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De-hubbing cases and recovery patterns

by

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De-Hubbing cases and recovery patterns

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ABSTRACT

The objective of this work is to analyze the cases of de-hubbing during period 1997-2009 in the world-wide air transport network. To the best of our knowledge, this is the first attempt to study de-hubbing in a systematic way. In order to identify those cases, this paper firstly addresses the issue of which quantitative conditions must be met for airports to be identified as de-hubbing cases. These conditions include the declining presence of the hub carrier, or hub alliance, within the airport, that results in a decrease in the number and quality of connections offered. The second phase is to study what happens after de-hubbing by clustering the cases into homogenous scenarios. Our results show that, on average, airports that suffered de-hubbing did not recover their original traffic in 5 years. Results suggest that de-hubbing is not likely to be reversible. When hub carriers are replaced at least partially by low-cost carriers, the airports on average show faster recovery trends. The most frequent case is when, after de-hubbing, the airports traffic declines. The impact of de-hubbing on the number of destinations is less severe than its effect on offered seats.

KEYWORDS: de-hubbing, recovery scenarios, airport network.

1. Introduction

On March 31, 2008 Alitalia abandons the Malpensa airport, by cutting 180 flights a day and moving 14 intercontinental routes to the Rome Fiumicino airport. That is an example of the numerous recent cases in which the dominating carrier dismantles its hub-activities in one of its main bases.

A hub is an airport where traffic is concentrated in order to foster connections typically to intercontinental long-haul destinations. To do this requires the presence of the feeding network, a series of medium-and short-haul connections that are concentrated in specific times and temporally coordinated with intercontinental flights. A hub is not simply a big airport, but an airport that can generate a high number of transit passengers. Due to the presence of transit passengers, in addition to origin passengers, the hub airline has a sufficient traffic volume to offer more routes and frequencies to long-haul destinations, compared to those that would have been provided based only on the origination traffic.

The partial or complete abandonment of a hub by the dominant carrier is known in literature under the term "de-hubbing" (Bhadra, 2009, Shaw and Ivy, 1994). It refers to the process of dismantling the structure of connections offered by the hub airline that could result in its complete withdrawal from the airport.

What are the development scenarios for an airport which suffered de-hubbing? Is it likely to be “re-hubbed” by the same carrier or other carriers? What strategies are necessary to prevent decline? The study of international cases can provide some guidance to answer these questions.

To the best of our knowledge this is the first attempt to study de-hubbing in a systematic and quantitative way.

The literature section introduces several well-known examples of de-hubbing highlighting their causes and direct effects. The methodology and data section analyzes the quantitative conditions to be met for a de-hubbing to take place. We apply those conditions to all airports with scheduled services operating world-wide in the period 1997-2009. The empirical results section examines the possible developments from de-hubbing paying particular attention to the implications for airports and passengers. The concluding section summarizes the main findings of the paper and discusses the directions for future research.

2. Literature Review

Hubbing activities have seen a big increase from the liberalization of the U.S. market in 1978, when large U.S. companies began to restructure their networks by adopting hub & spoke configurations (Morrison and Winston 1986). The advantages associated with such a configuration result from the presence of economies of density (Tretheway and Oum 1992) and in some cases economies of scale, although on the latter literature has produced only minor evidences (Antoniou, 1991). Hub & Spoke configurations allow hub carriers to offer a not-easily replicable service giving rise to positions of dominance (Borenstein, 1989).

The most natural cause of de-hubbing is the failure of the hub carrier. An example is the airport of Raleigh-Durham after the failure of Midway or the Brussels airport following the bankruptcy of Sabena. Zurich also suffered from the failure of Swissair and the subsequent formation of a new carrier, Swiss, although in this case there was only a partial dismantling of the hub & spoke system, supported by Swissair's partners.

In other cases, de-hubbing follows the strategic choice of hub carriers to reducing their presence, and often completely abandoning the airport. Among their motivations there are the performances and strategic objectives of the airport operators. When several airports could be employed as available alternatives, as in the case of US or EU, the type of services offered by the airport together with the related charges may influence the choice of carriers to locate their hub activities.

In this respect we classify the case of Denver, where in 1994 following the closure of the old airport and contextual opening of the new International airport, the incumbent carrier Continental decided to abandon its hub activities. In this case there was an evident mismatch between the interests and the strategic visions of the airport and the hub carrier. Szyliowlcz and Goetz (1995) showed that in a project of this magnitude airport and carrier are deeply involved and other factors, not least political motivations, play a determinant role.

Low cost carriers also play a prominent role to induce hub carriers to rationalize their multi-hubs networks, especially in contexts of recession. Berry and Jia (2008) identify in the entrance of low-cost carriers, the main element to induce changes in the US network, including the abandonment or partial withdrawal of the incumbent carrier in some hubs. This is the case of the airport in Baltimore, which was subjected to the so-called "Southwest effect" described by Vowles (2001).

The rationalization of the network in multi-hubs systems typically occurs as a result of mergers and acquisitions activities or as an effect of economic recession. Both these phenomena, often together, affect the balance between carriers by promoting the development of alliances and opening up new strategic options. In the case of Nashville (Johansson, 2007) following the bankruptcy of Eastern Airlines in 1995, American Airlines decided to enter the market to Latin America moving to Miami and thereby reducing hub activities at Nashville and Raleigh-Durham. In the case of San Jose, hubbing activities started by American Airlines after the acquisition of Air California, were then partially sold to Reno Air.

The liberalization process in Europe has also changed airline competition and network structure. Thompson (2002) and Dennis (2005) pointed out that the role of the secondary hub of Clermont-Ferrand failed within the new Air France network, because of its overlapping with Lyon.

Similarly, in the case of Barcelona (Burghouwt, 2008), the limited success of the hub structure is due to the failure to define a specific role for this airport within the Iberia network, and avoid duplications with Madrid.

