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Connectivity levels and the competitive position of Spanish airports and Iberia's network rationalization strategy, 2001 to 2007

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Abstract

This paper examines the connectivity of the Spanish airport system between 2001 and 2007 indirect and direct and indirect services. Over the period, hub carriers considerably strengthened the connectivity between Spanish airports and other European hubs. Although oneworld is still the dominant alliance in Spain, SkyTeam and Star additional connectivity share through the growth of indirect services provided through their northern European hubs. In addition, the network rationalization strategy of Iberia and its decision to concentrate operations at Madrid-Barajas had important implications for the connectivity of other Spanish airports. Low-cost carriers have boosted direct connectivity from secondary Spanish airports.

Keywords: Airport connectivity, Madrid-Barajas airport, Barcelona airport.

1. Introduction

The Spanish domestic and international aviation markets, the second largest in Europe in terms of passengers, witnessed a substantial growths in competition the introduction of the Third Package of liberalization measures in 1997. Two main developments stand out. The consolidation of low-cost carriers boosted air-service supply involving Spanish regional airport and Iberia developed Madrid-Barajas into a key hub for traffic between the EU and Latin America, while giving up its secondary operations in Barcelona.

Against the background of these and other market developments, we focus on changes Spanish airport connectivity between 2001 and 2007, defining connectivity as the number of direct and indirect connections between two airports, weighted by the quality of these connections in terms of transfer time and routing time. Therefore, network connectivity analyses respond to the rise and dominance of hub-and-spoke networks. Hence, studying airport connectivity hierarchy provides a complement to traditional top-ten passenger rankings for illustrating the real position of airports in the world-city network..

2. Methodology and data

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The Netscan model is used to the measurement of connectivity (Veldhuis, 1997). Netscan allows measurement of connectivity from two perspectives. The first takes the point of view of the consumer and measures the availability of connections for the passenger travelling between an origin airport A and a destination airport B. Such connections can be either direct or indirect. For a passenger, the quality of an indirect connection is not equal to the quality of a direct connection. In other words, one should take into account the connection quality when considering connectivity. Netscan counts the number of direct and indirect connections and weighs each connection by its quality in terms of transfer and detour time relative to a theoretical direct flight. The second perspective takes the point of view of the hub airport and measures the number of possible connections with a transfer at a particular hub airport.

As input for the Netscan model, we use Official Airline Guide (OAG) flight schedule data covering the 3rd week of September of 2001, 2003, 2005 and 2007. Direct flights can be directly derived from OAG, but it does not provide information about connections, they are built by means of an algorithm. For each incoming flight at a given airport, it identifies the connecting outgoing flights. The algorithm builds the connections for flights with a minimum connection time of 45 minutes, a maximum connecting time of 760 minutes and a maximum routing factor of 170%.[1] Only online, guided connections, transfers between flights of the same airline or flights between airlines of the same alliance group, are considered as being viable.[2]

Netscan attaches a quality index to each direct and indirect connection and scales it to the quality of a theoretical direct connection. The index for each connection ranges from zero to one, with direct, non-stop connections having the maximum value. The index of an indirect connection is always lower than unity because passengers experience poorer connection quality due to the transfer time at the hub and the detour time of the flight. The same holds for multi-stop connections.[3] If the additional travel-time for an indirect connection exceeds a given threshold, the quality index of the connection is zero. The quality threshold of a specific indirect connection depends on the theoretical direct-travel time between the two airports; thus the longer this is, the longer the maximum indirect travel-time. The geographical coordinates of origin and destination airport and assumptions on flight speed and time needed for take-off and landing determine the travel time of a theoretical direct connection. In addition, transfer-time has an additional penalty, as passengers dislike waiting at hubs. Finally, by taking the product of the quality index and the frequency of the connection per week, Netscan calculates the number of connections or connectivity units (CNU).

Over the study period, there were 48 airports in the Spanish system and 41 of these are included here; the remainder (Cordoba, Huesca, Madrid-Cuatro Vientos, Madrid-Torrejon, Sabadell, Burgos and Son Bonet) had no scheduled service during the

[1] The maximum routing factor is defined as the ratio between in-flight time and potential direct flight time. If the detour is excessive the connection is excluded.

