THE WELFARE EFFECTS OF THE ALLOCATION OF AIRLINES TO DIFFERENT TERMINALS

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The welfare effects of the allocation of airlines to different terminals[*]

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Abstract

Many airports around the world have recently built or are in the process of constructing or rebuilding new terminals. Airlines operating in those airports must be reallocated between the new and old facilities. In this paper we construct a theoretical model which shows that, in general, if airlines are allocated to separate terminals, the level of competition between airlines is reduced, ticket prices become higher and consumer surplus and social welfare lower. Only in some routes, and under certain conditions on the market size, ticket prices may be lower.

Keywords: airport terminal, airlines, ticket price, social welfare
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1. Introduction

Over the last 50 years, passenger traffic at airports has increased by an average of about 8 percent worldwide. However, the fraction of airport passengers transiting through the airports is frequently more than a half, with, at some airports, as many as three out of four passengers continuing their trip on another flight within one or two hours. Such a high rate of transfers in Europe can be found for example in Amsterdam (De Neufville, 1995). Those airports and airlines that cannot provide quick and reliable connections between flights for passengers, baggage and aircrafts, will not be competitive and will loose passengers and revenues.

Given the important growth of demand and the increased competition for transfer passengers, airports must invest in new facilities responding to airlines' needs (Barret, 2003; McLay and Reynolds-Feighan, 2006) Indeed, a number of main airports have recently built or are in the process of constructing or rebuilding new terminals in Europe. Some examples can be found in Appendix A.

The organization of airlines into worldwide groups is having significant repercussions on airports. As De Neufville (2000) points out, the international airlines associated with a given group will insist on being located in identifiable sections of an airport. They will want to facilitate transfers between themselves and they will attempt to wall themselves off from the rest of the airport, in order to minimize the loss of passengers to airlines outside their group. They will thus want to have their own customs and other operational services. The new American Airlines buildings at New York/Kennedy, the Continental/SAS facility at New York/Newark or the Iberia new terminal at Madrid/Barajas are clear examples of this phenomenon.[1]

The allocation of different airlines (or alliances of airlines) to different terminals that are not properly connected may have important consequences in terms of competition, especially for transfer flights. Once a transfer passenger is within a certain terminal, there are important costs associated with moving to another terminal.

[1] In some US airports there are the so-called dedicated terminals (terminals built and financed by a particular airline). However, this system is not usually applied in European airports.

In this paper we analyze how the allocation of airlines to different terminals affects the ticket prices of both transfer and direct flights. In particular, we consider a domestic and an overseas route. The overseas route is operated as a monopoly while in the domestic route there are two airlines competing with differentiated products.[2] If airlines operate within the same terminal, transfer flights may be operated firstly by a certain airline and secondly by the other. However, such a combination becomes more difficult or even not feasible when airlines operate in different terminals at the airport. We show that, if airlines operate in separate terminals, the lack of competition in transfer flights significantly affects ticket prices of the whole network. In general, the competition between air carriers is reduced, ticket prices become higher and consumer surplus and social welfare lower. Only in some routes and under certain conditions on the market size, ticket prices can be reduced.

The rest of the paper is organized as follows. In section 2 we present the Madrid/Barajas airport case. Such a case offers a good example of the type of network modeled in section 3. The main results for the cases in which airlines operate in separate terminals and within the same terminal, are obtained in sections 4 and 5, respectively. In section 6 we compare the prices, consumer surplus and social welfare for the situations analyzed in sections 4 and 5. Finally, section 7 concludes.

2. The Spanish case: The new terminal T4 at Madrid/Barajas airport

At the beginning of 2006, Madrid/Barajas opened new facilities - the terminal T4 -that left the airport with four passengers' terminal buildings, four runways, and a design capacity that duplicated the existing one. After this expansion, Madrid/Barajas is able to process a maximum of 80 million passengers per year.

Madrid/Barajas is the main gateway of the Spanish airport system. During 2007 more than 52 million passengers traveled through this airport, what represents an increase of

[2] Product differentiation may be due to different reasons such as brand loyalty, the existence of frequent flier programs, etc. (see, for example, Brueckner and Whalen, 2000, or Flores-Fillol and Moner-Colonques, 2006).

14 per cent with respect to the previous year. This significant growth was possible after the construction of the new facilities. The airport occupies a prominent position within the European ranking (5th) and also at the international level (13th).

Terminal T4 is a modern and nice facility, with an impressive undulating roof and beautiful modern structures.[3] Despite of its impressive design, T4 has a satellite, what implies higher transferring times on average. In addition, many consumers are still not familiar with the new terminal, and luggage delivery times are longer due to the longer distances it has to go through. On the contrary, the old terminals -T1, T2 and T3- are more flexible in this regard, with better connections and accessibility. Nevertheless, the buildings are older, though they are currently under renovation works.

Although terminals T1, T2, T3, and T4 are completely different in their main characteristics, they are subject to the same airport charges. Indeed, the level and structure of airport charges is quite homogeneous and barely differentiated among Spanish airports,[4] despite the recommendations included in the last Proposal for a Directive of the European Parliament and of the Council on Airport Charges (Article 8):[5]

"*Member States shall take the necessary measures to allow the airport managing body to vary the quality and scope of particular airport services, terminals or parts of terminals, with the aim to provide tailored services or a dedicated terminal or part of a terminal. The level of airport charges may be differentiated according to the quality and scope of such services.*"

Given the lack of charges differentiation by type of terminal in Madrid/Barajas, the initial allocation of slots at the new facilities was subject to great controversy among Spanish airlines. In June 2003 it was decided to allocate both Iberia (and its partners of Oneworld) and Spanair (and its partners of Star Alliance) to the new facilities at

[3] The design of the Terminal T4 in Madrid/Barajas is so grandiose that it has been awarded the Stirling prize, sponsored by the Royal Institute of British Architects.