Secondary hubs are more vulnerable than primarily hubs in times of recession. Financial problems may trigger a process of consolidation and contraction of existing networks. The de-hubbing of Cincinnati to favour Atlanta, following the merger between Delta and Northwest is an emblematic example. British Airways formerly decided to develop Gatwick to overcome the growth limitations imposed by congestion at Heathrow. However, this choice did not prove profitable, so that in 2000 the airline reduced its network in Gatwick and refocused on Heathrow (Halstead, 2001). Basel also suffered the dismantling of hub activities following the bankruptcy of Swissair (Dennis 2005). In this case the newly-born Swiss airline did not replace them.

<Table 1 about here>

Network restructuring has accelerated due to the aggregation process in the three major global alliances (Oneworld, Star, Skyteam). Dennis (2005) linked the main reasons for de-hubbing in Europe to the carriers' new role within alliances. However, studies in the literature do not clarify whether the ongoing consolidation will lead to a greater concentration of traffic on a few major hubs (Dudden, 2006) or whether the current network configurations are to remain.

The recent case of the Malpensa de-hubbing highlights the joint presence of several motivations discussed above. There is no doubt that the "Malpensa 2000" project was mainly driven by political motivations. Little thought was given at the time to the economic rationales for establishing a dual-hub system in Italy, or to the new role of the other Milan-based airport of Linate.

The prolonged financial difficulties of Alitalia and the gradual contraction of its network is the second factor that led in time to the unsustainability of a dual-hub system. Finally, in the light of the Alitalia' role within SkyTeam, the Malpensa proximity to the main hubs of Paris and Amsterdam further diminished the functionality of a hub located in northern Italy.

Table 1 summarizes the cases of de-hubbing considered by literature and their main references. This paper does not limit the analysis to those famous cases but, by considering quantitative criteria, takes into account also less known instances of de-hubbing and their effects on airport traffic.

3. Methodology and data

The main issue of this work is how to measure hub activities in airports. Since a hub is an airport that generates a high proportion of transit passengers, the volume of transit passengers itself could be employed to measure the extent of hub activities. However, there are certain drawbacks to this natural measure. The most relevant is about data availability. The volume of transit passengers is generally known only for major hubs. Then, even for those airports it is rarely possible to recover that information before the year 2000 and almost impossible to have monthly statistics. So, basing the analysis on the volume of transit passengers would have resulted in seriously limiting the study to major airports and for the recent years.

We decided to consider instead a supply-based measure of hubbing activities taken from literature on connectivity of air transport networks. See Burghouwt and Redondi (2010) for a review of the different measures in this field. They also show that traditional size-based measures as the number of passengers, number of flights or number of destinations, tend to overestimate the importance of airports as connecting hubs. Based on scheduled information, our measure is simply the number of "viable" connections between incoming and outgoing flights happening in a given airport. We considered three conditions for a connection to be considered as "viable":

- the connection must be between flights of the same carriers (online transfers) or between flights operated by different carriers belonging to the same alliance (interline-transfers).
- the time between the incoming and the outgoing flights must be between one hour (minimum connecting time) and three hours (maximum connecting time);
- the routing factor of the one-stop itinerary starting from the origin of the incoming flight, passing by the considered airport and arriving to the destination of the outgoing flight, must be less than or equal to 1.2. So, the detour necessary to complete the trip must be at maximum 20% of the direct distance between origin and destination.

The last two conditions discriminate the quality of connections, by considering only those that have a high probability to be employed by transit passengers. Since Burghouwt and Redondi (2010) show that the different connectivity measures yield similar results at an aggregate level and for longitudinal studies aimed to show how connectivity of a single airport changes over time, we deem further complications in the connectivity index unnecessary.

For each airport with scheduled flights and for each month in the period January 1997-September 2009, we compute this connectivity index. Since it requires actual connections in a specific day, we analyze every third Wednesday in each month of the period. Our sample covers all 2.141 airports worldwide with at least a viable connection during the period. We employ OAG scheduled flights data.

<Figure 1 about here>

Figure 1 shows the overall number of viable connections in the analyzed period. There are a few features worth of evidence. Starting from 1997 the number of connections, a proxy for hub activities, steadily increased till September 2001 when it dropped significantly. After that, it recovered in 2002-2004 and has ranged between 400,000 and little above 500,000 since. The average number of connections decreased in late 2008 and 2009 due to economic recession. One would also observe a marked seasonal effect, since May, June and July are by far the most relevant months in terms of number of offered connections.

<Table 2 about here>

Table 2 shows the first twenty airports in the world in terms of the number of viable connections, as defined above, computed for the last period of the analysis, on Wednesday 16th September, 2009. The first five in the ranking are US airports, confirming the importance of hub activities especially for the US domestic market. The Atlanta airport has the highest number of viable of connections by far. By this measure, the main European airports are Frankfurt, Paris Charles De Gaulle, Munich and London Heathrow with more than 8,000 viable connections per day.

After having defined the measure of hub activities, we now address the issue of de-hubbing identification. As the monthly number of connections is subjected to yearly seasonal trends as well as longer-term variations, we proceeded to de-season it in two steps.

Firstly, we de-season the monthly number of connections on an airport-base. So, for each airport, we smooth intra-year effects that could result in sharp decreases in monthly hub activities not induced by a de-hubbing process.

Secondly, we de-trend the number of connections from the overall longer-term variation. As the number of connections decreased sharply in September 2001, that could result in identifying a great number of (false) de-hubbing cases. After de-trending on the overall sample, de-hubbing is potentially identified for airports whose number of connections decreases significantly more than the average. The number of connections resulting from these modifications is referred to as the adjusted number of connections.