[2] Although "self-help hubbing" numbers have risen, and in some cases represent an important number of passengers, this kind of connection is not taken into account.

[3] A non-stop direct flight is a flight between airport A and airport B. 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. An indirect flight is a flight between airport A and airport B stopping at C with a change of aircraft and a change of flight number.

period. We distinguish six geographical destination markets – domestic, Europe, North America, Latin America, Africa and Asia-Pacific, and for 2005 and 2007, three alliances are distinguished (oneworld, SkyTeam and Star) and for 2001 and 2003 Wings is incorporated, it was integrated into SkyTeam in 2004.

3. Direct and indirect connectivity

In 2007, Spanish airports provided over 38,000 CNU to the consumer, half involving direct services. Table 1 shows direct and indirect connectivity in 2001 and 2007 by airport type.[4] On the one hand, direct connectivity increased more at third-, fourth- and fifth-tier airports due to the growing number of low-cost operations. On the other hand, indirect connectivity increased more at first- and second-tier airports, mainly at Madrid-Barajas and Barcelona. Palma de Mallorca, although being part of the second category, had an important loss in indirect connectivity due to its low-cost specialization.

[TABLE 1]

For short-haul routes, the attractiveness of an indirect connection for passengers is much lower due to long transfer and detour times relative to a theoretical direct flight. As Swan (2010) points out, there is a general decrease of the share of direct connections as distance increases. In fact, the share indirect connectivity was only 10% for Spanish domestic destinations, 37% for European destinations and 92% for intercontinental destinations (Table 2).

[TABLE 2]

Domestic destinations represented the majority of direct connectivity, 60% in 2001 against 54% in 2007. This decrease was due to the strong growth of connectivity in international markets, particularly within European. The relative importance of domestic direct connectivity reveals the prominent role of air transport in domestic transport. The country's geographical characteristics, the distribution of the main urban areas and the lack of an effective long-distance train service, until high-speed rail developments, have supported domestic air travel.

The European market was the fastest growing market between 2001 and 2007 in terms of direct connectivity, increasing by 79%. European destinations accounted for 43% of direct connectivity in 2007 and 25% of indirect connectivity (Table 2); about 68% of the direct connectivity being provided by low-cost and leisure carriers, and carriers not members of an alliance, such as Air Europa.[5] Significant growth of low-cost and leisure carriers took place between 2005 and 2007 when their connectivity to Europe increased by 50%. In 2007, Ryanair, easyJet, Air Berlin, Vueling and Clickair together accounted for 33% of the direct connectivity between Spain to the rest of Europe. Conversely, connectivity of major network carriers dropped, for example, Iberia reduced its direct connectivity by 11% and Air France by 6%,.[6]

[4] Here we follow the classification established of Suau-Sanchez and Burghouwt (2011). Using numbers of passengers in 2008 allows the 41 Spanish airports to be classified into five groups by using the natural breaks method and Jenks' optimization (Jenks, 1967).

[5] Air Europa did not join SkyTeam until the end of September 2007.

[6] If we measure competition at the route level using the Herfindahl-Hirschman Index (HHI) we find that, although flagship carriers have been rationalizing their networks to meet competition from LCCs, the average level of competition at the route level increased between 2005 and 2007. While Iberia's routes to

Intercontinental markets

In 2007, intercontinental destinations represented only 3% of direct connectivity, but 69% of indirect connectivity; the most important intercontinental markets being North American and Latin America, which accounted for 40% and 31%. During the period, Latin America exchanged its position of being the best-connected intercontinental market with North America; direct and indirect connectivity to the North American market increased 26% and 23%, whereas direct and indirect connectivity to Latin America decreased by 14% and 16%. Three reasons for the change can be identified. Iberia's network rationalization strategy caused a major drop of connectivity to the Latin American market between 2003 and 2005, which was partly recovered in 2005 to 2007. Second, the network expansion of US network carriers resulted in more direct connections to US hubs and, hence, a sharp growth of indirect connections via them. Third, the quality of the network developed by US carriers is superior to that of South American airlines. In 2001, each direct connection to North America from Spanish airports generated 19.6 indirect CNU via North American and by 2007, this number had risen to 20.1 CNU. In contrast, the number of indirect connections generated at Latin American hubs per direct flight from Spain to Latin America was 1.7 CNU in 2001 and 1.5 CNU in 2007.[7]

