Competition between hub airports: the case of Amsterdam Airport Schiphol

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Abstract

In this paper we present a methodology to analyze the competitive position of hub airports on markets served with a transfer at these airports, the so-called hub markets. This methodology results in the estimated passenger market shares of hub-airports on thousands of individual hub markets. The paper adds to the existing body of knowledge since earlier research mainly addressed the supply-side of airline network competition in terms of connectivity and generalized travel costs. In this paper, we add the demand side by modelling passenger choice behaviour in airline networks.

We apply this methodology to the competitive position of Amsterdam Schiphol vis-à-vis competing hub airports. We conclude that the most important hub markets for Amsterdam are the markets between North-America and Europe, Asia/Pacific and Europe and the hub markets within Europe. At about 30% of the hub markets via Schiphol, SkyTeam and partners have a monopoly. The majority of these markets are very small with only a few passengers per day. At bigger, long-haul markets, the airport faces heavy competition from other hubs.

The most important competitors of SkyTeam at Amsterdam are still the traditional two: Frankfurt (Star alliance) and Heathrow (Oneworld). Paris CDG frequently pops up as an important hub on markets also served by Amsterdam Schiphol. However, since the Paris and Amsterdam hubs belong to the same carrier Air France-KLM, this is rather network overlap than network competition.

In the various geographical submarkets, also competitors arise besides Heathrow and Frankfurt. Between Europe and North America, Chicago (Oneworld/Star) arises besides Heathrow and Frankfurt whereas alliance hubs of Newark (Continental) and New York JFK (Delta) also play an important role. Between Europe and Asia, Munich, Dubai, Singapore and Helsinki pop up as competitors, whereas in the intra-European market the Star alliance competes with SkyTeam not only via Frankfurt but also via Munich and Copenhagen. Between Europe and Latin-America, Iberia at Madrid is the biggest competitor on hub markets served via Schiphol whereas Air France via Paris shows a large overlap with the Schiphol hub.

The model presented here is in particular relevant for governments and airports that want to benchmark the competitive position of a hub airport accurately and go beyond the traditional 'top ten' list of passenger numbers.

Key words: airport competition, hub market, generalized travel costs, Amsterdam Schiphol

1. Background

In 2007, Madrid Barajas airport by-passed Amsterdam Airport Schiphol as the 4th airport in Europe in terms of passenger numbers. A Dutch newspaper quoted "Schiphol is losing from its competitors. Schiphol is still growing, but other airports are growing much faster. Madrid by-passed Schiphol and is now the 4th airport in Europe behind Frankfurt, Heathrow and Paris CDG. Also Munich and Barcelona are growing quickly and may take over Schiphol's position within a few years" (NRC 2008).

This newspaper quote is symptomatic of how the competitive position of an airport is traditionally being approached: the competitive position of airports and airlines is usually measured 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, broken down by geographical region. Although such indicators are valuable in itself, they do not give any information on the competitive position of an airport.

Taking again the example of Madrid and Schiphol, it is questionable if Iberia at Madrid really competes with KLM at Schiphol. Maybe Iberia snatches away a number of passengers that could have travelled directly with KLM to Lima, with an indirect travel option via Madrid. And most likely both carriers compete via their hubs for transfer passengers travelling between Stockholm and Lima. However, looking at the total passenger market travelling from, to and via Schiphol, Iberia at Madrid is only a minor competitor to KLM at Schiphol. Both carriers serve to large extent very different city-pair markets.

This example illustrates that the gap in the "top ten lists" approach lays in the fact that, as a consequence 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 markets (from A to B). On the other hand, 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 (frequency, travel time etc.).

1.1 The network connectivity approach

In the network connectivity approach, the complexity of airline network competition has been widely acknowledged. Veldhuis & Burghouwt (2006) for example, take explicitly into account the fact that airlines do not only compete head-to-head but also indirectly on markets with a transfer at their respective hub airports. Therefore, they measure the competitive position of airline networks and hub airports in terms of both direct and indirect connectivity

levels, using the Netscan model. They applied their model to the market between Northwestern Europe and the United States, with further extensions to the competitive position of hub airports in the Asia Pacific region (Matsumoto et al. 2008) and the Middle East region (Burghouwt & De Wit 2008). Similar connectivity models have been used by Burghouwt (2007), Burghouwt & De Wit (2005) and Malighetti et al. (2008). A recent improvement includes the translation of connectivity levels into generalized travel costs of all direct and indirect travel options, taking into account not only frequencies and travel time, but also ticket price and time values (Veldhuis et al. 2007).

