Triggering competition in the Spanish airline market: The role of airport capacity and low-cost carriers

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Abstract: We analyze the influence of airport capacity increases and low-cost carriers entry on airline competition. Taking advantage of a rich sample of routes for the Spanish market, we make use of parametric and non-parametric techniques. Concerning capacity increases in large airports, we find that airlines conduct is more competitive only in routes departing from non-hub airports. Also, we find that natural monopoly threshold decreases along time although entry choices are highly determined by traffic density. Finally, low-cost carriers have a moderate but still significant effect on prices and provide a higher number of alternatives to chose even in low-density routes.

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1.0 Introduction

Airline competition across European markets in the post-liberalization period has been usually affected by airport capacity constraints and dominance of former flag carriers. This is particularly true for routes departing from large hub airports. Furthermore, thin routes have been traditionally considered natural monopolies as long as density economies may be substantial.

In this paper, we analyze the influence of two major driving factors for a change in the competitive scenario where airlines operate. Indeed, a large amount of investments for increasing capacity of the largest airports have been made all over Europe in last years. Additionally, low-cost carriers have an increasing presence in most of the European markets. These factors may influence both the overall level of prices and the number of effective competitors across routes. The latter aspect is particularly relevant in thin routes as most of these routes have been characterized by a monopoly structure even in the post-liberalization period.

Hence, we want to address the following questions: To what extent airlines conduct is more competitive in routes departing from large airports when they are not subject to capacity constraints? Low-density routes have been benefited from the new competitive scenario? Are prices lower in routes where low-cost carriers operate? Do low cost carriers enter thin routes?

In order to tackle these questions, we examine the dynamics of airline competition in the Spanish airline market. We make use of parametric and non-parametric techniques taking advantage of a rich sample of routes for the period 2001-2007.

The analysis of the Spanish market for the considered period allows quantifying the influence of the two major drivers of airline competition. Indeed, the two main Spanish airports, Madrid and Barcelona, were subject to strong capacity constraints until 2004 (Reynolds-Feighan and Button, 1999; Spanish Ministry of Transports-Orders of October, 2002). The huge amount of investments made in these airports by the Spanish airport operator, AENA, has implied a high increase in their capacity since 2004.
Additionally, low cost-carriers have had an increasing presence in this market in the last years.\(^1\)

The paper has to do with empirical studies that analyze the influence of market structure variables on airline prices (Borenstein, 1989; Evans and Kessides, 1993; Marín, 1995; Berry et. al., 1996; Carlsson, 2004, and others). Controlling for cost shifters, a typical result in these studies is that airport concentration (along with route concentration) influences substantially on prices charged by airlines to travellers. Moreover, it is also connected with works that analyze entry choices in airline markets [Reiss and Spiller (1989), Morrison and Winston (1990), Bresnahan and Reiss (1991), Berry (1992), Joskow et al (1994), Dresner et al (2002) and others]. Most of this literature agrees on the fact that entry and exit are driven primarily by costs factors, which are likely to be both carrier and city pair specific.

In addition the paper is closely related to several papers that quantify conduct parameters in airline markets (Brander and Zhang, 1990, 1993; Oum et al., 1993; Brueckner and Spiller, 1994; Fisher and Kamerschen, 2003; Fageda, 2006a). Within this context, it is commonly found that, on average, airlines compete à la Cournot. It is also closely related to some papers that analyze the impact of low-cost carriers, most notably Southwest, on prices and entry (Morrison and Winston, 1995; Dresner et al., 1996; Morrison, 2001; Boguslaski et al., 2004; Goolsbee and Syverson, 2005). From these studies, it can be inferred that Southwest tends to enter high-density markets but the price effects of its entry go beyond the routes where it actually operates.

We add several insights to the previous literature on airline competition. First, we quantify how airlines conduct is affected by airport capacity expansions. It is typically assumed that airlines competes à la Cournot, but this result may be affected by capacity constraints as long as such capacity constraints condition airlines conduct.\(^2\)

Second, we examine entry choices of airlines considering route characteristics as major determinants, such as prices and traffic density. To this regard, the important issue of traffic thresholds for natural monopolies is analyzed. This has received little attention in the previous literature on the airline industry. From a social welfare point of

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\(^1\) Taking into account that there is an increasing convergence of the business models across different types of airlines, we consider low-cost carriers to be those airlines that use a single-fare class in their whole network of routes.

\(^2\) It is worth noting that airport dominance in a context of capacity constraints provides several demand and cost advantages to incumbents (Fageda, 2006b).
view, it is important to examine not only the general dynamics of airline competition but also whether low-density routes also take benefit from such dynamics. To our knowledge, only the work of Bitzan and Chi (2006) analyze empirically factors determining prices in airline markets focusing the attention on small communities from US.

Finally, the empirical analysis of the influence of low-cost carriers on prices and natural monopoly thresholds is made for an European market. In this way, the effects of the success of low-cost carriers in Europe have been analyzed in few works. Two unpublished papers (Alderighi et al., 2004; Gil-Moltó and Piga, 2005) analyze some implications of low-cost carriers entry in routes with origin in Italy and United Kingdom airports respectively, but these studies do not consider the natural monopoly threshold issue.

At this point, it is useful to mention some facts about the Spanish airline market. Data are available for 74 non-stop pair links for the period that goes from 2001 to the winter season of 2006-2007, where the origin is the city with the largest airport.\(^3\) Our data set excludes multi-segment markets so that the empirical analysis is made for routes matching city-pair markets. The frequency of the data is semi-annual so that we differentiate between the summer and winter season. We can found several types of airlines that operate in the Spanish domestic market. The two airlines with the largest market share, Iberia and Spanair, are network carriers that belong to Oneworld and Star alliance, respectively. The third largest carrier, Air Europe, is owned by a tourist operator. Importantly, two low-cost carriers have an active and increasing presence in the Spanish market since 2004, Vueling and Air Berlin. Finally, there are other regional airlines that operate in a very few number of routes.\(^4\)

Note that the Spanish market is the largest domestic market in the European Union and the third one in terms of total traffic. Additionally, the two main airports are ranked among the ten largest airports in Europe. However, only Madrid airport can be considered as a hub because only this airport moves a high amount of connecting traffic to final destinations.

\(^3\) Madrid is the origin in 30 routes, Barcelona in 24 and other airports (Palma de Majorca, Valencia, Bilbao, and Seville) in 20 routes.