The two intercontinental markets with the lowest level of direct connectivity were Asia-Pacific and the Middle East. The former accounted for less than 2% of intercontinental direct connectivity, and the latter for 10%. Despite third, Asia-Pacific ranks as the third largest intercontinental market, thanks to indirect connections. European hubs generated 93% of the indirect connectivity to the Asia-Pacific region, with London-Heathrow, Paris-CDG and Frankfurt-Main providing 64% of the indirect connectivity.

Alliances: the shapers of accessibility

Oneworld, with Iberia as its Spanish airline, is the dominant alliance in Spain; in 2007 it accounted for 40% of connectivity, 33% direct and 46% indirect (Table 3), with Iberian having 46% and 88% shares of this. In 2007, 19 of the 41 airports got more than the 50% of their connectivity from Iberia, and 31 airports for indirect connectivity.

[TABLE 3]

Although OneWorld and its hub at Madrid-Barajas dominates the provision of connectivity between Spanish airports and intercontinental destinations, other alliances and foreign hubs play an important role in shaping accessibility between Spain and the rest of the world (Figure 1). Madrid-Barajas and Barcelona stand out as the airports with the greatest level of connectivity; in both cases, more than 75% of their connectivity to

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European destinations had an average HHI of 0.61 in 2005, in 2007 it was 0.57. The effects of increasing competition is even more noticeable on the routes served by Air France; in 2005 the HHI was 0.73, in 2007 it was 0.64.

[7] Lipovich (2009) identifies hubs how the network is designed in terms of destinations, the excessive minimum connecting times; and large number of connections requiring a visa as the main reasons for the poor performance of Latin American.

intercontinental destinations was provided by foreign hubs. The rest of the airports show very modest numbers, because their intercontinental connectivity is mainly dependent on supply feeding services of Iberia and Air Nostrum in Madrid-Barajas. Even Palma de Mallorca, the third largest Spanish airport in terms of passengers and well connected to Germany (641 direct CNU) and to the rest of Spain (640.2 direct CNU) showed low intercontinental connectivity because its traffic is mainly low-cost and leisure related.

For some Spanish airports, however, indirect connectivity through European hubs has become a way of significantly increasing their overall connectivity level, this, for example is the cases regarding Vigo, Bilbao and Málaga. Vigo and Bilbao are the best examples. In the case of Vigo, 75% connectivity was provided by indirect flights and of this, 59% was indirect connectivity provided by Air France through Paris-CDG. Bilbao is a similar case; 70% of the total connectivity was provided by indirect flights; of this, 33% was provided through Paris-CDG, 17% via Frankfurt-Main and 14% via Milan-Malpensa. These cases are not only show that being connected to major hubs increases the level of connectivity and provides access to a wider market, but also the importance of non-Spanish carriers shaping the accessibility patterns at Spanish airports.

[FIGURE 1]

Oneworld lost part of its market position to SkyTeam and Star. Between 2001 and 2007 oneorld lost, in general terms 1% of its connectivity, while SkyTeam increased its connectivity by 133% and Star by 319%, althoiug both SkyTeam and Star started from a low base. In the case of SkyTeam, part of the growth was the result of the integration of Wings into SkyTeam in September 2004. In the case of Star, an important share of the growth was due to the entry of Spanair into the alliance in 2003. The growing importance of SkyTeam and Star in the Spanish market has not only been achieved by integrating new partners, but also from improving their feeding networks from Spanish airports to their hubs. In fact, of the top ten hubs with large increases in indirect connectivity from Spanish airports to the rest of the world between 2001 and 2007, five belong to Star (Frankfurt-Main, Munich, Philadelphia, Lisbon and Vienna), four to SkyTeam (Paris-CDG, New York-Newark, Milan-Malpensa and Amsterdam) and only one to OneWorld (Madrid-Barajas).

