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Abstract: This paper analyzes the geography of seat capacity at Spanish airports between 2001 and 2008. Concentration and deconcentration patterns for different markets have been identified. For this purpose, we use the Herfindahl-Hirschman Index (HHI), the Concentration Ratio (CX) and the Lorenz curve. From our analysis, we conclude that seat capacity follows a deconcentration pattern due to the growth of low-cost carriers at small- and medium-sized Spanish airports. This is in line with earlier studies for Europe as a whole. Intercontinental seat capacity still remains very much concentrated in Madrid and, to a lesser extent, in Barcelona. However, new strategies by long-haul airlines bypassing the primary European hubs foster the deconcentration of seat capacity in the Asian and North American markets. In the case of Spain, the recent liberalization of the EU-US market may become an important enabler of such network strategies, e.g., Delta has operated a route from Valencia to New York-JFK since 2009. In other intercontinental markets, capacity is more and more concentrated in Madrid. We highlight the restructuring of Iberia's network as an important factor behind the increasing dominance of Madrid in intercontinental markets.

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The geography of the Spanish airport system: spatial concentration and deconcentration patterns in seat capacity distribution, 2001-2008

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The geography of the Spanish airport system: spatial concentration and deconcentration patterns in seat capacity distribution, 2001-2008

1. Introduction

Air transport deregulation in Europe has developed in three steps known as the first, second and third deregulation package. These sets of deregulation measures were implemented in 1987, 1990 and 1993. The trend towards liberalization continues as an increasing number of bilateral air-service agreements are renegotiated at the EU level. A recent accomplishment includes the first phase of an Open Sky Agreement between the EU and the US, which came into force in March 2008. The agreement gives carriers registered in the EU or the US the right to operate services between any EU and US points. In addition, it includes EU states, which did not have individual Open Skies agreements with the US before the agreement came into force (among others the UK, Greece, Ireland, and Spain).[1]

There has been a flurry of research on the impact of the liberalization of the EU air transport market (e.g., CAA, 1997; Goetz and Graham, 2004; Burghouwt, 2007a)[2], the development of the European aviation market in general (e.g., EC 2008) and the spatial concentration of air transport supply at the European level (see Bel and Fageda, 2008a; Burghouwt, 2007b; Caves, 1997; Dennis, 1994a). The number of studies dealing with the specific impact on the Spanish aviation market, one of the largest aviation markets in Europe, has been much more limited. Some studies have looked into the changes in the scheduled flights of the Spanish aviation market (see Rey, 2003a; Rey, 2003b), behavior of and pricing by Spanish airlines in the new deregulated environment

[1] Sixteen EU countries had already concluded Open Skies agreements with the US during the 1990-2009 period (Button, 2009).

[2] See also volume 17 (4) of this journal on Airline Industry Liberalization, edited by Bowen (2009).

(see Fageda, 2006; Fageda and Fernández-Villadangos, 2009), Spanish airport efficiency and management (see Costas-Centivany, 1999; Martín and Román, 2001; Martín-Cejas, 2002; Bel and Fageda, 2007) and geographical efficiency of Spain's airports (see Tapiador et al., 2008). An analysis of the changes in the distribution of services throughout the Spanish airport hierarchy and its most important causes has not yet been performed.

Hence, this paper fills a gap in the current scientific literature analyzing the spatial distribution of seat capacity among Spanish airports between 2001 and 2008, broken down by geographical destination market. Our analysis is particularly relevant from the societal perspective since the availability of international air services strongly influences regional economic development (Button et al., 1999; Brueckner, 2003; Leinbach and Bowen, 2004; Green, 2007; Bel and Fageda, 2008b). In addition, an analysis of changing spatial patterns of air traffic may reveal opportunities and threats for future investments in various types of airport infrastructure in Spain.

This study also contributes to the international debate on the impact of the growth of hub-and-spoke networks (Dennis, 1994b; Button, 2002; Alderighi et al., 2005), the rise of low-cost carriers (Reynolds-Feighan, 2001; Gillen and Lall, 2004; Warnock-Smith and Potter, 2005; Barbot, 2006) and other airline network strategies on the spatial distribution of air transport supply throughout the airport population (O'Connor, 2003; Pitfield, 2007; Derudder and Witlox, 2009; Lohmann, et al., 2009; Heracleous and Wirtz, 2009; Huber, 2009).

Whereas some researchers find a spatial concentration pattern of air traffic at a few airports as a result of airline hub-and-spoke strategies in deregulated markets (Goetz and Sutton, 1997; Reynolds-Feighan, 1998, 2001, 2007), others end up with a more differentiated picture. Burghouwt & Hakfoort (2001) and Burghouwt (2007a) show that intra-European traffic displays a spatial deconcentration pattern due to the growth of regional and low-cost airlines, whereas intercontinental seat capacity is increasingly concentrated at a limited number of large hub airports because of the network strategies of the global airline alliances. However, there are indications that this concentration trend of intercontinental traffic in the European market may have been reversed in recent years. For a set of large European urban areas, Bel and Fageda (2008a) observe a deconcentration of intercontinental flights between 2004 and 2008. Hub-bypassing strategies of selected network airlines, airport congestion and economic growth of non-hub regions, introduction of smaller size, efficient long-haul aircraft and liberalization of air transport markets at the EU-level foster the development of direct intercontinental service from large, non-hub airports. O'Connor (2003) concludes that global air traffic also shows a dispersal pattern: global cities and traditional hubs lose out in favor of slightly smaller, large cities between 1990 and 2000. Finally, for the intra-US market, Reynolds-Feighan (2007) finds a spatial concentration of traffic between 1990 and 1997 followed by a decrease of spatial concentration between 1997 and 1998, and relative stability until 2002. In this paper, we add to the concentration-deconcentration debate by providing evidence from the Spanish aviation market.

The paper is organized as follows: Firstly, data and methodology are described. Secondly, our study provides a brief description of the Spanish airport system. Thirdly, deconcentration and concentration patterns analyzed in Spain between 2001 and 2008, broken down by geographical destination markets, are analyzed.

2. Data and methodology

For our analysis, we have used OAG (Official Airline Guide) data for the years 2001 to 2008. OAG contains several variables on direct scheduled flights, including flights of network, regional, low-cost and leisure airlines. The variables included in our analysis are departure airport, destination airport, airline, monthly flight frequency and monthly seat capacity. It should be noted that our dataset contains scheduled non-stop direct flights, multi-stop direct flights and multi-stop direct flights with a change of gauge. All of these types of flights are direct in the sense that they have a single flight number for the whole itinerary.[3] Including all of these types of direct flights in the analysis is particularly relevant for our study since Iberia, the main Spanish carrier, has been a heavy provider of multi-stop direct flights. Full freighter flights have not been included, since our study is restricted to passenger traffic only. Seat capacity provided on indirect[4] connecting services with a transfer at a hub is not included in the OAG database and has not been considered in the analysis. Future research should deal with capacity provided by indirect air services.[5] It should be noted that OAG does not provide details about realized passenger demand nor about realized supply, which may vary depending on variables such as load factor (see Devriendt et al. (2009) for a critical view on calculating load factors), weather conditions (see Abdelghany et al. (2004) for flight delays projecting during irregular operation conditions) or congestion (see Brueckner (2002) for an analysis of carrier behavior to airport congestion and Flores-Fillol (2010) for congested hubs).

