The competitive landscape of air transport in Europe

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Abstract

Competition between airlines and airports increased significantly since the deregulation of the intra-European air transport market in 1997. The passenger has a wider choice in terms of routings and departure airports than twenty-five years ago and pays a lower price. In this paper we investigate in which parts of Europe airline and airport competition are most intense and how the competitive landscape has changed since the liberalisation of the intra-European market.

Competition levels are modelled for all air transport markets available to consumers in each western-European municipality using a Multinomial Logit (MNL) model. This allows us to determine how competitive the air transport product available to consumers in each of those municipalities truly is and how competition levels have changed. As opposed to most other competition studies we take all viable direct and indirect flight alternatives into account, as well as competing alternatives from nearby (adjacent) airports. This makes it the most extensive analysis of competition in the European aviation industry performed to date.

As expected the results show that airline competition, allowing for grouping of the airlines belonging to the same alliance together, has in general increased since the liberalisation of the intra-European market. This can mainly be ascribed to the rise of the low cost business model. The spatial analysis however shows an uneven outcome. Changes in airline competition are most pronounced in areas that were previously not well served, such as the more remote regions in the United Kingdom, Spain and Italy. In Germany airline competition is lagging behind due to the strong dominance of the STAR alliance. In large parts of Scandinavia, but also in parts of France and Spain, airline competition is considerably less. These areas are often served only by a handful of airports and/or airlines, limiting airline choice and therefore competition.

Key words: Competition, liberalisation, Choice Modelling, Airport attractiveness, Low cost carriers

1. Introduction

Up to the late 1990s the intra-European air transport markets were regulated through bilateral air service agreements. This meant that most routes were only operated by one or two designated flag carriers who were constrained in terms of capacity and pricing. Starting in 1987, with the adoption of the first of three liberalization packages, the intra-European markets was gradually liberalized. The adoption of the third package in 1997 eventually led to the creation of a single European aviation market. From this moment on any EU carrier was allowed to operate from any EU country and beyond.

The process of deregulation resulted in important changes in the industry. The removal of constraints on market entry and capacity allowed airlines to optimize their network configuration and operate more efficiently. The removal of the price constraints allowed them to price more aggressively and strategically. Deregulation thus led to more effective competition and more efficient operations, resulting in lower prices and increased flight operations.

The less efficient airlines either went bankrupt or merged, while at the same time new business models emerged (Zhang et al., 2008; Fu et al., 2010). No group of airlines has taken more advantage of the new market characteristics than low-cost carriers. Their lean business models offer a compelling alternative compared to the traditional network carriers with their complex hub-and-spoke systems (Franke, 2004). As a result they can offer much lower fares than the traditional network carriers so that the competitive impact of low cost competition is generally more significant than that of network carriers. Although they were at first seen as niche players, targeting passengers with a low willingness-to-pay, business travellers increasingly viewed low cost carriers (and economy class products) as acceptable alternatives, particularly on short haul routes (Mason, 2005; Huse and Evangelho, 2007). Competition therefore especially lowered the prices at the top end of the price distribution (Gerardi and Hale Shapiro, 2009; Alderghi et al., 2012). The traditional network carriers have responded to the low cost threat by incorporating certain aspects of the low cost model into their own business model. Some airlines have launched their own low cost subsidiary. As a result of the lower prices and the increase in flight operations, there was a significant increase in the number of city pair served (Dobruszkes, 2011) and passengers carried (Mason, 2005; Dresner et al., 1996).

Deregulation also had a spatial impact, felt through the increased competition between airports. The newly formed low cost carriers preferably operate out of secondary uncongested airports where they can benefit from fast turnarounds and low airport charges. Between 1996 and 2008 the number of airports offering commercial jet services in Europe increased from 441 to 522 (Reynolds-Feighan, 2010). Increased use of regional airports means that airport catchment areas show greater overlap. The overlap is further enhanced by the fact that catchment areas widen, not only due to investments in road and rail infrastructure (which decrease airport access times), but also due to the low fares offered by low cost carriers which attract passengers from a wide geographical area (Lian and Rønnevik, 2011; Pantazis and Liefner, 2006). Especially time-insensitive leisure travelers are willing to accept longer access times to benefit from lower fares, even if that means travelling to a more distant airport (Dresner et al., 1996; Gillen and Lall, 2004; Greifenstein and Weiß, 2003; Fuellhart, 2007). The increased overlap in airport catchment areas means that more airports are competing for the same passengers. Airports responded to this increase in competition by investing in service quality and by more actively marketing their airport to airlines. Over the last ten years marketing and route development expenses have more than doubled (Copenhagen Economics, 2012).

