THE COMPETITIVE POSITION OF HUB AIRPORTS IN THE TRANSATLANTIC MARKET

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ABSTRACT

This article puts forward the argument that the measurement of connectivity in hub-and-spoke networks has to take into account the quality and quantity of both direct and indirect connections. The NETSCAN model, which has been applied in this study, quantifies indirect connectivity and scales it into a theoretical direct connection. NETSCAN allows researchers, airports, airlines, alliances and airport regions to analyse their competitive position in an integrated way. Using NETSCAN, the authors analysed the developments on the market between northwest Europe and the United States (US) between May 2003 and May 2005. One of the most striking developments has certainly been the impact of the Air France-KLM merger and the effects of the integration of KLM and Northwest into the SkyTeam alliance on the connectivity of Amsterdam Schiphol. Direct as well as indirect connectivity (via European and North American hubs) from Amsterdam to the US increased substantially. The main reason for this increase is the integration of the former Wings and SkyTeam networks via the respective hub airports. Moreover, the extended SkyTeam alliance raised frequencies between Amsterdam and the SkyTeam hubs (Atlanta, Houston, for example), opened new routes (Cincinnati) and boosted the network between Amsterdam and France. As a result of the new routes and frequencies, Amsterdam took over Heathrow's position as the third best-connected northwest European airport to the US.

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INTRODUCTION

Hub-and-spoke networks have been an essential feature of the operations of air carriers since the deregulation of the domestic American air transport market in 1978. Hub-and-spoke networks allow the hub airline to maximize the number of connected city pairs given a certain number of flights. Due to the consolidation of different origin-destination combinations on a limited number of routes, the hub airline may benefit from higher load factors, higher frequencies and the use of larger aircraft with lower unit costs (Dennis, 1994a, 1994b).

In a hub-and-spoke network, the carrier concentrates its network both spatially and temporally (Reynolds-Feighan, 2001). From a spatial point of view, the carrier organizes its network around one or a few central hub airports. At the hub, passengers transfer to their connecting flight. From a temporal perspective, the flight schedule at the hub is organised in a number of daily waves of incoming and outgoing flights, in which ideally all incoming flights connect to all outgoing flights (Bootsma, 1997). The wave system restricts the loss of passenger demand due to the additional transfer time of an indirect connection compared to a direct connection.

Also in Europe, the hub-and-spoke network has gained ground since the liberalisation of the internal European Union (EU) market (1988-1997). Already before the liberalisation of the EU market, the national airlines operated star-shaped networks, spatially concentrated around the national home bases. Yet, most of these carriers could not be characterised as hub-and-spoke airlines. The star-shaped networks were merely the result of the system of bilateral air service agreements that pinned down the designated carriers on their national home bases. Since the liberalisation of the market, many national and a few regional airlines built up their hub-and-spoke network by means of the intensification and adoption of wave systems (Burghouwt, 2005). However, since 2001 a shakeout on the hub market has taken place. Some hubs were torn down or rationalized by their home based carriers. British Airways dehubbed London Gatwick because the split-hub operation at Heathrow and Gatwick was not profitable. Iberia cancelled its hub operations at Miami because security measures at the airport had been tightened due to the events of September 11, 2001 (9/11), and connecting times had doubled. Air France rationalized the hub operation at Clermont-Ferrand after the take-over of Regional Airlines in 2000. The hub operation at Clermont-Ferrand (the former hub of Regional Airlines) duplicated substantially the hub operation of Air France at Lyon. Other hubs disappeared or were scaled down because of the bankruptcies of the hub carriers (Sabena at Brussels, Swissair and Zurich, Air Littoral at Nice, Crossair at Basle).

Global airline alliances are increasingly important for the future of hubs. The three global airline alliances (OneWorld, Star and SkyTeam) choose one or two hubs at each continent to function as primary intercontinental gateways. Other hubs fulfil secondary, regionally oriented roles (Dennis, 2005).

The growth of hub-and-spoke operations has changed the competition between airlines in a structural way. The competitive position of airlines and airports is usually expressed in terms of top ten lists. Airlines and airports are compared with respect to total passenger enplanements, number of aircraft movements or tonnes of freight. Although such indicators are valuable in itself, they do not give any information on the competitive position of airline networks and hub airports.

The gap in such analyses is the fact that, because of the rise of hub-and-spoke systems, competition between airlines takes place in both a direct and indirect way. On the one hand, airlines compete on direct routes (from A to B). On the other had, they compete indirectly with a transfer at a hub (from A to B via H). The passenger's choice for a certain route alternative will depend, among other things, on the ticket price and network quality. Especially in case of the availability of a direct route alternative, ticket price will be an important tool for an airline offering an indirect connection to compensate for lower network quality. Network quality is defined here as the frequency and associated travel times of a certain connection.

This paper discusses the competitive position between airports, airlines, alliances and their hubs on the market between northwest Europe and the US. The analysis is restricted to network quality. Reliable price data are scarce and, if available, hard to use because of the large number of quickly changing ticket prices on a single flight.

The paper is outlined as follows. The next section places this study in the context of earlier research on hub-and-spoke networks. The third section discusses the principles of hub-and-spoke systems in relation to network quality and connectivity. The fourth section deals with the NETSCAN model. The fifth and sixth sections discuss the empirical results of the research. The final section presents the conclusions of the research.

LITERATURE REVIEW

The rise of hub-and-spoke networks has been the subject of many academic studies. One branch of research deals with the advantages of hub-and-spoke networks in terms of economies of density and scope (Braeutigam 1999; Brueckner & Spiller, 1994; Caves, Christensen & Tretheway, 1984; Wojahn 2001), hub premiums, (Berry, Carnall & Spiller, 1996; Borenstein 1989; Leijsen, Rietveld & Nijkamp, 2000; Oum, Zhang & Zhang, 1995), entry deterrence (Zhang 1996) and the role of hub-and-spoke networks in airline alliances (Dresner & Windle, 1995; Oum, Park & Zhang, 2000; Pels, 2001). A second branch of research aims to optimize hub-and-spoke networks spatially by means of hub location-allocation models (Kuby & Gray 1993; O'Kelly & Miller, 1994; O'Kelly, 1998; O'Kelly & Bryan, 1998).