[3] A non-stop direct flight is a flight between airport A and airport B without any intermediate stop between origin and destination.
A multi-stop flight is a flight between airport A and airport B stopping at C with neither a change of aircraft nor a change of flight number.
A multi-stop flight with change of gauge is a flight between airport A and airport B stopping at C with a change of aircraft, but without a change of flight number.

[4] An indirect flight is a flight between airport A and airport B stopping at H, with both a change of aircraft and a change of flight number.

[5] See Burghouwt et al. (2009), Burghouwt and Veldhuis (2006), IATA, (2000), Veldhuis (1997) methodologies on the calculation of direct and indirect connectivity levels.

Various concentration and dispersion indices are available to measure the spatial distribution of seat capacity among an airport population, such as the Herfindahl-Hirschman Index (HHI), the Concentration Ratio (CR), the coefficient of variation, Theil's entropy measure and the Gini index (Reynolds-Feighan, 2001; Burghouwt et al., 2003). Recently, alternatives to these standard concentration indices have been applied in order to "decode" the spatiality and complexity of air transport networks (Limtanakool et al., 2007; Martín and Voltes-Dorta, 2008; Derudder and Witlox, 2009; Van Nuffel et al., 2008; Paleari et al., 2010).

In this paper, standard concentration and dispersion indices are applied. The advantages and disadvantages of the various concentration and dispersion measures have been frequently addressed in the literature, both with respect to applications in the air transport industry (see Reynolds-Feighan, 1998, for an thorough review) as well as in other areas of transport such as the container shipping industry (Notteboom, 2006; Sys, 2009). It is acknowledged that such measures do not capture the degree of airline hubbing and do not capture connecting behavior of passengers (Burghouwt and De Wit, 2005; Martín and Voltes-Dorta, 2008; Wojahn 2001). Since the goal of this paper is to measure the spatial distribution of traffic in an airport population, and because we do not aim to identify hubbing practices of airlines, concentration and dispersion measures are suitable for our analysis.

Herein, we use the commonly applied and straightforward HHI and Concentration Ratio. We note that these concentration measures are particularly useful to identify changes in the extremes of a distribution (Sen, 1976; Allison, 1978) and that we aim to identify the changing role of the larger and smaller Spanish airports. It is well known that the HHI is sensitive to the number of observations in the sample. However, the number of airports in our sample is stable during the period of analysis. Moreover, Wojahn (2001) shows that all concentration and dispersion measures are highly and significantly correlated to each other. It is therefore likely that the use of other measures would reveal similar concentration and dispersion patterns in our analysis.

HHI (Herfindahl, 1950) has traditionally been used in antitrust cases to measure the level of competition and the degree of concentration in a particular market, including the air traffic markets (DoJ and FTC, 1992; Reynolds-Feighan, 2001). Reynolds-Feighan (1998) and Wojahn (2001) introduced HHI as a measure for the spatial distribution of air traffic in the airport population.[6] We derive HHI as follows (1):

$$HHI = \sum_i (x_i / \sum x_i)^2 \quad , \tag{1}$$

where x_i is the air traffic at airport i. Here, air traffic refers to the scheduled seat capacity offered at each airport. A non-normalized HHI ranges between 1/n and 1. Results near 1/n indicate a non-concentrated distribution of the seat capacity among all of the airports, while results near 1 indicate a high concentration of seat capacity. An HHI of 1 indicates dominance by one single airport in that particular market. Additionally, the Lorenz curve has been used. Since we want to keep the interpretation of the results straightforward, but at the same time acknowledge the role of the two main airports in Spain, our results are supported with the two-firms concentration ratio (C_2) to measure the market share of Madrid-Barajas and Barcelona in each geographical market, as well as capacity shares of airport categories.[7]

[6] There are similar analyses using these types of concentration indices for other transport sectors; see, for example, Notteboom (2006) for a study of the concentration levels of European and North American container port systems, and Sys (2009) for the degree of concentration linked to the degree of oligopoly in the container shipping industry.

[7] Still, it has to be acknowledged that when only one airport is dominant, the C_2 conceals the subservience of the other airport.

Our study area concerns the Spanish commercial airport system, consisting of 47 airports. In our analysis 41 of the 47 airports have been considered (see Appendix and Figure 1). Córdoba, Huesca, Madrid-Cuatro Vientos, Madrid-Torrejón, Sabadell and Son Bonet have not been considered because they did not have scheduled service during the period of analysis. Burgos is not present in the analysis because it started to operate commercial traffic in July, 2008.

In order to analyze the contributions of various types of airports to the overall concentration of seat capacity in the Spanish airport system, the 41 airports have been classified into five groups using the natural breaks method and Jenks' optimization (Jenks, 1967). This method calculates the grouping of data values based on data distribution, seeking to reduce variance within groups and maximize variance between groups. We have used the number of passengers in 2008 to categorize the airport hierarchy.[8]

- 1st-tier airport (1 airport): At the upper-end level, we only find Madrid-Barajas. This is the only intercontinental airport in Spain having an airline hub operation with a clearly developed wave-system structure.[9] This is the home-base of Iberia, the main Spanish carrier and partner of the Oneworld alliance.
- 2nd-tier airports (2 airports): In this group we find airports with more than 20 million passengers annually, but with a smaller portfolio of intercontinental destinations. These airports are home-bases of smaller airlines and low-cost

[8] The natural breaks method has been readjusted for the Santiago de Compostela and Murcia airports. These airports have been moved from the 5th-tier to the 4th-tier group because they are not only domestic destinations, but they also offer an important share of low-cost traffic to European destinations.
[9] A wave-system structure is a set of integrated connection waves in the airline's flight schedule during the day (Bootsma, 1997). Ideally, in each wave or bank, each incoming flight connects to each outgoing flight in order to maximize connectivity.

carriers. Barcelona (base of AirEuropa, Spanair, Vueling and Clickair) and Palma de Mallorca (base of Spanair and airBerlin) are part of this group.

- 3rd-tier airports (4 airports): This group includes airports with more than 6 million passengers a year. These airports have a substantial domestic and European network. Low-cost airlines provide most of the connections and some of them are characterized by strong seasonality. In this group, we find Malaga, Gran Canaria, Alicante and Tenerife South.
- 4th-tier airports (11 airports): These airports have between 1.8 and 6 million passengers a year. Some of the airports predominantly serve the domestic market, such as Valencia, Sevilla, Bilbao and Santiago. Others are important gateways for tourists flying with low-cost carriers. Hence, in this group we also find regional airports specializing in low-cost flights such as Girona, a base of Ryanair.
- 5th-tier airports (29 airports): At the lower end of the airport hierarchy, we find airports with less than 2 million passengers, which mainly provide some services to domestic destinations and a few low-cost flights to international destinations

[FIGURE 1]
The Spanish airport system, number of passengers 2008.
Source: own elaboration from AENA (2009).