[4] As common for airports around the world, charges are differentiated according to the maximum aircraft take off weight and by taking into consideration the category of the airport as given by their traffic levels.

[5] http://ec.europa.eu/transport/air_portal/airports/doc/2007_proposal_directive_airports_charges_en.pdf.

terminal T4. However, in November 2004, such a decision was changed and all the slots in T4 were given to Iberia. Spanair was against such a decision and went to court, but finally lost. The judge argued that “the unique objective of Spanair was to capture Iberia’s traffic, which is legitimate from the commercial point of view, but does not affect the social welfare”.[6] At the end, Iberia and its partners of Oneworld operate from the new terminal T4, whilst its main national competitor, Spanair and its partners of Star Alliance (are located at the old facilities. In this paper we show that, despite the court’s ruling, the decision of allocating Iberia and Spanair to separate terminals does have important effects on the ticket prices, consumer surplus and social welfare.

The Spanish air transport system is organized as a hub-and-spoke network, where Madrid/Barajas is the main hub. Around 45 per cent of total passengers at Terminal T4 are transfer passengers, while 25 per cent of total passengers at T1, T2 and T3 make a transfer. Moreover, Madrid/Barajas is the main hub connecting Europe and Latin-America (see Figure 1 and Figure 2 in Appendix A).

There are some restrictions on international service due to bilateral agreements, which limit entry of new carriers on routes between some countries. Although these restrictions have been removed in many cases through “open skies” agreements, there are many examples in which those restrictions still exist. Such is the case between Spain and some Latin American countries, where Iberia and the Oneworld alliance enjoy bilateral agreements and operate either as monopolists or with a strong market power (see Figure 3 in Appendix A). Although Spanair is the main Iberia’s competitor in the Spanish domestic routes, Spanair and the Star Alliance group do not operate any direct flight connecting Madrid and Latin America. Figure 4 in Appendix A shows all the Spanish domestic routes in which Spanair and Iberia compete. This type of network configuration and level of competition is the basis framework for the model developed in the following section.

One of the main consequences of the allocation of airlines to separate terminals is quite probably the reduction in the level of competition among airlines. Terminal T4 is not

[6] Sentence nº 32/2006 pronounced on the 10th of February 2006 by “Juzgado Central de lo Contencioso-Administrativo nº 7 de Madrid”.

easily linked with the old terminals. At the moment there is a free bus service and a metro connection, but the whole journey, including waiting times at stops may take around 20 minutes. A transfer passenger should add the time needed to collect his luggage and exit the terminal in case of interconnection of flights. As a result, the combination of flights from the passengers' point of view has become more troublesome than in the past, when all airlines were closely located. This conclusion is confirmed by the survey made by the Spanish airports operator AENA in 2006. In such a survey transfer passengers where interviewed in order to find out their arrival terminal, their departure terminal, the required time for transfer, and the number of them that changed the airline and had to collect their baggage. A summary of the survey results is presented in Table 1.

Table 1: Transfer passengers at Madrid/Barajas airport

Arrival Terminal	Departure Terminal	Thousands of interviewed passengers	% with respect to total transfer passengers	% with respect to total passengers	Average time for transfer (hours)	% of interviewees that change the airline	% of interviewees that pick up their baggage
T123	**T123**	1937	24%	9%	3.33	56%	26%
T123	**T4**	422	5%	2%	4.00	100%	64%
T4	**T4**	5367	66%	24%	2.58	11%	7%
T4	**T123**	407	5%	2%	4.16	100%	66%
Total		8133	100%	36%	2.91	31%	18%

Source: AENA. EMMA survey 2006.

Most transfer passengers arriving or departing from a certain terminal do the transfer within the same terminal. Only 10 per cent of transfer passengers move from/to terminals T1, T2 or T3 to/from terminal T4. The reason is that moving from terminal T4 to terminal T1, T2 or T3 increases the average time for transfer around 60 per cent with respect to the case in which passengers do the transfer within T4. On the other hand, moving from terminal T1, T2 or T3 to terminal T4 increases the average time for transfer around 25 per cent with respect to the case in which passengers do the transfer within terminals T1, T2 or T3 (even though more than a half of transfers in terminals T1, T2 or T3 imply that passengers change the airline). Thus, in order to reduce their transfer time, most passengers prefer to depart from their arrival terminal.

From the data available in Table 1 we can conclude that, since Iberia (and its partners of OneWorld) and Spanair (and its partners of Star Alliance) are now located in different terminals, the combination of flights between these airlines has become more troublesome than in the past, when the airlines were closely located.

3. The model

We consider a simple network structure with a domestic and an overseas route. The domestic route is operated by two airlines, airline 1 and airline 2, while the overseas route is operated just by airline 1. Such a network structure is shown in Figure 5.

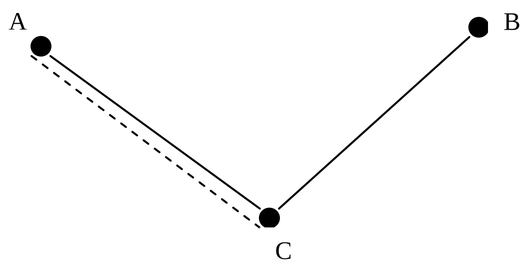


Figure 5. Network structure

Airline 1, which uses city C as a hub, operates both an overseas route to/from city B and a domestic route to/from city A. However, airline 2 operates just the domestic route to/from city A. In the Iberia - Spanair (Oneworld - Star Alliance) competition model, the domestic route AC may correspond, for example, to the route Gran Canaria - Madrid and the overseas route CB to Madrid - Sao Paulo.

