network Structure with the Low Cost Company

We start the analysis of the duopoly by considering how many varieties does a generic incumbent carrier offer after the entry of a low cost company. The entrance of an aggressive rival at the bottom of the quality ladder could induce the incumbent to sell both a high and low quality service in order to attract low income passengers.

On the one hand, when it provides only one type of service, the demand functions are similar to those obtained before, with the caveat that the incumbent provides a medium/high quality service, denoted by i, while the low cost company provides a low quality service, denoted by L:

$$D_i(p_i, p_L) = (1 - \frac{p_i - p_L}{u_i - u_L}), D_L(p_i, p_L) = (\frac{p_i - p_L}{u_i - u_L} - \frac{p_L}{u_L}). \tag{10}$$

The profit functions for the incumbent and for the low cost company are given by:

$$\pi_i(p_i, p_L) = (1 - \frac{p_i - p_L}{u_i - u_L})p_i - K_i, \tag{11}$$

$$\pi_L(p_1, p_L) = (\frac{p_i - p_L}{u_i - u_L} - \frac{p_L}{u_L})p_L - K_L. \tag{12}$$

From first-order conditions with respect to p_i and p_L we obtain optimal prices:

$$p_i^D = \frac{2\,u_i(u_i - u_L)}{4\,u_i - u_L},\ p_L^D = \frac{u_L(u_i - u_L)}{4\,u_i - u_L} \tag{13}$$

which are always positive.[7]

Demand functions are positive as well, and, by substituting p_i^* and p_L^* in profit functions (11) and (12), we get:

$$\pi_i^D = \frac{4\,u_i^2(u_i - u_L)}{(4\,u_i - u_L)^2} - K_i, \tag{14}$$

$$\pi_L^D = \frac{u_i\,u_L(u_i - u_L)}{(4\,u_i - u_L)^2} - K_L. \tag{15}$$

On the other hand, if the incumbent provides two variants of the flight service, indicated by h and l, demand functions are respectively given by:

$$D_h(p_h, p_l, p_L) = (1 - \frac{p_h - p_l}{u_h - u_l}), \tag{16}$$

$$D_l(p_h, p_l, p_L) = (\frac{p_h - p_l}{u_h - u_l} - \frac{p_l - p_L}{u_l - u_L}). \tag{17}$$

$$D_L(p_h, p_l, p_L) = (\frac{p_l - p_L}{u_l - u_L} - \frac{p_L}{u_L}). \tag{18}$$

[7] Second-order conditions are always verified, as one can easily check.

The profit functions for the carrier and for the low cost company write as follows:

$$\pi_{h,l}(p_h, p_l, p_L) = (1 - \frac{p_h - p_l}{u_h - u_l})p_h + (\frac{p_h - p_l}{u_h - u_l} - \frac{p_l - p_L}{u_l - u_L})p_l - (Kh + K_l), \quad (19)$$

$$\pi_L(p_h, p_l, p_L) = (\frac{p_l - p_L}{u_l - u_L} - \frac{p_L}{u_L})p_L - K_L. \quad (20)$$

Optimal prices are obtained through first-order conditions:[8]

$$p_h^D = \frac{1}{2}(u_h - \frac{3u_l\, u_L}{4\, u_l - u_L}),\ p_l^D = 2u_l(1 - \frac{3u_l}{4\, u_l - u_L}),\ p_L^{D\prime} = \frac{(u_l - u_L)u_L}{4\, u_l - u_L} \quad (21)$$

It is immediate to verify that optimal prices are always positive, being $u_h > u_l > u_L$. Moreover, the demands for the three qualities are positive as well, leaving room for the possibility that carrier 1 expands her quality range with respect to the monopoly case.

Optimal profits are easily computed by substituting the optimal prices (21) into profit functions (19) and (20):

$$\pi_{h,l}^D = \frac{1}{4}\left[u_h - \frac{u_l\, u_L(8u_l + u_L)}{(4\, u_l - u_L)^2}\right] - (K_h + K_l), \quad (22)$$

$$\pi_L^D = \frac{u_l\, u_L(u_l - u_L)}{(4\, u_l - u_L)^2} - K_L. \quad (23)$$

As we did in the previous section, we compare π_i^D and $\pi_{h,l}^D$ and find that:

Proposition 2 *After the entry of the low cost company, the incumbent continues to provide only one variant of the flight service. Moreover, when*

$$4\left[\frac{u_h^2(u_h - u_L)}{(4u_h - u_L)^2} - \frac{u_l^2(u_l - u_L)}{(4u_l - u_L)^2}\right] \geq K_h - K_l,$$

it opts for the high-quality variant, and viceversa.