3. The Spanish airport system

The Spanish aviation market is one of the largest in Europe. In 2007 the Spanish airports accounted for 21% of the total number of passengers transported by air in Europe (EU-27) (Eurostat, 2009). In 2008, airlines offered more than 123 million departing scheduled seats at Spanish airports. Between 2001 and 2008 the seat capacity increased by 50%. However, growth was not evenly distributed over all of the years. In 2001-2002, growth was negative (-4%) due to the impact of the 9/11 crisis and SARS. The recovery was fast and the annual growth until 2006 was, on average, 9%. The major move forward was in the 2006-2007 period, with a 15% growth figure. Again, in the 2007-2008 period, growth became negative (-1%) because of the impact of the world financial crisis (Table 2).

[TABLE 1]

[TABLE 2]

Spain is one of the few Western countries with all of its commercial airports managed by a single public company, AENA, which manages both airports and air navigation assistance services[10].

The seat capacity distribution in the Spanish airport system was highly skewed in 2008. The five largest airports accounted for 65% of total seat capacity. This is in line with the other large European air transport markets. The five largest airports accounted for 78% of total seat capacity in France, 71% in Germany, 64% in the UK and 57% in Italy.

The main airline serving the Spanish airport system is Iberia, which accounted for 25% of total seat capacity and 41% of seat capacity for intercontinental destinations from Spain in 2008; of the latter, 88% corresponds to Madrid-Barajas. From 2004 onwards, Iberia's strategy has been to downsize its network, not only by closing down its secondary hub at Barcelona, but also by concentrating its activity in the

[10] However, recent political developments point toward a change in this model (see GoS, 2008).

intercontinental market (from which it gets higher revenues), the feeder routes and the most profitable routes in each market (Iberia, 2008). The continuation of this restructuring policy was framed in the 2006-2008 Master Plan of Iberia (Iberia, 2006). The Master Plan strategy was to intensify the utilization of the network (fewer destinations and a more intensive use of the aircraft fleet), decrease domestic capacity while increasing the intercontinental share, focus on the Madrid-Barajas hub to Latin America and its feeder operations from Europe. The increasing importance of Madrid-Barajas in the Iberia network is illustrated in Table 3. The restructuring of Iberia's network has had important implications for the capacity distribution in the Spanish airport hierarchy, as we will show later on.

[TABLE 3]

4. Deconcentration processes

The seat capacity distribution in the Spanish airport hierarchy became more de-concentrated between 2001 and 2008. As Table 1 shows, 1st- and 2nd-tier airports lost capacity share to the benefit of 3rd-, 4th- and 5th-tier airports. This deconcentration process is also confirmed by HHI, C_2 and the Lorenz curve (Tables 4 and 5, and Figure 2). This is particularly true for the domestic, European, North American and Asian destinations. In contrast, the Latin American, Middle Eastern and African markets showed a concentration of seat capacity at a smaller number of airports. Overall, the HHI on the intercontinental market reveal a slight concentration pattern, whereas the European and domestic markets reveal clear deconcentration patterns.

One should note that several airports were responsible for the growth of the seat capacity share of the 3rd, 4th and 5th tiers. In particular, seat capacity increased at major coastal leisure destinations (Girona, Reus, Murcia, La Gomera, Alicante and Valencia), main inland tourist destinations (Granada and Sevilla) and regional capitals (Melilla, León, Santander, Zaragoza, Salamanca and Valladolid). In fact, these airports represent 35% of total seat capacity growth in the whole Spanish airport system between 2001 and 2008.

[TABLE 4]

[TABLE 5]

These results are roughly in line with the dynamics in the European seat capacity distribution (Figure 2). Also, Burghouwt (2007a) finds a deconcentration of European seat capacity and a concentration of intercontinental seat capacity for all European airports between 1990 and 2003. Yet, for a later period, Bel and Fageda (2008a) observe a deconcentration of frequencies in long-haul intercontinental business destinations between 2004 and 2008.

[FIGURE 2]
Lorenz curves for Spanish and European airport seat capacity, 2001 through 2008.
Source: OAG.

4.1 Low-cost carriers: the main deconcentration engines

The airlines that have contributed most to the growth of seat capacity in the period of study are low-cost carriers (LCCs). Ryanair, which mainly operates from secondary airports, was the primary driving force behind the deconcentration pattern. The airline accounted for 40% of the growth at the 4th- and 5th-tier airports. This represents 17% of the total seat capacity growth in the whole Spanish airport system. If we add the contribution of Ryanair to the rest of the tiers, this figure rises to 24%, despite the fact that Ryanair established a home base at Madrid-Barajas in 2006.[11] Besides Ryanair, many other LCC have contributed substantially to the deconcentration process, such as easyJet (14%), Clickair (14%)[12], Vueling (13%) and airBerlin (10%).

At the 4th-tier airport of Girona, for example, Ryanair established an operational base in 2002. The establishment of the Ryanair base resulted in fast growth of the airport from 49 flights per week by the carrier in December 2002 to 14,355 flights to 56 different destinations in 2007. Ryanair's growth at Girona accounted for 8% of the increase in seat capacity in the entire Spanish airport system.

The 3rd-tier airport of Alicante is another good example, in this case, of how the deconcentration process took place. This airport accounted for 8% of the increase in seat capacity in the Spanish airport system. Again, low-cost operations have been the leading factor for growth. Nevertheless, Alicante shows a different pattern from the one at Girona. A mix of airlines provides seat capacity instead of a monopoly by only one airline. Both the growth of operations of easyJet and Ryanair between 2002 and 2008 resulted in fast growth of this airport, although Iberia gradually ceased all international operations at Alicante. Instead, Iberia focused on feeding its Madrid hub from the airport.

4.2 North America: US carriers, engines for deconcentration

[11] Ryanair growth at Madrid-Barajas was 2.5% of the total seat capacity growth in the Spanish airport system, which is, in fact, an opposite concentration effect.

[12] Although Clickair contributes with 14% of the growth in seat capacity, it should be highlighted that this low-cost carrier subsidiary of Iberia was created as part of Iberia's strategy of hub-building in Madrid-Barajas and de-hubbing in Barcelona, and it has substituted part of Iberia's routes from Barcelona.
In addition, Vueling and Clickair have recently merged. The resulting carrier maintained the name of Vueling and started to operate in June, 2009. Forty-five percent of the shares of the new Vueling are owned by Iberia.