The conditions to be met for de-hubbing identification are as follows:

- we look for two successive months t_1 and t_2, $t_1<t_2$, where the adjusted number of connections decreases by at least 75%. We do not further constraint the de-hubbing period, t_2-t_1. By doing so we take into account both the cases of sudden de-hubbing, when the hub-carrier sharply decreases its hub activities, and gradual de-hubbing, when the hub carrier slowly but steadily reduced its hub activities from the airport.
- We also consider a dimensional constraint. We include de-hubbing when the initial adjusted number of connections, measured in t_1, is higher than 150 connections per day. This is to exclude smaller airports that are not to be considered as hubs in the first place. With no dimensional constraint, an airport with 4 daily flights in t_1, 2 incoming and 2 outgoing, and only 2 flights in t_2 could reduce its number of connections by 75% from 4 to 1 and so be included in the de-hubbing case. The limit of 150 connections, meaning that the airport offers connections between on average 12-13 incoming and outgoing flights per day, is set to a relatively low level, also accounting for de-hubbing in secondary airports. We find 123 airports in the initial month, January 1997, which satisfy this constraint. This number increases to 154 in the final month of our analysis, September 2009. There are also 90 airports with an adjusted number of connections higher than 150 for all the months in the period.
- The airport continues some of its scheduled services after de-hubbing. This condition is to exclude from de-hubbing cases in which old airports were closed and replaced by new ones.

4. The de-hubbing cases

By applying those conditions reported in the methodology section, we obtain 37 different cases of de-hubbing. Table 3 shows a geographical distribution of de-hubbing among the main areas. As expected, Europe and North America have the greatest number of cases, closely followed by Central-South America and Asia-Pacific region.

<Table 3 about here>

<Figure 2 about here>

Figure 2 reports the temporal distribution of de-hubbing cases. As seen above, each de-hubbing is identified within a period from t_1 to t_2. In this figure we classify a de-hubbing to the month t_3, included in the interval [t_1, t_2], where the decrease in the adjusted number of connections is higher.

From Figure 2 one would observe that the greater number of de-hubbing cases happened in the immediate aftermath of September 11th, 2001. The second wave of de-hubbing happened in the second half of 2003, after the spreading of SARS. So, crises in the air transport industry could trigger de-hubbing processes either directly by the bankruptcy of the hub carriers or indirectly by their decision to restructure their network.

<Table 4 about here>

Table 4 reports the major ten de-hubbing cases in terms of the adjusted number of connections just before de-hubbing. The most relevant and much studied de-hubbing cases happened in the US airports of Cincinnati, Pittsburgh and Lambert-St. Luis. There are then the three European cases of Milan Malpensa, Brussels and London Gatwick of which we already referred in the literature section. The Ronald Reagan National airport suffered temporal de-hubbing after September 11th, 2001, due to security restrictions imposed on air traffic in the Washington area. The Luis Munoz Marin airport suffered de-hubbing by American Airlines in September 2008, when the carrier truncated flights by over 50 percent. In the case of the Orlando International airport, Delta Air Lines pulled gradually much of its large aircraft operations from Orlando and ended all services in September 30, 2008. The tenth case is that of the Kimpo International airport that was the main airport for Seoul and South Korea before its international activities were moved to the Incheon International Airport in 2001. A similar case is that of the second Milan-based airport of Linate, also identified as a de-hubbing case in our analysis. In the end of 1998 the bulk of its international activities by Alitalia were moved to the newly restructured airport of Malpensa. Both the cases could be considered as de-hubbing following network restructuring in which political motivations played a relevant role. However, both airports continued their services, even if mainly at a national level, and no other carrier has so far replaced hub activities. So, we decided not to exclude these cases from our analysis. A complete list of the 37 de-hubbing cases is reported in Appendix[1].

5. De-hubbing effects and recovery patterns

We study the effects of de-hubbing on the airports offered seats. We compare seats offered the year before de-hubbing to those offered from 1 to 5 years after de-hubbing. Figure 3 shows average traffic variations for all 37 airports which suffered by-hubbing. On average, offered seats decrease by 19.1% one year after de-hubbing compared with the pre-de-hubbing year. Offered seats continue to decline also in the second year by 23.6%, compared to the year before de-hubbing. A slow-recovery trend starts from the third year after de-hubbing. However, after 5 years, offered seats are still below the pre-de-hubbing mark by 17.5%. One would observe that offered seats decline much less than the adjusted number of connections. In fact, to be considered as de-hubbing, the airport must see a reduction of at least 75% in terms of the adjusted number of connections. On the one hand, it confirms that hubbing activities cannot be approximated to size-related measures since the former has a square effect with respect to offered flights that the latter lacks. On the other hand, it validates the use of the adjusted number of offered connections as a supply-based proxy for hub activities.

Figure 3 also reports changes in offered seats for airports comparable to those which suffered de-hubbing. To be comparable, an airport has to have a size, in terms of offered seats, within 10% of the de-hubbed airport and has to operate in the same geographical region.

<Figure 3 about here>

Interestingly, the year after de-hubbing, offered seats in comparable airports remain almost unchanged (+0.1%), confirming that de-hubbing happens on average in periods of slow-growth or decline of the air transport industry. However, in five years comparable airports see offered seats increasing by 16.2%, against a decline by 17.5% in airports which suffered de-hubbing.

[1] Further information on the specific de-hubbing cases indentified in this study is available from the authors on request.

In order to identify the specific recovery patters after de-hubbing, we classify each of the 37 cases by the following two criteria:

1. if the adjusted number of connections after de-hubbing recovered its initial value in time, the case is classified as “re-hubbing”;
2. we consider offered seats after 5 years from de-hubbing. If de-hubbing took place less than 5 years before September 2009, we consider offered seats in September 2009.
    - If more than 50% of seats is then offered by an Alliance, we classify the case as “Alliance-dominated”;
    - If more than 50% of seats is then offered by low cost carriers, we classify the case as “Low cost-dominated”;
    - If more than 50% of seats is then offered by unallied carriers, we classify the case as “Unallied-dominated”;
    - or else, we classify the case as “Battleground”.

The “Battleground” category includes airports whose offered seats are strongly divided into the first three groups with no clear dominant positions.

Table 5 reports the changes in offered seats after de-hubbing dividing the cases into the categories above defined.

<Table 5 about here>

A number of interesting observations can be drawn. First of all, we indentified only 3 cases in which the adjusted number of connections recovered in time its value before de-hubbing (re-hubbing scenario). Those airports almost recovered their initial seats capacity. In the fifth year after de-hubbing they offer a number of seats below the level before de-hubbing by 3.9%, against -17.5% for all 37 cases and -20.4% for the other 34 where de-hubbing was not reversed.