One of the unanticipated developments following deregulation has been the widespread adoption of hub-and-spoke systems (Burghouwt and Hakfoort, 2001; Gowrisankaran, 2002). [1] An important consequence was a concentration of operations at selected hubs by a single carrier, reducing competition in the local markets in what became fortress hubs (Pels, 2008, 2009). Frenken at al. (2003) found evidence that competition at these airports indeed decreased after deregulation.

Technological and economic developments further intensified competition. Developments in aircraft technology reduced the minimum efficient scale for operating routes, increasing the possibilities for hub-bypassing. Technological developments also increased the range of aircraft, widening the route choice available to airlines. High-speed rail networks increased competition for short-haul intra-European travel. The internet led to more price-transparency. Additionally internet bookings reduced entry costs for airlines into new markets. To sum up, competition between airlines and airports increased significantly after the deregulation of the intra-European market in 1997.

[1] Radial star-shaped networks already existed in Europe before deregulation, as national carriers generally concentrated their flights in one central point. Arriving and departing flights however were not yet synchronised to maximise transfer connections.

In this paper we investigate this new airline and airport competition context. The level of competition is modelled for all air transport markets available to consumers in each western-European municipality using a Multinomial Logit (MNL) model. This allows us to determine how competitive the air transport product available to consumers in each of those municipalities truly is and so explore the spatial dimension of changes in competition. In contrast to most other competition studies we take all viable direct and indirect flight alternatives into account, as well as competing alternatives from nearby (adjacent) airports. This provides the most extensive analysis of competition in the European aviation industry performed to date.

In section 2 we discuss the relevant literature with respect to airport and airline competition. Section 3 presents the methodology to assess airline and airport competition in small geographic entities such as municipalities. Section 4 shows how competitive the air transport product available to consumers in each western-European municipality is and how the competitive landscape has changed between 2002 and 2012. Section 5 concludes.

2. Literature review

There has been extensive analysis of the impact of deregulation on competition and air fares (Maillebiau et al., 1995; Government Accountability Office, 2006; Squalli, 2014; Uittenbogaart, 1997). The competitive impact of low cost carriers is generally found to be substantially larger than that of the traditional network carriers (Alderighi et al., 2012; Dresner et al., 1996; Fisher and Kamerschen, 2003; Goetz and Vowles, 2009; Morrison, 2001; Vowles, 2001; Windle and Dresner, 1995, 1999). Most of these studies are however limited in scope, based on only a small sample of routes.

A correct measurement of competition levels depends to a large extent on an accurate definition of relevant markets (Lijesen, 2004). In the liberalised airline industry this requires recognition and measurement of the right spatial market level, which calls for deep understanding of the potential passenger. A passenger willing to travel from A to B generally has multiple travel alternatives to choose from. The relevant market thus consists of all competing alternatives perceived as viable by the passenger. Many studies however either omit indirect flight alternatives and/or do not take flight alternatives from nearby (secondary) airports into account.

Indirect travel alternatives are known to contribute significantly to competition, especially in medium- and long-haul markets so that omitting them will significantly underestimate competition levels in these markets. Furthermore, most studies assess competition at the level of individual airport-pairs or city-pairs. As was pointed out above, with the rise of the low cost carriers, passengers generally have a wider choice in terms of departure and arrival airports to choose from and are willing to use more distant airports if they can benefit from lower fares. A correct measurement of competition therefore also requires that travel alternatives from nearby (secondary) airports are taken into account. To date studies focusing on airport- or city-pairs have largely ignored competition from adjacent airports.

Preferably one uses statistics on actual demand to estimate market shares and competition levels. Such figures are however not publicly available in Europe on the O&D level. Therefore most studies use supply statistics (frequencies) to estimate market shares and competition levels. Passenger choice, and therefore airline and airport market shares, however do not only depend on frequency levels, but also on fares and travel time (Cohas et al., 1995; Lian and Rønnevik, 2011). Indirect flights for instance are of lower quality than direct flights, due to the extra travel time involved. Airlines often compensate passengers for this lower quality via reduced fares on indirect flights. Similarly, passengers travelling on low cost carriers are compensated for the longer access and egress times by the lower fares offered. When such quality aspects are not taken into account, competition levels are not measured correctly.

