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 services at relatively cheap prices. We demonstrate 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.

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1 Introduction

The entrance 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 (see Brueckner and Pels, 2003). 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). The concentration rate of the air transport market decreased, while the degree of differentiation among flight services increased significantly (Tucci, 1998).

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. Moreover, it manages to decrease the cost

[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 any additional service which was previously provided in combination with the transport service (for example, food, beverage and newspapers are optional and passengers have to pay for them). Moreover, they make use of secondary airports (see Bardot, 2006) and reduce the booking price by resorting to an on-line reservation system.

of production, without altering the quality of the service, by taking advantage of both economies of scale and economies of scope or density. As Oum et al. (2000) pointed out:

> "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).

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 the market is dominated by two traditional carriers which act as monopolists on their respective routes. Given the particular nature of the 'good' under consideration, we introduce vertical differentiation as the main theoretical feature of the model. We verify that, in absence of competitive pressures, traditional flag carriers provide only one type of service for consumers.

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 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 benefit from a reshaping of the cost structure and verify that there exists a cost region where it is indeed profitable to form such alliance. It follows that the incumbent may recover the profit in the segment which otherwise would have been lost.

The paper is laid out as follows. The next section presents the basic model and the benchmark case where the traditional flag carriers are monopolists in their respective routes. Section 3 examines the effect of the entrance of the low cost company, pointing out in particular the profit loss for the incumbent firm. Section 4 analyses the incentive for the existing firms to form a strategic alliance by implementing a hub-and-spoke system. Section 5 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: the European carrier 1 serves routes AB and AC, while the US carrier 2 serves route BC. The network is represented in Figure 1:

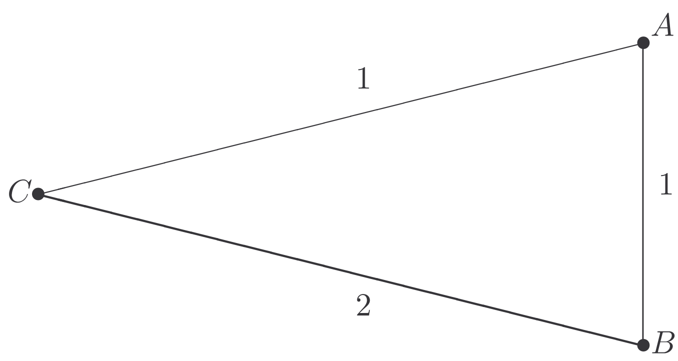

Figure 1 : Initial Network Structure

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. 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 $K_h > K_l$. Although this cost formulation is not entirely realistic, it captures the essential difference between the two types of service available.[3]

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, $\theta \in [0, 1]$, 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.[4] 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.

We start by analyzing the air transport market before the deregulation process. This will serve as a benchmark case. We consider two flag carriers

[3]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 $k_h > k_l$.

[4]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.

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 firm 1 (resp. 2). Accordingly, the profit accruing to firm 1 is the sum of the monopoly profits of routes AB and AC, while the profit accruing to firm 2 consists only of the monopoly profit of route BC.

As we introduced before, in every route the carrier has to decide upon the quality of the service to be provided. Given that we limit the analysis to fully connected flights, we can normalize β to 1.

We proceed by evaluating formally whether the carrier finds it optimal to provide only a single variant or both. We consider carrier 1' decision problem 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 $K_i \leq u_i/4$, otherwise the monopolist would not find it profitable to offer the aforementioned service. 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 services. Moreover, when*

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

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 one fourth of the quality difference $(u_h - u_l)$ is large enough to cover the cost gap $(K_h - K_l)$. This happens when the utility that travellers enjoy from a high quality flight service allows the monopolist to charge a fare that compensate the additional cost required to operate such a flight service.

3 The Entry of the Low Cost Company

The airline industry has been strongly affected by the deregulation process. As we have stressed 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 firm 1, the incumbent. In terms of our model, the main advantage for the newcomer is represented by a very low cost K_L of operating the flight.

The new scenario entails for competition on the segment AB between firm 1 and the low-cost company, indicated by L. Remind that firm 1 can provide either a high quality or a low quality service, or both simultaneously. However, the quality of both services is always higher than the one offered by the low-cost carrier. Low cost companies, in fact, target price sensitive consumers by setting convenient flight fare in exchange of a transport service of very low quality, at least compared to those offered by firm 1.