The case of Paris-CDG demonstrates the changing balance of alliances providing indirect connectivity to Spanish airports. Since Iberia is part of OneWorld, one would expect that the non-Spanish European hub providing most indirect CNU would be London-Heathrow. This was, indeed, the case in 2001, but Paris-CDG became the most important onward hub for Spanish airports by 2007. Between 2001 and 2007, indirect connectivity provided by Air France via Paris-CDG from Spanish airports to the rest of the world increased by 76%; with Madrid-Barajas, Barcelona, Bilbao and Vigo feeding Air France's Paris hub. These developments were related to the changes in the feed structure of Air France; after it merged with KLM in 2004 it intensified its operations involving southern European countries.

4. The hub airport perspective: hub connectivity

Table 4 shows hub connectivity, broken down by alliances, at Madrid-Barajas, Barcelona and Palma de Mallorca, the Spanish airports with substantial amounts of hub

connectivity. First, oneworld and Iberia dominated the hub market, with a share of 87% and 75% of hub connectivity via these airports. Second, the hub role of Barcelona disappeared. These chnages show the importance of Iberia's decisions in relation to the competitive position of the Spanish airports.

[TABLE 4]

Iberia, from multi-hub to single hub

Iberia has been restructuring and rationalizing its network for a time. In 1996, it implemented a four wave-system structure for its hub at Madrid-Barajas and a three wave-system at Barcelona (Figure 2). The lack of capacity at the airports, however, did not allow for the improvement of the wave-system at either. However, in February 2006, Madrid-Barajas opened the new Terminal 4 and its Satellite Terminal together with two new runways. This gave Iberia the opportunity to restructure its network.

The first step in the rationalization of Iberia's network involved the de-hubbing of its Miami extra-territorial hub in 2004, but this cannot be directly attributed to its concentration strategy on Madrid-Barajas. The implementation of new US security regulations stipulation that foreign travelers needed to obtain US visas even if they were merely passing through American airports to catch a connecting flight to another country hit the airline's business (Burghouwt, 2007). Nevertheless, since Miami is one of the hubs of Iberia's partner, American Airlines, it remains an important gateway to the US and Latin America for the Spanish consumer.

The second base dismantled by Iberia was its secondary hub in Barcelona. The coupling of operations with the main hub at Madrid-Barajas and the *Puente Aéreo* (the air shuttle between Madrid and Barcelona) operations made Barcelona's hub dependent on Madrid-Barajas' wave-system structure. This, however produced an inconvenient situation in which the first bank of departing flights was at 9:30 am that did not match the demand of the incoming-outgoing business market.

Between 2004 and 2008 Iberia withdrew 5.6 million seats from Barcelona, 785,000 of them to intercontinental destinations, representing 69% of its intercontinental seat capacity at the airport (Suau-Sanchez and Burghouwt, 2011).[8] It also dismantled the wave-system at the airport. As a result, oneworld's hub connectivity at Barcelona fell 69% from 2003 to 2007 (Table 4). The end of hub operations in Barcelona should be understood in the context that concentrating of operations at one hub is generally more profitable than its dispersion over two hubs in close proximity (Burghouwt and de Wit, 2005)[9]

Nonetheless, most of the intercontinental flights served by Iberia from Barcelona were multi-stop flights via Madrid-Barajas, that in most of the cases also involved a

[8] To avoid losing its market position at Barcelona in short-haul markets, Iberia set up the low-cost subsidiary Clickair in 2007, which provided 3.3 million seats to domestic, European and North African destinations from Barcelona. Clickair merged in 2009 with Vueling, and 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.

[9] Iberia's network restructuring is not unique. Since 2000, for example, British Airways de-hubbed London Gatwick and Air France ceased hub operations at Clermont-Ferrand after taking over Regional Airlines. Dual-hub networks can result in profitability problems for airlines if services are duplicated and coordinating two hubs poses financially and operationally challenges.

change of gauge (Suau-Sanchez and Burghouwt, 2011). In fact, in 2003, of Iberia's 168 direct intercontinental flights taking off from Barcelona in the week studies, only 18 were non-stop, the rest were multi-stops, although marketed as direct flights.