\(^4\) At the end of 2006, Air Madrid has collapsed. This airline has been typically considered to be a low-cost carrier but its prices were based on different fare classes. On the other hand, the Iberia group includes a large regional airline, Air Nostrum. Recently Clickair, a new recently created low-cost carrier in which Iberia has a minor participation, has expanded operations in Barcelona airport since 2006.
Our main results confirm that airport capacity expansions and low-cost carriers entry trigger airline competition in the Spanish market. However, it is not clear that hub airports take benefit of that. Additionally, we obtain evidence that airlines entry choices are highly dependent upon route traffic density but also that the natural monopoly threshold decreases along time. Finally, low-cost carriers presence has a moderate but significant impact on prices and more importantly they foster competition on low-density routes.

The remainder of the paper is organized as follows. In the second section, we estimate a pricing and demand equation system that allows quantifying changes in airlines conduct in the event of capacity expansions in large airports. Then, an ordered probit model is estimated to measure the relationship between the number of competitors and traffic levels and we make use of spline regressions to examine the evolution of natural monopoly thresholds. Finally, we study the impact of low-cost carriers both on price competition and the natural monopoly threshold through pricing and spline regressions. The last section is devoted to the concluding remarks.

2.0 Changes in airlines conduct in the event of airport capacity expansions

We follow the works of Parker and Roller (1997) and Fageda (2006a) in order to develop a demand-supply equation system that allows identifying conduct and cost parameters for airline markets.

In this way, the demand function \((Q)\) for route \(k\) in period \(t\) is expressed through the following semi-logarithmic function:

\[
\log(Q_{kt}) = a_0 + a_1 \log(pop_{kt}) + a_2 \log(GDPc_{kt}) + a_3 \log(tour_{kt}) + a_4 D_{hub}^k + a_5 D_{modal}^k + a_6 p_{kt} + a_7 \text{Trend} + e_{kt}^d
\]

(1)

The demand function is composed of variables for the mean values of population \((pop)\), gross domestic product per capita \((GDPc)\), and tourism intensity \((tour)\) of the route city-pairs. The variables for population and GDP per capita capture the demographic and economic size of the city-pairs. The variable for tourism captures traffic generation that comes from tourist activities.

Our demand function also includes a dummy variable that takes value 1 for routes with origin in Madrid airport \((D_{hub})\). Indeed, connecting traffic represents a much higher proportion of total traffic in this airport than in the rest of the Spanish airports. Furthermore, it includes a dummy variable that takes value 1 for routes with no islands.
as an endpoint and less than 450 kilometres \( (D_{modal}^k) \) to account for the fact that air traffic in a route may be lower where other modes may offer the transport service at competitive conditions.

Demand also depends on prices \( (p) \) as it is usually considered in a demand equation for any service. Finally, we also consider a time trend \((Trend)\) to account for the fact that both air traffic demand and its explanatory variables tend to increase along time. Furthermore, this latter variable may also capture the higher traffic that can arise since capacity constraints have been increasingly alleviated in the considered period.

Given the inverse demand function, the marginal revenue function of airline \( i \) is:

\[
IM_{ikt} = p_{kt} + \lambda (\partial p_{kt}/\partial q_{ikt})q_{ikt}, \tag{2}
\]

where \( \lambda = \partial Q_{kt}/\partial q_{ikt} \). If we assume a quadratic total cost function, marginal costs \((MC)\) of airline \( i \) at the route \( k \) in period \( t \) can be expressed as follows:

\[
MC_{ikt} = b_o + b_1 dist_k + b_2 q_{ikt}, \tag{3}
\]

The marginal cost function includes a parameter \( (b_o) \) that captures the allocation of costs at the firm level. In addition, it includes a variable for distance \((dist)\) as a major determinant of the costs than an airline must afford when providing services in a route. Finally, the sign of the parameter \( (b_2) \) associated with the number of passengers carried by airlines on the route \( (q_{ikt}) \) determines the slope of marginal costs.\(^5\)

The equilibrium condition for each airline is the result of equating cost and revenue functions; \( IM_{ikt} = MC_{ik} \). At the market level, such an equilibrium condition comes from the aggregation of the individual equilibrium conditions. Hence, the price equation can be expressed as follows:

\[
p_{kt} = b_o + b_1 dist_k + b_2 Q_{mkt} - \theta (\partial p_{kt}/\partial Q_{kt})Q_{kt}, \tag{4}
\]

where \( \theta = \lambda/N, Q_{mkt} \) is the average market demand and \( N \) is the number of route competitors. The demand term of the mark-up expression in (4) can be dropped due to

\(^5\) Marginal costs of carrying an additional passenger should include its direct cost plus a random fraction of costs of providing additional capacity. Under this interpretation, marginal costs would be equivalent to average variable costs. The slope of marginal costs would be the sensitivity of average variable costs to traffic density.
the form of the price elasticity of demand in a semi-logarithmic equation. Thus, the pricing equation to be estimated can be expressed in the following way:

\[ p_{kt} = b_o + b_1 \text{dist}_{kt} + \beta Q_{mkt} - \theta (1/\alpha_k) + \epsilon^s_{kt}, \tag{5} \]

where prices \( p_{kt} \) are a function of the mark-up \([\theta(1/\alpha_k)]\) on marginal costs \( MC_{kt} = b_o + b_1 \text{dist}_{kt} + \beta Q_{mkt} \). The mark-up is composed of the conduct parameter \( \theta \), and the parameter that determines the price elasticity of demand \( \alpha_k \) that should take a negative value. \( \epsilon^s_{kt} \) is a random error term. Note that the value of the parameter \( \theta \), which measures the average degree of collusion, should be ranked from 0 to 1.

Our identification procedure of conduct and cost parameters should rely on the assumption that \( \theta = 1 \) in monopoly routes. Indeed, the pricing equation can be expressed as follows after applying some mathematical arrangements:

\[ p_{kt} = c_0 + b_1 \text{dist}_{kt} + \beta Q_{mkt} + D_{kt}^{\text{monopoly}} \gamma + \epsilon^s_{kt}, \tag{6} \]

where \( c_0 = b_0 - D_{kt}^{\text{monopoly}} \alpha_k^{(-1)} \) and \( \gamma = \alpha_k^{(-1)}(1 - \theta_{kt}^{\text{oligopoly}}) \). Note that \( \theta_{kt}^{\text{oligopoly}} \) is the conduct parameter in oligopoly routes and \( D_{kt}^{\text{monopoly}} \) is a dummy variable for monopoly routes. In case that the conduct parameter in monopoly routes takes the value 1, then the conduct parameter in oligopoly routes is ranked from 0 (prices equal to marginal costs) to 1 (prices set on a joint profit maximization setting). Importantly, \( \theta \) would take a value equal to the inverse of the number of competitors under the Cournot assumption.