Two recent studies on airline competition have taken a comprehensive approach and included competition from nearby (secondary) airports. Dobruszkes (2009) analysed airline competition on a European scale. Competition was based on direct flight supply on all city pairs within the European area under the liberalised policy in 2005. The author acknowledges that limiting the analysis to direct flights might have underestimated competition levels. The underestimation is probably limited as indirect travel in the intra-European markets is limited. In short-haul markets indirect travel is relatively unattractive, as total travel time can be a major disadvantage. To incorporate the quality of the various flight alternatives (in terms of travel time and price) average competition levels were obtained for individual airports by weighing the competition level on each route offered from the airport by the seat volume. The author found that competition increased since the liberalisation of the European airspace, but has certainly not become the general rule, notably because liberalisation has also led to the creation of many new routes operated as a monopoly by a single airline.

Brueckner et al. (2013) investigated competition and prices in US domestic markets. The authors included both direct and indirect travel alternatives. It was found that most forms of legacy carrier competition have weak effects on average fares. In contrast, competition from low cost carriers had dramatic fare impacts. At the airport-pair itself, fares reduced more strongly than when competition took place from a secondary airport. The ideas in this literature have provided a foundation for the methodology that follows, where an approach is developed that provides a correct measurement of market shares by (1) defining markets correctly and (2) taking into account the quality aspect of different travel alternatives.

3. Methodology

3.1 Markets

Airlines and airports compete with one another for passengers in distinct airline markets. Therefore we determine competition at the level of airline markets, where airline markets are defined as combination of municipalities and destination regions. This means that all airlines and airports serving passengers travelling between a European municipality and a destination region are assumed to compete with one another.

Table 3.1 provides an overview of these countries and how the municipalities are distributed among these countries. The table shows that the number of municipalities per country differ substantially and do not show a direct relationship to the population level. In France for instance the number of municipalities is very high and the average number of inhabitants per municipality is low. In Denmark the number of municipalities is relatively low for the size of the population. As airline and airport competition are measured for each municipality this means that the analysis will be more detailed for countries that have relatively small municipalities.

Table 3.1 Countries and municipalities covered in the analysis, 2010

Country	No. of municipalities	Population	Population per municipality
Austria	2,259	8,209,745	3,634
Belgium	580	10,470,694	18,053
Denmark	95	5,357,909	56,399
Germany	11,558	80,926,103	7,002
Finland	413	5,266,266	12,751
France	35,640	61,390,398	1,723
Ireland	78	2,322,963	29,782
Italy	8,092	60,005,767	7,415
Luxemburg	36	314,046	8,724
Netherlands	488	15,258,452	31,267
Norway	419	4,192,080	10,005
Portugal	282	9,576,549	33,959
Spain	7,850	45,125,239	5,748
Sweden	1,845	7,496,434	4,063
Switzerland	2,511	7,335,468	2,921
United Kingdom	2,916	51,034,820	17,502
All territories	75,062	374,282,933	4,986

Source: Eurostat and national statistics agencies

In total 409 destination airport regions were identified. Airlines (including regional subsidiaries) belonging to the same alliance were grouped together, which implies that we assume that they are not competing.[2]

[2] In practice some alliance partners may work more closely together than others. We assume however that alliance partners do coordinate capacity and fares, thereby reducing competition. The extent to which competition is reduced depends on the strength of the ties between the partner airlines. It is however difficult to take account of this in a modelling framework.