Figure 2 represents the airline network after the entrance of the low-cost company.

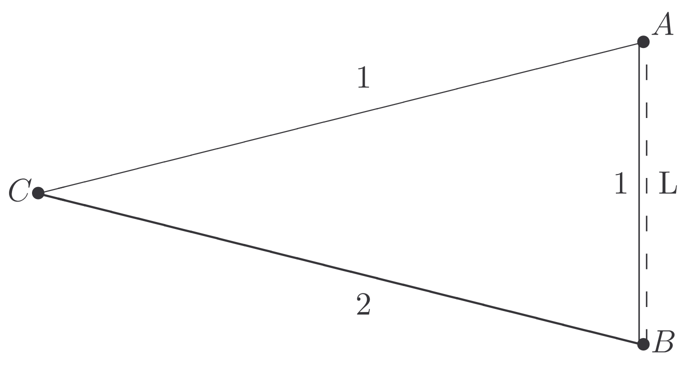

Figure 2 : The Network Structure with the Low Cost Company

We start the analysis of the duopoly by considering how many varieties does firm 1 offer on the segment AB. The entrance of a rival at the bottom of the quality ladder could lead firm 1 to sell both a high and low quality service in order to attract low income passengers.

One the one hand, when the incumbent provides only one type of service, the demand functions are similar to those obtained before, with the caveat that firm 1 provides a medium/high quality service, denoted by i, while the low cost company provides a low quality service, denoted by L:

$$D_i(p_i, p_L) = (1 - \frac{p_i - p_L}{u_i - u_L}), D_L(p_i, p_L) = (\frac{p_i - p_L}{u_i - u_L} - \frac{p_L}{u_L}). \tag{8}$$

The profit functions for firm 1 and for the low cost company on the segment AB are given by:

$$\pi_i(p_i, p_L) = (1 - \frac{p_i - p_L}{u_i - u_L})p_i - K_i, \tag{9}$$

$$\pi_L(p_1, p_L) = (\frac{p_i - p_L}{u_i - u_L} - \frac{p_L}{u_L})p_L - K_L. \tag{10}$$

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

$$p_i^D = \frac{2\,u_i(u_i - u_L)}{4\,u_i - u_L},\ p_L^D = \frac{u_L(u_i - u_L)}{4\,u_i - u_L} \tag{11}$$

which are always positive.[5]

Demand functions are positive as well, and, by substituting p_i^* and p_L^* in profit functions (9) and (10), we get:

$$\pi_i^D = \frac{4\,u_i^2(u_i - u_L)}{(4\,u_i - u_L)^2} - K_i, \tag{12}$$

$$\pi_L^D = \frac{u_1\,u_L(u_i - u_L)}{(4\,u_i - u_L)^2} - K_L. \tag{13}$$

On the other hand, if the incumbent provides two variants of the flight service, demand functions for firm 1 and for the low cost company are respectively given by:

$$D_h(p_h, p_l, p_L) = (1 - \frac{p_h - p_l}{u_h - u_l}), \tag{14}$$

$$D_l(p_h, p_l, p_L) = (\frac{p_h - p_l}{u_h - u_l} - \frac{p_l - p_L}{u_l - u_L}). \tag{15}$$

$$D_L(p_h, p_l, p_L) = (\frac{p_l - p_L}{u_l - u_L} - \frac{p_L}{u_L}). \tag{16}$$

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

The profit functions for firm 1 and for the low cost company write as follows:

$$\pi_{h,l}(p_h, p_l, p_L) = (1 - \frac{p_h - p_l}{u_h - u_l})p_h + (\frac{p_h - p_l}{u_h - u_l} - \frac{p_l - p_L}{u_l - u_L})p_l - (Kh + K_l), \quad (17)$$

$$\pi_L(p_h, p_l, p_L) = (\frac{p_l - p_L}{u_l - u_L} - \frac{p_L}{u_L})p_L - K_L. \quad (18)$$

Optimal prices are obtained through first-order conditions:[6]

$$p_h^D = \frac{1}{2}(u_h - \frac{3u_l\, u_L}{4\, u_l - u_L}),\ p_l^D = 2u_l(1 - \frac{3u_l}{4\, u_l - u_L}),\ p_L^D = \frac{(u_l - u_L)u_L}{4\, u_l - u_L} \quad (19)$$

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 space for the possibility for firm 1 expands her quality range with respect to the monopoly case.