The seat capacity distribution to North America has been following a deconcentration pattern, according to HHI. The dominance of Madrid-Barajas decreased substantially: Its HHI decreased from 0.79 in 2002 to 0.54 in 2008. However, this deconcentration tendency took place at only three of the 41 airports. Seat capacity decreased at Madrid-Barajas and increased at Barcelona; besides, airlines started some seasonal flights between the US and Malaga (3rd-tier airport). In 2008, 67% of the seat capacity to North America was concentrated at Madrid-Barajas and was provided by a number of airlines, including American Airlines, Iberia, US Airways, Continental and Delta. Nevertheless, seat capacity to the North American market from Madrid-Barajas decreased in absolute numbers between 2005 and 2008, with Iberia being largely responsible for the drop in seat capacity. From 2004 on, Iberia started to rationalize its network. The major fall happened in 2005 when Iberia's seat capacity from Madrid-Barajas to North America went down by 24% (161,000 seats). The drop continued in 2006 with a loss of 52,000 additional seats, increasing the drain of capacity by up to 31%. However, as part of the hub-building strategy in Madrid-Barajas, 111,000 seats were recovered during 2007 and 2008.

In 2008, Delta, the second airline in terms of capacity from Madrid-Barajas to North America, operated a daily flight to New York-JFK, Atlanta and Tampa. Other North American airlines flying from Madrid-Barajas were US Airways (Philadelphia), Continental (New York-Newark) and American Airlines (Miami).

The rationalization strategy of Iberia seems to have been especially harmful for Barcelona. While in 2003, Iberia's seat capacity from Barcelona to North America was 200,000 seats, in 2008 it was only 61,000 seats, which represents a 70% decrease. Almost 900 annual frequencies via Madrid-Barajas were lost on the routes to Boston, Chicago, New York-JFK and San Juan. The only route that survived Iberia's network restructuring was the daily flight to Miami. However, we should note that most of the lost direct services were multi-stop flights through Madrid, even involving a change of gauge (i.e., a change of aircraft without a change of flight number) in a number of them. Hence, the loss of direct connections to North America mainly constitutes a change in the marketing of the flights from direct multi-stop connections to indirect hub connections, rather than a real loss of direct service.

Nonetheless, network growth of other airlines partly compensated the rationalization by Iberia. In 2008, Delta provided almost half of the capacity to North America from Barcelona. From 2007 on, Delta has started to increase its seat capacity from Barcelona, and in 2008 it almost reached the same level as at Madrid-Barajas (see Table 6). Not only has Delta's flight to New York-JFK benefited from the capacity increase, the seasonal flight to Atlanta also became a year-round service. Another important airline in Barcelona is Continental, which has been serving New York-Newark daily since May, 2006. Other airlines operate from Barcelona in a more seasonal fashion, such as Air Transat (Montreal, Toronto) and US Airways (Los Angeles, Miami and Philadelphia)

Finally, Málaga, the fourth Spanish airport, benefited from the growth of Air Transat and the strategy of Delta of feeding its New York-JFK hub directly from secondary European markets. From June, 2009 on, Delta connects Valencia (4th-tier airport) with New York-JFK.

Delta's hub-bypassing network strategy has been one of the main engines for deconcentration of intercontinental capacity in the North American market. Traditionally, intercontinental seat capacity has been strongly concentrated in hub airports, partly because of the restrictive "Bermuda type" bilateral agreements. However, Delta's intercontinental strategy differs from that of most of the other US legacy carriers. Instead of concentrating the intercontinental traffic between its US hubs and the hubs of its alliance partners on other continents ("dog-bone" networks), Delta directly serves primary as well as secondary European destinations from its Atlanta and New York hubs.

Delta services from Málaga commenced just three months after the agreement became effective, and it would be tempting to attribute the Málaga services to the EU-US Open Sky Agreement of 2008 since Spain had a fairly restrictive bilateral agreement with the US prior to then. However, already under the Spain-US air-service agreement of 1973 and the 1991 modification, Delta would be allowed to operate a New York-Málaga service (DoS, 1973; DoS, 1989; DoS, 1991a; DoS, 1991b). Hence, the Delta services from Málaga cannot be directly attributed to the EU-US Open Sky Agreement, yet, the new New York-Valencia Delta service would not have been possible without the EU-US Open Sky Agreement of 2008.

[TABLE 6]

4.3 Asia: Difficulties in establishing stable routes

Carriers have difficulties in establishing sustainable service between Spain and Asia. Furthermore, the level of service (capacity and frequency) is generally low. Until 2004, flights to Asia were fully concentrated at Madrid-Barajas (HHI=1) with just two destinations served (Thai Airways to Bangkok and Singapore Airlines to Singapore), the latter being cancelled in November, 2004. In 2005, Air Comet and Air Europa brought Barcelona into play when they launched flights from Madrid-Barajas and Barcelona to Singapore. But in 2006, all direct services to Asia were again closed down and the only option to travel to Asia was to transfer at a hub outside Spain.

HHI (Table 4) shows a substantial decrease, but this is misleading since the C_2 value is at its maximum level (Table 5). The HHI decrease is mainly due to the Singapore Airlines flight from Barcelona to Singapore launched in mid-2006. This is a daily flight that takes advantage of the fifth freedom of the air[13], operating a multi-stop flight from Barcelona to Singapore via Milan with a B-777. In 2008, Madrid-Barajas remained the only Spanish airport with direct non-stop flights to Asia (2 per week by Air China to Beijing and 3 per week by Korean Air to Seoul). Travelers between Spain and Asia remain largely dependent on indirect connections via foreign hubs.

5. Concentration processes

We have shown that the deconcentration process in seat capacity is mainly the result of LCC network strategies and other specific airlines, such as Delta and Singapore Airlines. Now, we shall look at those markets that show a concentration of seat capacity.

5.1 Iberia's gateway to Latin America at Madrid-Barajas

In terms of seat capacity, the Latin American market is the most important intercontinental market of Spain, representing 51% of the total intercontinental seat capacity. It is also the most concentrated market with an HHI of 0.84, indicating a strong dominance of Madrid-Barajas. The HHI of 0.69 in 2001 indicates that the Latin American market has increasingly become concentrated at Madrid.

This airport accounts for 91% of seat capacity to Latin America. Barcelona provides 8%, and 1% is shared among other Spanish airports.

[13] Fifth freedom of the air: the right to carry traffic between two foreign countries by an airline of a third country, whose carriage is linked with third- and fourth-freedom rights of the airline (ICAO, 2004).

The strong position of Iberia in the Latin American market is widely known. Iberia's capacity to Latin America has always been concentrated at Madrid-Barajas. In addition, Iberia operated Miami as an "extraterritorial" hub to Central America until 2004. At Miami, direct flights from Madrid connected with four Airbus 319, and 110 employees stabled at the airport. The implementation of new US security regulations severely hurt Iberia's hub operations at Miami, since foreign travelers needed to obtain US visas even if they were merely passing through US airports to catch a connecting flight to another country. Hence, at the end of 2004 Iberia dismantled its Miami base. This action was framed in a wider strategy of rationalizing the whole network of the airline. This strategy also affected Iberia's secondary hub at Barcelona, which was de-hubbed in 2005. Iberia withdrew 5.6 million seats from Barcelona, 785,000 of them to intercontinental destinations, which represented 69% of the total intercontinental seat capacity at the airport. Barcelona lost 84% of the seat capacity to Latin America[14].