There are no re-hubbing cases where the airport is dominated by low cost carrier (Low cost-dominated) or contended by different groups of carriers (battleground scenario). So, some forms of dominance by traditional carriers seem necessary for re-hubbing to take place.

Looking at the 34 cases in which de-hubbing did not reverse, one would observe very different recovery patterns. In the Low cost-dominated scenario, the initial offered seats volume is recovered in five years with offered seats above their initial mark by 12.8%.

The other scenarios, Allied-dominated, Unallied-dominated and Battleground have very negative developments. Those airports, on average, do not show any recovery trend. Only in the Battleground scenario, offered seats bottom out in the second year after de-hubbing and then show a slow partial recovery to -22.6% in the fifth year. The next part of this section considers an in-depth analysis these findings.

5.1. Re-hubbing

Following the criteria described in the methodology and data section, we identify three cases of airports which had suffered de-hubbing and later recovered their initial hub activities, measured as the adjusted number of connections.

From table 5, the only re-hubbing case classified as Alliance-dominated as that already mentioned of the Ronald Reagan National airport in Washington. In this case, de-hubbing was due to stricter security limitations for the Washington airspace following the September 11th, 2001. So, after some months security partially relaxed and the hub carrier, US Airways, operated again its hub activities. However, in terms of offered seats, after 5 years the airport did not recover its initial traffic.

All the other two are classified in the Unallied scenario since five years after de-hubbing airports are dominated by a traditional and unallied carrier. In the case of the Ninoy Aquino International Airport, in Philippines, the hub carrier Philippine Airlines was severely affected by the 1997 Asian Financial Crisis. So, it was forced to downsize its international operations by the airport. After corporate restructuring, the airline gradually restored its services. In the case of the Shanghai Hongqiao airport, China Eastern Airlines transferred international activities to the new Shanghai Pudong International Airport in 1999. However, due to the strong growth of the Chinese domestic market, in time even the Shanghai Hongqiao airport recovered hub activities.

There are no cases where re-hubbing took place by another carrier. In general, conditions that can make possible a re-hubbing by another carrier are demanding. If an airport is employed as hub by a carrier, then its geographical position is favorable to be connected to other airports of its network. In other words, the detour necessary to connect the origin to the destination airports via the hub, compared with a direct connection, is low. For this reason, it is very difficult to find another airline for which the same airport is ideal for hub location. This condition is more likely to be met when the new carrier operates, or has an interest in expanding, in the origin and destination markets served by the former hub carrier.

5.2. The low-cost alternative

When the airline abandons its hubbing activity, re-hubbing is not likely to take place, especially by other carriers. So, what should an airport do to avoid decline?

The four European airports of Birmingham, Basel-Mulhouse, East Midlands Nottingham and Glasgow have fostered the development of low-cost carriers which became dominant five years after de-hubbing, respectively FlyBE, Easyjet Switzerland, bmibaby and easyJet. They show the best recovery development in five years with offered seats above the pre-de-hubbing mark of 12.8%, from table 5. However, out of 37 de-hubbing cases, only 4 followed this development patter.

It is also of interest to look at airports where the major airline is a low-cost carrier, even if it offers less of 50% of seats. We find that in the Battleground scenario, out of the 12 cases shown in table 5, in four the main carrier is low-cost. Table 6 reports traffic developments for those cases.

<Table 6 about here>

When the first carrier is low-cost, seats capacity decreases much less year by year. Five years after de-hubbing offered seats are above the initial value by 9% against a decrease of 27.1% in the other cases. So, even if the airport is not clearly dominated by carriers or alliances, a recovery path is still possible if low-cost carriers take the lead. These cases are that of the American airports of Albany, Orlando and New Orleans Louis Armstrong with a relative dominance of Southwest, and the recent case of Milan Malpensa by easyJet. However, as in the case of Low cost-dominated scenario, complete traffic recovery does not come before 4-5 years from de-hubbing.

<Figure 4 about here>

Figure 4 shows the relationship between the percentage of offered seats by low cost carriers and the increase in seats capacity 5 years from de-hubbing, including all airports considered in this study. It confirms a robust positive relation with a statistically significant coefficient of about 0.5, meaning that, on average, each percentage point of seats by low cost carriers brings an extra-growth of 0.5%.

The airport's strategy to favour low-cost carriers has profound implications. It implies an effort to reduce costs and airport charges. Infrastructures dedicated to the support of long-haul flights may no longer be adequately remunerated. Furthermore, this strategy is likely to be irreversible. The probability of traditional carriers offering new hub services is very low since they would face aggressive competition for their short-haul feeding flights.

5.3. The decline

Table 7 reports statistics on de-hubbing effects for airports with no majority presence of low-cost carriers. Looking at averages and medians value one would see very declining trends.

However, there are relevant variations within these 26 cases. The most positive exception is the Adelaide airport, classified in the Alliance-dominated scenario which suffered de-hubbing at the end of 2001 by the bankruptcy of Ansett Australia but later recovered seats capacity by Qantas Airways. The only other case of de-hubbing which later recovered capacity in five years with no predominant presence of low-cost carriers is that London Gatwick, classified in the Battleground scenario. Five years after de-hubbing by British Airways in 2000, the first carrier was still British Airways just offering 31.6% of seats, almost half of its the pre-de-hubbing share. However, a significant part of the growth was due to the rapid development of easyJet, that later became the most important carrier in that airport. A part from these two cases that recovered in five years their initial traffic, even if they grew much less than their comparables, all other 24 cases saw significant reductions in capacity.

<Table 7 about here>

The three main de-hubbing cases considered in this study as reported in table 4, the US airports of Cincinnati, Pittsburgh and Lambert-St. Luis suffered similar fate. The former hub carriers, Delta Air Lines, US Airways and American Airlines remained the first carriers in the airports. At the end of our monitoring periods, their traffic declined to respectively 43%, 57% and 42% of their initial levels. A similar case is that of the French Clermont-Ferrand airport, a secondary hub for Air France. After de-hubbing, the former hub carrier remained the main operator in the airport. As a result, in five years it lost 50% of seats capacity.