Fageda (2006a) shows that the assumption that \( \theta = 1 \) in monopoly routes is essentially correct in a scenario where capacity constraints are binding. Indeed, entry barriers can be high enough to protect incumbents when airport congestion takes place. However, this may not be the case just after the expansion in airport capacity. Thus, the conduct parameter in a period with no capacity constraints for monopoly routes may be lower than 1.

Our aim here is to examine changes in airlines conduct in the event of airport capacity expansions. Indeed, our purpose is not to provide robust tests of alternative oligopoly models because we are not able to test that the assumption \( \theta = 1 \) is correct when airport capacity constraints do not hold. However, we can see differences in

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\text{Footnotes:}

6 The price elasticity of demand in a semi-logarithmic equation is: \( \eta_{kt} = \alpha_k p_{kt} \). This is the case due to the fact that \( \alpha_k = \partial \log(Q_{kt})/\partial p_{kt} \) and so \( \alpha_k = \partial Q_{kt}/\partial p_{kt} Q_{kt} \) given that \( \partial \log(Q_{kt}) = \partial Q_{kt}/Q_{kt} \).

7 See Fageda (2006a) for details.
monopoly and oligopoly routes in terms of the mark-ups that airlines charge over costs and the impact of airport capacity expansions on these differences.

In this way, we include in the pricing equation (6) two dummy variables as indicators for airport capacity expansions; $D^\text{Barcelona\_capacity}$ and $D^\text{Madrid\_capacity}$. The variable $D^\text{Barcelona\_capacity}$ takes value 1 from the winter season of 2004-2005 to the end of the considered period. The variable $D^\text{Madrid\_capacity}$ takes value 1 from the summer season of 2006 to the end of the considered period, the winter season of 2006-2007. A new runway has been fully working in Barcelona airport since October 2004, while two new runways (and a new terminal building) have been fully working in Madrid airport since February 2006. These variables allows us to capture the effects of the alleviation of airport capacity constraints in the two main Spanish airports. If the coefficients associated with these variables are statistically significant, we will find evidence of a structural change in the pricing behaviour of airlines when airport capacity constraints do not condition such behaviour.

Additionally, we estimate our equation system for a sub-sample of routes: 1) routes with origin in Barcelona airport in the period in which capacity constraints are not binding (that is, since the winter season of 2004-2005); 2) routes with origin in Madrid airport in the period in which capacity constraints are not binding (that is, since the summer of 2006). These additional estimations of the pricing equation will allow us to determine the specific competitive scenario in these two large airports.

In the appendix, we specify how the variables used in the empirical analysis have been constructed, providing data sources and descriptive statistics for those variables. Following strict rules for data collection (see the appendix), it is worth mentioning here that the variable for prices is the lowest mean round trip price charged by airlines offering services in the route weighted by their corresponding market share. We use the lowest mean price across airlines because one of our main purposes is to analyze the impact of low-cost carriers on prices. In this way, we are particularly concerned on price-sensitive passengers.

Furthermore, it must be noted that we include a dummy variable that takes value 1 for the summer season, $D^{\text{summer}}$, both for the demand and pricing equations. Such variable accounts for differences across seasons.
Table 1 shows the results of the system equation estimates (equations 1 and 6) using the Two-Stage Least Square estimator (2SLS-IV). It must be said that our estimation procedure does not take into account the panel data nature of the sample. The use of a fixed-effects model is not appropriate in our context since this technique drops anything that is time-invariant from the model, such as route distance. Since the individual effects, the routes, are likely correlated with the error term (as indicated by Hausman test) the random-effects model is not appropriate either. Finally, the Hausman-Taylor estimator assumes that all explanatory variables are exogenous. To this regard, we take into account the possible endogeneity of the dummy variable for oligopoly routes, in addition to that related to the variables for prices and demand in each equation of our system.\(^8\) Finally, in order to assess the suitability of the instruments chosen we have considered the goodness of fit (partial \(R^2\)) and their joint significance. To this aim Bound, Jaeger and Baker (1995) have suggested to focus the attention on the first stage results. They conclude that partial \(R^2\) and \(F\) statistics are useful guides to assess the quality of estimations.

**Insert Table 1**

Concerning the estimation for the whole sample period, we can affirm that the overall explanatory power of the equations of the system is reasonably good. Furthermore, most of the coefficients of the control variables for both the demand and pricing equations are statistically significant and with the expected signs. Only the variables for GDP per capita and the time trend are not statistically significant in the demand equation. Tests of validity of instruments indicate that the excluded instruments are strongly correlated with the endogenous regressors.

As expected, air traffic in a route is greater in city-pairs with a higher amount of population and a higher intensity of tourism. Additionally, air traffic in a route is lower in case that other transport mode is able to offer transport services at competitive conditions. The exploitation of connecting traffic in Madrid airport also seems to be statistically relevant. Additionally, we find a value of the price elasticity of demand of 1.24, which is consistent with the values found in previous studies (Oum et al., 1992).

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\(^8\) We use as an additional instrument for the dummy variable for oligopoly routes, a variable for airport concentration at both endpoints of the route. The number of competitors in a route should be correlated with the variable for concentration at the airport level as it captures the relative presence of the dominant carrier’s rivals both in the endpoints of the route.
If we look at the pricing equation, we find some evidence of density economies as long as the variable for demand in the pricing equation is statistically significant and with a negative sign. In terms of elasticities, we find that a ten per cent increase in route traffic density implies about a one per cent decrease in prices charged to consumers. In fact, the existence of density economies is a common result in previous studies of airline markets (Caves et al., 1984; Brueckner et al., 1992). We also confirm the existence of distance economies and the estimated elasticity of about 0.39 is similar to that obtained in previous studies (Oum et al., 1993; Brueckner and Spiller, 1994; Fageda, 2006a).

In the estimation for the whole sample period, we also find that the increase in capacity has a statistically significant and negative effect on prices when considering the dummy variable for such an increase in Barcelona airport. On the contrary, the increase in capacity in Madrid does not seem to have a statistically significant effect on prices. Thus, a change in the competitive behaviour of airlines after the event of airport capacity expansions is only taking place in Barcelona airport.

Interestingly, demand and prices are higher for the summer. In a tourist oriented market as it is the case in Spain, people both travel and are willing to pay more in the summer season.