[FIGURE 2]

The efforts of the airline to intensify its hub activity at Madrid-Barajas by improving its wave-system structure increased oneworld's hub connectivity by 18% between 2005 and 2007. The restructuring policy was framed in the Iberia Master Plan 2006-2008 (Iberia, 2006) that aimed to optimize the network structure by decreasing the number of destinations, increasing frequencies, and improving aircraft utilization. In addition, the aim was to decrease domestic capacity while increasing the intercontinental market shares focusing on the Madrid-Barajas hub to Latin America as well as feeder services. The Master Plan had a positive impact on the connectivity level to Latin America, with the connectivity increasing by 22%, from 2005 to 2007.

Hub connectivity: the implications of Iberia's rationalization for the consumer

Overall, the larger role of Iberia's hub at Madrid-Barajas provided more possibilities for consumers to access intercontinental destinations. From 2005 to 2007, direct intercontinental connectivity increased by 14%[10] and by 2007, 50% of the airline's direct intercontinental connectivity was to Latin American destinations.

The strategy of Iberia at Madrid-Barajas affected direct and indirect connectivity levels over the rest of the Spanish airports (Figure 3). On the one hand, those airports connected with Madrid-Barajas increased their indirect connectivity because for each Iberia flight arriving at Madrid-Barajas there are more onward flights to connect with. On the other hand, those airports not well served by Iberia lost the possibility of benefiting from the growth at Madrid-Barajas. In particular, the airports where Iberia reduced services are those in which the airline was suffering increasing competition from low-cost carriers and the development of high-speed train services adversely affected Iberia's connectivity in Seville, Zaragoza and Malaga.

[FIGURE 3]

5. Conclusions

We have measured the connectivity level of the Spanish airport system looking both at direct and indirect connectivity the consumer's perspective and at hub connectivity as it affects the performance of airports' hub operations. In the former case, the share of domestic connectivity is quite high showing the good level of connection within the domestic market. For Europe, the growth of direct connectivity by low-cost carriers has been the leading trend, together with a decrease of direct services by network carriers. Regarding intercontinental destinations, North America and Latin America are well covered from Spain because of the dominance of Iberia and oneworld. For other markets, such as Asia-Pacific, the Spanish consumer is almost fully dependent on indirect connectivity through non-Spanish hubs showing the importance these hubs have in generating additional accessibility for consumers. The analysis of hub connectivity centered on the rationalization of the network of Iberia. This had a positive impact on

[10] On the other hand, Iberia's direct domestic and European connectivity decreased by 1% and 11%.

airports connected to Madrid-Barajas, but a negative influence on those airports that were excluded in the rationalization. In the case of Barcelona, although hub connectivity values collapsed, this did not have a significant impact on overall connectivity because the airport is well connected to major European hubs.

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Table 1 Direct and indirect connectivity in 2001 and 2007 by airport tier.

		2001		2007		Δ 2001-2008		
Group	Airport	Direct	Indirect	Direct	Indirect	Direct	Indirect	Total
First-tier								
	Madrid-Barajas	3,857.0	4,738.5	4,626.1	5,998.3	19.9%	26.6%	23.6%
Second-tier								
	Barcelona	2,605.5	3,691.3	3,356.0	5,054.8	28.8%	36.9%	33.6%
	Palma de Mallorca	1,209.1	628.4	1,839.0	425.9	52.1%	-32.2%	23.3%
	Subtotal	3,814.6	4,319.7	5,195.0	5,480.7	36.2%	26.9%	31.2%
Third-tier								
	Málaga	625.1	948.5	1,182.5	742.7	89.1%	-21.7%	22.3%
	Las Palmas	575.5	478.2	794.1	527.4	38.0%	10.3%	25.4%
	Alicante	355.0	331.5	742.0	294.9	109.0%	-11.0%	51.0%
	Tenerife South	201.2	178.0	287.2	168.7	42.8%	-5.2%	20.3%
	Subtotal	1,756.8	1,936.1	3,005.8	1,733.7	71.1%	-10.5%	28.3%
Fourth-tier								
	All (11 airports)	2,643.3	3,139.3	4,432.4	3,352.4	67.7%	6.8%	34.6%
Fifth-tier								
	All (23 airports)	1,112.5	1,858.4	1,890.6	2,569.4	69.9%	38.3%	50.1%
Total		13,184.2	15,992.1	19,149.9	19,134.5	45.2%	19.6%	31.2%

Table 2 Connectivity at Spanish airports by destination market.