Analogously, the Nice airport suffered de-hubbing by Air France in 2001 that decided to concentrate intercontinental services to its main hub of Paris Charles de Gaulle. In this case, however, the favorable position of the airport to serve the south coast of France, attracted in time other carriers, among which the low-cost easyJet and carriers from other alliances. For this reason, the Nice airport, classified in the Battleground scenario, contained its reduction in seats capacity to 5% in 5 years with respect to its initial value.

This case exemplifies several characteristics of the airports in the Battleground scenario. After the abandonment by the hub carrier, the traffic potentiality of their catchment areas attracts other carries. Alliances are very keen to enter the airport to offer passengers connections to intercontinental destinations by their main hubs. In this respect, other examples are those already mentioned of Milan Malpensa, London Gatwick and Brussels in Europe, and the US airports of Albany International, Louis Armstrong International, Lambert-St. Louis International, Colorado Springs and Raleigh/Durham.

A further primary objective of alliances to offer at least a minimum service is to preempt competition and make re-hubbing by rival alliances or unallied carriers much less likely. For that reason, as showed in table 6, airports classified in this scenario have better prospective if a low-cost carrier takes to lead.

5.4. Impact on territories

In this section we assess the impact of de-hubbing on region accessibility by looking at the number of destinations available for departing passengers. Figure 5 compares the impact of de-hubbing on offered seats and on the number of destinations and intercontinental destinations.

In each year, the number of destinations offered after de-hubbing decreases less than offered seats. So, the decline in offered seats is driven mainly by a decrease in frequencies or in aircraft seats capacity rather than by cutting the number of destinations. The negative effect on accessibility suffered by territories is less severe than the direct impact of de-hubbing on airports.

We also look at variations in the number of intercontinental destinations. As one would expect, the decrease in the number of long-haul destinations exceeds, even if only marginally, the reduction in the number of destinations.

<Figure 5 about here>

Table 8 shows variations in the number of destinations and intercontinental destinations for each of the scenarios introduced in the previous section. In the low-cost dominated scenario and in the Battleground scenario with a low-cost main carrier, the number of destinations recovers speedily. In these cases, 5 years from de-hubbing the number of destinations grew by 28.3% and 26% respectively, mainly driven by short-haul connections. Those airports gained more in the number of destinations than in offered seats. That is consistent with the strategy of low-cost carriers to offer a wide range of short-haul destinations served less intensely than traditional carriers. In the other cases, the number of destinations decreased severely, especially for the Alliance-dominated scenario, with -22.5% of destinations and -32.6% of intercontinental destinations after 5 years.

<Table 8 about here>

Interestingly, in the three cases where re-hubbing took place, the number of destinations recovered much more speedily than the number of intercontinental destinations, meaning that even if those airports recovered hub activities, their offers changed towards short and medium-haul destinations.

6. Conclusion

The objective of this work is to analyze the cases of de-hubbing during period 1997-2009 in the world-wide air transport network by looking at scheduled flights. To the best of our knowledge, this is the first paper to study de-hubbing in a systematic way. Other works which dealt with de-hubbing adopted case study approaches.

After introducing quantitative criteria we find 37 different instances of airports which suffered de-hubbing in the world. We did not find any case in which those airports recovered their hub activities by other carriers.

Our results show that, on average, airports that suffered de-hubbing did not recover their original traffic in 5 years. When low-cost carriers enter the airport, traffic, measured in terms of seats capacity, shows much faster recovery trends. If low-cost carriers are not significantly involved, the most frequent case is that in which the airports decline.

From a passenger's and region's perspective, the number of destinations and intercontinental destinations decline less than offered seats. So, the negative effect of de-hubbing on air-side accessibility is less severe than its impact on airports traffics.

Other future developments could study the characteristics of the cases indentified in this study, in order to estimate the probability of future de-hubbing to take place.

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Appendix

Rank	Airport	Country	Adjusted connections decrease	Period	Hub carrier
1	Cincinnati/Northern Kentucky	United States	86%	November-05	Delta Air Lines
2	Pittsburgh International	United States	98%	September-01	US Airways
3	Lambert-St. Louis International	United States	95%	October-03	American Airlines
4	Milano Malpensa	Italy	94%	March-08	Alitalia
5	Brussels National	Belgium	83%	November-01	Sabena
6	London Gatwick	United Kingdom	79%	October-01	British Airways
7	Ronald Reagan National	United States	85%	September-01	US Airways
8	Luis Munoz Marin International	Puerto Rico	82%	December-01	American Airlines
9	Orlando International	United States	77%	May-01	Delta Air Lines
10	Metropolitan Area	Republic of Korea	100%	March-01	Korean Air Lines
11	Nice Cote D'Azur	France	98%	November-01	Air France
12	Milano Linate	Italy	97%	October-98	Alitalia
13	Raleigh/Durham	United States	84%	August-01	Midway
14	Jorge Newbery	Argentina	84%	April-00	Aerolineas Argentinas
15	Birmingham	United Kingdom	86%	April-03	British Airways
16	Simon Bolivar	Venezuela	78%	January-03	Aeropostal
17	Anchorage International	United States	83%	October-01	Alaska Airlines
18	Basel-Mulhouse	Switzerland	98%	March-03	Swissair
19	Ninoy Aquino International	Philippines	84%	June-98	Philippine Airlines
20	King Khaled International	Saudi Arabia	81%	April-08	Saudia
21	Hongqiao	China	90%	October-99	China Eastern Airlines
22	Philip S.W. Goldson International	Belize	99%	September-03	Maya Island Air
23	Ketchikan International	United States	99%	August-98	Alaska Airlines
24	Belize City Municipal	Belize	100%	September-03	Maya Island Air
25	Sangster International	Jamaica	97%	August-03	Air Jamaica
26	Louis Armstrong International	United States	92%	September-05	Southwest Airlines
27	East Midlands Nottingham	United Kingdom	94%	March-98	bmi
28	Nadi International	Fiji	92%	June-00	Air Pacific
29	Glasgow	United Kingdom	75%	September-06	British Airways
30	Adelaide	Australia	75%	October-01	Ansett Australia
31	Albany International	United States	96%	November-04	US Airways
32	Caye Caulker	Belize	100%	March-04	Tropic Air
33	Kaliningrad	Russian Federation	96%	September-08	KD Avia
34	Clermont-Ferrand Aulnat	France	91%	April-03	Air France
35	Colorado Springs	United States	98%	February-98	United Airlines
36	Gen Pesqueira Garcia	Mexico	79%	June-02	Aeromexico
37	Taichung	Chinese Taipei	100%	February-99	Islas Airways