Optimal profits are easily computed by substituting the above optimal prices on profit functions (17) and (18):

$$\pi_{hl}^D = \frac{1}{4}\left[u_h - \frac{u_l\, u_L(8u_l + u_L)}{(4\, u_l - u_L)^2}\right] - (K_h + K_l), \quad (20)$$

$$\pi_L^D = \frac{u_l\, u_L(u_l - u_L)}{(4\, u_l - u_L)^2} - K_L. \quad (21)$$

Similarly to what 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, firm 1, if it stays in the market, continues to provide only one variant of the flight service. Moreover, when*

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

firm 1 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 firm 1 to offer only one

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

variant of the flight service. This is consistent with the evidence that comes 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.[7]

Once we have verified that firm 1 offers one quality variant, we analyse the impact of the entry of the low cost company. Non-negativity of π_i^D and π_L^D respectively requires

$$\begin{aligned} K_i &< \frac{4\,u_i^2(u_i - u_L)}{(4\,u_i - u_L)^2} = \widehat{K}_i, \\ K_L &< \frac{u_i\,u_L(u_i - u_L)}{(4\,u_i - u_L)^2} = \widehat{K}_L. \end{aligned} \tag{22}$$

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 the low cost is always present in the market. Nonetheless, the same reasoning cannot apply for firm 1, which still faces a relatively expensive cost structure. Notice first that the presence of a very aggressive rival entails a profit loss on the route AB. Such loss is equal to the difference between the pre-entry monopoly profit (4) and the post-entry duopoly profit (12):

$$\Delta\pi_i = \pi_i^M - \pi_i^D = \frac{u_i u_L(8u_i + u_L)}{4(u_L - 4u_i)^2} \tag{23}$$

Moreover, two possibilities may appear, depending on the value of the cost K_i borne by firm 1:

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

[7] In particular, traditional carriers tried to replicate the cost saving strategy adopted by the low cost companies in order to offer cheaper fares. Some companies created their own low cost subsidiary with the aim of competing on the same ground with 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 Jarich, 2004).

2. $\widehat{K}_i < K_i < \overline{K}_i$, firm 1 incurs in negative profits when providing the flight service and therefore drops out of the route AB.

The entry of the low cost company brings about a profit loss for the traditional carrier, firm 1, whose market share shrinks. In addition, the threshold level for the cost of providing the high quality is lower than before and there exists the possibility that firm 1 exits from the route AB. Forming an alliance with firm 2 could result in a way to reduce the cost of operating the flight on route AB and to either recoup the profit lost or re-enter into the abandoned route.

In the following section we will consider how an alliance can be implemented in order to reduce the cost of operating a route and whether it is profitable for both carriers 1 and 2 to 'sign' such an agreement.

4 The Alliance

In this section we assume that as the high quality carrier 1 incurs in negative profits due to the entrance of the low cost company, it is forced to leave the route *AB*, which is then monopolized by the low-cost firm. Thus, we only focus on the extreme case when $\widehat{K}_i < K_i < \overline{K}_i$.[8]

In this new scenario, represented in Figure 3, carriers 1 and 2 still provide a fully connected service on their respective routes *AC* and *BC*, while the low cost carrier only operates the route *AB.*

[8]The other alternative, where $K_i < \widehat{K}_i < \overline{K}_i$ and firm 1 is still active on the market AB, can be easily considered with minor changes in the analysis.

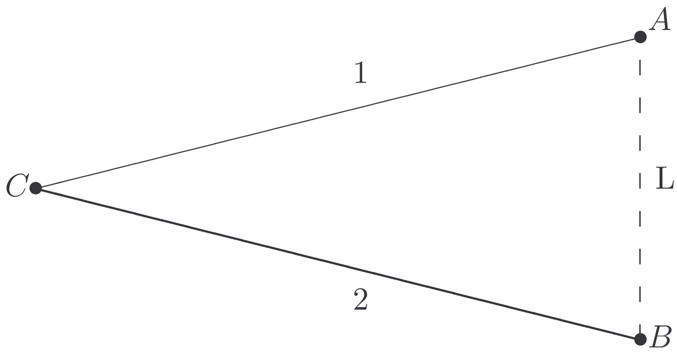

Figure 3 : The Network Structure with the Low Cost Company

In order to recoup the lost segment AB, carrier 1 can propose to carrier 2 an alliance offering a hub-and-spoke service on the route AC through the point B. In fact, deregulation brought about not only the entrance of new competitors, but also changed the air transport structure by allowing the emergence of strategic alliances.