1.2 Demand side and supply side

A major shortcoming of the network connectivity approach is that it is a supply-oriented approach. The competitive position of airline networks and airports is benchmarked in terms of connectivity, reflecting the quality of the network including frequencies, connection times, travel times and sometimes ticket price. The demand side in terms of the resulting passenger behaviour and the passenger market share of an airport or airline hub vis-à-vis its competitors is not taken into account.

1.3 Objective

In this paper, we add to the existing body of acknowledge by extending the supply-oriented network connectivity approach with the demand side. We present a methodology to analyse the competitive position of hub-airports in an integrated way. By doing so, we are able to estimate the passenger market share of hub-airports in the downstream airline markets.

The model will be applied to Amsterdam Airport Schiphol. For this airport, we estimate its market share in all individual hub-markets served by KLM and SkyTeam partners with a transfer at this airport. We will identify the hub's most important competitors for the various geographical submarkets.

1.4 Outline

First, we discuss briefly the nature of airline network competition. Here, we limit our analysis to hub competition. Next, we introduce the methodology to estimate the market share of airline hubs in hub markets, the so-called Netcost model. Then, we apply our model to the competitive position of Amsterdam Airport Schiphol vis-à-vis its competitors. We limit our analysis to the markets served via/ with a transfer at Amsterdam Schiphol. We will identify

the most important and upcoming competitors of Amsterdam as a hub. Finally, we wrap up and outline the research steps to further improve the model presented here.

2. Direct and hub connectivity

The extent to which airlines can play a role 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. If the market size if below this threshold, the market can only be served indirectly via hubs.
However, this does not mean that, if a direct travel opportunity is available, that 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 ticket prices, mainly dependent on two things. First, the geographical location of the respective hub in relation to the main continental and intercontinental traffic flows. Amsterdam has certainly an excellent location for serving the transfer market between Asia and the UK but is less suited to serve the market between Southern-Europe and the United States. 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.

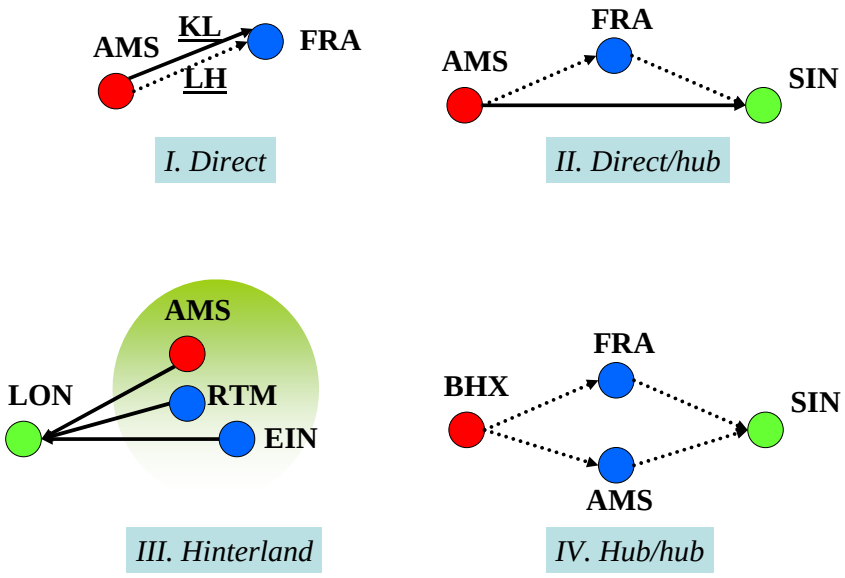
Against the background of hub-and-spoke networks, we may distinguish two types of connections:

- Direct connections: flights between A and B without a hub-transfer (A-B)
- Hub connections: connections via (with a transfer at) hub A between origin C and destination B (C-A-B).

3. Airline network competition

From this follows that airlines can compete in four basic ways via their networks. We have outlined them in figure 1

Figure 1: Four types of airline network competition



I. Direct competition: airline A and B compete head to head, for example on the city-pair market Amsterdam-Frankfurt. Ticket price, flight frequency and customer loyalty play the most important role in the passenger choice behaviour

II. Hinterland competition: airlines A and B serve the same city-pair market, but from different airports in an overlapping catchment area. For example, airline A and B may compete on the city-pair market between the Randstad metropolitan area to London. Not only ticket price, flight frequency and customer loyalty, but also access and egress times are important variables in the competitive position of each airline at the various airports (see e.g. Hess 2005; Pels 2001).