The network structure depicted in Figure 5 yields two possible routes, AC and CB, but three city-pair markets, AC, CB, and AB. In the city-pair AC, passengers may travel either with airline 1 or airline 2, while in the city-pair CB they can only use airline 1. For the city-pair AB, passengers can choose to fly just with airline 1 from A to C and from C to B, or they may choose to fly with airline 2 in the route AC, and then change to airline 1 for the route CB. We will assume that, for the city-pair AB, changing from airline 2 to airline 1 implies a switching cost for passengers denoted by s.

We assume passengers exhibit brand loyalty to particular carriers, that is, airlines sell differentiated products. In particular, we consider that, whenever airlines 1 and 2 compete, passengers have preferences over the two airlines and they like variety. Following Dixit (1979) and Singh and Vives (1984), we consider that passengers maximize $U(q_1,q_2)-\sum_{i=1}^{2} p_i q_i$, where q_i is the round-trip traffic operated by airline i in a certain city-pair market and p_i is its price. U is assumed to be quadratic and strictly concave:

$$U(q_1,q_2)=\alpha q_1+\alpha q_2-\frac{1}{2}(\beta q_1{}^2+\beta q_2{}^2+2\gamma q_1 q_2), \tag{1}$$

where α , β and γ are positive parameters (goods are substitutes) and $\beta>\gamma$. This utility function gives rise to a linear demand structure, and direct demands can be written as (see Dixit, 1979, and Singh and Vives, 1984, for further details):

$$\begin{aligned} q_1 &= a-bp_1+dp_2 \\ q_2 &= a-bp_2+dp_1, \end{aligned} \tag{2}$$

where $a=\alpha/(\beta+\gamma)$, $b=\beta/(\beta^2-\gamma^2)$, and $d=\gamma/(\beta^2-\gamma^2)$. γ/β expresses the degree of product differentiation, ranging from zero when the goods are independent to one when goods are perfect substitutes (homogenous market).

For the sake of simplicity and similarly to Brueckner (2001), we consider that the demand for travel is the same in each city-pair. Airlines 1 and 2 compete with differentiated products in the route AC, so the demand in the AC market is given by:

$$\begin{aligned} q_1{}^{AC} &= a-bp_1{}^{AC}+dp_2{}^{AC} \\ q_2{}^{AC} &= a-bp_2{}^{AC}+dp_1{}^{AC}. \end{aligned} \tag{3}$$

The route CB is operated just by airline 1, so the demand in the CB market is given by:

$$q_1{}^{CB}=a-bp_1{}^{CB}. \tag{4}$$

Finally, for the city-pair AB, passengers may fly with airline 1 from A to C and from C to B, or they may decide to fly with airline 2 the first segment and then change to airline 1. Thus, the demand in the AB market is given by:

$$\begin{aligned} q_1{}^{AB} &= a-bp_1{}^{AB}+dp_{2+1}{}^{AB} \\ q_2{}^{AB} &= a-bp_{2+1}{}^{AB}+dp_1{}^{AB}, \end{aligned} \tag{5}$$

where $p_{2+1}{}^{AB}=p_2{}^{AC}+p_1{}^{CB}+s$, and $p_1{}^{AB}\le p_1{}^{AC}+p_1{}^{CB}$. In other words, if passengers decide to fly with airline 2 the first segment and then change to airline 1, they must pay the ticket price of airline 2 in the first segment AC, plus the ticket price of airline 1 in the second segment AC, plus a switching cost s. This is possible because of the brand loyalty that implies that a carrier can raise its fare above that charged by its competitor without losing all of its traffic. On the other hand, if passengers decide to fly with airline 1 in both segments the non-arbitrage condition must be satisfied, that is, purchasing the round trip AB should not be more costly than buying two round trips, one from A to C and the other from C to B. Otherwise, nobody would purchase the round trip AB and airline 1's pricing policy would be no valid.[7]

The level of the switching cost that AB passengers must pay if they decide to fly the first segment with airline 2 depends on how easy is switching from airline 2 to airline 1. In general, if both airlines operate within the same terminal the shift would be easier. On the contrary, if both airlines operate in different terminals, far from each other and with poor connections, switching costs may be excessive. For the sake of simplicity, we consider only two extreme cases for the switching cost. On the one hand, and without loss of generality, we normalize the switching cost to zero for the case in which airlines operate within the same terminal. On the other hand, we consider the extreme case in which the swithching cost is so high that it is no worth for any passenger to travel first with airline 2 and then change to airline 1 (which corresponds to the case in which airlines operate in separate terminals and shifts become too costly).

Finally, marginal operating costs for airlines are assumed to be constant and identical for both airlines in all the routes. In particular, the round-trip cost of carrying q_i passengers on the route r is given by $C(q_i^r) = cq_i^r$, where $c > 0$ denotes the constant marginal operating cost, and q_i^r denotes the passengers carried by airline i (for $i = 1,\ 2$) on the route r (for $r = AC,\ CB$ in case of airline 1 and $r = AC$ in case of airline 2). In order to have the model well-defined, we assume that $a > c.$ Notice that the marginal cost of carrying passengers for the city-pair AB is $2c$, since no direct flights are available.

[7] A similar assumption is made by Brueckner (2001).