However, it is important to note that all flights to Latin America served by Iberia from Barcelona were multi-stop direct flights via Madrid-Barajas, in most of the cases implying a change of gauge, which means that there was not a real loss of seat capacity in the Barcelona-Madrid route. Apparently, 628,000 seats from Barcelona to Latin America via Madrid-Barajas were lost, but in fact, just 58,000 seats were lost in the Barcelona-Madrid route. The connections to Latin America in Madrid-Barajas were still possible after rationalization, now involving connecting flights with different flight numbers for each leg. In other words, the intercontinental routes from Barcelona that existed until 2005 were in fact hidden indirect connections via Madrid with a single

[14] Nonetheless, to avoid losing its market position at Barcelona, in 2007 Iberia set up the low-cost subsidiary Clickair, which provided 3.3 million seats to domestic, European and North African destinations from Barcelona.

flight number for marketing reasons. Only the commercial strategy to market them changed (see Table 7).

[TABLE 7]

Despite the commercial policy change of Iberia at Barcelona, the airline did not increase capacity at Madrid-Barajas to this region in absolute numbers. In fact, Iberia's seat capacity from Madrid-Barajas to Latin America decreased by 29% from 2004 to 2005 as part of its rationalization strategy. Iberia canceled five of its 20 Latin American destinations. The canceled routes were the daily flights to Cancún, Managua, Panamá, San Pedro Sula, and the every-two-day flight to El Salvador. The remaining routes either experienced a decrease in seat capacity (i.e., San José, Santo Domingo, Guatemala) or an increase (i.e., Rio de Janeiro, São Paulo, La Havana, México City).

Although Iberia is the leading carrier between Spain and Latin America (50% capacity share in 2008), other airlines also play a role, including Aerolineas Argentinas, Aeromexico, Avianca, Lan Airlines and Air Madrid. With respect to Air Madrid, the carrier operated several Latin American destinations on a low-cost basis, taking advantage of the strong origin-destination demand between Spain and Latin America. In 2006, this airline was the second carrier in this market (17% capacity share). Air Madrid offered services from Barcelona to Buenos Aires (2 per week) and weekly flights to seven other destinations. The airline was also operating from Madrid-Barajas to Buenos Aires and eight other destinations. In December, 2006, however, Air Madrid went bankrupt. The gap left by Air Madrid in the Latin American market was filled by other airlines in the following years, such as Air Comet and Air Europa. In 2008, Air Europa became the second airline in the market between Spain to Latin America in terms of seat capacity (14% capacity share).

5.2 Middle East: Airlines intensify their operations at Madrid-Barajas

In contrast to the Latin American case, the concentration of seat capacity to Middle East destinations took place not because Barcelona lost seat capacity, but because Madrid-Barajas doubled its seats offered from 2005 to 2008. In 2008, the Middle East was the second most-concentrated intercontinental market in terms of seat capacity (Table 3). In 2008, the only airports serving the Middle East market were Madrid-Barajas (79% of the seats) and Barcelona (21% of the seats); besides these two airports, in 2008 there was also one weekly flight by Kuwait Airways from Málaga during the summer months due to the high-yield origin-destination niche demand that exists between the region of Málaga-Marbella and the Middle East.

Madrid's seat capacity growth has been driven by the intensified operations by Iberia, Qatar Airlines, El Al Israel Airlines, Hola Airlines and Gadair. As part of its rationalization strategy, in 2004 Iberia canceled some of its flights from Madrid-Barajas to the Middle East in favor of more profitable connections in the same region (Istanbul and Tel Aviv). From Barcelona, Iberia also abandoned the daily flight to Istanbul in 2007 and the daily flight to Tel Aviv in 2008.

5.3 Africa: A future opportunity?

Apparently, Africa is the intercontinental market with the lowest HHI (0.48). In 2008, the African market was served from 10 Spanish airports, but four airports provided 97% of the seat capacity: Madrid-Barajas (65%), Barcelona (23%), Las Palmas (5%) and Girona (4%). Nevertheless, not all flights to Africa should be considered as being long-haul. In fact, proximity seems to be very important: 48% of the seat capacity from Spain to Africa corresponded to connections with Morocco. If we sum up the seat capacity to Algeria, Tunisia and Egypt, this number rises to 78%. In 2008, seat capacity to sub-Saharan Africa represented only 18% of total capacity and was mostly provided by Iberia from Madrid. Spain is in close proximity to the African continent, and this proximity seems to offer opportunities for Spanish hub carriers to connect the European market with West-African destinations, as Paris-CDG is already doing. Until now, this opportunity has not been fully exploited, possibly because of the lack of a strong local origin-destination market.

6. Conclusions

In this paper we have discussed the changes in the spatial distribution of seat capacity among Spanish airports. We have shown that, overall, seat capacity tends to de-concentrate. With respect to intra-European capacity, this is mainly because of the network growth of low-cost carriers at 3rd-, 4th- and 5th-tier airports. Although overall spatial concentration in intercontinental markets decreased slightly, there are great differences between geographical markets. Some intercontinental markets, such as the Latin American, Middle Eastern and African markets, show an increase in spatial concentration of supplied capacity, while other markets show a decrease in concentration.

Most intercontinental markets are heavily concentrated at Madrid-Barajas, Spain's intercontinental gateway and hub of Iberia. Iberia's network rationalization and hub-building strategy in Madrid-Barajas has been one of the major contributors to the concentration of intercontinental seat capacity. Due to this strategy of Iberia, intercontinental coverage is good for Latin and North American markets, but quite poor for sub-Saharan Africa, Asia and the Middle East. Indeed, the size of the Latin American market made it possible for charter airlines such as Air Comet to enter this market. On the other hand, other network carriers, such as Delta and Singapore Airlines, are having a greater role in the favoring of a slight deconcentration tendency of the seat capacity distribution in other intercontinental markets. Although it is still too early to know the consequences of the EU-US Open Sky Agreement in the allocation of seat capacity and our time-line data only covers a few months after it came into force, the fact that Delta opened a route from Valencia to New York-JFK in 2009 is a good example of the consequences of the new Open Sky regime for the Spanish market.