Another branch of research has studied the structure, performance and growth of hub-and-spoke networks from an empirical point of view. Most studies focus on the spatial dimension of hub-and-spoke networks: the level to which an airline has concentrated its network on a few key nodes in the network (Bania, Bauer & Zlatoper, 1998; Burghouwt, Hakfoort & Ritsema-Van Eck, 2003; Ivy, 1993; Shaw, 1993; Reynolds-Feighan, 2001; Wojahn, 2001). However, Bootsma (1997), Burghouwt (2005), Burghouwt and de Wit (2005); Dennis (1994a, 1994b), Reynolds-Feighan (2001) and Wojahn (2001) explicitly underline the temporal dimension or schedule structure as an essential element for the empirical study of the structure, performance and development of hub-and-spoke networks. Hub-and-spoke airlines offer consumers both direct and indirect travel opportunities (via their hub). To maximize indirect travel opportunities and to minimize passenger loss due to transfer time and detour time indirect travel opportunities need efficient schedule coordination in terms of a well developed wave system structure at the hub.

However, schedule coordination and the resulting hub performance are not captured by the traditional graph theoretical or spatial concentration measures. Only a few authors have included the level of schedule coordination in the measurement of the performance and structure of hub-and-spoke networks (for example, Bootsma, 1997; Burghouwt, 2005; Dennis, 1994b; Veldhuis, 1997). These studies include the possibility of making transfers from one flight to another, taking into account minimum and maximum connecting times and the quality of those connections. In this study, the NETSCAN model, developed by Veldhuis (1997) and owned by SEO Economic Research, has been applied to measure the performance of airline networks in the transatlantic market.

NETWORK QUALITY, HUB-AND-SPOKE SYSTEMS AND CONNECTIVITY

The extent to which airlines can play a role in the market between A and B depends on a number of factors. First, the size of the market is important. If the size of the origin-destination market is larger than a certain critical threshold, an airline may decide to serve that market directly. The critical threshold will also depend on the critical load factor, the size of the smallest airplane that can be operated on the route and the minimum desired weekly frequency. If the market size is below this threshold, the market can only be served indirectly. However, this does not mean that, if a direct travel opportunity is available all passengers will choose the direct travel alternative. In reality, traffic will be spread over direct and indirect travel opportunities, depending on ticket prices and the network quality of the indirect connection.

The quality of an indirect connection between A and B with a transfer at hub H is not equal to the quality of a direct connection between A and B. In other words, the passenger travelling indirectly will experience additional costs due to longer travel times, consisting of detour time and transfer time. The transfer time equals at least the minimum connecting time, or the minimum time needed to transfer between two flights at hub H.

Hence, the extent to which an airline is able to serve successfully an indirect market is, besides prices, mainly dependent on two things. First, the geographical location of the respective hub in relation to the main continental and intercontinental traffic flows. Second, the efficiency of the airline's schedule is crucial. If a carrier is able to coordinate its incoming and outgoing flights effectively so that all incoming flights connect to all outgoing flights, the quality loss of an indirect connection can be kept to a minimum.

Against the background of hub-and-spoke networks, this article distinguishes three types of connections:

1. Direct connections: flights between A and B without a hub transfer (e.g., from Amsterdam to Los Angeles)
2. Indirect connections: flights from A to B, but with a transfer at hub X (e.g., from Amsterdam to Los Angeles via Detroit)

Hub connections: connections via (with a transfer at) hub A between origin C and destination B (e.g., from Hamburg via Amsterdam to Los Angeles).

In fact, hub connections are equal to indirect connections. However, indirect connectivity is measured from the perspective of the originating airport and hub connectivity is measured from the perspective of the hub airport. The measurement of indirect connectivity is particularly important from the perspective of consumer welfare (e.g., how many direct and indirect connections are available to consumers between Amsterdam and Los Angeles). The concept of hub connectivity is particularly important for measuring the competitive position of airline hubs in a certain market (e.g., how does Amsterdam perform as a hub in the market between Hamburg and Los Angeles).

METHOD AND DATA

The NETSCAN model

As the authors argued earlier, the quality of an indirect connection is not equal to the quality of a direct connection. The NETSCAN model quantifies the quality of an indirect connection and scales it to the quality of a theoretical direct connection. The authors discuss briefly the methodology of the NETSCAN model in general terms. For a detailed discussion, refer to Veldhuis (1997) and IATA (2000).

NETSCAN assigns a quality index to every connection, ranging between 0 and 1. A direct, non-stop flight is given the maximum quality index of 1. The quality index of an indirect connection will always be lower than 1 since extra travel time is added due to transfer time and detour time of the flight. The same holds true for a direct multi-stop connection: passenger face a lower network quality because of en-route stops compared to a non-stop direct connection.

If the additional travel time of an indirect connection exceeds a certain threshold, the quality index of the connection equals 0. The threshold of a certain indirect connection between two airports depends on the travel time of a theoretical direct connection between these two airports. In other words, the longer the theoretical direct travel time between two airports, the longer the maximum indirect travel time can be. For example, a maximum indirect travel time of three hours belongs to a direct flight of one hour, while the maximum indirect travel time of a 12-hour flight equals 24 hours. The travel time of a theoretical direct connection is determined by the geographical coordinates of origin and destination airport and assumptions on flight speed and time needed for take-off and landing. By taking the product of the quality index and the frequency of the connection per time unit (day, week, and year), the total number of connections or connectivity units (CNUs), can be derived. Summarizing the following model has been applied for each individual (direct, indirect or hub) connection:

$$MAXT = (3 - 0.075 * NST) * NST \quad (1)$$

$$PTT = FLY + (3 * TRF) \quad (2)$$

$$QUAL = 1 - ((PTT - NST)/(MAXT - NST)) \quad (3)$$

$$CNU = QUAL * FREQ \quad (4)$$

Where MAXT is the maximum perceived travel time, NST is the non-stop travel time, PTT is the perceived travel time, FLY is the flying time, TRF is the transfer time, QUAL is the quality index of an individual connection and CNU is the number of connectivity units.