Destination market	2001		2003		2005		2007	
	Direct	Indirect	Direct	Indirect	Direct	Indirect	Direct	Indirect
Europe (without domestic)	4,607.6	3,431.7	5,221.5	3,641.3	6,173.0	4,303.3	8,226.1	4,845.0
Domestic	7,886.4	1,227.8	7,567.9	995.1	8,750.6	1,034.2	10,238.3	1,194.7
North America	111.0	4,356.3	116.6	4,716.0	104.5	4,942.8	140.1	5,353.6
Latin America	315.8	4,635.3	307.5	4,158.5	243.0	3,253.1	272.6	3,930.2
Asia-Pacific	7.9	1,317.8	8.1	1,429.8	12.2	1,957.1	11.2	2,350.7
Africa	208.1	490.1	152.4	602.7	166.0	666.7	194.0	755.1
Middle East	47.4	533.2	48.7	463.8	56.2	619.7	67.5	705.0
Total	13,184.1	15,992.1	13,422.7	16,007.1	15,505.5	16,776.9	19,149.8	19,134.5

Table 3 Connectivity at Spanish airports by alliance.

Alliance	2001		2003		2005		2007	
	Direct	Indirect	Direct	Indirect	Direct	Indirect	Direct	Indirect
SkyTeam	338.3	2,199.7	352.2	2,630.2	606.2	4,611.0	651.9	5,275.0
Star	327.6	1,338.8	1,576.4	2,199.7	2,105.7	3,217.1	2,816.2	4,162.5
OneWorld	5,962.5	9,394.6	6,088.4	9,228.9	6,484.5	8,154.7	6,343.2	8,876.4
Wings	217.9	1,128.2	224.8	1,030.8	-	-	-	-
Non-network carriers	6,337.8	1,930.8	5,180.9	917.5	6,309.0	793.8	9,338.6	820.6
Total	13,184.2	15,992.1	13,422.7	16,007.1	15,505.5	16,776.9	19,149.9	19,134.5

Table 4. Hub connectivity at Madrid-Barajas, Barcelona and Palma de Mallorca.

	Alliance	2001		2003		2005		2007	
		CNU	%	CNU	%	CNU	%	CNU	%
Madrid-Barajas	OneWorld	15,139.8	93.2	14,882.4	94.5	13,933.4	91.7	16,919.6	91.0
	SkyTeam	93.4	0.6	67.8	0.4	185.4	1.2	233.5	1.3
	Star	4.0	0.0	578.2	3.7	767.2	5.1	1,016.2	5.5
	Wings	21.4	0.1	21.6	0.1	-	-	-	-
	Others	982.1	6.0	203.7	1.3	302.8	2.0	419.1	2.3
	Total	16,240.7	100	15,753.7	100	15,188.8	100	18,588.3	100
Barcelona	OneWorld	3,208.2	97.6	3,701.3	95.0	1,838.1	80.3	1,144.9	62.2
	SkyTeam	36.9	1.1	34.8	0.9	63.9	2.8	91.4	5.0
	Star	-		152.9	3.9	369.5	16.1	589.0	32.0
	Wings	-	-	2.4	0.1	-	-	-	-
	Others	42.6	1.3	6.6	0.2	18.1	0.8	16.6	0.9
	Total	3,287.6	100	3,898.0	100	2,289.7	100	1,841.9	100
Palma de Mallorca	OneWorld	5.4	66.1	2.9	2.6	6.3	1.7	7.4	1.7
	SkyTeam	-	-	-	-	-	-	-	-
	Star	-	-	2.8	-	3.8	1.0	9.8	2.3
	Wings	-	-	-	-	-	-	-	-
	Air Berlin	-	-	103.3	-	369.3	97.3	411.4	96.0
	Others	2.8	33.9	1.7	1.5	0.1	0.0	0.2	0.0
	Total	8.1	100	110.6	100	379.5	100	428.7	100