4. Airlines 1 and 2 operate in separate terminals

In this section we analyze the ticket prices charged by airline 1 and airline 2 when airlines operate in separate terminals and shifts from one airline to the other are too costly. In other words, we analyze the situation in which the switching cost s is so high that no AB passengers is willing to flight with airline 2 in the AC route and move to airline 1 in the route CB. Thus, the demand for airline 2 in the AB market is cero and airline 1 captures all the AB traffic. Airline 1 operates as a monopolist in the AB market and its demand is given by:

$$q_1^{AB} = 2a - bp_1^{AB}. \tag{6}$$

Airline 1 chooses the optimal ticket prices for each market - p_1^{AC}, p_1^{CB}, and p_1^{AB} - in order to maximize its total profit. Airlines 1's total profit includes the profit that airline 1 obtains in the AC market -when competing against airline 2 with differentiated products-, and the profits that airline 1 obtains in the CB market and in the AB market as a monopolist. Formally:

$$\underset{p_1^{AC}, p_1^{CB}, p_1^{AB}}{Max} \begin{Bmatrix} (a - bp_1^{AC} + dp_2^{AC})(p_1^{AC} - c) + (a - bp_1^{CB})(p_1^{CB} - c) \\ +(2a - bp_1^{AB})(p_1^{AB} - 2c) \end{Bmatrix} \tag{7}$$

Airline 1's first order conditions are obtained by setting the first derivatives of its total profits with respect to p_1^{AC}, p_1^{CB}, and p_1^{AB}, respectively, equal to zero:

$$a - 2bp_1^{AC} + dp_2^{AC} + bc = 0. \tag{8}$$

$$a - 2bp_1^{CB} + bc = 0. \tag{9}$$

$$2a - 2bp_1^{AB} + 2bc = 0. \tag{10}$$

Airline 2 only competes with airline 1 in the AC market. Therefore, airline 2 must chooses the optimal ticket price p_2^{AC} in order to maximize the profits that it obtains in the AC market when competing against airline 1 with differentiated products:

$$\underset{p_2^{AC}}{Max} \left\{ (a - bp_2^{AC} + dp_1^{AC})(p_2^{AC} - c) \right\} \tag{11}$$

The first order condition for airline 2 is given by:

$$a - 2bp_2^{AC} + dp_1^{AC} + bc = 0. \tag{12}$$

Let us denote by $\overline{\overline{p_1^{AC}}}$, $\overline{\overline{p_2^{AC}}}$, $\overline{\overline{p_1^{CB}}}$, and $\overline{\overline{p_1^{AB}}}$ the optimal ticket prices charged by airline 1 and airline 2 when airlines operate in separate terminals and shifts from one airline to the other are too costly. The optimal ticket prices are obtained by solving the system of equations given by expressions (8), (9), (10), and (12):

$$\overline{\overline{p_1^{AC}}} = \overline{\overline{p_2^{AC}}} = \frac{a+bc}{2b-d}; \ \overline{\overline{p_1^{CB}}} = \frac{a+bc}{2b}; \ \overline{\overline{p_1^{AB}}} = \frac{2a+2bc}{2b}. \qquad (13)$$

Proposition 1: *If airlines operate in separate terminals and shifts from one airline to the other are too costly, airline 1 and airline 2 charge the same ticket price in the AC market, while in the CB and the AB market airline 1 charges the monopoly price.*

5. Airlines 1 and 2 operate within the same terminal

In this section we analyze the ticket prices charged by airline 1 and airline 2 when both airlines operate within the same terminal and shifts from one airline to the other are completely costless, that is, $s = 0$. Airline 1 is a monopolist for the overseas route CB, while airline 1 and airline 2 compete with differentiated products in the domestic route AC. For the city-pair AB, passengers must do a transfer at airport C. Transfer passengers may decide to flight the whole trip with airline 1 and pay a ticket price p_1^{AB}, or they may decide to flight from A to C with airline 2 and from C to B with airline 1, paying $p_{2+1}^{AB} = p_2^{AC} + p_1^{CB}$ for the whole round-trip.

Similarly to section 4, airline 1 chooses the optimal ticket prices for each market - p_1^{AC}, p_1^{CB}, and p_1^{AB} - in order to maximize its total profit. In this case, airlines 1's total profit includes the profit that it obtains in the AC market -when competing against airline 2 with differentiated products-, the profit that it gets in the CB market as a monopolist, plus the profit that it obtains in the AB market. For the AB market airline 1 can earn profits either through those transfer passengers that decide to make the whole trip within airline 1's aircrafts, or through those AB passengers that decide to flight in the route AC with airline 2 but who must compulsorily flight in the route CB with airline 1. Formally, airline 1 must solve the following maximization program:

$$\underset{p_1^{AC}, p_1^{CB}, p_1^{AB}}{Max} \begin{Bmatrix} (a - bp_1^{AC} + dp_2^{AC})(p_1^{AC} - c) + (a - bp_1^{AB} + dp_2^{AC} + dp_1^{CB})(p_1^{AB} - 2c) \\ +(a - bp_1^{CB})(p_1^{CB} - c) + (a - bp_2^{AC} - bp_1^{CB} + dp_1^{AB})(p_1^{CB} - c) \end{Bmatrix} \quad (14)$$

Once again, first order conditions are obtained by setting the first derivatives of airline 1's total profits with respect to $p_1^{AC}, p_1^{CB},$ and $p_1^{AB},$ respectively, equal to zero:

$$a - 2bp_1^{AC} + dp_2^{AC} + bc = 0. \quad (15)$$

$$2a - 4bp_1^{CB} + 2dp_1^{AB} - bp_2^{AC} + 2bc - 2cd = 0. \quad (16)$$

$$a - 2bp_1^{AB} + 2dp_1^{CB} + dp_2^{AC} + 2bc - dc = 0. \quad (17)$$

Airline 2 operates just in the AC route. However, it may sell tickets to both AC passengers and AB passengers, since there might be AB transfer passengers willing to flight the AC route with airline 2 and the CB route with airline 1. Thus, airline 2 chooses the optimal ticket price p_2^{AC} in order to maximize the profit that it obtains both in the AC and the AB market. Formally:

$$\underset{p_2^{AC}}{Max} \left\{(a - bp_2^{AC} + dp_1^{AC})(p_2^{AC} - c) + (a - bp_2^{AC} - bp_1^{CB} + dp_1^{AB})(p_2^{AC} - c)\right\} \quad (18)$$