Table 1 illustrates the NETSCAN model. Consider the example of the connectivity between Amsterdam and Cincinnati. The SkyTeam alliance operates a daily direct connection to Cincinnati in May 2005. The direct flight has a quality index of 1 since no transfer time or detour time is involved. Hence, the number of CNUs per week equals the frequency per week. Besides a direct connection, SkyTeam, and to a lesser extent the Star alliance, offers indirect connections via other American and European hubs. In this respect, Detroit is the most important hub. In theory, the number of viable connections (quality index > 0) via Detroit is 89 per week. However, as a result of transfer time and detour time, the average quality index equals 0,32. This results in a total number of weighted CNUs of 28,7. Because NETSCAN scales the indirect connection to a theoretical direct connection, the CNUs via Detroit can be read as follows: between Amsterdam and Cincinnati 89 indirect flights per week are offered by SkyTeam via Detroit. These 89 flights are comparable to 28,7 direct flights from Amsterdam to Cincinnati.

Table 1. Quality indices, frequency per week and connectivity units (CNU's), Amsterdam-Cincinnati, 3rd week of May 2005

Origin	Hub	Destination	Alliance	Average Quality Index	Frequency per Week	CNU/week
Amsterdam	--	Cincinnati	SkyTeam	1,00	7	7,0
Amsterdam	Atlanta	Cincinnati	SkyTeam	0,42	14	5,9
	Boston		SkyTeam	0,49	7	3,4
	Paris CDG		SkyTeam	0,35	47	16,6
	Detroit		SkyTeam	0,32	89	28,7
	New York Newark		SkyTeam	0,40	46	18,2
	Rome FCO		SkyTeam	0,38	7	2,6
	Frankfurt		SkyTeam	0,47	7	3,3
	Washington Dulles		SkyTeam	0,46	14	6,4
	Houston		SkyTeam	0,35	7	2,4
	New York JFK		SkyTeam	0,37	28	10,5
	Memphis		SkyTeam	0,19	7	1,4
	Minneapolis		SkyTeam	0,30	41	12,1
	Chicago O'Hare		SkyTeam	0,39	14	5,4
			Star	0,31	7	2,2
	Philadelphia		Star	0,30	6	1,8
	Montreal Dorval		SkyTeam	0,58	7	4,1
	Toronto		SkyTeam	0,41	6	2,5
TOTAL				**0,37**	**361,00**	**134,50**

Source: OAG (2005); own calculations

Data and classifications

The authors used OAG flight schedules in the third week of May in 2003, 2004 and 2005 (OAG 2005). Direct connections are directly available from the OAG database. Indirect connections have been constructed using an algorithm, which identifies for each incoming flight at an airport the number of outgoing flights that connect to it. The algorithm takes into account minimum connection times and puts a limit on the maximum connecting time and routing factor. Next, the NETSCAN model assigns to each direct and indirect connection a quality index, ranging between 0 and 1.

Within the NETSCAN model, only online connections are considered as viable connections. In other words, the transfer between two flights has to take place between flights of the same airline or global airline alliance. For the years 2004 and 2005, we distinguish three global airline alliances: OneWorld, SkyTeam and Star. For the year 2003, the authors distinguish an additional alliance, Wings (KLM/Northwest), which submerged into SkyTeam in 2004.

The analysis considers the connectivity between airports in northwest Europe and airports in the US. Northwest Europe is defined as Belgium, the Netherlands, and Luxemburg (Benelux), the UK, Ireland, France and Germany. Only westbound connections (from northwest Europe to the US) have been taken into account. The return connections have not been considered in the analysis. It is important to note that the total market between northwest Europe and the US has been analysed. This means that indirect connections in this market can be provided by hubs within the geographical boundaries of this market (Amsterdam and Frankfurt, for example) but also by hubs located outside the geographical boundaries of this market (Madrid, for example).

Furthermore, we make a distinction between primary, secondary and tertiary airports. European primary airports are the four largest airports: London Heathrow, Paris CDG, Frankfurt and Amsterdam. The American primary airports are the major gateways: Chicago O'Hare, Atlanta, Los Angeles and New York JFK. Secondary airports are all those airports having a direct connection from northwest Europe to the US in May 2005 (Munich, Minneapolis, for example). Tertiary airports are all other airports.

DIRECT AND INDIRECT CONNECTIVITY

Recovery and stabilisation

The total number of direct flights between northwest Europe and the US increased about 21 percent between May 2003 and May 2005 (Table 2). For a large part, this growth took place between 2003 and 2004 (+17%). This period can be considered as a recovering period from the downturn after 9/11 and the economic recession. The period between 2004 and 2005 demonstrates lower growth rates (+4%), which is much closer to the long-term growth rates in international air transport. The same holds true for indirect connectivity (with a transfer at a hub). The number of indirect connections increased at a higher rate between 2003 and 2005 (+41%) than direct connectivity.

The highest growth percentages can be found at the only primary airport in the Benelux (Schiphol), both with respect to direct and indirect connectivity. The authors later show that this has been largely the consequence of the integration of KLM into the SkyTeam alliance after the Air France-KLM merger. The primary airport of the UK and Ireland region (London Heathrow) experienced modest growth levels in terms of the number of direct frequencies. This is partly the result of the capacity shortages at the airport. The crisis in the global air transport sector and the orientation of Heathrow towards North America had eased the capacity shortages at the airport. Not surprisingly, the number of flights increased between 2003 and 2004. Between 2004 and 2005, the growth percentages were again reduced to zero. No more flights could be accommodated at the airport. The growth in the number of indirect connections was mainly due to better/more connections via other hubs to the US.