Table 2 shows the conduct parameters obtained from the system equation estimates. The conduct parameter estimated for the whole period takes a value of 0.72. This implies a substantial market power for Spanish airlines. Concerning the whole sample period, we both reject that the conduct parameter takes a value of 0.53 (the inverse of the mean number of competitors) and that takes a value of 1. Hence, we can roughly argue that conduct is less competitive than predicted by the Cournot solution.

Results for the conduct parameter are substantially different for routes with origin in Barcelona and Madrid airports in the period after the event of airport capacity expansions. Indeed, the conduct parameter takes a value of 0.68 in routes with origin in Barcelona airport, while it takes a value of 0.95 in routes with origin in Madrid airport. Airlines seem to behave approximately as the Cournot solution predicts in routes with origin in Barcelona, which implies a value of the conduct parameter equal to the inverse of the mean number of competitors. Otherwise, airlines conduct does not differ between monopoly and oligopoly routes in Madrid airport.
We must be cautious interpreting the estimation results for the sub-sample of routes with origin in Barcelona and Madrid since the number of observations resulting from splitting the sample in two is low. However, both results for the dummy variables of airport capacity increases in Barcelona and Madrid in the estimation for the whole sample period, and results for the conduct parameters in these estimations for the sub-sample of routes, go in the same direction.

Note that Madrid airport is the main hub of the former Spanish flag carrier, while the presence of other airlines like low-cost carriers is increasing in Barcelona airport. In this way, a general trend in the European airline market is that network carriers tend to concentrate operations in their main hubs. This may imply to strengthen their dominance in those airports and reduce operations in other airports.

Insert Table 2

In short, the scenario where airlines compete becomes more competitive after the event of capacity expansions in airports that do not play a role of a hub for a network carrier.

Aside from the origin airport, it is also of interest analyzing other route characteristics that influence on the benefits of a more competitive scenario in airline markets. Accounting for the fact that density economies can be exploited up to some traffic levels, it must be examined to what extent low-density routes are still monopoly routes even when airport capacity constraints do not necessarily prevent the entry of new airline carriers. We deal with this question in the following section.

3.0 Entry patterns and route traffic density

Entry choices of airlines across routes are determined by the expected profitability of these choices. The empirical literature about entry in airlines markets typically account for several route characteristics as major factors explaining the profitability of entry. This is the case in those papers of Johnson (1985), Joskow et al (1994), Boguslaski et al (2004) and others. In this way, route traffic density and different variables that capture the competitive position of incumbents (route concentration, airport presence, service quality of incumbents and so on) are commonly considered to be the main determinants of entry choices by airlines not still operating the route. Additionally, some studies also include in their empirical analysis some indicator of the
prices charged in the route. Among them we can cite those from Reiss and Spiller (1989), Strassmann (1990), Dresner et al (2002), Schipper et al (2003) and others.

In our context, the determinants of the number of competitors in route $k$ at period $t$ can be analyzed through the following equation:

$$
\text{Num_competitors} = d_0 + d_1 p_{kt} + d_2 Q_{kt} + d_3 HHR_{\text{route}(kt)} + d_4 D_{ki}^{\text{hub}} + \\
+ d_5 D_{\text{Barcelona_capacity}} + d_6 D_{\text{Madrid_capacity}} + e_{kt},
$$

(7)

where the number of competitors in a route is made dependent of the following explanatory variables. First, the number of route competitors should depend positively both on prices, $p$, and route density, $Q$. Indeed, higher prices and demand should imply higher profitability rates for airlines operating there. Second, entry choices are also influenced by the level of competition. In this way, we include a variable for concentration at the route level, $HHR_{\text{route}}$. Furthermore, we also include a dummy variable that takes value 1 for routes with origin in Madrid airport, $D_{\text{hub}}$. This variable may capture an airport dominance effect as the main hub of the largest Spanish airline, Iberia, is Madrid airport.

To this point, it is worth mentioning that our aim here is not to make an exhaustive analysis of airline entry choices as long as such analysis would require considering the dynamics of the airlines decision making process.

What we want to analyze is which type of routes are affected by the competition benefits derived from several airlines operating there. Such benefits refer particularly to the period that follows investments in airport capacity. In this way, we also include in equation (7) two dummy variables for increases in airport capacity in Barcelona ($D_{\text{Barcelona_capacity}}$) and Madrid ($D_{\text{Madrid_capacity}}$) airports. These dummy variables are constructed in the same way as the analogous variable in the pricing equation of the previous section. These variables should capture the expected increase in the number of route competitors due to the reduction (maybe even withdrawal) of the entry barriers associated to airport access for non-incumbent airlines.

Table 3 shows the results of the estimates concerning the determinants of the number of competitors in a route. The estimation has been made using the ordered probit technique due to the discrete and ordinal form of the dependent variable. The possible endogeneity of the variables for demand, prices and route concentration are
considered in our estimation procedure. As before, we include a dummy variable that takes value 1 for the summer season to account for differences across seasons.

**Insert Table 3**

The overall explanatory power of the equation is good. All the explanatory variables are significant, with the exception of the dummy variable for the season. In general terms, the number of competitors is higher after the increase in airport capacity but that result is particularly relevant for routes with origin in Barcelona airport.

Moreover, the higher the prices and demand are, the greater the number of competitors in a route. Additionally, the number of competitors decreases as long as the degree of concentration at the route level increases. Given prices, this means that the relative strength of major incumbents may deter the entry of new airlines. Finally, the number of airlines offering services seems to be lower in routes with origin in Madrid airport. This latter result seems to confirm the hub dominance effect of Madrid airport previously mentioned. In fact, this could also explain the lower effect on the number of competitors that has had the capacity increase in Madrid in relation to the increase in capacity in Barcelona.

Given the value of other control factors, it seems that travellers of high-density routes take benefit from several airlines offering services there. However, some routes may not be able to generate enough traffic to attract more than one airline. Indeed, the main concern that can be inferred from the estimates of the equation on the number of route competitor determinants is referred to low-density routes. Indeed, travellers of low-density routes may not take benefit from airline competition as long as just one airline may monopolize the supply of air services.

A central issue here is to identify the natural monopoly thresholds and their evolution. Density economies imply that average costs (and even marginal costs as we found above) decrease as long as the number of passengers moved at the route level increases. Hence, competition may be neither efficient nor possible for low-density

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9 The explanatory variables of the equation system previously formulated are used as instruments for the demand and price variables. The variable for route concentration is instrumented using data of the previous period. In this way, the considered period in this estimation goes from the summer of 2002 to the winter of 2006-2007 since we cannot make use of data for 2001.