Airline 2's first order condition is given by:

$$2a - 4bp_2^{AC} + dp_1^{AC} - bp_1^{CB} + dp_1^{AB} + 2bc = 0. \quad (19)$$

Let us denote by $\overline{p_1^{AC}}$, $\overline{p_2^{AC}}$, $\overline{p_1^{CB}}$, and $\overline{p_1^{AB}}$ the optimal ticket prices charged by airline 1 and airline 2 when both airlines operate within the same terminal and shifts from one airline to the other are completely costless, that is, $s = 0$. In this case, the optimal ticket prices are obtained by solving the system of equations given by expressions (15), (16), (17), and (19):

$$\begin{aligned} \overline{p_1^{AC}} &= \frac{1}{2}\frac{15ab^3 - 2ad^3 + 15b^4c - 2cd^4 - 6abd^2 + 7ab^2d - 3bcd^3 + 7b^3cd - 3b^2cd^2}{b^3d - 9b^2d^2 + 15b^4 + d^4}, \\ \overline{p_2^{AC}} &= \frac{6ab^3 - ad^3 + 6b^4c - 2abd^2 + 3ab^2d - 3bcd^3 + 6b^3cd - 3b^2cd^2}{b^3d - 9b^2d^2 + 15b^4 + d^4}, \\ \overline{p_1^{CB}} &= \frac{1}{2}(3b + d)\frac{4ab^2 - ad^2 + 4b^3c + cd^3 - 3bcd^2 - 3b^2cd}{b^3d - 9b^2d^2 + 15b^4 + d^4}, \\ \overline{p_1^{AB}} &= \frac{1}{2}\frac{9ab^3 - 2ad^3 + 24b^4c + 2cd^4 - 3abd^2 + 10ab^2d - 7b^3cd - 21b^2cd^2}{b^3d - 9b^2d^2 + 15b^4 + d^4}. \end{aligned} \quad (20)$$

Proposition 2: *If airlines operate within the same terminal and shifts from one airline to the other are completely costless, airline 2 charges a lower ticket price than airline 1 in* *the AC market. On the other hand, if the market size is high enough, airline 1 charges a ticket price higher than the monopoly price in the CB market.*

Proof: *See Appendix B.*■

When airlines operate within the same terminal and shifts from one airline to the other are completely costless, there exist some AB passengers willing to flight the domestic route with airline 2 and the overseas route with airline 1. Thus, in order to encourage AB passengers to fly the first part of their trip within its aircraft, airline 2 has incentives to reduce the ticket price in the AC market. On the contrary, in order to encourage AB passengers to buy the whole trip to airline 1 instead of flying the first part with airline 2, airline 1 may have incentives to increase the ticket price in the CB market over the monopoly price.

6. Comparisons

Let us compare the ticket prices, airlines' total profits, the consumer surplus, and the social welfare in the cases in which airlines operate and do not operate within the same terminal.

On the one hand, lower prices and higher quantities are always better in welfare terms. On the other hand, consumer surplus for market M, with prices (p_1^M, p_2^M) and quantities (q_1^M, q_2^M) is defined as:

$$CS^M = U(q_1^M, q_2^M) - p_1^M q_1^M - p_2^M q_2^M, \tag{21}$$

which is a decreasing and convex function of prices.

Proposition 3: *If we compare the ticket prices, the consumer surplus, and the social welfare in the cases in which airlines operate and do not operate within the same terminal, we can conclude that:*

- *For the AC and AB markets:* *if airlines operate within the same terminal, ticket prices are lower, and the consumer surplus and the social welfare are higher.*
- *For the CB market:* *if airlines operate within the same terminal, ticket prices can be lower, equal or higher. In particular, if the market size is large enough, tickets prices are higher and the consumer surplus and the social welfare are lower.*

Proof: *See Appendix B.*

The lack of competition in the AB market when airlines operate in separate terminals affects the ticket prices of the whole network. For the AC and AB market the effect is unambiguous: the lack of competition in the AB market when airlines operate in separate terminals is always detrimental in social terms. However, for the CB market the effect may be welfare decreasing if the market size is high enough. The reason is that if the market size is high enough (i.e. the traffic level is high enough), airline 1 has incentives to increase the ticket price over the monopoly price in order to discourage AB transfer passenger to flight the domestic route with airline 2.

Proposition 4: *If we compare airlines' total profits in the cases in which airlines operate and do not operate within the same terminal, we can conclude that total profits for airline 2 are higher if airlines operate within the same terminal, while profits for airline 1 are lower.*

Undoubtedly, airline 1 is always better when there is no competition in the AB market and it operates as a monopolist in both the CB and AB market. On the contrary, airline 2 is always better when operating the domestic route and it can carry passengers from both the AC and AB market.

Proposition 5: *Even if the network effects are not considered, if airlines operate in different terminals with different characteristics, the degree of product differentiation increases. Thus, ticket prices are higher and the consumer surplus and the social welfare are lower.*
Proof: *See Appendix B.*

Throughout all the paper, we have considered the fact that airlines operate in separate terminals only affects the competition in the AB market, since shifts from one airline to the other may be too costly. However, if airlines operate in different terminals with different services and different characteristics, the degree of product differentiation may also be affected. Passengers flying in the domestic route may prefer airline i not only because of the brand loyalty, but also because they prefer the services and facilities of the terminal used by airline i. The higher the degree of product differentiation, the more different airlines are for passengers. Thus, the higher the degree of product differentiation, the lower the competition between airlines and the higher ticket prices.