In addition, Table 2 demonstrates the demand threshold, which airlines need in order to serve transatlantic routes. Only between primary/secondary European airports on the one hand and primary/secondary American airports on the other, demand levels are sufficiently large to justify direct connections. Tertiary European airports depend on European hub airports for their connections to the US.

Table 2. Direct and indirect connectivity units (CNU) from primary, secondary and tertiary airports in northwest Europe to the US, 2003-2005[1]

		CNU		% growth					
		2003	2003	2003-2004		2004-2005		2003-2005	
Initial origin	Type of origin	Direct	Indirect	Direct	Indirect	Direct	Indirect	Direct	Indirect
Benelux	primary (AMS)	185	2790	14	78	8	17	24	109
	secondary	43	1296	10	10	1	6	11	17
	tertiary	.	150		39		28		78
UK and Ireland	primary (LHR)	501	3698	14	37	0	1	14	38
	secondary	354	7245	17	30	9	10	28	43
	tertiary	.	605		21		8		30
France	primary (CDG)	257	4662	18	30	3	5	22	36
	secondary	9	1324	-19	12	0	16	-19	29
	tertiary	.	501		10		19		31
Germany	primary (FRA)	267	5144	18	28	1	3	20	32
	secondary	81	4819	36	33	7	-1	46	31
	tertiary	.	1355		7		12		19
Total		**1696**	**33590**	**17**	**32**	**4**	**7**	**21**	**41**

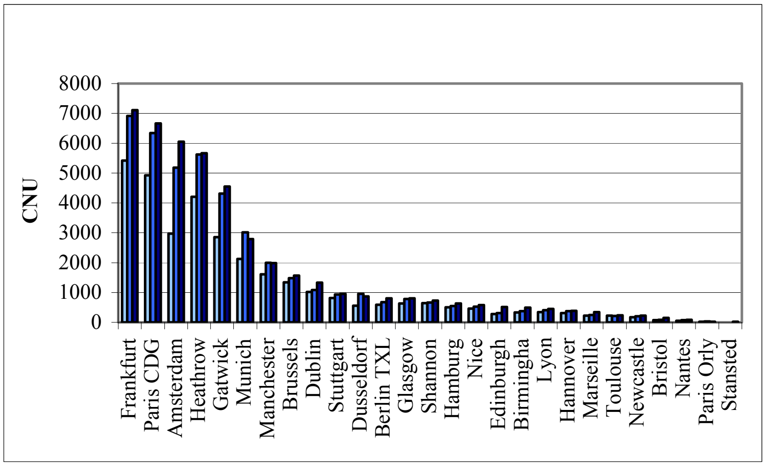
Source: OAG (2005); own calculations

Changing connectivity levels of European Airports

To what extent did the position of individual European airports change with respect direct and indirect connectivity levels? Figure 1 shows some remarkable changes between 2003 and 2005.

First, the primary and secondary airports show a recovery of the industry crisis between 2003 and 2004 (see also the previous section). Yet, at most of the European airports, growth rates were considerably lower between 2004 and 2005. Some airports even demonstrated negative growth rates, such as Munich, Manchester and Düsseldorf.

Figure 1. Total connectivity (direct + indirect) from primary and secondary NW-European airports, 2003-2005



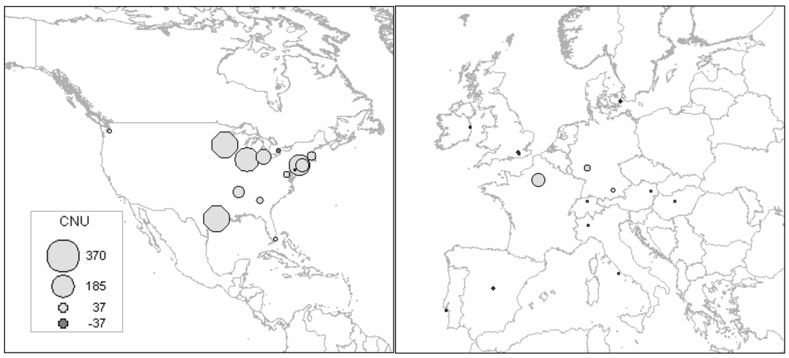
Source: OAG (2005); own calculations

Secondly, Amsterdam Schiphol is an exception to the more modest growth rates in the 2004-2005 period. How can we understand the continued growth at Schiphol? The explanation for this observation can be found in the Air France-KLM merger and the entry of KLM to the SkyTeam alliance. In 2003, KLM was still part of the Wings alliance (KLM/Northwest). Indirect connections to the US were primarily generated by the Wings alliance via the Northwest hubs in the US (Detroit, Minneapolis and Memphis) and to a lesser extent by other alliances. Our NETSCAN model did not consider connections between, for example, KLM and Delta as viable connections since both carriers did not belong to the same alliance in 2003.

The entry of Northwest and KLM to the SkyTeam alliance resulted in an integration of the Wings and SkyTeam networks. From 2004 on, the NETSCAN model considers the connections between, for example, the KLM and Delta flights at Schiphol, as online, viable connections. As Figure 2a illustrates for Amsterdam, the impact of the network integration between 2003 and 2004 is substantial. A good example is Houston. In 2003, the KLM flights to Houston did not connect to the domestic flights of Continental. From 2004 on (due to the Air France-KLM merger and the integration of KLM into SkyTeam) the NETSCAN model considers these connections as online and thus viable connections. As a result, the number of connections from Amsterdam via Houston to the rest of the US increased substantially.