III. Direct/hub competition: on the largest long-haul city-pair markets, both direct connections and connections with a transfer at hub airports exist. For example, the market between Amsterdam and Singapore is served by KLM and Singapore Airlines (directly), but also indirectly, for example via Frankfurt with Lufthansa. In addition to the variables of flight frequency and ticket price, the in-flight time and transfer time becomes an important competitive variable. As the transfer and in-flight time of an

indirect connection become longer, the probability of a passenger choosing that option becomes smaller. In reality we see that, when a direct connection is available, passengers show a huge tendency to choose the airline(s) that offers a direct connection, leaving the indirect connect a relatively small market share.

IV. Hub/hub competition: on city-pair markets where no direct connection is available, various airlines/ alliances may compete via their hubs for transfer passengers. The same holds true for city pair markets where a direct connection is available. However, as stated earlier, the direct connection is then likely to get the lion's share of the total origin-destination market.

For the sake of simplicity, we will focus on the analysis of hub/hub competition in this paper (type IV competition). We apply the model to those airport-pair markets served via/ with a transfer at Schiphol.

Our model (see description in next paragraph) can be easily applied to the direct/hub and direct competition or other airports than Amsterdam Schiphol. In the current stage of the model, it cannot be applied to hinterland competition. However, an extensive body of knowledge is available on the modelling of passenger choice behaviour and airport/ airline market shares in the multi-airport regions (Cohas et al. 1995; Furuichi & Koppelman 1005; Hess 2005; Pels 2001).

In the next section, we will briefly describe the model and data used.

4. Methodology: the Netcost model

4.1 Netcost

We have used the Netcost model, developed by Amsterdam Aviation Economics, to estimate the market share of the Schiphol hub of KLM and SkyTeam partners in all airport-pair markets served with a connection (transfer) at Schiphol vis-à-vis all competing hub airports or direct connections on these airport-pair markets (type IV competition).

Since a detailed description of this model is beyond the scope of this paper, we simply present its major elements. For a detailed discussion of Netscost, we refer to Veldhuis & Heemskerk (2006).

4.1.1 Gravity module: estimation of potential origin-destination demand

For air transport researchers, real origin-destination passenger numbers at the airport of city-pair level are extremely difficult to get hold of or very expensive for markets outside the United States. Therefore, in order to estimate the market share of Schiphol in the hub markets served via this airport, we have estimated total origin-destination demand on the airport-pairs served via/with a transfer at Amsterdam Schiphol using a gravity model.

Based on the distance between airport X and airport Y and its 'gravity' in terms of total seat capacity of the airports on both ends of the market, the total potential origin-destination demand between airport X and Y can be estimated as follows:

$$\text{PotentialOD market}_{xy} = C * \frac{(Capacity_X)^{\alpha} * (Capacity_X)^{\beta}}{(\text{Distance}_{XY})^{\gamma}} \qquad (1)$$

where C is a constant and α, ß, γ the coefficients. We have estimated the coefficients and C using the Amsterdam Schiphol survey.

However, due to its simplicity, at the individual airport pair market level, over- and underestimation have been regularly observed. This is because the gravity model does not reflect unique historical or cultural relationships, trade flows or dependence of air travel of island economies. Future research should further extend the gravity model to better reflect these and other variables

4.1.2 Generalized travel costs

Now that we have estimated total origin-destination passenger demand between all markets served via Schiphol, the question is what share of the total market Amsterdam Schiphol may take.

We estimate this market share using a generalized travel cost model. Generalised travel costs are monetary (€) representations of all travel inconveniences, including travel time, waiting time for the next flight and ticket price. All these travel attributes can be determined by analyzing the OAG-schedules (see next paragraph), except from the ticket prices.

Detailed data on ticket prices are, outside the United States, difficult to get. Therefore, we use a ticket price model. The average ticket price for an individual carrier-market combination is a function of the route length, type of carrier (full service/ low-cost), type of flight (direct/ indirect), type of passenger (non-business or business) and competition level. The ticket price module has recently been calibrated using a dataset of over 400 routes from Amsterdam Airport Schiphol (Van der Flier 2008).

4.1.3 Travel alternatives and the route choice module

For each individual airport-pair market served with a transfer via Schiphol, we have translated the inconvenience attributes of each travel alternative on this market into generalized travel costs. The travel alternatives are carrier/alliance specific and may be direct (without a transfer) or indirect (with a transfer).