Our results for the Spanish airport system support earlier findings on spatial concentration and dispersion patterns in the European airport system. Earlier studies showed that intra-European capacity had a spatial deconcentration trend since deregulation because of the growth of services in particular by regional and low-cost carriers between lower-ranked airports. On the intercontinental level, results from previous studies are more mixed. At the least, our findings support the conclusions by Bel and Fageda (2008a) about the spatial deconcentration of intercontinental seat capacity in Europe in recent years. Yet, we note that different geographical markets display different concentration and dispersion patterns. However, longer periods of analysis should be applied both at the European and country levels to obtain more robust results. In this respect, the spatial concentration analysis for the US airline industry by Reynolds-Feighan (2007) provides a good example of how such an analysis could be carried out for Europe. In addition, it would be interesting to see to what extent such an analysis yields similar results at the country level.

From a societal perspective, the observed deconcentration of seat capacity indicates that more regions in Spain may benefit economically from the growth in the availability of direct air services, mainly to European, but also to some intercontinental, destinations. Availability of (low-cost) air services from more airports allows Spanish consumers to travel directly to a wider range of destinations with lower prices and shorter travel times. In addition, incoming tourism may be stimulated. Still, most intercontinental seat capacity remains highly concentrated at Madrid-Barajas, which will give the region an advantage as a location for international companies. Hence, the results can draw the attention of society and regions to know their position in the world city network (see Derudder and Witlox, 2005, 2008 for the relevance of mapping world city networks).

In addition, our analysis gives policy makers indications about the underlying trend in the spatial distribution of air traffic in Spain. Such information is important in assessing uncertainties and risks of future investments in airport infrastructure in the country. Attention should also be paid here to the specific concentration and dispersal mechanisms behind traffic development in multi-airport regions (De Neufville, 1995; Derudder et al., 2009), such as the multi-airport system in Catalonia (Barcelona, Girona, Reus, Lleida[15]), in Galicia (Santiago de Compostela, Vigo, A Coruña), in the Basque Country (Bilbo, Donostia-San Sebastián, Vitoria-Gasteiz), in Valencia and Murcia (Valencia, Alicante, Murcia), and in Andalucía (Sevilla, Málaga, Jerez de la Frontera, Granada, Almería).

We have indicated that empirical research on the spatial concentration and deconcentration patterns in Europe over substantial time periods (1990-2010) is still lacking. Further research will examine these long-term changes. In addition, we have looked at the capacity that airlines directly provide from Spanish airports. Thus, follow-up research should take into account not only the capacity provided on direct flights, but also capacity provided indirectly via hub airports.

[15] Lleida airport is a regional airport opened in January 2010, promoted and managed by Airports of Catalonia, a company owned by the Catalan Regional Government.

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Appendix

[TABLE A.1]

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Table 1
Distribution of seat capacity by airport category. Source: OAG.

	2001	2002	2003	2004	2005	2006	2007	2008
1st tier	34.9%	33.7%	32.0%	30.6%	28.6%	28.5%	27.7%	28.0%
2nd tier	29.0%	29.8%	29.4%	28.7%	28.0%	28.2%	27.6%	26.6%
3rd tier	14.2%	15.3%	16.3%	16.5%	16.6%	16.6%	16.7%	16.8%
4th tier	15.9%	15.5%	16.5%	18.1%	19.6%	19.6%	20.7%	21.4%
5th tier	6.0%	5.7%	5.7%	6.2%	7.1%	7.1%	7.3%	7.2%
Total	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*

Table 2

Table 2
Seat capacity yearly growth rates by airport category. Source: OAG.

	2001/2002	2002/2003	2003/2004	2004/2005	2005/2006	2006/2007	2007/20008
1st tier	-7.4%	3.1%	4.9%	1.6%	4.8%	12.2%	0%
2nd tier	-1.4%	7.4%	7.1%	6.2%	5.9%	12.9%	-4.9%
3rd tier	3.5%	16.1%	10.6%	9.8%	5.3%	15.3%	-0.4%
4th tier	-6.5%	16.4%	20.0%	18.1%	5.1%	21.7%	2.5%
5th tier	-8.3%	8.0%	19.1%	24.8%	5.0%	18.5%	-1.4%
Total	*-4.0%*	*8.7%*	*9.8%*	*8.7%*	*5.3%*	*15.2%*	*-1.0%*

Table 3

Table 3

Iberia's intercontinental seat capacity distribution by airport of origin. Source: OAG.

Airport	2001	2002	2003	2004	2005	2006	2007	2008
Madrid-Barajas	3,335,768	3,339,083	3,257,392	3,475,238	2,666,532	2,724,606	2,957,360	3,094,113
Barcelona	1,125,866	1,199,041	1,144,587	1,154,879	362,518	358,750	352,498	375,927
Palmas de Gran Canaria	37,656	21,780	20,800	21,000	20,800	20,272	19,371	19,716
Valencia	0	0	0	0	2,350	5,000	5,550	8,700
Málaga	7,933	3,770	397	276	0	0	0	4,740
Tenerife Norte	0	0	1,560	31,469	0	0	0	0
Tenerife Sur	19,500	14,300	11,960	0	0	0	0	0
Total	*4,526,723*	*4,577,974*	*4,436,696*	*4,682,862*	*3,052,200*	*3,108,628*	*3,334,779*	*3,503,196*
Madrid-Barajas	73.7%	72.9%	73.4%	74.2%	87.4%	87.6%	88.7%	88.3%
Barcelona	24.9%	26.2%	25.8%	24.7%	11.9%	11.5%	10.6%	10.7%
Palmas de Gran Canaria	0.8%	0.5%	0.5%	0.4%	0.7%	0.7%	0.6%	0.6%
Valencia	0%	0%	0%	0%	0.1%	0.2%	0.2%	0.2%
Málaga	0.2%	0.1%	0%	0%	0%	0%	0%	0.1%
Tenerife Norte	0%	0%	0%	0.7%	0%	0%	0%	0%
Tenerife Sur	0.4%	0.3%	0.3%	0%	0%	0%	0%	0%
Total	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*

Table 4
Herfindahl-Hirschman Index (HHI) of the Spanish airport seat capacity. Source: own elaboration from OAG.

Region	2001	2002	2003	2004	2005	2006	2007	2008
Latin America	0.69	0.67	0.69	0.71	0.90	0.84	0.88	0.84
Middle East	0.50	0.47	0.48	0.51	0.51	0.56	0.62	0.66
North America	0.79	0.71	0.69	0.69	0.72	0.68	0.62	0.54
Asia	1	1	1	1	0.82	0.52	0.57	0.51
Africa	0.31	0.33	0.36	0.39	0.41	0.39	0.44	0.48
Total intercontinental	0.64	0.61	0.63	0.64	0.72	0.68	0.69	0.67
Europe (without domestic)	0.17	0.17	0.15	0.14	0.13	0.13	0.12	0.12
Domestic	0.15	0.14	0.14	0.13	0.13	0.12	0.12	0.11
Total	*0.18*	*0.17*	*0.16*	*0.15*	*0.14*	*0.14*	*0.13*	*0.13*

Table 5

Table 5
Two-airport Concentration Ratio (C_2) (Madrid-Barajas and Barcelona) of the Spanish airport seat capacity. Source: own elaboration from OAG.