10 However, it must be taken into account that high prices are affected by market structure features. In this way, a high market concentration could likely attract the entry of other airlines as they can find opportunities for capturing extraordinary profits.
routes. However, pressures for cost reduction coming from competition could reduce the amount of route traffic needed for making optimal the fact that more than one airline operates in this route. In such a case, travellers of low-density routes would also benefit from airline competition even though the number of competitors is strongly correlated with the traffic levels at the route.

The analysis of the natural monopoly thresholds is made through non-parametric analysis. Non-parametric techniques are used to estimate the value of a regression function among two or more variables in a given point, using observations near to this point without introducing any constraint about the functional form. Additionally, it allows considering results across different ranges of values for at least one of the variables of interest. In particular, our analysis makes use of spline regressions, which is a suitable non-parametric tool in those cases in which one or more of the implied variables have a discrete nature.

Figure 1 shows the spline regression that relates the number of competitors with the traffic levels for low-density routes. We define low-density routes as those that have a traffic lower than 205,828 passengers per season, which is the mean number of passengers of our sample of routes for the considered period (see appendix for details). In order to see the evolution of the natural monopoly thresholds along time, we present the results of the spline regression for the mean values of demand and number of competitors concerning three sub-periods: 1) seasons going from summer of 2001 to summer of 2004, 2) the period that goes from the winter of 2004-2005 to the winter of 2005-2006, and 3) the period that goes from the summer of 2006 to the winter of 2006-2007. Recall that these three periods capture the event of airport capacity expansions in the two main Spanish airports, Barcelona (the new runway has been fully working since the end of 2004) and Madrid (the new runways and terminal have been fully operating since the beginning of 2006).

For 2001-2004, the natural monopoly threshold seems to break up definitely at the traffic level of about 125,000 passengers per season. From that amount of passengers, the mean number of competitors tends to be higher than two. In routes with a traffic that lies between 110,000 and 125,000 passengers, the mean number of competitors is about 1 so that most routes within these traffic levels are monopoly routes. Routes with less than 110,000 passengers are monopolies in most cases.
For the period ranging from 2004 to winter 2005-06, the natural monopoly threshold is broken up at 60,000 passengers per season since the mean number of routes at these traffic level is higher than 1.5. This trend is sustained across all traffic densities, and becoming even stronger for those routes with more than 150,000 passengers.

For the period that goes from summer 2006 to the winter season of 2006-2007, the natural monopoly threshold seems to break up at the traffic level of about 50,000 passengers per season, although this trend is not fully consistent until we consider routes of more than 125,000 passengers. It must be taken into account that the fewer number of observations for this period may be distorting the spline regression, at least for some range of traffic densities.

Thus, increasing competition in the Spanish market after the expansion of airport capacity at the main airports has dramatically altered the traffic thresholds that determine the existence of a natural monopoly in almost every route, even those with low traffic density.

Insert Figure 1

The increase in the number of competitors seems to be the outcome of a liberalized airline market in which airport congestion does not become a strong entry barrier. However, are the capacity expansions at major airports the only driving factor for the increase in competition?. A current central issue in the European airline industry is the success of low-cost carriers to compete in short-haul routes. Hence, it is critical to examine the role of low-cost carriers with regard to the more competitive scenario that characterize the Spanish airline market in last years.

4.0 The impact of low-cost carriers on airline competition

In Europe, former flag carriers and other airlines integrated in international alliances are progressively concentrating main business in long-haul air services, whereas low-cost carriers are exploiting some cost advantages to be competitive in short-haul routes. Indeed, low-cost carriers tend to operate with lower labour costs than legacy carriers. Additionally, they take advantage of a more simple business structure as long as they usually use a unique type of plane (with the maximum seat configuration), they concentrate operations in non-stop services and offer a single-fare class. Some low-cost carriers, most notably Ryanair, also benefit from the lower costs that involves operating from secondary airports.
Along with these cost advantages, a major factor for a low-cost carrier to be competitive is that they may exploit density economies derived from a high utilisation of the planes and crew. However, this could require developing a network of short-haul routes but also operating in routes with a minimum amount of traffic. In this way, it is generally accepted that low-cost carriers contribute to the reduction of prices in the routes in which they operate (Morrison and Winston, 1995; Morrison, 2001). However, some studies about entry patterns of low-cost carriers reveal that they prefer to operate on high-density routes, particularly in the first years of operation (Boguslaski et al., 2004; Ito and Lee, 2003; Gil-Moltó and Piga, 2005). And even other works suggest that carriers enter those routes consistent with the hypothesis that they pursue a differentiation strategy in order to expand the variety of products offered in the market [Lederman and Januszewski (2003)].

Here we analyze not only the impact of low-cost carriers on prices but also their influence on the relationship between traffic and number of competitors in low-density routes.

Price effects of low-cost carriers are considered through a price equation for oligopoly routes $k'$. In this way, we put the attention on non monopoly routes to isolate the low-cost carriers impact on prices from the global effect associated to the increase in the number of airlines offering services in the route (with respect to a monopoly scenario). This price equation accounts for the main cost shifters; demand at the route level, $Q$, and route distance, $dist$. In addition to this, it includes a dummy variable that takes value 1 for routes with presence of low-cost carriers, $D_{low\_cost}$. The equation to be estimated is as follows:

$$p_{k'\gamma} = e_0 + e_1 dist_{k'\gamma} + e_2 Q_{k'\gamma} + e_3 D_{k'\gamma}^{low\_cost} + e_{k'\gamma},$$  \hspace{1cm} (8)

Table 4 shows the results of the pricing equation estimates using the Two Stage Least Squares technique. We take into account the possible endogeneity of the variables for demand and presence of low-cost carriers.\footnote{We use the variable for airport concentration at both endpoints of the route as an additional instrument for the dummy variable of low cost carriers presence. This variable accounts for the relative presence of the rivals of largest carriers, among them low-cost carriers, both in the endpoints of the route.} As in previous estimations, we also include a dummy variable that takes value 1 for the summer season, $D_{summer}$. 


The overall explanatory power of the equation is high, and all the variables are significant and with the expected sign. For oligopoly routes, the presence of low-cost carriers seems to reduce prices in a statistically significant way. In terms of elasticities, the decrease of prices in oligopoly routes due to the presence of low-cost carriers is 4 per cent.