Proof. See Appendix. ■

The most important lesson that derives from Proposition 2 is that the presence of a strong rival does not alter the choice of carrier 1 to offer only one variant of the flight service. This is consistent with the evidence that comes

[8] Second-order conditions are always verified, as one can easily check.

from the air transport sector. In fact, many traditional carriers tried to fight low cost companies by offering low quality services, in particular by creating their own low cost services, but their attempts failed.[9]

Once we have verified that a generic incumbent offers only one quality variant, we focus on the impact of the entry of the low cost company in terms of profit. Non-negativity of π_i^D and π_L^D respectively requires

$$\begin{aligned} K_i &< \frac{4\,u_i^2(u_i-u_L)}{(4\,u_i-u_L)^2}=\widehat{K}_i, \\ K_L &< \frac{u_i\,u_L(u_i-u_L)}{(4\,u_i-u_L)^2}=\widehat{K}_L. \end{aligned} \tag{24}$$

Obviously, $\widehat{K}_i<\overline{K}_i$, as one can easily verify. On the basis of the aforementioned discussion about the cost structure of low cost companies, we assume that $K_L<\widehat{K}_L$, meaning that it is always present in the market. Nonetheless, the same reasoning cannot apply for the other carrier, which still faces a relatively expensive cost structure. Notice first that the presence of a very aggressive rival entails a profit loss equal to the difference between the pre-entry monopoly profit (4) and the post-entry duopoly profit (14):

$$\Delta\pi_i=\pi_i^M-\pi_i^D=\frac{u_iu_L(8u_i+u_L)}{4(u_L-4u_i)^2} \tag{25}$$

Moreover, two possibilities may appear, depending on the value of the cost K_i:

1. $K_i<\widehat{K}_i<\overline{K}_i$: the incumbent still operates in the market while incurring in the profit loss $\Delta\pi_i$.

2. $\widehat{K}_i<K_i<\overline{K}_i$, the incumbent incurs in negative profits and therefore drops out of the market.

[9] In particular, traditional carriers tried to replicate the cost saving strategy adopted by the low cost companies. Some companies created their own low cost subsidiary in order to fight on the same ground the new entrants. British Airways created Go, SAS did the same with Snowflawes, KLM with Basiq Air and Lufthansa with Germanwings. Nonetheless many of these companies failed and others have been taken over. Other traditional companies reorganized their production process by imitating the low cost example but found many difficulties and become a sort of 'hybrid', like Meridiana in Italy and Air Lib Express in France (see Jarach, 2004).

In terms of our airline structure, the entry of the low cost company brings about a profit loss for carrier 1, whose market share shrinks in segment AB. In addition, there exists the possibility that carrier 1 is squeezed out from the route AB. In particular, this happens when:

$$\widehat{K}_{AB} < K_{AB} < \overline{K}_{AB}, \tag{26}$$

where

$$\widehat{K}_{AB} = \frac{4\,u_{AB}^2(u_{AB} - u_L)}{(4\,u_{AB} - u_L)^2} \tag{27}$$

and $\overline{K}_{AB} = (u_{AB})/4$. In this cost interval carrier 1 is forced to leave the segment AB, while it was enjoying positive profits when it was a monopolist. As we will illustrate in the following section, forming an alliance with carrier 2 could result in a way to reduce the cost of operating the flight on AB and to either recoup part of the profit lost or re-enter into the abandoned route.

Before proceeding, we write the overall profit functions for carrier 1 after the entry of the low cost company,

$$\begin{cases} \Pi_1^{M,D} = \pi_{1_{AC}}^M + \pi_{1_{AB}}^D = \dfrac{u_{AC}}{4} + \dfrac{4\,u_{AB}^2(u_{AB} - u_L)}{(4\,u_{AB} - u_L)^2} - (K_{AC} + K_{AB}), \text{ when } K_{AB} \leq \widehat{K}_{AB}; \\ \Pi_1^{M\,\prime} = \pi_{1_{AC}}^M = \dfrac{u_{AC}}{4} - K_{AC}, \text{ when } K_{AB} > \widehat{K}_{AB}, \end{cases} \tag{28}$$

while the overall profit for carrier 2 remains unchanged and is given by (9).