3.2 Competition indicators

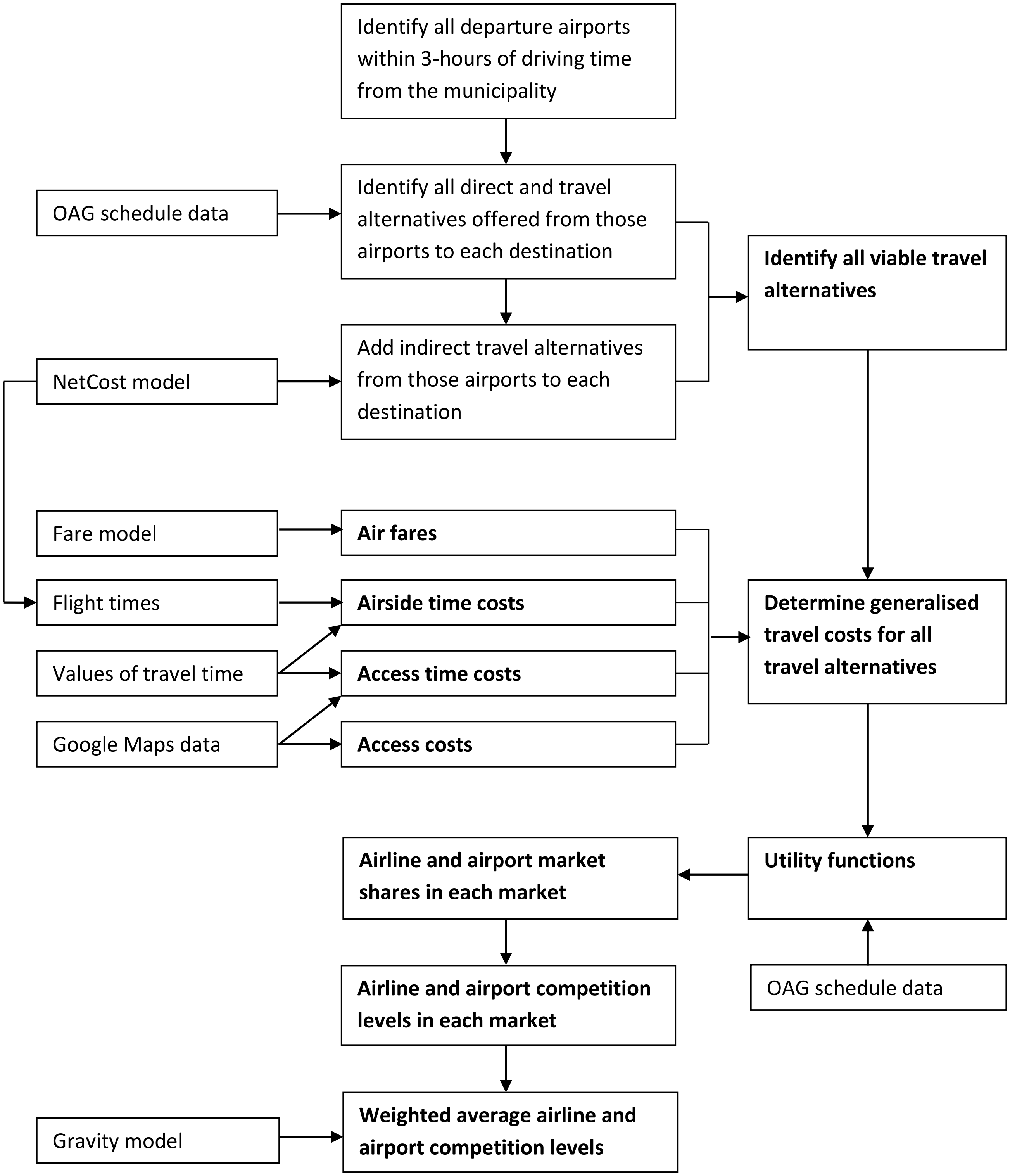
Airline and airport competition in a municipality is measured as the weighted average competition level of all intra-European and 40 most important intercontinental destinations (see Appendix A) that are available to the passengers from that municipality.

The Herfindahl-Hirschman Index (HHI) is widely used to measure market concentration in economic markets, including air traffic markets (Reynolds-Feighan, 1998; Alderghi et al., 2012), and it is easily interpretable. We shall therefore use this concentration measure as a proxy for market competition. The HHI is calculated by summing the squared market shares of competing travel alternatives.

3.3 Model

This section describes the model used to estimate the level of competition in the air transport markets available to consumers in a certain municipality. The concept of the model is depicted in Figure 3.1. It shows the various steps and inputs required. First the model identifies all viable direct and indirect travel alternatives offered in a specific market, ie. between a municipality and a destination that can be reached by either direct or indirect services from airports within a 3 hour radius from the municipality. For each of those alternatives the model estimates each airlines' market share, based on the generalised travel costs associated to each alternative and the airline's frequency. These airline and airport market shares are subsequently used to determine the level of airline and airport competition in each market. Finally the competition levels in the markets available from a municipality are weighted by the size of the market to obtain weighted airline and airport competition levels. The remainder of this section describes the model in more detail.

Figure 3.1 Overview of the methodology to estimate the level of competition in the air transport markets available to consumers in a certain municipality



Identify all viable travel alternatives available in each market

First, the set of viable departure airports is determined for each municipality. Based on material from questionnaires to 43 airports relevant involved in the Ryanair-Aer Lingus case, the European Commission assumes that airport catchment areas stretch to at least 100 kilometres or 1 hour driving time (European Commission, 2013). Most airports however argue that their catchment area exceed these limits, sometimes considerably. The Commission considers, therefore, that 100km or 1 hour driving time is a conservative estimate of an airport's typical minimum catchment area. It should be noted that the Commission uses the 100km/1 hour-"rule" only as a first "proxy" and that catchment areas are determined case by case. Studies conducted by the UK Civil Aviation Authority suggest that the catchment area of airports in the United Kingdom extends up to 2 hours driving time (CAA, 2006).