Region	2001	2002	2003	2004	2005	2006	2007	2008
Latin America	99.0%	99.1%	99.1%	98.8%	98.9%	97.9%	99.6%	99.7%
Middle East	100%	100%	100%	100%	100%	100%	100%	100%
North America	99.9%	98.5%	98.9%	99.3%	99.8%	99.9%	99.6%	96.9%
Asia	100%	100%	100%	100%	100%	99.8%	100%	100%
Africa	72.2%	75.7%	78.8%	81.4%	82.4%	79.5%	84.7%	88.1%
Total intercontinental	95.8%	95.8%	96.5%	96.7%	96.5%	95.8%	97.0%	97.2%
Europe (without domestic)	52.0%	52.0%	47.9%	44.5%	41.8%	424%	41.3%	40.7%
Domestic	49.5%	49.0%	48.1%	46.5%	45.4%	45.0%	43.8%	41.9%
Total	*54.7%*	*54.5%*	*52.0%*	*49.7%*	*47.1%*	*47.2%*	*45.8%*	*45.1%*

Table 6
Delta's seat capacity distribution by airport of origin. Source: OAG.

Airport	2001	2002	2003	2004	2005	2006	2007	2008
Madrid-Barajas	194,954	204,798	140,598	156,006	156,220	145,827	214,893	275,672
Barcelona	110,638	100,152	93,564	114,490	110,852	111,922	197,513	259,396
Málaga	0	0	0	0	0	0	0	43,188
Total	*305,592*	*304,950*	*234,162*	*270,496*	*267,072*	*257,749*	*412,406*	*578,256*
Madrid-Barajas	63.8%	67.2%	60.0%	57.7%	58.5%	56.6%	52.1%	47.7%
Barcelona	36.2%	32.8%	40.0%	42.3%	41.5%	43.4%	47.9%	44.9%
Málaga	0%	0%	0%	0%	0%	0%	0%	7.5%
Total	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*

Table 7

Iberia's Intercontinental flights from Barcelona. Source: OAG.

2001				2008			
Destination	Change of gauge	Stops	Average Weekly Freq	Destination	Change of gauge	Stops	Average Weekly Freq
Bogotá	Y	1	6.85	Bogotá	Y	1	3.04
Buenos Aires	Y	1	13.27	Buenos Aires	Y	1	7.46
Caracas	Y	1	6.00	Caracas	Y	1	4.23
Guatemala	Y	2	3.73	Chicago	Y	1	0.12
Lima	Y	1	6.56	Guatemala	Y	1	0.10
Managua	Y	2	5.73	Guayaquil	Y	1	0.56
Mexico	Y	1	7.02	La Habana	Y	1	7.04
New York-JFK	N	0	6.31	Mexico	Y	1	6.46
Quito	Y	1	5.12	Miami	Y	1	6.94
Rio de Janeiro	Y	1	4.58	New York-JFK	Y	1	0.08
Salt Lake City	Y	1	6.62	Quito	Y	1	0.56
San José	Y	2	7.02	Santo Domingo	Y	1	6.94
San Juan	Y	2	3.02				
San Pedro Sula	Y	2	4.19				
San Salvador	Y	3	4.02				
Santo Domingo	Y	1	3.02				
Santo Domingo	Y	2	4.00				
Sao Paulo	Y	1	6.85				
Total Average Frequency			5.77	Total Average Frequency			3.63

Table A.1
Spanish airports considered in the analysis. Source: AENA, 2009.

Group	Airport	Airport Code	Passengers 2001	Passengers 2008
First tier				
	Madrid-Barajas	MAD	34,050,215	50,846,104
Second tier				
	Barcelona	BCN	20,745,536	30,208,134
	Palma de Mallorca	PMI	19,206,964	22,832,865
Third tier				
	Málaga	AGP	9,934,899	12,813,764
	Las Palmas de Gran Canaria	LPA	9,332,132	10,212,106
	Alicante	ALC	6,541,962	9,578,308
	Tenerife Sur	TFS	9,111,065	8,252,017
Fourth tier				
	Valencia	VLC	2,301,191	5,779,336
	Girona	GRO	622,410	5,507,294
	Lanzarote-Arrecife	ACE	5,079,790	5,438,178
	Ibiza	IBZ	4,426,505	4,647,487
	Fuerteventura	FUE	3,577,638	4,492,076
	Sevilla	SVQ	2,205,117	4,391,794
	Tenerife Norte	TFN	2,511,277	4,236,169
	Bilbao	BIO	2,491,770	4,172,901
	Menorca	MAH	2,825,147	2,605,938
	Santiago de Compostela	SCQ	1,281,334	1,917,434
	Murcia	MJV	217,306	1,879,189
Fifth tier				
	Asturias	OVD	816,087	1,530,248
	Granada	GRX	514,966	1,422,013
	Jerez de la Frontera	XRY	802,067	1,302,770
	Reus	REU	744,096	1,279,024
	Vigo	VGO	790,540	1,278,762
	A Coruña	LCG	654,092	1,174,970
	La Palma	SPC	943,536	1,151,357
	Almería	LEI	892,311	1,024,273
	Santander	SDR	272,383	856,606
	Zaragoza	ZAZ	222,167	594,952
	Valladolid	VLL	195,172	479,716
	Pamplona	PNA	340,513	434,062
	San Sebastián	EAS	281,059	403,221
	Melilla	MLN	229,806	314,643
	El Hierro	VDE	134,851	195,275
	León	LEN	24,816	122,809
	Badajoz	BJZ	54,229	81,032
	Vitoria	VIT	129,102	67,818
	Salamanca	SLM	32,056	60,096
	Logroño	RJL	0	47,861
	La Gomera	GMZ	23,404	41,903
	Ceuta (Heliport)	JCU	0	25,645
	Albacete	ABC	0	19,263
Total			*144,559,511*	*203,719,413*