Year	Airport	Hub-carrier	Main cause of de-hubbing	Main References
1994	Denver	Continental	New airport	Szyliowlcz and Goetz, 1995
1995	Nashville	American Air.	Network restructuring	Johansoson, 2007
1995	San Jose	American Air.	Network restructuring	
2000	Gatwick	British Air.	Downsizing/ Restructuring	Halstead, 2001
2001	Bruxelles	Sabena	Bankruptcy	Dennis, 2005
2001	Zurich	Swissair	Bankruptcy	Knorr and Arndt, 2004 Burghouwt, 2007
2001	Basel	Swissair/ Crossair	Bankruptcy	Burghouwt, 2007 Dennis, 2005
2001	Baltimore	US Airways	Network restructoring	Wolves, 2001
2001	Raleigh-Durham	Midway	Bankruptcy	Johansoson, 2007
2003	Pittsburgh	US Airways	Network restructoring	Berry, 2008
2004	Clermont-Ferrand	Air France	Network restructoring	Burghouwt, 2007 Thompson, 2002
2005	Cincinnati	Delta-Northwest	Marger	Sorkin and Bailey, 2008
2007	Barcellona	Iberia	Network restructoring	Burghouwt, 2008
2008	Malpensa	Alitalia	Downsizing/ Bankruptcy	IRER, 2008

Table 1. Major cases of de-hubbing in Europe and US.

Rank	Airport	Country	Number of connections
1	Hartsfield-Jackson Atlanta	United States	55,360
2	O'Hare	United States	33,761
3	Dallas/Ft. Worth	United States	30,303
4	George Bush	United States	19,430
5	Douglas	United States	17,483
6	Frankfurt	Germany	15,463
7	Denver	United States	13,553
8	Wayne County	United States	13,204
9	Philadelphia	United States	11,510
10	Paris Charles De Gaulle	France	11,197
11	St Paul	United States	10,697
12	Munich F.J. Strauss	Germany	8,850
13	London Heathrow	United Kingdom	8,033
14	Newark Liberty	United States	7,791
15	Dulles	United States	7,503
16	Amsterdam-Schiphol	Netherlands	7,481
17	Pearson	Canada	7,426
18	Madrid Barajas	Spain	6,478
19	Sky Harbor	United States	5,224
20	Los Angeles	United States	4,702

Table 2. First twenty airports in the world for the number of connections on September 16th, 2009

Area	Number of cases
Europe	11
North America	11
Central-South America	8
Asia-Pacific	7
Total	**37**

Table 3. Geographical distribution of the de-hubbing cases.

Rank	Airport	Country	Adjusted number of connections	Decrease	De-hubbing month	Hub Carrier
1	Cincinnati/Northern Kentucky	United States	22,105	86%	November-05	Delta Air Lines
2	Pittsburgh International	United States	16,790	98%	September-01	US Airways
3	Lambert-St. Louis International	United States	15,165	95%	October-03	American Airlines
4	Milan Malpensa	Italy	4,434	94%	March-08	Alitalia
5	Brussels National	Belgium	3,576	83%	November-01	Sabena
6	London Gatwick	United Kingdom	2,744	79%	October-01	British Airways
7	Ronald Reagan National	United States	2,136	85%	September-01	US Airways
8	Luis Munoz Marin International	Puerto Rico	1,790	82%	September-08	American Airlines
9	Orlando International	United States	1,575	77%	May-01	Delta Air Lines
10	Kimpo International	South Korea	1,411	100%	March-01	Korean Air Lines

Table 4. Main ten de-hubbing in terms of the adjusted number of connections.

Offered seats	Number	Year+1	Year+2	Year+3	Year+4	Year+5
All de-hubbing cases	37	-19.8%	-23.6%	-22.3%	-21.1%	-17.5%
No Re-hubbing	34	-20.3%	-25.2%	-23.8%	-22.1%	-20.4%
Low Cost-dominated	4	-13.2%	-18.0%	-14.6%	-8.9%	12.8%
Alliance-dominated	6	-28.5%	-24.0%	-21.4%	-18.3%	-19.3%
Unallied-dominated	12	-15.3%	-24.7%	-24.2%	-23.1%	-26.8%
Battleground	12	-23.8%	-28.8%	-27.2%	-25.0%	-22.6%
Re-hubbing	3	-20.1%	-13.2%	-6.0%	-10.7%	-3.9%
Low Cost-dominated	-	-	-	-	-	-
Alliance-dominated	1	-29.9%	-18.6%	-12.7%	-2.8%	-2.5%
Unallied-dominated	2	-15.2%	-10.5%	-2.6%	-14.6%	-4.6%
Battleground	-	-	-	-	-	-

Table 5. De-hubbing effects on offered seats. We distinguish between the re-hubbing and the no re-hubbing case and between the four categories based on the offered seats structure five years after de-hubbing.

Offered seats	Number	Year+1	Year+2	Year+3	Year+4	Year+5
Battleground	12	-23.8%	-28.8%	-27.2%	-25.0%	-22.6%
the first carrier is low-cost	4	-20.8%	-22.3%	-17.9%	-16.3%	9.0%
the first carrier is not low-cost	8	-25.3%	-31.6%	-31.3%	-28.8%	-27.1%

Table 6. De-hubbing effects on offered seats. We distinguish between the re-hubbing and the no re-hubbing case and between the four categories based on the offered seats structure five years after de-hubbing.