The amount of the price reduction related to low-cost carriers seems to be modest but we must take into account that our price indicator refers to the mean average prices weighted by the market share of each airline. Since the market share obtained by low-cost carriers in Spanish routes is generally low, the price discounts of low-cost carriers with regard to other airlines must be substantial. Thus, some travellers may benefit from very low prices in specific flights, not to mention the benefits derived from low-cost carriers presence if they offer services in low-density routes. And even more important, the aggregate effect on prices of the low-cost carriers presence may be higher as these carriers enter a variety of routes including those previously operated under monopoly conditions. According to our estimations with regard to equation (6), the mark-ups that airlines charge over costs represent 70 per cent respect to those in monopoly routes.

Figure 2 shows the spline regression that relates the number of competitors with the traffic levels for low-density routes, which are the routes with traffic lower than the mean number of passengers of our sample of routes for the considered period. Here we differentiate among all routes, those with presence of low-cost carriers and routes without low-cost carriers. The analysis is restricted to the period after the increase in capacity at major airports because most of low-cost carriers entries have taken place in this period.

Note that we consider the number of competitors in the period before the expansion in airport capacity. This allows avoiding any possible endogeneity bias related to the simultaneous determination of low-cost carriers presence and number of competitors.

From figure 2, it can be observed that low-cost carriers alter substantially the relationship between the number of competitors and traffic levels at the route. This is true in routes with traffic from 50,000 passengers per season and even more dramatically for traffics of more than 90,000 passengers. Here the presence of low-cost
carriers implies more than double the mean number of competitors according to traffic levels. Such mean number lies at 1 for all routes and routes without low-cost and from 1.5 to 2.5 for the restricted sample of routes with presence of low-cost carriers.

This result fits well with our previous finding that the mean number of competitors has increased for low-density routes after the airport capacity expansions. It seems that low-cost carriers have played a major role concerning this effect.

In fact, low-cost carriers may also explain our previous result related to the more competitive environment in Barcelona than in Madrid airport after the increase in capacity. Indeed, figure 3 shows that the presence of low-cost carriers has increased substantially in Barcelona airport since 2004, while their presence is modest in Madrid airport even in the last season of the considered period. On the contrary, Iberia maintains a high market share in Madrid airport but its market share has been strongly reduced in Barcelona airport in last years. To this regard, Iberia and its partners in Oneworld alliance enjoy a very privileged access to the new facilities (terminal building and the two new runways) of Madrid airport.\(^\text{12}\)

In short, travellers have taken several benefits from the success of low-cost carriers in the Spanish market. First, they may take advantage of low prices in specific flights. And second, low-cost carriers allow travellers to have a higher number of alternatives to chose in low-density routes. However, those benefits may be just obtained by travellers flying from some airports. Concerning large airports, benefits seem to affect particularly to non-hub airports at least for the considered period.

5.0 Concluding remarks

This paper has dealt with the dynamics of airline competition in the Spanish airline market, which is one of the largest markets in the European context. Our main purpose has been to measure the role of two major triggering factors for the Spanish market becoming more competitive; the withdrawal of capacity constraints at main airports and the increasing presence of low-cost carriers there.

\(^{12}\) However, it is worth noting that the two largest low-cost carriers in Europe, Ryanair and Easyjet, have announced an increase of operations in Madrid airport for the second half of 2007. Such an increase in operations includes some few direct flights in domestic links. This could change the competitive scenario at Madrid airport in the coming years.
The main empirical findings of the paper are the following. First, we find that airlines conduct is more competitive in a large airport that is not a hub of a network carrier. On the contrary, price-sensitive travellers flying from a large hub airport do not seem to take benefit from the increase in capacity.

Our empirical results also show that prices and traffic density are major determinants of the number of competitors at the route level. However, we obtain evidence that the natural monopoly threshold breaks up dramatically at low traffic density levels after the increase in airport capacity.

Finally, the presence of low-cost carriers has a modest but still significant estimated effect on prices although their aggregate impact may be higher as long as they enter previously monopoly routes. In this way, low-cost carriers alter the relationship between the number of competitors and traffic levels for low-density routes. In addition to this, the more competitive environment that we find in a large non-hub airport seems to be related to the increasing presence of low-cost carriers in that airport.

To sum up, tough competition in airline markets requires providing enough capacity at main airports. To this regard, the allocation of the new slots, gates, check-in counters, lounges and so on that are available after an increase in capacity should be distributed among several airlines. In this way, the discretionarilily of airport operators in such allocation is high even if rules such as the grandfather right must be respected.

In addition to this, low-cost carriers have a positive impact on the traveller welfare as long as they provide lower prices in some flights and more alternatives to chose even in low-density routes. Nevertheless, their market share is still low in most routes so that competition concerns are still in place in the post-liberalization period. In this way, a number of low-density routes remain operated by just one airline.

Finally, policies for maximizing the impact of competition in the airline industry should involve preventing capacity constraints in large airports, avoiding a position of abuse of just one airline at hub airports, and promoting the entry of low-cost carriers in short-haul routes.
References


Appendix: Variables description and data sources:

- **Prices** ($p$): The lowest mean round trip price charged by airlines offering services weighted by their corresponding market share. Information has been obtained from airlines websites following these homogeneous rules. Price data refer to the city pair link that has as its origin the city with the largest airport. Additionally, it has been collected one month before travelling, the price refers to the first trip of the week, and the return is on Sunday.

- **Demand** ($Q$): Total number of passengers carried by airlines in the route, including direct and connecting traffic. Information has been obtained from the website of Spanish Airports and Air Navigation (AENA) agency

- **Number of competitors** ($Num_{competitors}$): Number of airlines offering more than one flight per week in the route. Service frequency of airlines operating in the route has been obtained from Official Airlines Guide (OAG) website.

- **Population** ($pop$): Total mean population in a route’s origin and destination provinces (NUTS3). Data has been obtained from the National Statistics Institute (INE).

- **Gross domestic product per capita** ($GDPc$): Mean gross domestic product per capita in a route’s origin and destination regions (NUTS2). Data, which it is not available at the province level for the recent years of the considered period, has been obtained from the National Statistics Institute (INE).

- **Tourism** ($tour$): Number of tourists per capita in the destination region (NUTS2). Data has been obtained from the Institute of Tourist Studies (IET).

- **Distance** ($Dist$): Number of kilometres that are needed to flown between the origin and destination airport of the route. Data has been collected from WebFlyer site.

- **Route concentration** ($HHI_{route}$): Index of Herfindahl-Hirschman at the route level. The concentration index is calculated in terms of airlines’ departures. Data on departures of each airline in each route have been obtained from Official Airlines Guide (OAG) website.