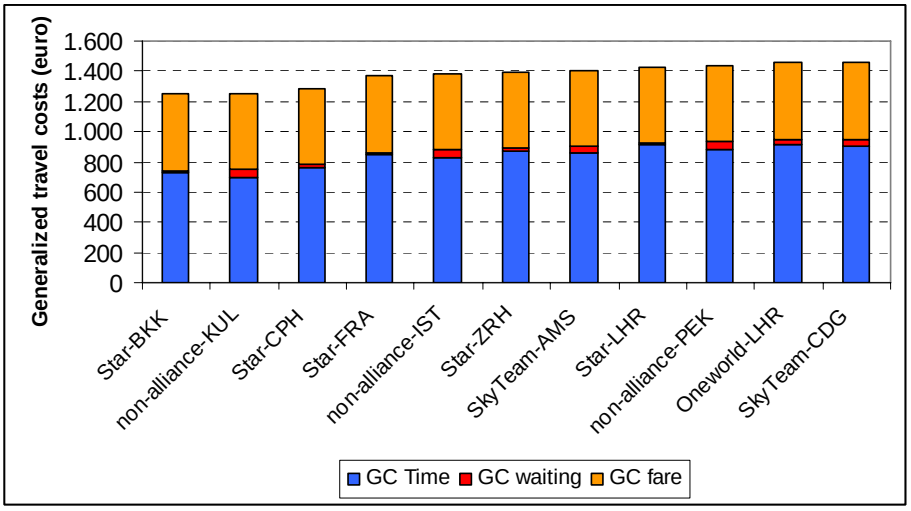
For example, the market between Stockholm and Singapore is served with a transfer at Schiphol. For this market, we have identified all travel alternatives[1]. No direct travel options are available on this market. All passengers travel via hub airports. Then, the Netcost model computes the total generalized costs consisting of its various components (ticket price, waiting time and travel time) (see figure 2b). As figure 2 shows, the total generalized travel costs for this particular market vary between 1200 and 1400 euros (one-way). Air fares are low due to the high competition level (about 1000 euros for a return fare). The Star alliance offers via Bangkok the most attractive option, mainly because the high frequencies between Bangkok and Singapore and the daily frequency between Stockholm and Bangkok[2]. Amsterdam has an intermediate position, whereas Paris CDG is the least attractive airport from a generalized cost perspective.

Figure 2a: Travel alternatives on the Stockholm to Singapore market

[1] Indirect travel alternatives are not available from the OAG database. The Netcost model constructs the indirect connections, combining 'relevant' legs. A relevant combination of legs means that the destination airport of leg 1 equals the originating airport of leg 2, the connection is made within the same alliance or airline and the connection meets restrictions with respect to maximum routing and transfer times.

[2] For further and detailed examples and illustrations of this conversion, we refer to the Netcost section on the AAE website.

Figure 2b: Generalized travel costs on the market between Stockholm and Singapore (leisure one-way)



Now that we have estimated the generalized travel costs for each travel alternative on markets served via Schiphol, we apply a route choice model to distribute the total potential origin-destination demand per individual market (section 4.1.1) over the various available travel alternatives. We can then easily compute the market share of Amsterdam Schiphol in terms share in total potential origin-destination demand per individual hub market.

4.2 Data

Our dataset consists of OAG (Official Airline Guide Schedules) for 3rd week of September 2007. The OAG dataset contains variables based on published information on scheduled flights. Variables include departure airport, destination airport, flight times, airport coordinates, flight frequency, aircraft type and seat capacity.

5. Competitive position of Amsterdam Schiphol in hub markets

We have used the Netscan model to estimate the market share of Amsterdam Airport in the hub markets served *via* (with a transfer at) this airport. Since only KLM and its SkyTeam partners operate as hub operation at Amsterdam Schiphol, the results presented here apply only to the SkyTeam hub operation.

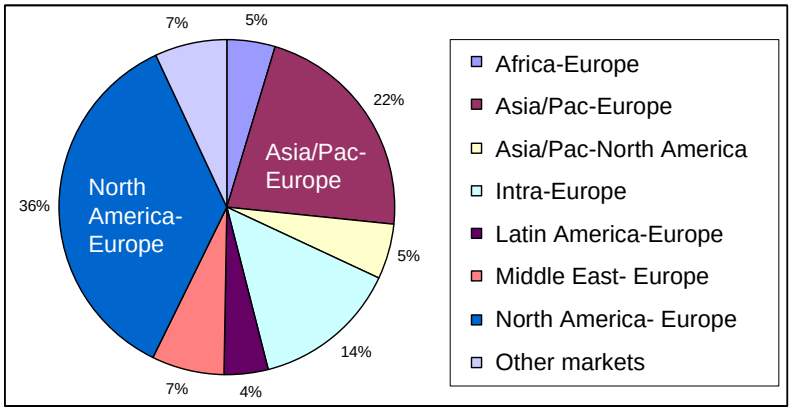
5.1 Relative size of the hub markets

In order to get an idea of the importance of the various geographical submarkets served via Schiphol, we have estimated the relative total size of the hub markets served via Schiphol. By relative size, we mean the share of the geographical submarket in the total hub market (passenger numbers).