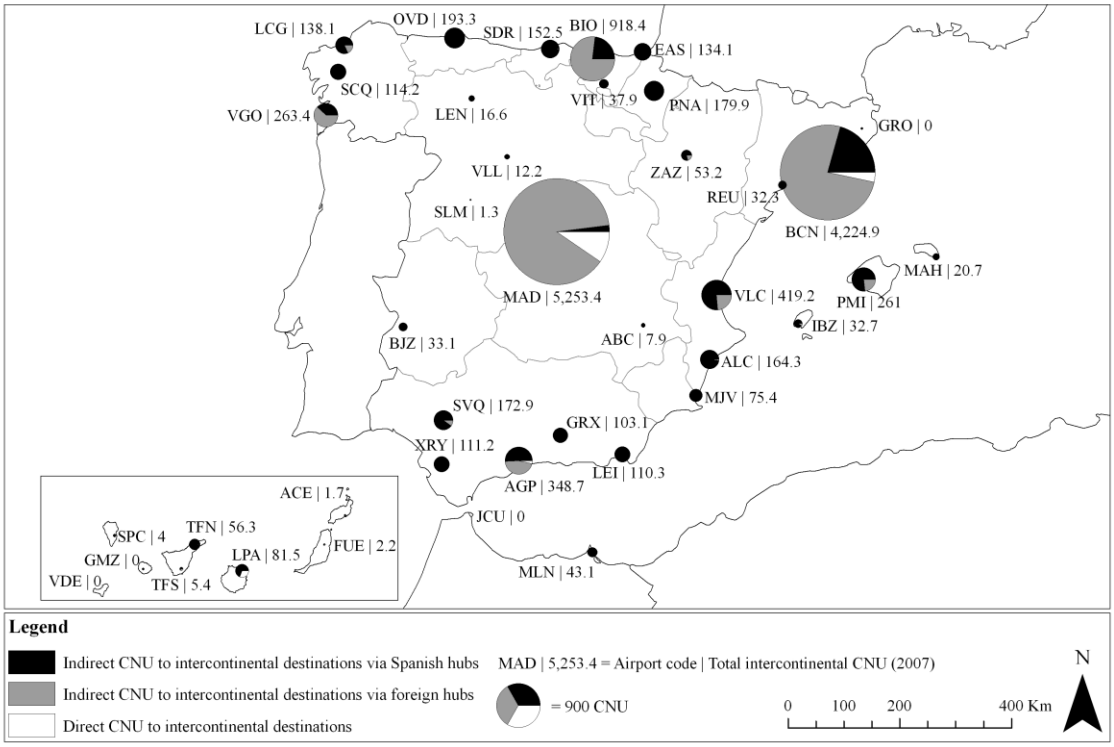

FIGURE 1. Connectivity to intercontinental destinations, share of national and foreign hubs in indirect connectivity, and direct connectivity, 2007.