Figure 1

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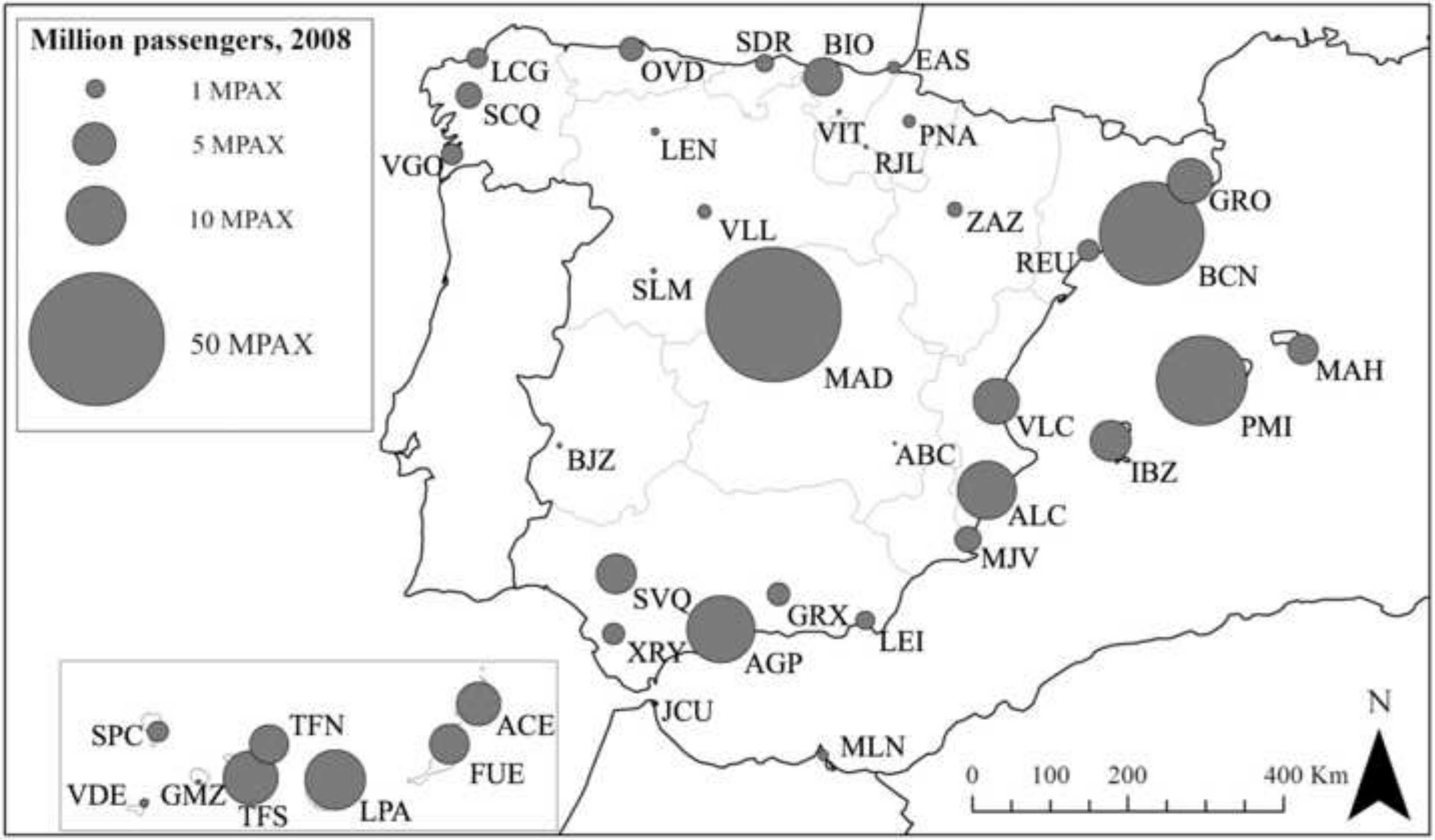

Figure 2

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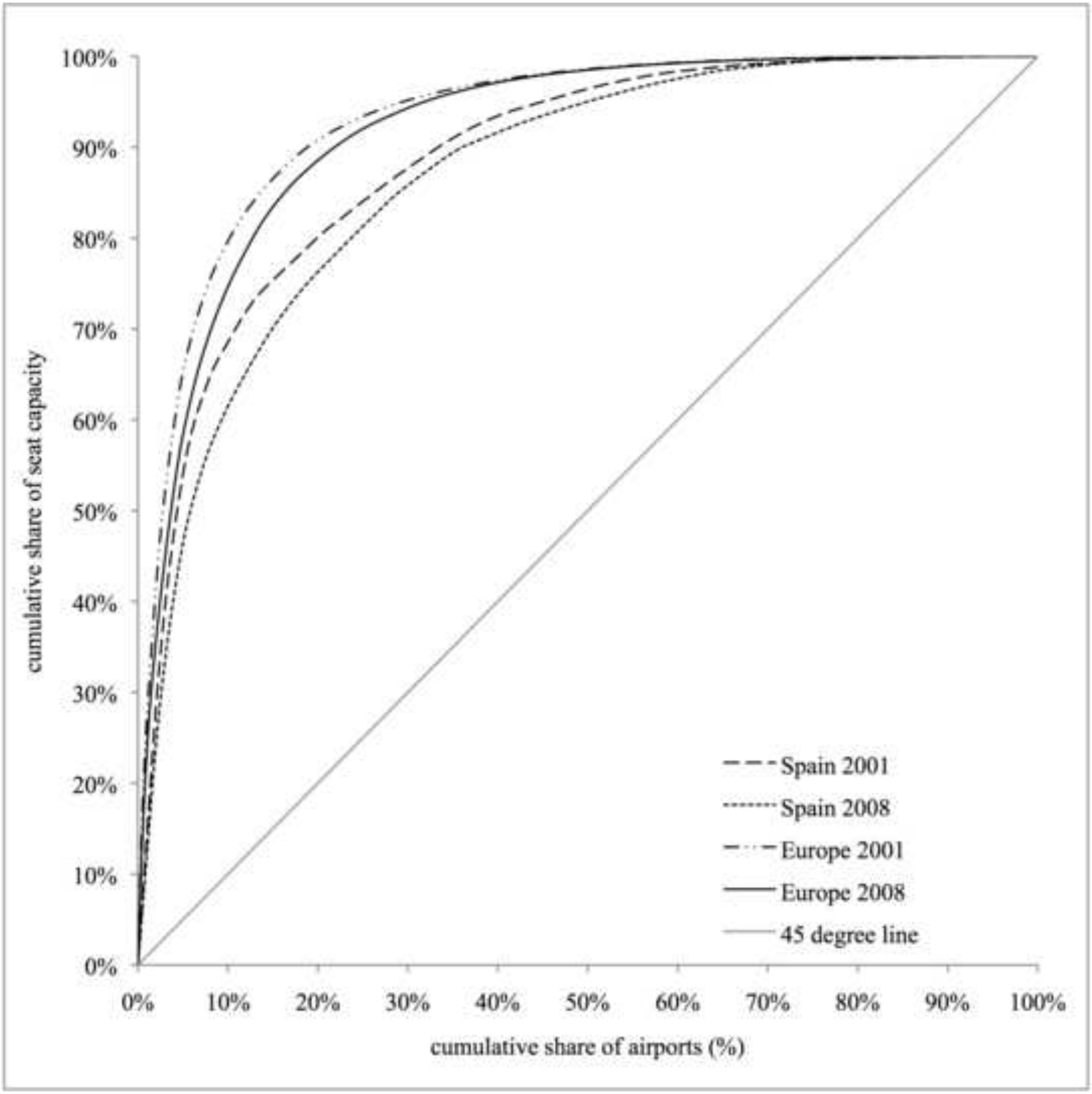

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The geography of the Spanish airport system: Spatial concentration and deconcentration patterns in seat capacity distribution, 2001-2008

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