From figure 3, we can conclude that the market between Europe and North-America, Europe and Asia and the intra-European connecting market are the most important ones. Together, they account for about 72% of the total hub market in which Schiphol plays a role.

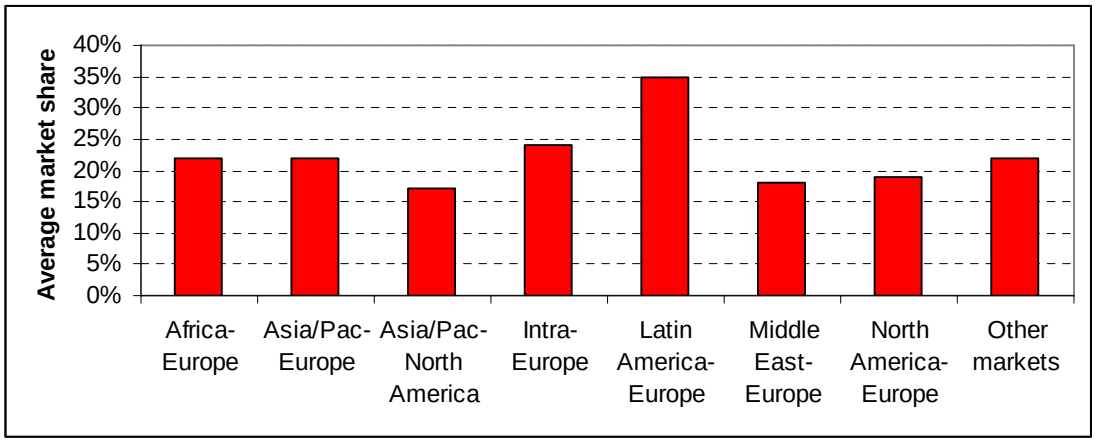
The 'hinterland' markets between Europe on the one side and the Middle East, Latin America and Africa take account of another 16% of the market. The intercontinental to intercontinental markets are responsible for the remaining part of the hub markets.

Figure 3 Relative size of the hub markets served via Schiphol



In these various geographical submarkets, the average competitive position in terms of passenger market share of SkyTeam at Amsterdam Schiphol varies. Not surprisingly, competition is toughest at the largest market: the market share of SkyTeam at Amsterdam in the North America to Europe. Also the market share in the Europe-Middle East market is low on average. In these geographical submarkets, SkyTeam mostly serves markets also served by competing hubs.

Figure 4 Average market share of Amsterdam Schiphol in the various geographical submarkets



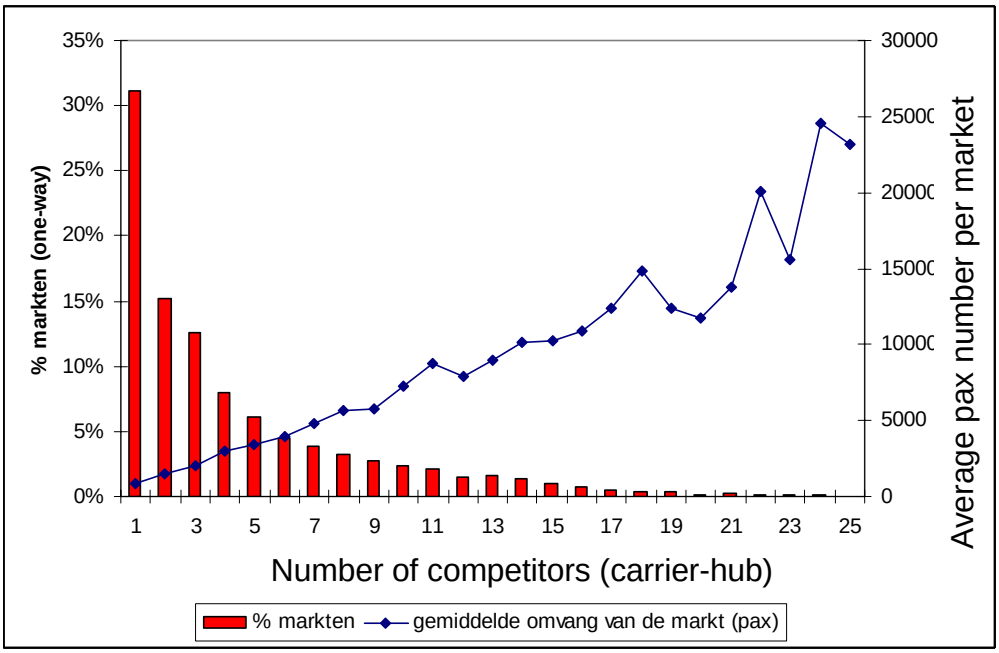
On the other hand, the average position of Schiphol is much better in the Latin-America to Europe market as well as the intra-European market. SkyTeam has a much more unique position here. Many of the individual hub markets are not served by competing alliances. However, one should not that the Latin America-Europe market is relatively small market for Schiphol as a hub.