- **Airport concentration** ($HHI_{airport}$): Index of Herfindahl-Hirschman at the airport level. The concentration index is calculated in terms of airlines’ national departures both in the origin and destination airports of the route. Then we obtain the mean value of the Hirschman-Herfindahl index regarding both endpoints. Data on the percentage of departures of each airline in origin and destination facilities have been obtained from Spanish Airports and Air Navigation (AENA) agency

- $D_{Barcelona\, capacity}$: Dummy variable that takes value 1 from the winter season of 2004-2005 to the end of the considered period, which is the winter season 2006-2007.

- $D_{Madrid\, capacity}$: Dummy variable that takes value 1 from the summer season of 2006 to the end of the considered period.

- $D_{oligopoly}$: Dummy variable that takes value 1 for routes with more than one airline offering services

- $D_{low\, cost}$: Dummy variable that takes value 1 for routes in which at least one low-cost airline operates.

- $D_{hub}$: Dummy variable that takes value 1 for routes with origin in Madrid
- **D\text{modal}**: Dummy variable that takes value 1 for routes with no islands as an endpoint and less than 450 kilometers
- **D\text{summer}**: Dummy variable that takes value 1 for the summer season that goes from April 26\textsuperscript{th} to October 26\textsuperscript{th}.

### Table A1. Descriptive statistics for continuous variables (Number of observations: 821)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Standard deviation</th>
<th>Minimum value</th>
<th>Maximum value</th>
</tr>
</thead>
<tbody>
<tr>
<td>prices (\textit{p}) : euros</td>
<td>196.60</td>
<td>98.58</td>
<td>49.85</td>
<td>829.67</td>
</tr>
<tr>
<td>demand (\textit{Q}) : Number of passengers</td>
<td>205,828.8</td>
<td>307,761.6</td>
<td>1,361</td>
<td>2,514,338</td>
</tr>
<tr>
<td>Num_competitors: Number of airlines</td>
<td>1.89</td>
<td>1.02</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>pop (\textit{pop}) : Number of inhabitants</td>
<td>2,803,385</td>
<td>896,873</td>
<td>841,668</td>
<td>5,658,794</td>
</tr>
<tr>
<td>GDP per capita (GDPc): euros</td>
<td>20,913.67</td>
<td>2,768.101</td>
<td>14,064</td>
<td>28,598</td>
</tr>
<tr>
<td>tourism (\textit{tour}): Number of tourists per capita</td>
<td>2.52</td>
<td>3.40</td>
<td>0.11</td>
<td>11.34</td>
</tr>
<tr>
<td>distance (\textit{dist}): Number of kilometers</td>
<td>644.70</td>
<td>485.08</td>
<td>131</td>
<td>2,190</td>
</tr>
<tr>
<td>Airport concentration (HHI\text{airport}): index</td>
<td>0.53</td>
<td>0.12</td>
<td>0.27</td>
<td>0.76</td>
</tr>
<tr>
<td>Route concentration (HHI\text{airport}): index</td>
<td>0.74</td>
<td>0.35</td>
<td>0.21</td>
<td>1</td>
</tr>
</tbody>
</table>
### Table 1. Demand and pricing equation estimates (2SLS-IV)

**Demand equation (dependent variable: Q)**

<table>
<thead>
<tr>
<th>(1) Baseline: whole sample period N = 821</th>
<th>(2) Period without capacity restrictions in routes with origin in Barcelona N = 114</th>
<th>(3) Period without capacity restrictions in routes with origin in Madrid N = 58</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>prices (p)</strong></td>
<td>-0.0063 (0.0007)** ***</td>
<td>-0.0030 (0.0015)** ***</td>
</tr>
<tr>
<td>population (pop)</td>
<td>1.31 (0.09)** ***</td>
<td>7.40 (1.70)** ***</td>
</tr>
<tr>
<td>GDP per capita (GDPc)</td>
<td>0.21 (0.42)</td>
<td>0.75 (1.02)</td>
</tr>
<tr>
<td>tourism (tour)</td>
<td>0.37 (0.03)** ***</td>
<td>0.35 (0.08)** ***</td>
</tr>
<tr>
<td>D\textsuperscript{modal}</td>
<td>-0.74 (0.09)** ***</td>
<td>-0.64 (0.24)** ***</td>
</tr>
<tr>
<td>D\textsuperscript{hub}</td>
<td>0.33 (0.09)** ***</td>
<td>-</td>
</tr>
<tr>
<td>D\textsuperscript{summer}</td>
<td>0.54 (0.08)** ***</td>
<td>0.32 (0.22)</td>
</tr>
<tr>
<td>Trend</td>
<td>-0.01 (0.02)</td>
<td>-</td>
</tr>
<tr>
<td>Intercept</td>
<td>-9.00 (4.20)** ***</td>
<td>-106.16 (31.31)** ***</td>
</tr>
<tr>
<td><strong>R\textsuperscript{2}</strong></td>
<td>0.33</td>
<td>0.57</td>
</tr>
<tr>
<td>(\chi^2\text{ (joint sig.)})</td>
<td>77.66***</td>
<td>22.34***</td>
</tr>
<tr>
<td>Partial R\textsuperscript{2} (instruments)</td>
<td>0.34</td>
<td>0.32</td>
</tr>
<tr>
<td>Test F (sig. instruments)</td>
<td>162.03***</td>
<td>36.63***</td>
</tr>
</tbody>
</table>

**Pricing equation (dependent variable: p)**

| demand \((Q_m)\)                        | -0.00019\( (0.5e-4)\)** ***   | 0.000223 \( (0.0003)\)           | -0.00003 \( (0.0001)\)       |
| distance \((dist)\)                     | 0.11 \( (0.006)\)** ***        | 0.10 \( (0.01)\)** ***           | 0.11 \( (0.036)\)** ***      |
| D\textsuperscript{oligopoly}            | -44.32 \( (10.18)\)** ***      | -106.71 \( (31.04)\)** ***       | -25.48 \( (59.29)\)          |
| D\textsuperscript{summer}               | 61.24 \( (5.50)\)** ***        | 96.50 \( (16.31)\)** ***         | 59.73 \( (24.72)\) **       |
| D\textsuperscript{Barcelona_capacity}    | -29.22 \( (6.92)\)** ***       | -                                  | -                          |
| D\textsuperscript{Madrid_capacity}       | 11.92 \( (8.23)\)              | -                                  | -                          |
| Intercept                               | 142.75 \( (6.84)\)             | 138.06 \( (25.55)\)** ***        | 90.46 \( (27.36)\)** ***    |
| **R\textsuperscript{2}**               | 0.44                            | 0.43                             | 0.39                       |
| \(\chi^2\text{ (joint sig.)}\)        | 93.25***                       | 26.87***                         | 4.51***                    |
| Partial R\textsuperscript{2} (instruments for demand) | 0.46                           | 0.53                             | 0.63                       |
| Test F (sig. Instruments for demand)    | 61.97***                       | 24.39***                         | 40.91***                   |
| Partial R\textsuperscript{2} (instruments for D\textsuperscript{oligopoly}) | 0.46                           | 0.62                             | 0.34                       |
| Test F (sig. Instruments for D\textsuperscript{oligopoly}) | 242.53***                     | 76.55***                         | 11.70***                   |