Scenario		Number	Year 1	Year 2	Year 3	Year 4	Year 5
Decline	Average	26	-21.4%	-26.9%	-26.1%	-24.7%	-26.3%
	25% percentile		-33.9%	-39.3%	-41.7%	-41.7%	-49.3%
	Median		-16.7%	-29.0%	-29.3%	-22.1%	-27.2%
	75% percentile		-6.2%	-11.6%	-11.6%	-7.5%	-6.8%
Alliance-dominated	Average	6	-28.3%	-25.1%	-23.2%	-22.2%	-23.5%
	25% percentile		-29.8%	-37.0%	-42.6%	-47.4%	-51.9%
	Median		-17.2%	-27.8%	-34.9%	-22.5%	-25.9%
	75% percentile		-8.6%	-11.8%	-0.1%	2.8%	2.5%
Unallied dominated	Average	12	-15.3%	-24.7%	-24.2%	-23.1%	-26.8%
	25% percentile		-30.0%	-36.0%	-35.6%	-33.8%	-48.9%
	Median		-7.5%	-27.6%	-21.5%	-21.4%	-21.5%
	75% percentile		-4.7%	-12.1%	-14.4%	-13.8%	-10.3%
Battleground- Non low-cost first carrier	Average	8	-25.3%	-31.6%	-31.3%	-28.8%	-27.1%
	25% percentile		-42.0%	-41.0%	-46.5%	-45.9%	-43.3%
	Median		-22.5%	-29.3%	-29.3%	-30.0%	-30.1%
	75% percentile		-12.9%	-20.1%	-18.4%	-13.2%	-16.3%

Table 7. De-hubbing effects for airports with no relatively dominant presence of low-cost carriers.

Number of destinations	Number	Year+1	Year+2	Year+3	Year+4	Year+5
All de-hubbing cases	37	-15.0% (-18.9%)	-15.9% (-20.3%)	-14.9% (-17.1%)	-15.7% (-17.7%)	-11.6% (-14.8%)
No Re-hubbing	34	-14.7% (-18.6%)	-15.9% (-20.1%)	-15.6% (-17.8%)	-16.3% (-16.9%)	-12.4% (-14.0%)
Low Cost-dominated	4	-0.9% (-17.0%)	-6.4% (-7.6%)	-1.3% (-11.5%)	2.8% (-12.5%)	28.3% (16.3)
Alliance-dominated	6	-22.6% (-18.9%)	-13.6% (-8.7%)	-15.3% (-13.7%)	-20.8% (-24.1%)	-22.5% (-32.6%)
Unallied-dominated	12	-9.8% (-14.4%)	-14.6% (-15.8%)	-17.7% (-6.5%)	-17.7% (-7.7%)	-20.1% (-8.2%)
Battleground	12	-20.2% (-27.7%)	-22.2% (-31.2%)	-19.0% (-32.7%)	-18.6% (-24.6%)	-12.0% (-13.6%)
the first carrier is low-cost	4	-17.7% (-32.0%)	-17.3% (-27.7%)	-9.0% (-21.6%)	-11.2% (-12.7%)	26.0% (+6.6%)
the first carrier is not low-cost	8	-21.4% (-24.8%)	-24.4% (-33.2%)	-23.3% (-39.4%)	-21.8% (-31.8%)	-17.4% (-29.6%)
Re-hubbing	3	-18.7% (-20.7%)	-15.7% (-21.4%)	-8.2% (-13%)	-9.8% (-21.4%)	-4.3% (-18.8%)

Table 8. De-hubbing effects on the number of destinations. We distinguish between the re-hubbing and no re-hubbing case. For the latter we consider the four clusters defined in the previous section. Changes in the number of intercontinental destinations are in brackets.

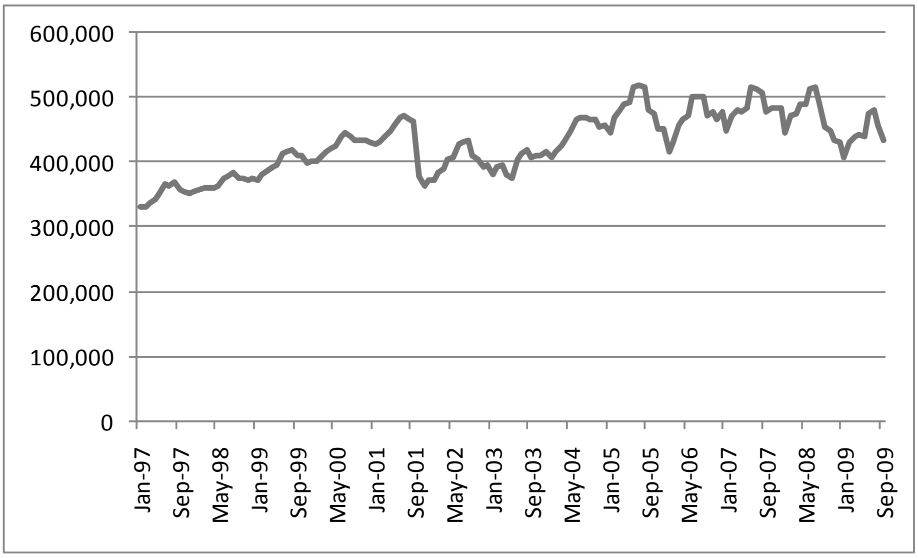

Figure 1. Worldwide number of daily connections for each day considered in the period January 1997 – September 2009.