5.2 Monopoly routes

At 31% of the hub markets served via Amsterdam, Air France-KLM has a monopoly. These markets are not served with a direct flight or via any other hub airport (figure 5). At 31% of the markets, Air France-KLM has thus the opportunity to achieve higher yields by setting higher prices. However, the average size of these monopoly markets is small. Most of them have only a few passengers a day.

The number of markets with more airline offering direct or indirect connections quickly increases with the average size of the individual hub market as figure 5 shows. At the markets with 2-4 competitors, the (competing) hubs are mostly Air France-KLM at Paris CDG, Lufthansa at Frankfurt and BA at Heathrow. At the very large markets, the number of alternatives to Amsterdam (directly or via another hub), is large.

Figure 5: % of markets, number of competitors and average hub market size (pax)

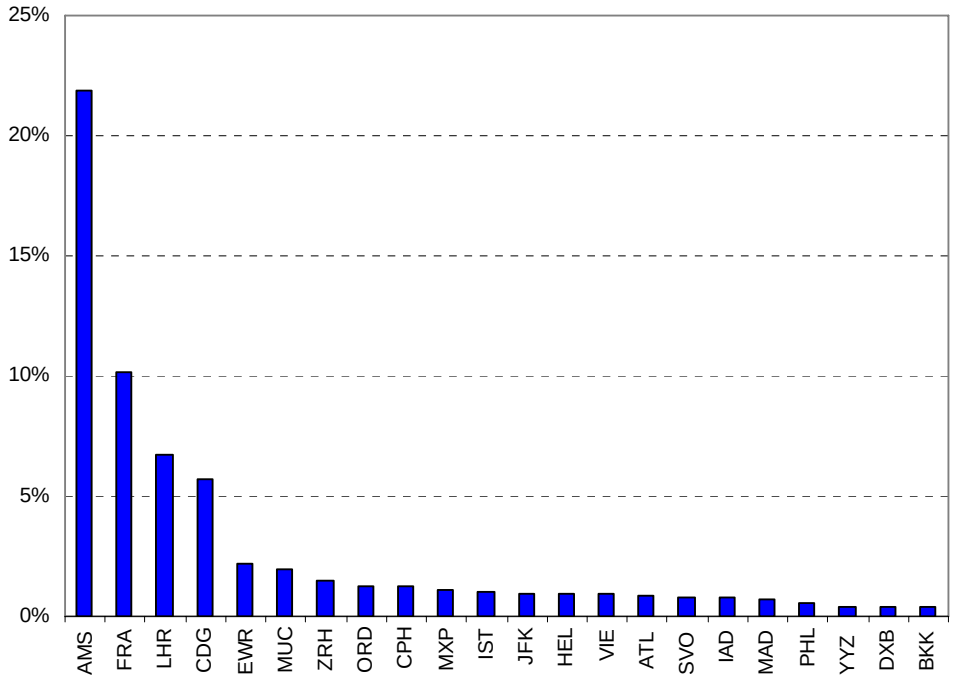


5.3 Most important competitors

Which hubs are the most important competitors for SkyTeam at Schiphol? Figure 6 answers this question. It shows the market share of the various hubs on those markets served via Schiphol. The share of direct connections is not shown here.

SkyTeam at Amsterdam has the largest share in the total estimated transfer passenger volume on markets served via this airport (>20%). This is not a surprise, given the fact that a 30% of the markets, SkyTeam has a monopoly. If we would do the same exercise for, let's say, Frankfurt, Frankfurt would rank highest in terms of market share. This is because since many unique markets via Frankfurt would then be included. These unique Frankfurt markets have not been included in the current analysis because we have limited our research to markets served via Amsterdam Schiphol.