7. Conclusions

Many airports around the world have recently built or are in the process of constructing or rebuilding new terminals. Airlines operating in those airports must be reallocated between the new and old facilities. However, the international airlines associated with a given group will insist on being located in separate terminals in order to facilitate transfers between themselves and minimize the loss of passengers to airlines outside their group.

In order to better understand the main insights of the model we consider the case of the Madrid/Barajas airport. At the beginning of 2006, Madrid/Barajas opened new facilities, the new terminal T4. The new terminal is poorly connected with the existing facilities. Iberia and the Oneworld group were allocated to the new facilities while Spanair and the Star Alliance remained at the old terminals. Spanair was against this decision and went to court, but it finally lost. The judge argued that the allocation of Iberia to the new terminal T4 and Spanair to the old facilities does not affect the social welfare. In this paper we show that, despite the court's ruling, such a decision may affect social welfare.

We use a theoretical model to show that, in general, if airlines are allocated to separate terminals, the lack of competition in transfer flights significantly affects the ticket prices of the whole network, the competition between airlines is reduced, the ticket prices are higher and the consumer surplus and the social welfare are lower. Only in some routes, and under certain conditions on the market size, the ticket prices are lower.

Following the recommendations of the last Proposal for a Directive of the European Parliament and of the Council on Airport Charges (Article 8), different terminals with different characteristics should be subject to different airport charges. Moreover, the allocation of airlines to terminals should promote the competition between airlines, and be non-discriminatory. Finally, we would like to highlight that the adverse network effects of allocating airlines to different terminals may be mitigated if terminals were well connected, and shifts from one terminal to the other were not too costly in terms of time for transfer passengers. All these considerations should be carefully taken into account when constructing new facilities in airports and deciding the reallocation of airlines to such new facilities.