5 The Strategic Alliance

In this section we consider whether there exist an incentive for carriers 1 and 2 to form a strategic alliance based on a hub-and-spoke system. Deregulation, in fact, brought about not only the entrance of new competitors, but also changed the air transport structure by allowing the emergence of strategic alliances.

In our model, carrier 1 suffers from a profit loss subsequent to entry of the low cost company in AB . We ask now the following question:

Is it convenient for carriers 1 and 2 to form a strategic alliance and offer a hub-and-spoke service on the route AC through the point B?

In this new scenario, represented in Figure 3, carrier 1 and 2, while still providing the full connection on their respective routes AB and BC, form an alliance to connect A and C through the hub located in B. The hub-and-spoke network is represented by the dashed line, where AL indicates that it is implemented by the alliance.

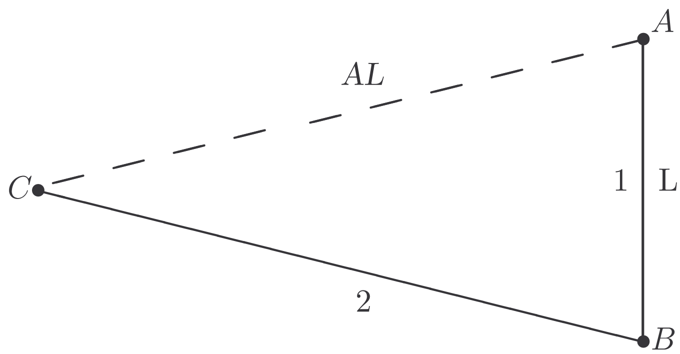

Figure 3 : The Network Structure with the Alliance

We consider a *broad commercial alliance,* which is the most common agreement between carriers. This type of alliance "involves linking the two partners' networks to a substantial degree and feeding traffic to each other's hub airports" (Oum, 2000, page. 33). As already stressed, partners cooperate through coordination of flight schedule and ground handling, joint use of ground facilities, flight code-sharing, block seat sale, and joint advertising and promotion: thus, they mainly share the cost of flight service taking advantage of economies of scale and scope and higher traffic density.

On these grounds, we introduce the crucial assumption that members of the alliance benefit from a reduction in the overall cost of providing the hub-and-spoke connection. Consistently with this assumption, when carriers 1 and 2 jointly serve the route AC through B, the whole cost is given by:

$$K_{ABC} \equiv K_{AB} + K_{BC} - \delta \tag{29}$$

where the parameter $\delta > 0$ indicates the extent of the cost reduction.

Passengers routing via the hub suffer a loss of utility measured by parameter $\beta < 1$, as we know from (1). The profit deriving from the hub-and-spoke ABC

is:

$$\pi_{ABC} = (1 - \frac{p_{ABC}}{\beta\, u_{AC}})p_{ABC} - (K_{AB} + K_{BC} - \delta). \qquad (30)$$

It can be easily demonstrated that, maximizing with respect to p_{ABC}, optimal price equals $p_{ABC} = \beta u_{AC}/2$, yielding optimal profit:[10]

$$\pi_{_{ABC}} = \frac{\beta u_{AC}}{4} - (K_{AB} + K_{BC} - \delta). \qquad (31)$$

Let us examine how the alliance can be implemented. Carrier 1, which proposes the alliance, asks carrier 2 to convey passengers from point C to the hub B while operating the route BC, then carrier 1 itself carries those same passengers from B to A while operating the route AB. In this way carrier 1 and 2, the potential partners, while still providing the flight services on their respective routes, use the same aircraft to jointly build a hub-and-spoke system.

If we assume that a flight can costlessly accommodate additional passengers, then carrier 1 operates both the full connection on AB and part of the hub-and-spoke connection at the cost K_{AB}. Similarly, carrier 2 bears K_{BC} and provides both the full connection on BC and the remaining part of the hub-and-spoke.[11] Moreover, they enjoy an overall cost reduction which is split between according to a fraction $\alpha \in (0, 1)$.