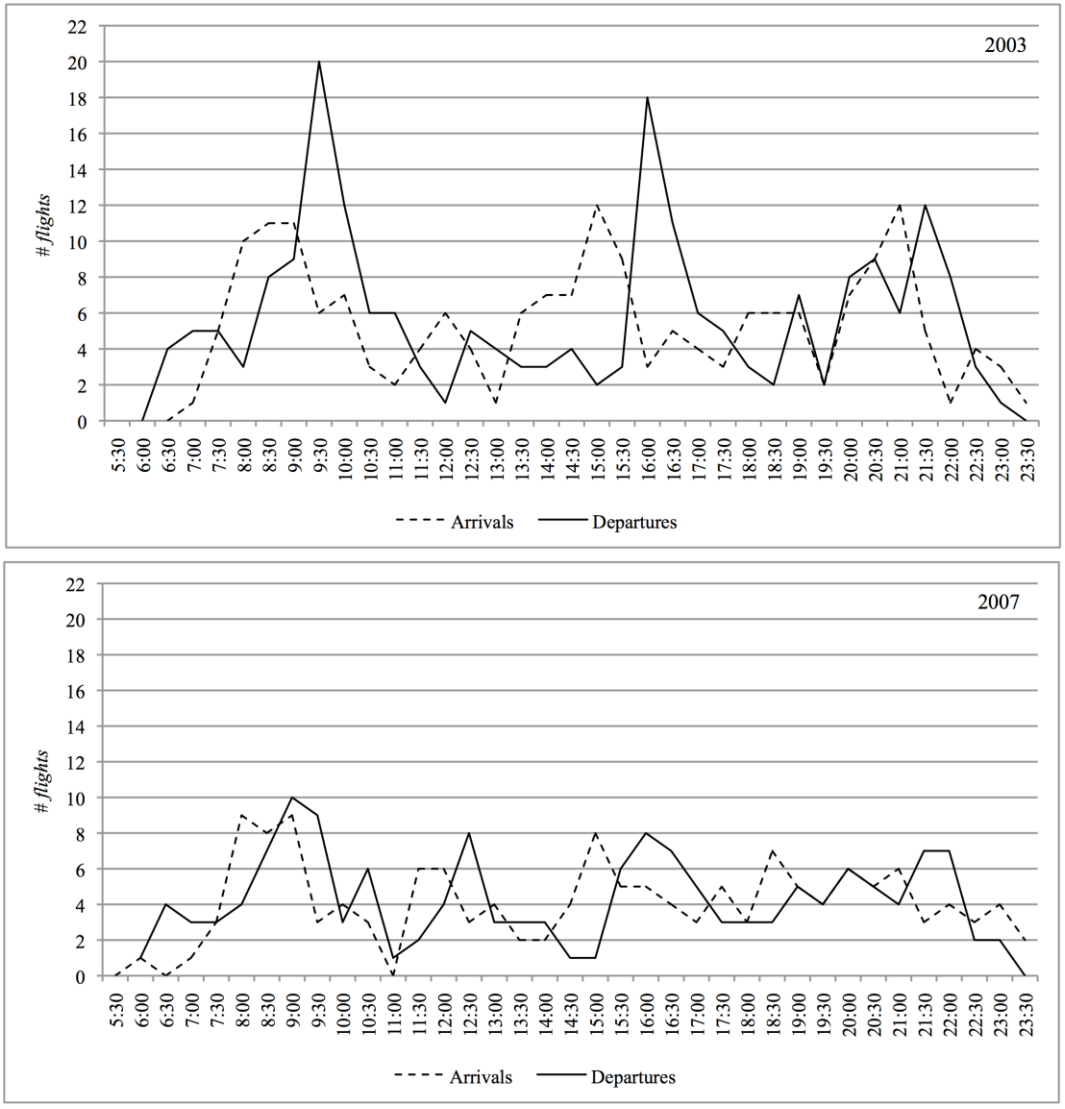

FIGURE 2. Wave-system structure of Iberia at Barcelona (2003, 2007)

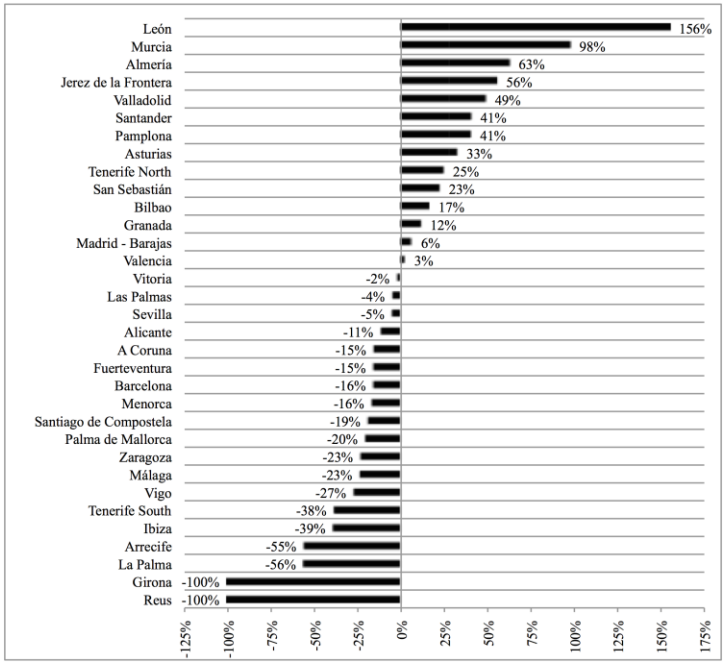

FIGURE 3. Connectivity growth of Iberia by airport (2001 to 2007).