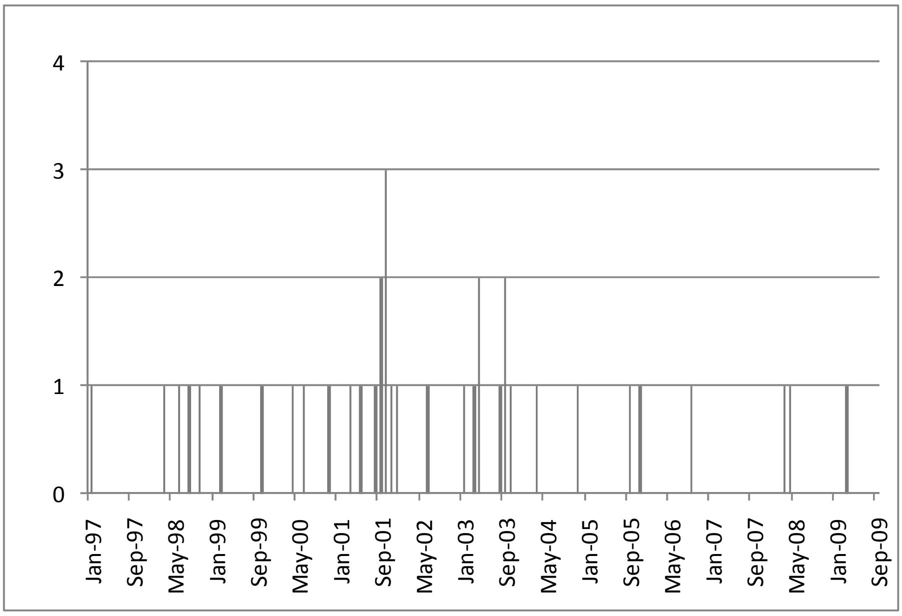

Figure 2. Temporal distribution of the number of de-hubbing cases.

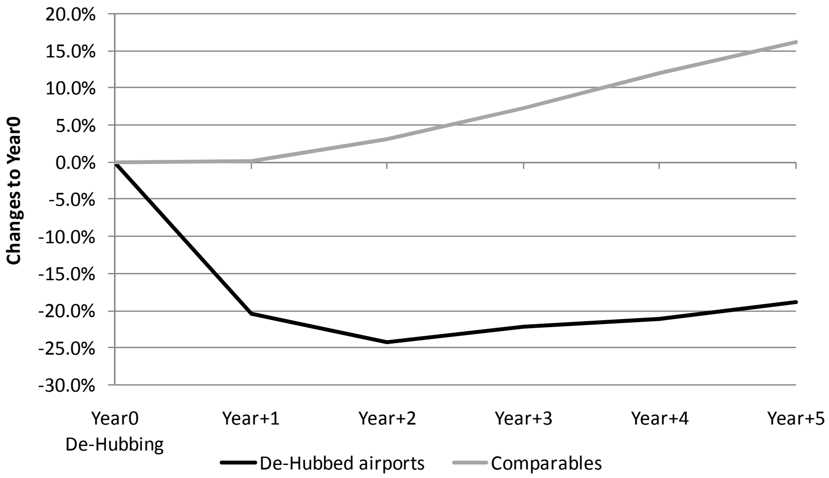

Figure 3. De-hubbing effects on offered seats compared with seats offered by similar-size airports (±10% in terms of seats) on the same region (Europe, North America, Central-South America, Asia-Pacific).

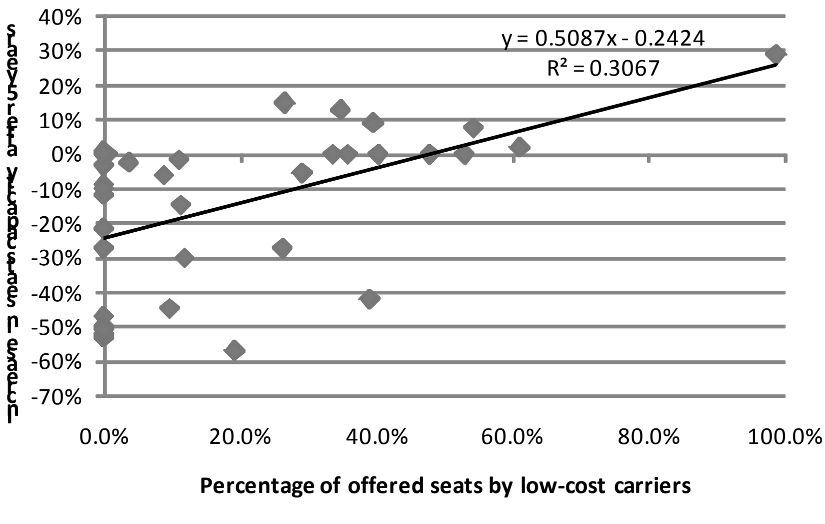

Figure 4. Relationship between the percentage of offered seats by low-cost carriers and the increase in seats capacity five years from de-hubbing.

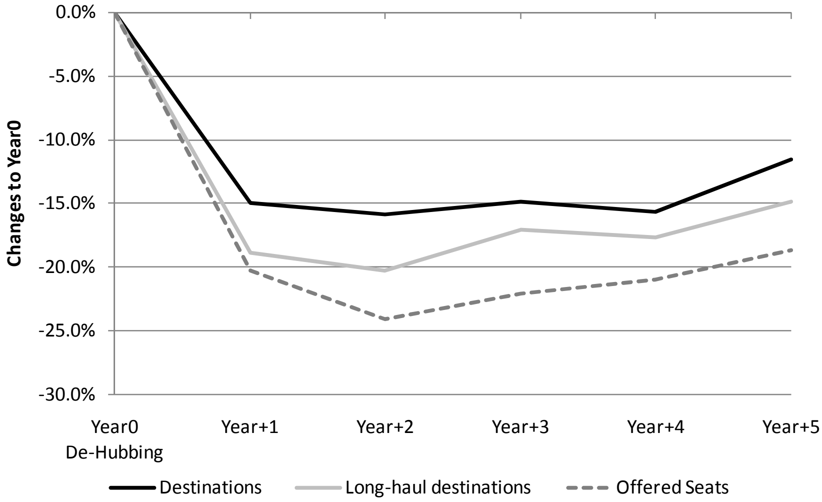

Figure 5. Comparison of de-hubbing effects on offered seats, the number of destinations and the number of intercontinental destinations.