The expressions for the overall profits accruing to carrier 1 and 2 when they form the alliance are as follows:

$$\Pi_1^{AL} = \pi^{AL}_{1_{ABC}} + \pi^{D}_{1_{AB}} = \frac{\beta u_{AC}}{4} + \frac{4\, u_{AB}^2 (u_{AB} - u_L)}{(4\, u_{AB} - u_L)^2} - (K_{AB} - \alpha\delta), \qquad (32)$$

[10]From Proposition 1 we know that every carrier never provides two quality variants of the flight service on the same route. It is straightforward to show that full connection and hub-and-spoke connection are perceived by passengers as high and low quality variant, their difference being represented only by parameter β. This is the reason why we disregard the possibility that the alliance could offer both the direct and the indirect connection between A and C.

[11]More realistically, it is reasonable to assume that due to the alliance the frequency of flights on the routes BC and AC increases. Moreover, larger and more comfortable aircraft could be employed to accomodate additional passengers, thus rising the cost of providing the connection. However, synergies and cost reduction may well compensate these additional costs (Barla and Constantatos, 2005b).

$$\Pi_2^{AL} = \pi_2^{AL} = \frac{u_{BC}}{4} - [K_{BC} - (1-\alpha)\delta]. \qquad (33)$$

Let us take into account the incentives for carrier 1 to propose the alliance. The comparison between (28) and (32) reveals that:

$$\begin{aligned} (i)\ \Pi_1^{AL} &> \Pi_1^{M,D} \text{ if } \delta > \delta_1, \\ (ii)\ \Pi_1^{AL} &> \Pi_1^{M\prime} \text{ if } \delta > \delta_2, \end{aligned}$$

where:

$$\begin{aligned} \delta_1 &= \frac{1}{4\alpha}[u_{AC}(1-\beta) - 4K_{AC}]; \\ \delta_2 &= \frac{1}{\alpha}\left[K_{AB} - K_{AC} + \frac{u_{AC}(1-\beta)\,(4\,u_{AB}-u_L)^2 - 16u_{AB}^2(u_{AB}-u_L)}{4\,(4\,u_{AB}-u_L)^2}\right]. \end{aligned}$$

Moreover, as $\delta_1 \geq \delta_2$ iff $K_{AB} \leq \widehat{K}_{AB}$, we can formally state the following:

Proposition 3 *Carrier 1 proposes an alliance to carrier 2 consisting on a hub-and-spoke network when the gain in terms of economies of scope is sufficiently high. In particular, if $K_{AB} < \widehat{K}_{AB}$ then $\delta > \delta_1$, or alternatively if $K_{AB} > \widehat{K}_{AB}$ then $\delta > \delta_2$.*

Proof. See Appendix. ■

As a consequence, there exist threshold values for the potential gain represented by the economies of density δ above which carrier 1 involves carrier 2 in a hub-and-spoke service on the route AC through the hub B. Moreover, this is more likely to happen the lower the loss of utility incurred by passengers using the indirect connection, measured by $(1-\beta)\,u_{AC}$. In fact, it is easy to demonstrate that:

$$\frac{\partial \delta_1}{\partial \beta} < 0, \frac{\partial \delta_2}{\partial \beta} < 0. \qquad (34)$$

This implies that, *ceteris paribus*, the region where it is convenient for carrier 1 to propose the alliance tend to enlarge when passengers' satisfaction regarding the hub-and-spoke service is not too distant from the fully connected service, i.e. when β is relatively high.

We can now consider the incentives for carrier 2 to become member of this alliance. Carrier 2 still serves passengers which fly only between B and C.

Yet, it also serves passengers stopping at B as a hub point. As we assumed that it uses the same aircraft when providing the two services and that the overall cost K_{BC} does not change, carrier 2 is willing to accept the alliance as it gains a positive fraction $(1-\alpha)$ of the cost reduction δ. This can be easily verified by comparing the pre-alliance profit (9) with the post-alliance profit (33). Moreover, the agreement between carrier 1 and carrier 2 is stable as it holds for every $\alpha \in (0,1)$.