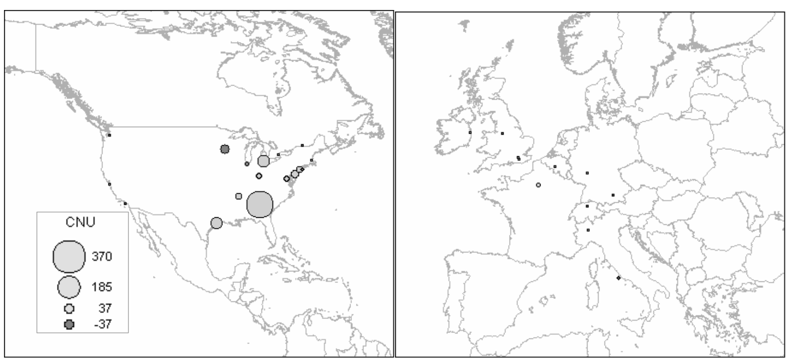
In addition, new services and frequencies between the US and Amsterdam were added against the background of the SkyTeam extension and the Air France-KLM merger. Delta Airlines, for example, started to operate a daily frequency between its Cincinnati hub and the new SkyTeam hub in Amsterdam during the period 2003 and 2004. The same holds true for the growth in frequencies between Amsterdam and Atlanta in 2005. KLM started a daily frequency to Atlanta in 2005, which brought the total SkyTeam frequency to a twice-daily level. Figure 2b shows that, as a result of the additional daily frequency, the indirect connectivity between Amsterdam and the US via Atlanta was boosted.

Figure 2a. Absolute growth of indirect connectivity (CNU) from Amsterdam via North-American and European hubs to the US, 2003-2004



Source: OAG (2005); own calculations

Figure 2b. Absolute growth of indirect connectivity (CNU) from Amsterdam via North-American and European hubs to the US, 2004-2005



Source: OAG (2005); own calculations

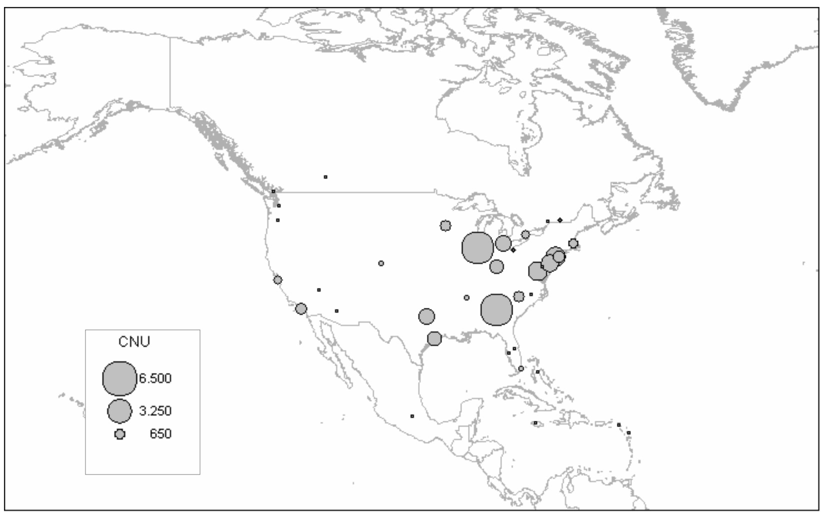
Finally, London Heathrow lost its third position to Amsterdam in the ranking of best-connected airports to the US (Figure 1). Whereas Amsterdam benefited from the integration of KLM into the Air France and SkyTeam network, Heathrow suffered from its capacity limitations. The capacity problems at Heathrow make it extremely difficult for the OneWorld and other alliances to increase frequencies or add new routes.

HUB CONNECTIVITY

The dominance of American hubs

Until now, we have only considered direct and indirect connectivity. These measures give a good indication of the direct and indirect service levels available at the respective airports to the consumers. However, they do not measure the competitive position of an airport in the connecting market. Hence, we have analysed the hub connectivity of airports in the transatlantic market.

Figure 3a. Hub connectivity on the market between NW-Europe and the US per hub in 2005, North-American hubs



Source: OAG (2005); own calculations

Figure 3b. Hub connectivity on the market between NW-Europe and the USA per hub in 2005, European hubs

Source: OAG (2005); own calculations

With regard to hub connectivity on the market between northwest Europe and the US, American airports have a dominant position (Figures 3a & b). Moreover, they have further strengthened their position between 2003 and 2005. In 2003, almost 65% of the hub connections were generated at American airports. In 2005, this percentage had increased to 69%. The share of northwest European airports in total hub connectivity decreased from 30% in 2003 to 27% in 2005. The dominance of American hubs is largely the consequence of the difference in market size between the US and northwest Europe. The number of tertiary airports in the US is much higher than the number of tertiary airports in northwest Europe. Since tertiary American airports are only served by American hubs and not by European airports, the hub connectivity of American airports is essentially larger than the hub connectivity of northwest European airports.

Chicago O'Hare and Atlanta can be considered as superhubs. The two hubs offered more hub connections than all northwest European hubs together. Both airports are the main home bases of large hub-and-spoke carriers and their alliance: Chicago for both American (OneWorld) and United (Star), Atlanta for Delta (SkyTeam). In addition to the superhubs, a group of second tier hubs can be identified, on both the European and

American side. In Europe, the primary airports London Heathrow, Frankfurt, Paris CDG and Amsterdam belong to this group of second tier airports. Further down the hierarchy, the only European airport that plays a substantial role in the connecting market is Lufthansa's secondary hub Munich. Other airports have too little direct flights to the US or are too decentrally located in a geographical sense (such as Madrid or Milan Malpensa) to be competitive in the hub market. London Gatwick was an important hub to the US during the nineties, but lost its position after British Airways decided to dehub Gatwick (Burghouwt, 2005).

On the American side, the number of second tier airports is larger. In particular, the airports that are a hub for SkyTeam are important second tier airports (Newark, Detroit, Cincinnati, and Houston). In addition, the Dallas DFW (OneWorld) and Washington Dulles and Philadelphia (Star) can be considered as second tier airports. The fact that the SkyTeam hubs seem to dominate the hub market is in line with the development of alliance market shares, which will be discussed in the next section.

Changing alliance patterns

The global airline alliances fully dominated the connecting market between northwest Europe and the US during the period of analysis. Only 1% of the hub connectivity was generated by airlines not belonging to a global airline alliance. SkyTeam had the largest share in the number of hub connections (CNUs) in 2004 and 2005, followed by Star and OneWorld. In addition, the share of SkyTeam increased from 30% in 2003 to 46% in 2005, because of the integration of the Wings networks (KLM/Northwest) into SkyTeam. Because of the integration, Star lost its first position in the hub market to SkyTeam. Because of the synergy effects due to network integration, the share of SkyTeam in 2004 (44%) was substantially larger than the sum of the market shares of Wings (9%) and SkyTeam (30%) in 2003.