We ask now the following question:

> *Is it convenient for carriers 1 and 2 to form an alliance and provide a hub-and-spoke service on the route AC through the hub B?*

We assume that this alliance takes the form of 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). 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.

Consistently with this assumption, as carriers 1 and 2 serve the route AC through B, we assume that they share the cost K_{ABC} and the revenue π_{ABC} deriving from this hub-and-spoke service.

Let us start by analyzing whether it is convenient for the carrier 1 to become member of this alliance.

The emerging alliance would make carrier 1 offering two variants of the flight service on the route AC. We know from the previous analysis that it is never convenient for a carrier to provide travellers with two variants of the service (Proposition 1). Thus, an alliance turns out to be convenient for carrier 1 if and only if it modifies revenues and costs borne by this carrier while marketing both services. We assume that the alliance entails the distinction between a fully connected 'high quality' and a hub-and-spoke 'low quality flight service. Carrier 1 gets both a share α of the profit arising from the hub-and-spoke service on the route AC where B represents the 'hub' point and the profit coming from the fully connected service on the same route.

Then, let $\pi_{1_{All}}(p_{AC}, p_{ABC})$ be the profit function of the carrier 1 when the alliance is formed. It writes:

$$\pi_{1_{All}}(p_{AC}, p_{ABC}) = \pi_{AC}(p_{AC}, p_{ABC}) + \alpha\pi_{ABC}(p_{AC}, p_{ABC}) \qquad (24)$$

where π_{AC} and $\alpha\pi_{ABC}(p_{AC}, p_{ABC})$ represent the profit coming respectively from the fully connected and the hub-and-spoke services on the route AC, being p_{AC} and p_{ABC} the correspondent prices. Taking into account that flying from A to C without (res. with) stopping at B is the high-quality (res. low-quality) service, we can rewrite the above expression as follows:

$$\begin{aligned}\pi_{All}(p_{AC}, p_{ABC}) &= (1 - \frac{p_{AC} - p_{ABC}}{u_{AC} - \beta u_{AC}})p_{AC} + \alpha(\frac{p_{AC} - p_{ABC}}{u_{AC} - \beta u_{AC}} - \frac{p_{ABC}}{\beta u_{AC}})p_{ABC} + \\ &\quad -(\alpha K_{ABC} + K_{AC}). \end{aligned} \qquad (25)$$

We remark here that $u_{AC} > \beta u_{AC}$ as $\beta < 1$, this parameter mirroring the loss of utility incurred when using the hub-and-spoke service.

From the joint maximization of (25) with respect to p_{AC} and p_{ABC}, we obtain the equilibrium prices

$$p^*_{AC} = \frac{2u_{AC}\alpha(u_{AC} - \beta u_{ABC})}{4\alpha u_{AC} - (1+\alpha)^2\beta u_{AC}}, \qquad (26)$$

$$p^*_{ABC} = \frac{(1+\alpha)(u_{AC} - \beta u_{AC})\beta u_{AC}}{4\alpha u_{AC} - (1+\alpha)^2\beta u_{AC}}. \qquad (27)$$

Finally, plugging these prices in (25) yields the optimal profit accruing to the carrier 1 if the alliance is formed:

$$\pi^*_{1_{All}} = \frac{\alpha u_{AC}(u_{AC} - \beta u_{AC})}{4\alpha u_{AC} - (1+\alpha)^2 \beta u_{AC}} - (\alpha K_{ABC} + K_{AC}) \quad (28)$$

The alliance turns out to be profitable for carrier 1 if and only if $\pi^*_{1_{All}} > \pi^*_{AC_{ba}}$, where $\pi^*_{AC_{ba}}$ represents the profit accruing to firm 1 on the route AC before the alliance.