We can now answer to the question proposed at the beginning of this section, namely whether it is profitable for carriers 1 and 2 to form a strategic alliance and build a hub-and-spoke service on the route AC through the hub B. If we consider a joint use of the same aircraft by member partners without additional costs of carrying more passengers, then the alliance turns out to be profitable in presence of sufficiently strong economies of density and when consumers' utility is not significantly decreased by the additional connecting trip required by the hub-and-spoke system.

6 Conclusions

In this paper we have provided a theoretical model which explains the effects of deregulation in the airline industry. We have used a simple model of vertical differentiation to study a three gateway points' network where initially only two firms operate as monopolists in different routes. In this first case, which serves as a benchmark to represent the situation before the deregulation, we have shown that firms provide only one quality service in each route.

The appearance of low cost companies has probably represented the most significant event and modified the concept of flight service itself. We have therefore considered the entry of a low cost company in one segment and analysed the consequences for the incumbent firm, whose market share shrunk. Moreover, the presence of such an aggressive newcomer entails the possibility that traditional carriers could be wiped out from the market.

We have then examined the possible remedies taken by the incumbents. First, we have verified that they cannot answer by expanding the product range, as this would eventually increase the cannibalization effect. Second, we have taken into account the possibility to form strategic alliances with other existing firms, thus exploiting economies of scope/density and recover at least a part of the profit lost.

In our model the alliance consists mainly in the use of a hub-and-spoke service instead of the traditional fully connections. We have analysed whether there is a reciprocal incentive for firm 1 and firm 2 to adopt this kind of strategy and we have proven that the alliance is convenient for both firms when they enjoy a sufficient degree of economics of scope/density and when consumers are not too much annoyed at the additional inconveniences implied by a hub-and-spoke connection.

Our paper provides a rationale for the growth of strategic alliances through hub-and-spoke networks as a way for traditional carriers to defend themselves from the assault of low cost companies.

Appendix

Proof of Proposition 1

When the carrier provides both qualities it obtains (7). When it decides to offer only the high quality service its profit amount to:

$$\pi_h^M = \frac{u_h}{4} - K_h \tag{A1}$$

while in case of provision of the low service alone the profit is:

$$\pi_l^M = \frac{u_l}{4} - K_l \tag{A2}$$

Let $\Delta u = u_h - u_h$. From easy computations, we obtain:

$\pi_h^M > \pi_{h,l}^M$ always;
$\pi_l^M \geq \pi_{h,l}^M$ when $\Delta u \leq 4K_h$;
$\pi_h^M \geq \pi_l^M$ when $\Delta u \geq 4(K_h - K_l)$.

As a consequence, the following ranking for profits applies:

$$\begin{cases} 0 < \Delta u \leq 4(K_h - K_l) \Longrightarrow \pi_l^M \geq \pi_h^M > \pi_{h,l}^M \\ 4(K_h - K_l) < \Delta u \leq 4K_h \Longrightarrow \pi_h^M > \pi_l^M \geq \pi_{h,l}^M \\ 4K_h < \Delta u \Longrightarrow \pi_h^M > \pi_{h,l}^M > \pi_l^M \end{cases} . \tag{A3}$$

Then, it is never profitable to supply both services. Moreover, the high quality service is more profitable than the low quality service when $\Delta u > 4(K_h - K_l)$. **Q.E.D.**

Proof of Proposition 2

The profit accruing to carrier 1 when it decides to provide both qualities is given by (22). One the contrary, when it offers only the high quality variant the profit is:

$$\pi_h^D = \frac{4\,u_h^2(u_h - u_L)}{(4\,u_h - u_L)^2} - K_h, \tag{B1}$$

while in case of provision of the low service alone it gains:

$$\pi_l^D = \frac{4\,u_l^2(u_l - u_L)}{(4\,u_l - u_L)^2} - K_l. \tag{B2}$$

Firstly, $\pi_h^D \geq \pi_l^D$ when:

$$4\left[\frac{u_h^2(u_h - u_L)}{(4u_h - u_L)^2} - \frac{u_l^2(u_l - u_L)}{(4u_l - u_L)^2}\right] \geq K_h - K_l, \tag{B3}$$

or, alternatively, $\pi_h^D \geq \pi_l^D$ when $K_h \leq \widetilde{K_h}$, where

$$\widetilde{K_h} \equiv K_l + 4\left[\frac{u_h^2(u_h - u_L)}{(4u_h - u_L)^2} - \frac{u_l^2(u_l - u_L)}{(4u_l - u_L)^2}\right]. \tag{B4}$$