American hubs dominate the market in all alliances. Within SkyTeam, the share of American hubs was 73% in 2005. Within the networks of all of the alliances, the share of European hubs decreased and the share of American hubs increased. The same holds true for all other alliances. A small percentage of the hub connectivity of the alliances is generated at hubs outside northwest Europe or the US. Examples of such hubs are Madrid (Oneworld), Mexico (SkyTeam) and Toronto Lester (Star).

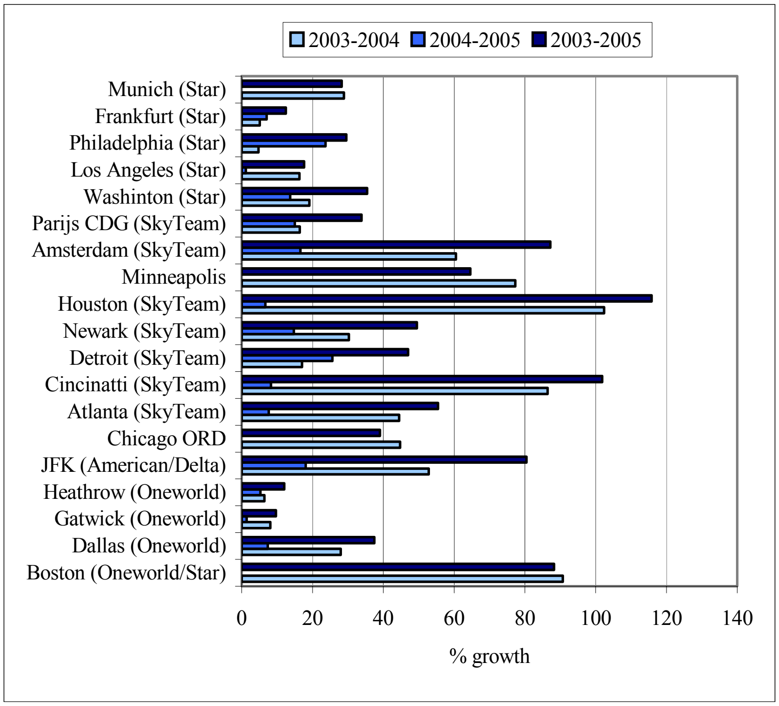
Table 3. Share of regions in total hub connectivity of alliance and share of alliance in total hub-connectivity, 2003-2005

			2003	2004	2005
% in total alliance	ONEWORLD	NW-Europe	34	30	31
		US	57	62	62
		Rest of the world	9	8	8
% in grand total			**23**	**21**	**20**
% in total alliance	SKY TEAM	NW-Europe	19	21	22
		US	74	73	73
		Rest of the world	7	6	5
% in grand total			**30**	**44**	**46**
% in total alliance	STAR	NW-Europe	30	27	28
		US	59	64	63
		Rest of the world	11	9	10
% in grand total			**36**	**34**	**33**
% in total alliance	WINGS	NW-Europe	34	--	--
		US	61	--	--
		Rest of the world	5	--	--
% in grand total			**9**	--	--
% in total alliance	NON-ALLIANCE	NW-Europe	0	0	0
		US	0	0	0
		Rest of the world	100	100	100
% in grand total			**1**	**1**	**1**

Source: OAG (2005); own calculations

Not surprisingly, the growth of European hubs has been on average lower than the growth of American hubs (Figure 4). In the US, Cincinnati, Houston, New York JFK, Minneapolis and Boston demonstrated high growth rates in particular. In Europe, only Amsterdam Schiphol experienced growth levels comparable to its American counterparts. In contrast to Frankfurt, Munich and Heathrow, this growth continued in between 2004 and 2005.

Figure 4. Percent growth in hub-connectivity, NW-Europe to US for selected airports, 2003-2005

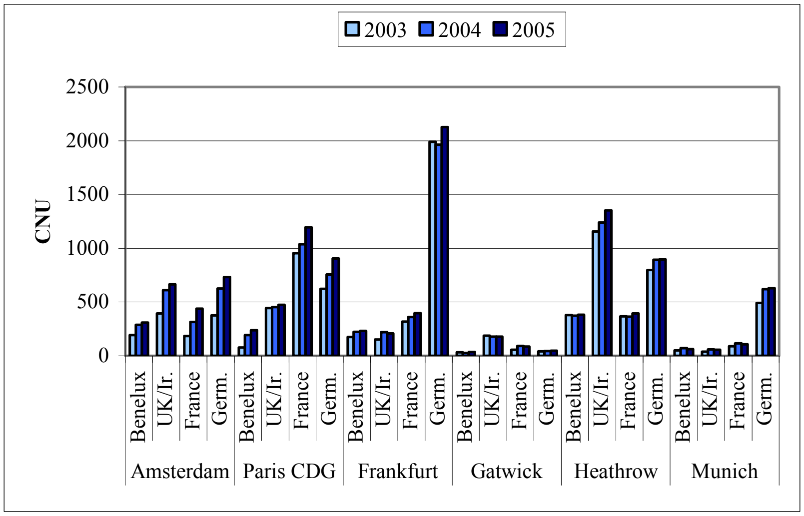


Source: OAG (2005); own calculations

Developments within alliances

As the authors showed earlier, growth at the SkyTeam hubs can be attributed largely to extension of the SkyTeam alliance and the growth of transatlantic frequencies to the European hubs Amsterdam Schiphol and Paris CDG. In addition, Air France-KLM increased feeder frequencies between Schiphol and the French hinterland. Paris CDG is more orientated towards France and Germany for attracting transfer passengers. There is a clear distinction in geographical market segmentation between the two hubs. Paris CDG's feeder network in northwest Europe is primarily located in France, whereas the feeder network of Amsterdam is more focused on the UK and has in general less CNUs per feeder airport (Figure 5 and Appendix).