From easy computations, we obtain that $\pi^*_{1_{All}} > \pi^*_{AC_{ba}}$, when the cost of the hub-and-spoke service borne by this firm is lower than a threshold value, say $\hat{K}_{ABC}$, where:

$$\hat{K}_{ABC} = \frac{u_{AC}(\alpha - 1)^2 \beta u_{AC}}{4\alpha[4\alpha u_{AC} - (1+\alpha)^2 \beta u_{AC}]}. \quad (29)$$

Then, we can state the following:

Proposition 3 *When $K_{ABC} < \hat{K}_{ABC}$ carrier 1 proposes an alliance to carrier 2 aiming at the creation of a hub-and-spoke service on the route AC.*

As a consequence, there exists a threshold value for the cost for the hub-and-spoke service below which carrier 1 involves carrier 2 in a hub-and-spoke service on the route AC through the hub B.

We now consider the incentives for carrier 2 to become member of this alliance. Let $\pi^*_{2_{All}}$ be the profit accruing to the carrier 2 after the 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. For both these service, namely when both B represents the arrival (or starting) airport and in the alternative case when it is the hub airport, this carrier only pays a cost equal to $(1 - \alpha)K_{ABC}$. Further, it is reasonable to assume that due to the alliance the frequency of flights on the route BC increases, larger and more comfortable aircraft are employed and s.o., namely the service quality on this route after the alliance gets higher than it was before. Then, $\pi^*_{2_{All}}$ writes as:

$$\pi^*_{2All}(p^*_{AC}, p^*_{BC}, p^*_{ABC}) = \frac{u_{BC_{all}}}{4} + (1-\alpha)\pi^*_{ABC}(p^*_{AC}, p^*_{ABC}) \quad (30)$$

where $u_{BC_{all}}$ represents the service quality on the route BC perceived by travellers after the alliance and:

$$\pi^*_{ABC}(p^*_{AC}, p^*_{ABC}) = (\frac{p^*_{AC} - p^*_{ABC}}{u_{AC} - \beta u_{AC}} - \frac{p^*_{ABC}}{\beta u_{AC}})p^*_{ABC} - K_{ABC}. \quad (31)$$

By substituting (26) and (27) in the above expression, we obtain:

$$\pi^*_{2All} = \frac{u_{BC_{all}}}{4} + \frac{(1+\alpha)(-1+\alpha)^2 u_{AC}(\beta u_{AC} - u_{AC})\beta u_{AC}}{(-\alpha 4 u_{AC} - (1+\alpha)^2 \beta u_{AC})^2} - (1-\alpha)K_{ABC} \quad (32)$$

Finally, we know from Section 3 that the profit accruing to the carrier 2 before the alliance, indicated by $\pi^*_{BC_{ba}}(p^*_{BC})$, writes as:

$$\pi^*_{BC_{ba}}(p^*_{BC}) = \frac{u_{BC_{ba}}}{4} - K_{BC} \quad (33)$$

and $u_{BC_{all}} > u_{BC_{ba}}$.

It remains to verify whether $\pi^*_{2_{All}}(p^*_{AC}, p^*_{BC}, p^*_{ABC}) \gtreqless \pi^*_{BC_{ba}}(p^*_{BC})$. Let $\Delta\pi = \pi_{2_{All}}(p^*_{AC}, p^*_{BC}, p^*_{ABC}) - \pi^*_{BC_{ba}}(p^*_{BC})$ and $\Delta u_{BC} = u_{BC_{all}} - u_{BC_{ba}}$. Easy computations yield the following:

$$\Delta\pi = \Delta u_{BC} - \frac{(1+\alpha)(-1+\alpha)^2 u_{AC}(u_{AC} - \beta u_{AC})\beta u_{AC}}{(-\alpha 4 u_{AC} - (1+\alpha)^2 \beta u_{AC})^2} + K_{BC} - (1-\alpha)K_{ABC} \quad (34)$$

Then $\pi^*_{2All}(p^*_{AC}, p^*_{BC}, p^*_{ABC}) > \pi^*_{BC}(p^*_{BC})$ if and only if $K_{BC} \geq \bar{K}_{BC}$, where

$$\bar{K}_{BC} = (1-\alpha)K_{ABC} - \frac{(1+\alpha)(-1+\alpha)^2 u_{AC}(u_{AC} - \beta u_{AC})\beta u_{AC}}{(-\alpha 4 u_{AC} - (1+\alpha)^2 \beta u_{AC})^2} - \Delta u_{BC}. \quad (35)$$