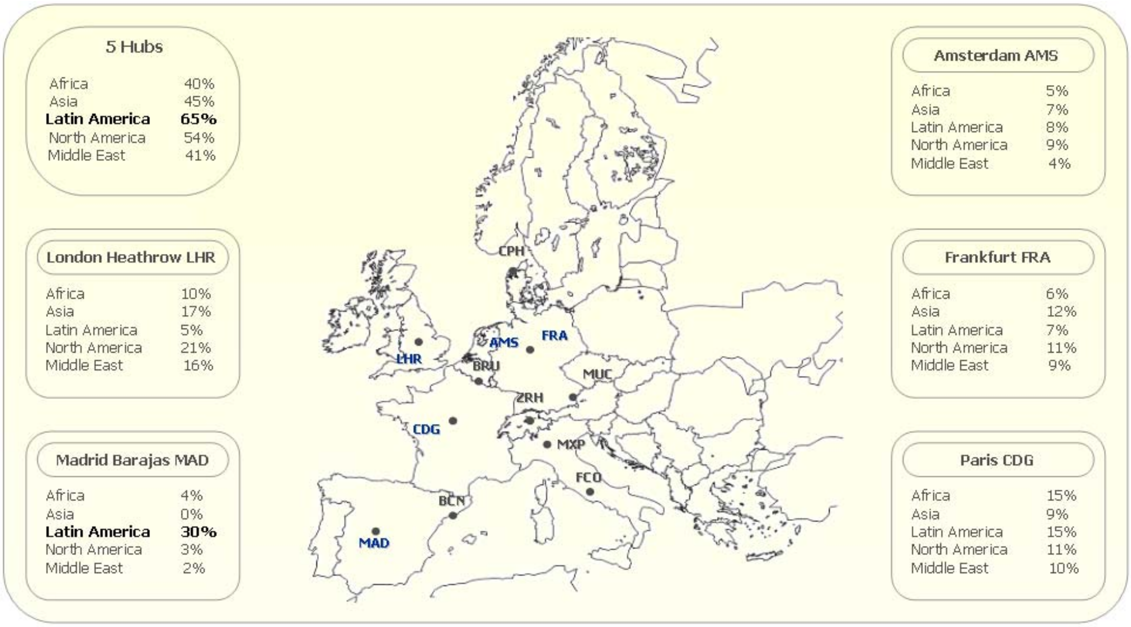
Appendix A

Examples of airports that are constructing or rebuilding new terminals

Airport	New terminal investments
Dublin airport	- It is in the process of constructing a new terminal capable of handling up to 15 million passengers per year. - The new terminal T2 will raise capacity at the airport to a potential 35 million passengers per year. - This new terminal will cost €365 million.
Düsseldorf international airport	- It completed a huge six-year expansion project in 2003, called Airport 2000 Plus, at a cost of €378 million. - It included restructuring Terminal A, deconstruction of an underground garage and an access road in front of the terminal, extension and architectural refitting of the central building and its extension in front of gate C
Frankfurt airport	- It is in the process of building Terminal 3. - The project includes construction of 75 aircraft stands and docking positions and associated taxiways. A new maintenance hangar for Lufthansa's A380s will be built in the south area. - The airport operator Fraport AG has earmarked €3.4 billion for the expansion, the most significant privately financed investment project in Germany.
London/ Heathrow airport	- It is in the process of constructing the new terminal 5. - The ongoing construction of Terminal 5 is the biggest capital improvement project at this airport, costing £4.2 billion. - Phase one of the project is scheduled to be completed and open by April 2008 with the second phase opening in 2011. - Passengers numbers are expected to grow by 27 million a year as a result of phase one, and then by a further three million a year after phase two.
London/ Stansted airport	- It is one of the fastest-growing airport in Europe and it is dominated by low-cost carriers Ryanair, easyJet and Air Berlin. - The British Airport Authority (BAA) expects to invest £550 million to address the gap between the facilities this airport has today and what is needed to cope with 35 million passengers per year with a single runway. - The major elements of the strategy are progressive expansion of the terminal and satellites.
Madrid/ Barajas airport	- It has recently constructed the new terminal T4, at a cost of €6200 million. - The new terminal area includes a main building and a satellite, two new runways, 65 fingers, a car park and roadways. - The new terminal T4 is 2 kilometers away from Terminals 1, 2 and 3. - T4 is dedicated to Iberia flights (and all the flights of the members of Oneworld Alliance). While all the flights of Air Europa and Spanair (and all the flights of the members of Skyteam and Star Alliance) remain in Terminals 1, 2 and 3.
Manchester airport	- Terminal 2 Phase 2 is part of a multimillion-pound project that will see capacity more than doubled from its current 7 million passengers to more than 18 million per year. - It is also investing in the airfield, adding apron capacity to Terminals 1 and 2 in the form of six widebody/twelve narrowbody stands.
Milan/ Malpensa airport	- Its ongoing capital improvement programs include a third module and new satellite added to the terminal that cost €320 million, and €103 million invested in a third runway.
Paris/ Roissy-Charles de Gaulle international airport	- On March 17, 2005, it decided to tear down and rebuild the whole part of Terminal 2E, whose roof partially collapsed, at a cost of approximately €100 million. - There are also other extensions taken place in 2007: * Satellite 3, whose construction can been seen by arriving passengers at Terminals 2E and 2F, is scheduled to open in the first half of 2008. A further Satellite 4 is planned to open in 2012 to provide additional capacity, again relying on the check-in and baggage handling infrastructure of 2E and 2F. * The construction of a new terminal building, Terminal 2G, began in September 2006.
Stockholm/ Arlanda airport	- It has recently completed $1.1 billion in improvements including a new control tower and runway and expansion of one of the international terminals.
Vienna international airport	- Its expansion program, with €245 million in investments scheduled in 2005, included completion of a new control tower, expansion of the Cargo Center, addition of another level to the Car Park, addition of 30 new check-in counters and expansion of the baggage sorting system.

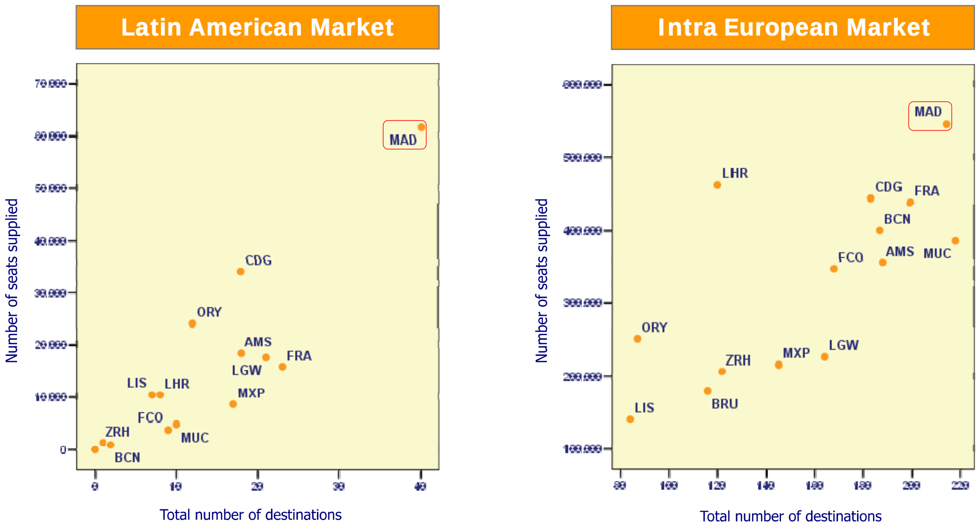
Source: Own elaboration.

Figure 1: Madrid/Barajas airport is the main European hub to Latin America



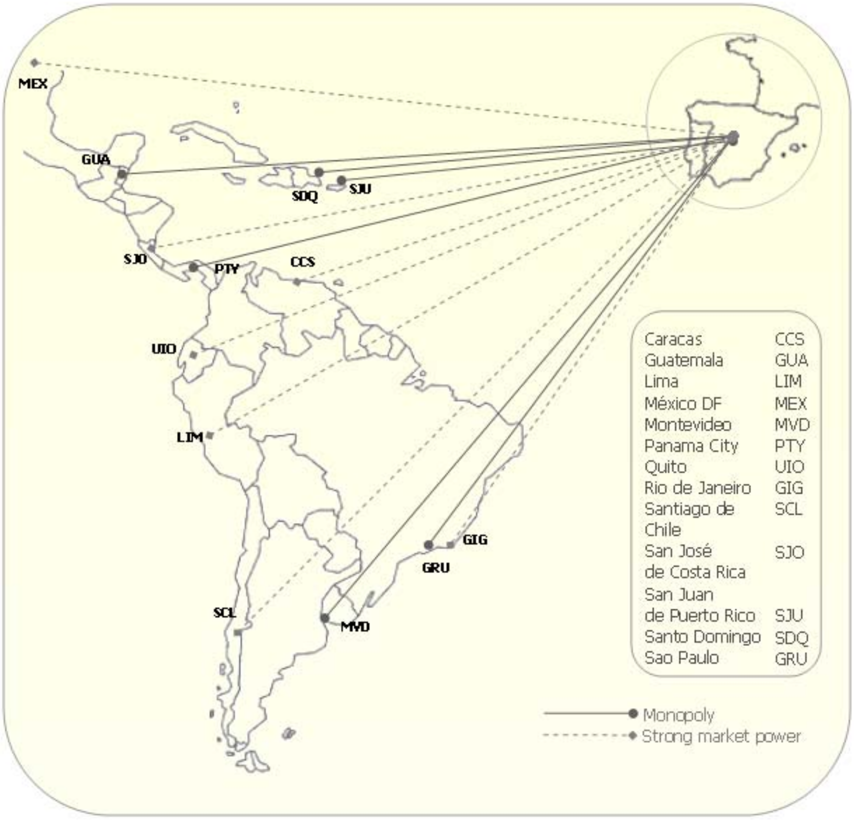
Source: AENA. EMMA survey 2006.