Figure 5 Connectivity units between NW-European regions and the US via selected European hubs, 2003-2005



Source: OAG (2005); own calculations

Within the SkyTeam alliance, Minneapolis (Northwest) seems to start to play a less important role. Although the number of frequencies between European origins remained equal between 2004 and 2005, the hub connectivity of Minneapolis decreased because of fewer frequencies to the American domestic market. This conclusion is in line with the strategy of Northwest to convert Detroit into the primary intercontinental hub and to give Minneapolis a secondary, continental role. After the large-scale expansion of Detroit Metro, the airport is much better equipped to facilitate and the hub system of Northwest, which requires high peak-hour capacity and short connecting times.

The Star alliance has two primary European hubs for the market between northwest Europe and the US: Frankfurt and Munich. The secondary hub of Star, Copenhagen, only plays a marginal role for the market under consideration. At Frankfurt, growth percentages were moderate due to severe capacity restrictions at the airport. In contrast to Amsterdam, Paris CDG and Heathrow, both hubs are largely orientated towards the large German domestic market for attracting feeder traffic (see Appendix). In 2005, the percentage of hub connections with a German origin was 72% at Frankfurt and 74% at Munich. In comparison, for Amsterdam, the percentage of hub connections originating in Benelux was only 14%, for Paris CDG (French origins) 43% and for Heathrow (UK/Ireland origins)

45% (see Appendix). Outside Germany, there are not many airports in northwest Europe used as feeder airports by Frankfurt and Munich.

Finally, OneWorld has little opportunities to grow on the northern part of the transatlantic market as far as London Heathrow is concerned. Heathrow is capacity restricted while the Gatwick hub strategy did not prove to be a success at the end of the 1990s. As the Appendix shows, connectivity is mostly generated at the large British and European airports. On the American side, Chicago O'Hare saw its position as a hub decline to some extent between 2004 and 2005. Chicago is a dual hub of both American (OneWorld) and United (Star). Possibly, the implementation of the rolling hub concept by American may be the cause of the slightly declining hub position between 2004 and 2005. American depeaked its hub operation in order to ease congestion problems at the airport. Depeaking might have had a negative impact on connectivity levels at O'Hare.

Some first evidence on concentration levels after the Air France/KLM merger

Until now, the impact of the Air France-KLM merger and the integration of Wings into SkyTeam seem to have had only positive network impacts. But what about the impact of these developments on market concentration levels at the transatlantic market? The number of global airline alliances decreased from four to three.

Although market concentration is somewhat outside the scope of the paper, the results of our model allow us to compute average market concentration levels in terms of the Hirschman-Herfindahl Index[1] (HHI) at the route level. Figure 6 shows the average HHI between 2003 and 2005 for a selection of European airports. The HHI was defined at the airport-pair level. Input for the HHI is the share of an alliance in the total number of direct and indirect connectivity units per airport pair.

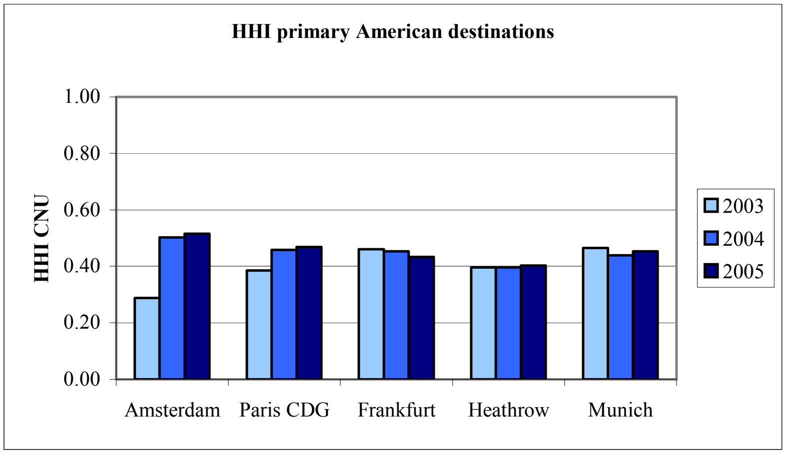
The Air France-KLM merger and the integration of Wings into SkyTeam have had a market concentration increasing impact. Both at Amsterdam and Paris CDG, concentration levels increased substantially. This conclusion holds for all route types, but is stronger for primary and secondary American destinations than for tertiary destinations. However, concentration levels at the (thin) tertiary destinations were already high in 2003. In addition, the concentration increasing effects are larger for Amsterdam than for Paris CDG. At the same time, concentration levels at three other major northwest European airports remained virtually stable between 2003 and 2005.

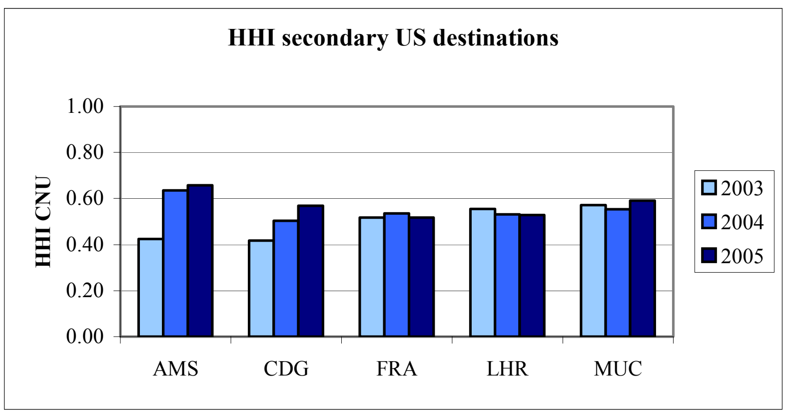
Increasing concentration levels generally allow airlines to set higher fares (see for example, Borenstein, 1992). Hence, evaluation of the consumer