Figure 6: Share of hub airports (%) in total transfer passenger volume on markets served via Amsterdam Schiphol



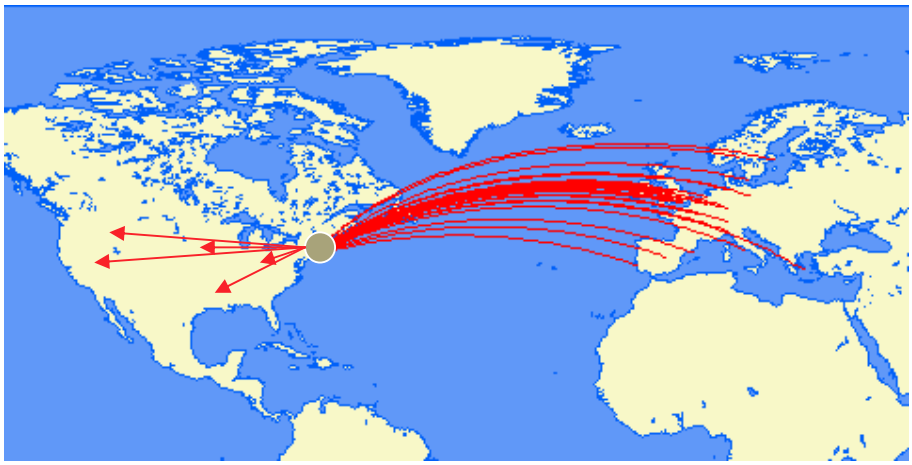
The most important competitors of SkyTeam at Amsterdam Schiphol are to a large extent still the traditional ones: Oneworld via Heathrow and Star via Frankfurt. Also Paris is an important hub in many of the hub markets served via Amsterdam. Because of the dual hub system of Air France-KLM, this is much more network overlap rather than network competition.

Further down the scale, we find a few non-European hubs that play a role in hub markets also served by Schiphol. First of all, this is Newark. From here, Continental serves not only many primary destinations in Europe but also a number of smaller, secondary destinations such as Bristol, Edinburgh and Glasgow. Because of this hub-bypassing strategy, Continental serves a quite large number of hub markets between Europe and the US, also being served via Amsterdam (figure 7). Yet, Continental belongs to the same alliance as Air France-KLM at Schiphol. It is questionable if Continental can be labelled as a competitor for Air France-KLM at Schiphol. However, the Continental case shows clearly the consequences of a strong hub-bypassing strategy for traditional hubs such as Amsterdam.

Other non-European competitor is Chicago (United), Istanbul (Turkish Airlines) and Dubai (Emirates). Munich (Star), Zurich (Star), Copenhagen (Star), Vienna (Star) and Helsinki are all second-tier European competitors for the Amsterdam hub.

Asian, African and Latin American hubs do not play a role as substantial competitors for Amsterdam Schiphol. Of course, at specific individual hub markets, other hubs than listed here may play a role.

Figure 7: The hub-bypassing strategy of Continental



5.4 Geographical submarkets

Finally, we have broken down the competitive position of SkyTeam at Amsterdam vis-à-vis other hubs by geographical submarket. Without going into too much detail, we have listed the most important (competing) hubs for Amsterdam on the markets between hinterland Europe to intercontinental regions in the table below. The hubs have been ranked according to their share in total transfer passengers at hub markets served via Amsterdam.

In a number of cases, the hubs belong to the SkyTeam alliance. Apart from Paris CDG, it is open to discussion if these hubs should be considered as competitors for Air France-KLM's hub at Schiphol.

Table 1: Most important (competing) hubs for Amsterdam Schiphol between Europe and various intercontinental regions

North America	**Asia/Pacific**	**Europe**	**Middle East**	**Africa**	**Latin America**
Heathrow (BA/ Oneworld)	Frankfurt (LH/Star)	Frankfurt (LH/Star)	Frankfurt (LH/Star)	Frankfurt (LH/Star)	Paris CDG (AF/SkyTeam)
Frankfurt (LH/Star)	Paris CDG (AF/SkyTeam)	Paris CDG (AF/SkyTeam)	Istanbul (TK/Star)	Heathrow (BA/ Oneworld)	Madrid (IB/Oneworld)
Paris CDG (AF/SkyTeam)	Heathrow (BA/ Oneworld)	Heathrow (BA/ Oneworld)	Heathrow (BA/ Oneworld)	Zurich (LX/Star)	Frankfurt (LH/Star)
Newark (SkyTeam)	Munich (LH/Star)	Munich (LH/Star)	Paris CDG (AF/SkyTeam)	Paris CDG (AF/SkyTeam)	Heathrow (BA/ Oneworld)
Chicago	DXB (Emirates)	Copenhagen	Munich	Istanbul	Newark

(AA/Oneworld; UA/Star)		(SK/Star)	(LH/Star)	(TK/Star)	(SkyTeam)
	Singapore (SQ/Star)		DXB (Emirates)		
	Helsinki (AY/Oneworld)		Cairo (Egypt Air)[3]		

Some interesting conclusions can be drawn from this table. First of all, the Oneworld alliance is mainly a competitor with respect to the hub markets between Europe and the United States (LHR) as well as to Africa (LHR) and Latin America (MAD). In all other markets, Frankfurt is Schiphol's most important competitors in the hub markets.