Figure 2: Madrid/Barajas airport is the main link between Europe and Latin America



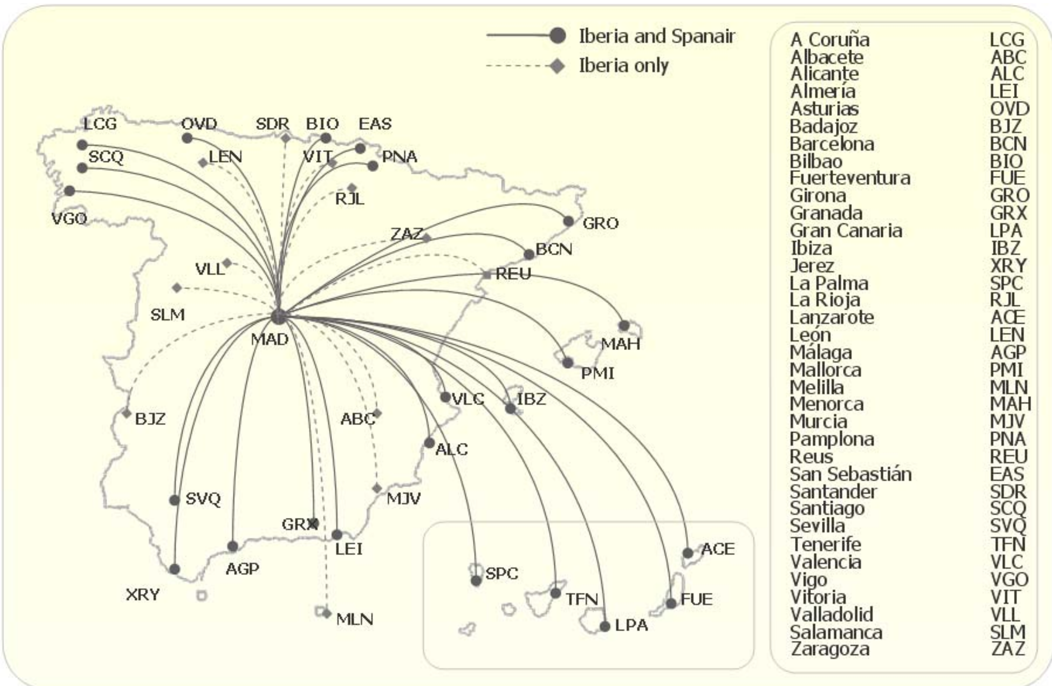
Source: AENA. EMMA survey 2006.

Figure 3: Latin American routes in which Iberia and the Oneworld alliance operate either as monopolists or with a strong market power



Source: Own elaboration.

Figure 4: Spanish domestic routes in which Spanair and Iberia compete



Source: Own elaboration.

Appendix B

Proof of Proposition 2: *Taking into account that b>d and a>c, it can be easily proved that* $\overline{p_1^{AC}} > \overline{p_2^{AC}}$*. It can be also proved that if* $a > \frac{3cb^4 + 3cb^3 d}{6b^2 d - 3b^3 - d^3}$ *then* $\overline{p_1^{CB}} > \frac{a + bc}{2b}$*, that is, airline 1 charges a higher ticket price than the monopoly price in the CB market.* ■

Proof of Proposition 3: *Taking into account that b>d and a>c, it can be easily proved that* $\overline{\overline{p_1^{AC}}} > \overline{p_1^{AC}}$, $\overline{\overline{p_2^{AC}}} > \overline{p_2^{AC}}$, and $\overline{\overline{p_1^{AB}}} > \overline{p_1^{AB}}$*. Moreover, from the proof of Proposition 2 we have that if* $a > \frac{3cb^4 + 3cb^3 d}{6b^2 d - 3b^3 - d^3}$ *then* $\overline{p_1^{CB}} > \overline{\overline{p_1^{CB}}}$*. Since lower prices, higher quantities and more variety are always better for the consumer surplus and the social welfare, it is straight forward to prove that, if airlines operate within the same terminal, in the AC and AB market the consumer surplus and the social welfare are always higher, while in the CB market the consumer surplus and the social welfare are lower if the market size is large enough.* ■

Proof of Proposition 5: *If airlines operate in different terminals then* $\overline{\overline{p_1^{AC}}} = \overline{\overline{p_2^{AC}}} = \frac{a + bc}{2b - d}$*. Recall that* $a = \alpha/(\beta + \gamma)$, $b = \beta/(\beta^2 - \gamma^2)$, $d = \gamma/(\beta^2 - \gamma^2)$, *and* γ/β *expresses the degree of product differentiation, ranging from zero when the goods are independent to one when goods are perfect substitutes. Thus, the degree of product differentiation increases if* γ *decreases. We can rewrite ticket prices as* $\overline{\overline{p_i^{AC}}} = \frac{c\beta + \alpha\beta - \alpha\gamma}{2\beta - \gamma}$, *with* $\frac{\partial \overline{\overline{p_i^{AC}}}}{\partial \gamma} = -\beta \frac{\alpha - c}{(2\beta - \gamma)^2} < 0$*. Therefore, if the degree of product differentiation increases,* $\overline{\overline{p_1^{AC}}}$ and $\overline{\overline{p_2^{AC}}}$ *also increase. Since lower prices and higher quantities are always better for the consumer surplus and the social welfare, as the degree of product differentiation increases, the consumer surplus and the social welfare decrease.* ■

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