**Notes:**
- **Note 1:** Instruments for prices in the demand equation: Distance, airport concentration
- **Note 2:** Instruments for demand and D\textsuperscript{oligopoly} in the pricing equation: Population, GDP per capita, tourism, D\textsuperscript{modal}, airport concentration, and D\textsuperscript{hub} in specification 1.
- **Note 3:** Standard errors in parentheses
- **Note 4:** Significance at the 1% (***)**, 5% (**), 10% (*)
Table 2. Estimated conduct parameters (Evaluated at sample means)

<table>
<thead>
<tr>
<th>Conduct parameter: θ</th>
<th>Test θ = 0</th>
<th>Test θ = (1/number of competitors)</th>
<th>Test θ = 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline: whole sample period N = 821</td>
<td>0.72</td>
<td>124.38***</td>
<td>18.92***</td>
</tr>
<tr>
<td>Period without capacity restrictions in routes with origin in Barcelona N = 114</td>
<td>0.68</td>
<td>52.05***</td>
<td>11.82***</td>
</tr>
<tr>
<td>Period without capacity restrictions in routes with origin in Madrid N = 58</td>
<td>0.95</td>
<td>97.36***</td>
<td>0.18</td>
</tr>
</tbody>
</table>

Note: Significance at the 1% (***) , 5% (**), 10% (*)

Table 3. Number of competitors equation estimates (IV-Ordered probit). N= 688

<table>
<thead>
<tr>
<th>demand (Q_m)</th>
<th>prices (p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.41e-06 (1.07e-06)***</td>
<td>0.003 (0.001)***</td>
</tr>
<tr>
<td>0.003 (0.001)***</td>
<td>-0.78 (0.17)***</td>
</tr>
<tr>
<td>-0.78 (0.17)***</td>
<td>0.57 (0.11)***</td>
</tr>
<tr>
<td>0.57 (0.11)***</td>
<td>0.31 (0.14)***</td>
</tr>
<tr>
<td>0.31 (0.14)***</td>
<td>-0.07 (0.12)</td>
</tr>
<tr>
<td>-0.07 (0.12)</td>
<td>-3.14 (0.63)***</td>
</tr>
<tr>
<td>-3.14 (0.63)***</td>
<td>Log likelihood -480.50</td>
</tr>
<tr>
<td>Log likelihood -480.50</td>
<td>LR χ² (joint sig.) 427.03***</td>
</tr>
</tbody>
</table>

Note 1: Instruments for prices and demand: Distance, population, GDP per capita, tourism, D_{modal}, airport concentration. Route concentration is instrumented with data of the previous period.

Note 2: Significance at the 1% (***) , 5% (**), 10% (*)

Figure 1. Evolution of the natural monopoly threshold: Spline of number of competitors respect to route traffic density (if route traffic less than 205,828)
Table 4. Pricing equation estimates (2SLS – IV)

<table>
<thead>
<tr>
<th>Non monopoly routes</th>
<th>( N = 422 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( Q_m ) demand</td>
<td>-0.0002 (0.4e-4)*****</td>
</tr>
<tr>
<td>( dist ) distance</td>
<td>0.11 (0.006)*****</td>
</tr>
<tr>
<td>( D_{low_cost} )</td>
<td>-32.85 (13.08)*****</td>
</tr>
<tr>
<td>( D_{Summer} )</td>
<td>78.26 (6.01)*****</td>
</tr>
<tr>
<td>Intercept</td>
<td>99.53 (9.82)*****</td>
</tr>
</tbody>
</table>

\[ \begin{align*}
R^2 & = 0.63 \\
\chi^2 \text{ (joint sig.)} & = 144.18***** \\
\text{Partial } R^2 \text{ (instruments for demand)} & = 0.47 \\
\text{Test } F \text{ (sig. Instruments for demand)} & = 43.83***** \\
\text{Partial } R^2 \text{ (instruments for } D_{low\_cost} \text{)} & = 0.29 \\
\text{Test } F \text{ (sig. Instruments for } D_{low\_cost} \text{)} & = 32.36*****
\end{align*} \]

Note 1: Instruments for demand and \( D_{low\_cost} \) in the pricing equation: Population, GDP per capita, tourism, \( D_{modal} \), \( D_{hub} \), airport concentration

Note 2: Standard errors in parentheses

Note 3: Significance at the 1% (*****), 5% (**), 10% (*)

Figure 2. Comparison between low-cost and all carriers: Spline of number of competitors respect to route traffic density (if route traffic less than 205,828)
Figure 3. Evolution of airline’s market share in Madrid and Barcelona airports

Note: 2007 considers data until June.
Source: Web site of AENA
NOTE FOR REFEREES:

Mathematical arrangements for equation (6) at page 7

The supply relationship can be expressed in the following way:

\[ p = b_0 + b_1 \text{dist} + \beta \mathbf{Q}_m - D_{\text{monopoly}} \alpha^{(1)} - D_{\text{oligopoly}} \theta_{\text{oligopoly}} \alpha^{(1)} + \epsilon_{kr} \]

where \( D_{\text{monopoly}} \) and \( D_{\text{oligopoly}} \) are dummy variables that refer to monopoly and oligopoly routes respectively. The intercept term \( (c) \) in monopoly routes is \( c_{\text{monopoly}} = b_0 - \alpha^{(1)} \), whereas it is \( c_{\text{oligopoly}} = b_0 \) in oligopoly routes. For this reason, the term \( D_{\text{oligopoly}} \alpha^{(1)} \) should be added to the previous equation in order to express properly the intercept term:

\[ p = b_0 + b_1 \text{dist} + \beta \mathbf{Q}_m - D_{\text{monopoly}} \alpha^{(1)} - D_{\text{oligopoly}} \theta_{\text{oligopoly}} \alpha^{(1)} + D_{\text{oligopoly}} \alpha^{(1)} + \epsilon_{kr} \]

From this expression, we can easily derive equation (6)