Secondly,

$$\pi_h^D - \pi_{h,l}^D = K_l + \frac{(u_h - u_L)u_L^2\,[80u_h u_l - u_L(8u_h + 8u_l + u_L)]}{4\,(4\,u_h - u_L)^2\,(4\,u_l - u_L)^2} > 0 \tag{B5}$$

given that $80u_h u_l > u_L(8u_h + 8u_l + u_L)$, as $u_h > u_l > u_L$ by definition. It follows that $\pi_h^D > \pi_{h,l}^D$ for every admissable value of parameters at stake. Finally, $\pi_l^D > \pi_{h,l}^D$ when $K_h > (u_h - u_L)/4$. To sum up:

$\pi_h^D > \pi_{h,l}^D$ always;
$\pi_l^D \geq \pi_{h,l}^D$ when $K_h \geq (u_h - u_L)/4$;
$\pi_h^D \geq \pi_l^D$ when $K_h \leq \widetilde{K_h}$.

We compare $\widetilde{K_h}$ with $(u_h - u_L)/4$:

$$\widetilde{K_h} - (u_h - u_L)/4 = K_l + \frac{(u_h - u_L)u_L^2\,[80u_h u_l - u_L(8u_h + 8u_l + u_L)]}{4\,(4\,u_h - u_L)^2\,(4\,u_l - u_L)^2} > 0. \tag{B6}$$

As a consequence, the following profit ranking holds:

$$\begin{cases} 0 < K_h \leq (u_h - u_L)/4 \Longrightarrow \pi_h^D > \pi_{h,l}^D \geq \pi_l^D \\ (u_h - u_L)/4 < K_h \leq \widetilde{K_h} \Longrightarrow \pi_h^D \geq \pi_l^D > \pi_{h,l}^D \\ \widetilde{K_h} < K_h \Longrightarrow \pi_l^D > \pi_h^D > \pi_{h,l}^D \end{cases}. \tag{B7}$$

Then, it is never profitable to supply both flight services. Moreover, the high quality service is more profitable than the low quality service when $K_h < \widetilde{K_h}$, and viceversa. **Q.E.D.**

Proof of Proposition 3

The pre-alliance profit for carrier 1 is given by (28), while in case of the alliance it gets (32). As we know that:

$$\begin{aligned} (i)\ \Pi_1^{AL} &> \Pi_1^{M,D} \text{ if } \delta > \delta_1 \\ (ii)\ \Pi_1^{AL} &> \Pi_1^{M\prime} \text{ if } \delta > \delta_2 \end{aligned}$$

and $\delta_1 \geq \delta_2$ when $K_{AB} \leq \widehat{K}_{AB}$, the profit ranking in the different cases considered is as follows:

$$(i) \text{ iff } K_{AB} \leq \widehat{K}_{AB}\text{:} \begin{cases} 0 < \delta < \delta_2 \Longrightarrow \Pi_1^{M,D} > \Pi_1^{M\prime} > \Pi_1^{AL} \\ \delta_2 < \delta < \delta_1 \Longrightarrow \Pi_1^{M,D} > \Pi_1^{AL} > \Pi_1^{M\prime} \\ \delta_1 < \delta \Longrightarrow \Pi_1^{AL} > \Pi_1^{M,D} > \Pi_1^{M\prime} \end{cases}; \tag{C1}$$

$$(ii) \text{ iff } K_{AB} > \widehat{K}_{AB}\text{:} \begin{cases} 0 < \delta < \delta_1 \Longrightarrow \Pi_1^{M\prime} > \Pi_1^{M,D} > \Pi_1^{AL} \\ \delta_1 < \delta < \delta_2 \Longrightarrow \Pi_1^{M\prime} > \Pi_1^{AL} > \Pi_1^{M,D} \\ \delta_2 < \delta \Longrightarrow \Pi_1^{AL} > \Pi_1^{M\prime} > \Pi_1^{M,D} \end{cases}. \tag{C2}$$

Hence, the alliance is profitable for carrier 1 when: (i) $K_{AB} < \widehat{K}_{AB}$ and $\delta > \delta_1$; $(ii) K_{AB} > \widehat{K}_{AB}$ and $\delta > \delta_2$. **Q.E.D.**

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