Secondly, Air France-KLM's other hub Paris CDG shows a lot of network overlap in a number of submarkets. This is in particular true for the Europe to Latin America market, but also for the markets to Asia and within Europe. Although other factors may be of importance here, the network overlap suggests that there is room for further optimization of the Air France-KLM dual hub network.

Third, Istanbul is a surprising hub competitor for Schiphol. Turkish Airlines offers, as one of the new fast growing members of the Star alliance, access from Europe to the Middle East and Africa.

Fourth, at this moment, the role of Emirates at Dubai as a competitor for SkyTeam at Schiphol is still limited. Only on a number of markets between the Northwestern Europe and Asia-Pacific, Emirates competes with Air France-KLM via its Dubai hub. On these markets, it is able to get a substantial market share. Given the aggressive network expansion of Emirates in Europe, the US and Asia, we may expect the role of Dubai to grow in the years to come.

6. Conclusions and suggestions for further research

6.1 Summary

In this paper, we have presented the general components of a model to analyze the competitive position of hub airports on hub markets. This methodology results in the estimated passenger market shares of hub-airports on thousands of individual hub markets. The paper adds to the existing body of knowledge since earlier research mainly addressed the supply-side of airline network competition in terms of connectivity and generalized travel

[3] Plans to entry the Star alliance within five years

costs. In this paper, we add the demand side by modelling passenger choice behaviour in airline networks.

We have applied the model to the competitive position of Amsterdam Schiphol vis-à-vis competing hub airports. We conclude that the most important hub markets for Amsterdam are the markets between North-America and Europe, Asia/Pacific and Europe and the hub markets within Europe. At about 30% of the hub markets via Schiphol, SkyTeam and partners have a monopoly. The majority of these markets are very small with only a few passengers per day. At bigger, long-haul markets, the airport faces heavy competition from other hubs.
The most important competitors of SkyTeam at Amsterdam are still the traditional two: Frankfurt (Star alliance) and Heathrow (Oneworld). Paris CDG frequently pops up as an important hub on markets also served by Amsterdam Schiphol. However, since the Paris and Amsterdam hubs belong to the same carrier Air France-KLM, this is rather network overlap than network competition.
At the different geographical submarkets, we have identified additional competing hubs such as Istanbul (Turkish Airlines/ Star), Dubai (Emirates), Madrid (Iberia/Oneworld), Munich (Star), Copenhagen (Star), Helsinki (Oneworld) and Chicago (United/American Airlines).

6.2 Relevance for policy makers and airports

The model and analyses presented here are in particular relevant for policy makers and airport that want to go beyond the 'top ten lists' to benchmark or monitor the competitive position of their airport. The analyses described in this paper show the capabilities of the model in identifying the competing airline hubs in various geographical submarkets. The model can be easily applied to direct competition and direct/hub competition.
One of the advantage of the model applied here is that has few data requirements. The only data input that is needed are OAG data, which allow for benchmark or monitoring studies independent of airport or government air traffic statistics.

Further research steps

With regard to the further improvement of the Netcost model, the following steps should be addressed in future research:

- Currently, the model is not capable of analyzing competition between airports in multi-airport regions (hinterland competition). This is not only relevant when the competitive position of airports in the same catchment area needs to be analysed, it is

also relevant with respect to the analysis of hub/hub, direct or direct/hub competition. In this paper, we carried out the analysis at the airport-pair market level. This means that airports within the same multi-airport region or catchment area are considered to be endpoints of different markets. In reality, this is of course not the case. For a passenger travelling from New York to London, the arrival airport within that city is not always that relevant. Gatwick and London may then have to be considered as part of the same market.

- The model has been calibrated on Schiphol surveys. Calibration with European-wide or US-wide statistics (e.g. DB1A), would improve the quality of the model.
- We have used a simple gravity model to estimate the total potential origin-destination market on a city-pair. The two variables included in the model are distance and total seat capacity of the endpoints. This leads to serious over- and underestimations of origin-destination demand on a number of markets. Therefore, future research should include more variables to better reflect historical, cultural, geographical and economic relationships.

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