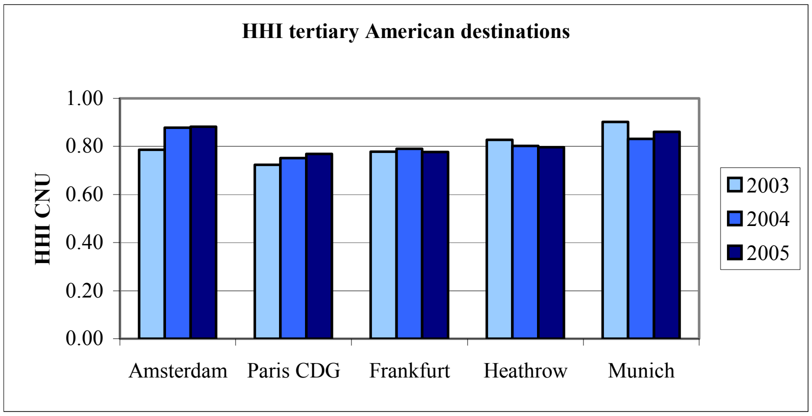
[1] Sum of squared market shares.

welfare impacts of the Air France-KLM will have to take into account both the positive impacts of the enlargement of the network scope as well as potential impacts on airfares. Yet, this issue is outside the scope of this paper and should be dealt with in future research.

Figure 6. Average Hirschman-Herfindahl Index (HHI) per airport pair between selected European airports and primary, secondary and tertiary US destinations, 2003-2005







Source: OAG (2005); own calculations

CONCLUSIONS

In this paper, the authors argued that the measurement of network performance in hub-and-spoke systems should take into account the quantity and quality of both direct and indirect connections. The NETSCAN model quantifies the potential direct and indirect connectivity and scales the quality of these connections to the quality of a theoretical direct connection. As a result, direct and indirect connections (via hubs) are additive and can be compared. NETSCAN allows for an integrated analysis of the competitive position of airline/alliance networks, airports and regions.

The authors applied NETSCAN to the network between northwest Europe and the US between 2003 and 2005. One of the most striking developments has certainly been the impact of the Air France-KLM merger on the competitive position of Amsterdam Schiphol and the SkyTeam alliance in general. Both the number of direct and indirect travel opportunities for the passengers travelling from and via Schiphol increased at a higher rate than at the neighbouring European hub airports. On the one hand, the integration of Wings into SkyTeam resulted in a substantial increase in connecting opportunities at the hubs of the extended SkyTeam alliance. On the other hand, frequencies between Amsterdam and the new SkyTeam hubs as well as French secondary airports were increased and new services were initiated.

Yet, the paper has also demonstrated some first signs of the potential impact of the Air France-KLM merger and the integration of Wings into SkyTeam on concentration levels in the transatlantic market. In particular, at the routes between Amsterdam/Paris and the primary and secondary American destinations, average concentration levels increased substantially.

In contrast, concentration levels between some other large European airports and the US remained virtually unchanged. Increasing concentration levels might eventually result in higher airfares for consumers. The positive welfare effects of the Air France-KLM merger in terms of a large network scope will have to be evaluated against potential upward effects on fare levels. Yet, this issue will have to be addressed in future research.

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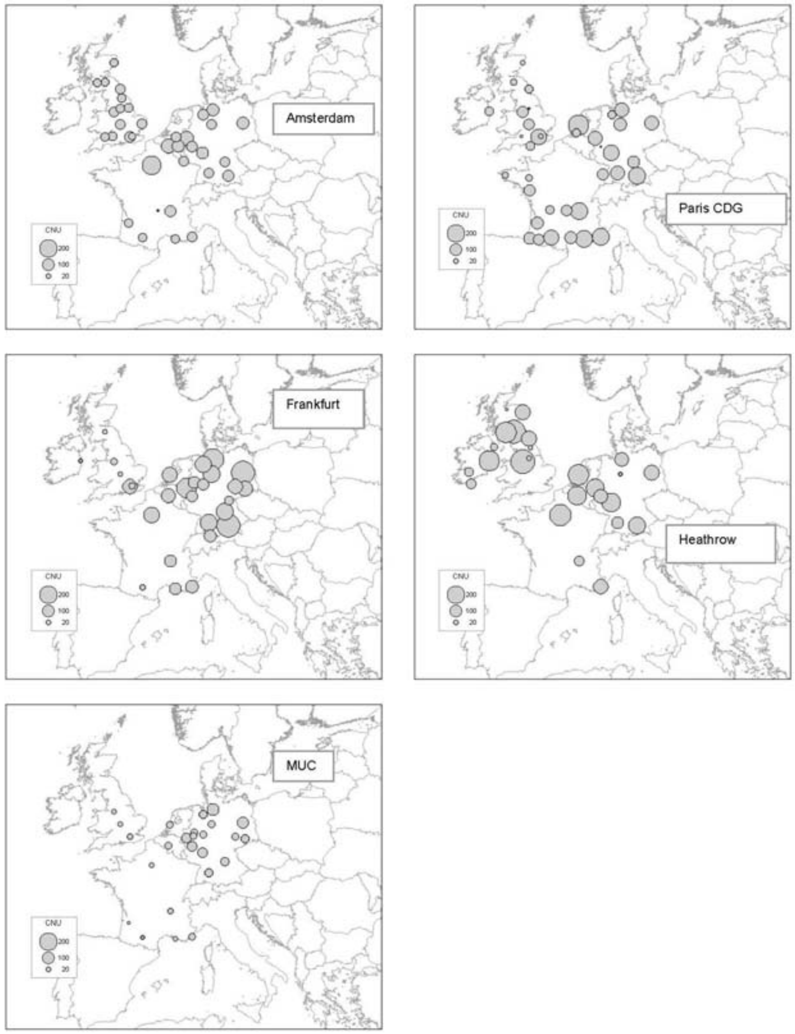
APPENDIX

Annex A Indirect connectivity (CNU per week) of Northwest-European airports via selected, major European airports, 2005



Source: OAG (2005); own calculations