We summarize this result as follows:

Proposition 4 *When $K_{BC} > \bar{K}_{BC}$ carrier 2 accepts the alliance proposed by carrier 1 and they provide a hub-and-spoke service on the route AC through B while still providing a flight service on the route BC.*

We can now answer to the question proposed at the beginning if this section, namely whether it is profitable for carriers 1 and 2 to form an alliance which provides a hub-and-spoke service on the route AC through the hub B. We have shown that this type of alliance turns out to be profitable for both the partners only if costs of the hub-and-spoke service on the route AC are low compared with costs of (i) only providing fully connection service on AC and (ii) serving passengers only flying between B and C.

5 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. We have shown that firms provide only one quality service.

The appearance of low cost companies has probably represented the most significant event and modified the concept of flight service itself. We have considered the entry of a low cost company in one segment and analysed the consequences for the incumbent firm, whose market shares 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 hub-and-spoke services along with 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 there exist intervals for the cost of the hub-of-spoke service in which the alliance is convenient for both firms. This 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 both qualities are marketed, the monopolist obtains:

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

The profit for the monopolist when it only provides the high quality service is:

$$\pi_h = \frac{u_h}{4} - K_h$$

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

$$\pi_l = \frac{u_l}{4} - K_l$$

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

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

As a consequence, the following ranking for profits applies:

$$\begin{cases} 0 < \Delta u < 4(K_h - K_l) \Longrightarrow \pi_l > \pi_h > \pi_{h,l} \\ 4(K_h - K_l) < \Delta u < 4K_h \Longrightarrow \pi_h > \pi_l > \pi_{h,l} \\ 4K_h < \Delta u \Longrightarrow \pi_h > \pi_{h,l} > \pi_l \end{cases}$$

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 firm 1 when it decides to provide both qualities is:

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

One the contrary, when it offers only the high quality the profit is

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

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

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

Firstly, $\pi_h^D - \pi_l^D > 0$ when:

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

or, alternatively, $\pi_h^D > \pi_l^D$ when $K_h < \widetilde{K_h}$, where

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

Secondly,

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

because $80u_hu_l > u_L(8u_h+8u_l+u_L)$, given that $u_h > u_l > u_L$ by definition. It follows that $\pi_h^D > \pi_{h,l}^D$ for every admissable value of parameters. 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;
$\pi_l^D > \pi_{h,l}^D$ when $K_h > (u_h-u_L)/4$;
$\pi_h^D > \pi_l^D$ when $K_h < \widetilde{K_h}$.

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

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

As a consequence, the following ranking for profits applies:

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

Then, it is never profitable to supply both 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

Let π_{2All} be the profit accruing to the carrier 2 after the alliance. It writes as:

$$\pi_{2All}(p_{AC}, p_{BC}, p_{ABC}) = \pi_{BC}(p_{BC}) + (1-\alpha)\pi_{ABC}(p_{AC}, p_{ABC})$$

We know from Section 3 that

$$\pi^*_{BC}(p^*_{BC}) = \frac{u_{BC}}{4} - K_{BC}$$

while $(1-\alpha)\pi_{ABC}(p_{AC}, p_{ABC})$ results to be:

$$(1-\alpha)\pi_{ABC}(p_{AC}, p_{ABC}) = (1-\alpha)(\frac{p_{AC} - p_{ABC}}{u_{AC} - \beta u_{ABC}} - \frac{p_{ABC}}{\beta u_{ABC}})p_{ABC}$$

or, given the optimal values of p^*_{AC} and p^*_{ABC}

$$\frac{(1+\alpha)(-1+\alpha)^2 u_{AC}(u_{AC} - \beta u_{ABC})\beta u_{ABC}}{(-\alpha 4 u_{AC} - (1+\alpha)^2 \beta u_{ABC})^2}$$

which is strictly positive for any $\alpha \in [0, 1[$.

Then $\pi^*_{2All}(p_{AC}, p_{BC}, p_{ABC}) > \pi^*_{BC}(p^*_{BC})$.**Q.E.D.**

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