Although 2 hours seems to be a reasonable limit and in most cases the airport market shares are in fact negligible beyond 2 hours of driving time. However in this research a wider radius of 3 hours is used.. This is justified by recognising the need for passengers to travel longer distances in remote regions, along with an understanding that leisure passengers seeking cheap low cost options have been shown to travel further to their departure airport than less price-sensitive passengers (Dresner et al., 1996; Gillen and Lall, 2004; Greifenstein and Weiß, 2003). Extending the size of airport's catchment areas by an hour in most cases results in a wider set of departure airports for passengers to choose from. However, the airports 2 to 3 hours away in most locations will generally have very low market shares and passengers volumes..

Second, all direct flight options between the viable departure airports and the selected final destinations were identified using OAG flight schedules data for a typical off-peak day in September 2012. Charter flights therefore were not included in the analysis. The share of unscheduled charter flights is however very small and decreasing. Not only is a large part of the charter supply in Europe being replaced by low cost carriers, but the traditional charter carriers increasingly operate according to a fixed flight schedule. This also allows them to sell seat-only tickets on their flights, making them less dependent on the tour operators. These flights are in the OAG data.

Indirect flight options were added by identifying all viable indirect options using the NetCost model. This model was first presented by Heemskerk and Veldhuis (2006a, 2006b) and developed by Veldhuis and Lieshout (2010) and Lieshout (2013). Especially on long-haul routes, a significant number of passengers use indirect flight alternatives. As opposed to direct connections, indirect connections contain a stop at an intermediate hub airport.[3] Flight options for which the great circle distance was less than 400 kilometers were excluded from the analysis, as airlines most likely have a very small share in these markets.

[3] A hub airport is an airport at which at least one airline is coordinating its incoming and outgoing flights in such a way as to optimize transfers between these flights.

Although it is generally acknowledged that high-speed trains compete with air transport in the short-haul, we did not include rail as a competitive transport mode due to the lack of train schedule data and rail fares across Europe. Competition between air and rail however should not be overestimated, as only a very limited share of air routes are contested by high-speed rail lines (Dobruszkes, 2009). It is expected however that the European high-speed rail network will be further developed in the future for economic and environmental purposes and to enhance social cohesion (Adler et al., 2010). Also high-speed rail does not always offer competitive prices. This appears especially true on lines where low cost carriers compete (Steer Davies Gleave, 2006).

Determine generalised travel costs for all travel alternatives

The attractiveness of each travel alternative between each municipality and each destination is assessed by estimating the associated generalised travel costs. These include the pecuniary and time costs related to the trip, including access (time) costs, airfares and airside time costs.

Access costs

As only the car is included as access mode, the access costs are the costs associated with using an average car to travel between municipality r and departure airport x. The costs depend on the distance between municipality r and airport x and the number of car passengers over which the costs are split:

$$access\ costs_{r,x,m} = \frac{costs\ per\ km\ \cdot distance\ (km)_{r,x}}{car\ passengers_m} \tag{1}$$

Where:

$access\ costs_{r,x,m}$	Out of pocket costs (€) related to the landside trip between municipality r and departure airport x, for passengers with travel motive m.
$costs\ per\ km$	Average car costs per kilometre (€), including fuel, maintenance, insurance and depreciation.[4]
$distance\ (km)_{r,x}$	Landside distance in kilometres between municipality r and departure airport x.
$car\ passengers_m$	Average number of passengers per car, for passengers with travel motive m.[5]

The access distances between municipalities r and departure airports x were obtained from the Google online route planner using web scraping technology. The distances were calculated from the core of a municipality to the departure airport.

4 These costs were estimated to be 0.20 € / kilometer on average.

5 The number of passengers per car was not known for each of the airports included in the analysis. Therefore an assumption was made that the average number of car passengers for leisure travel averages 3 and for business travel 1.5.

Air fares

Reliable data on air fares is hard to come by. Therefore a fare model was used whose parameters were obtained by econometric analysis using MIDT data for Amsterdam Schiphol Airport. The analysis showed that distance, market concentration, the presence of a low cost carrier and the circuity and transfer times associated with indirect travel alternatives all had a significant effect on air fares. The following formulae were used to estimate the expected air fares (in dollars)[6] for leisure and business passengers:

$$fares_{x,h,y,m,a} = \begin{cases} 0.78 \cdot e^{4.165+0.214 \cdot NST_{x,y}-0.005 \cdot NST_{x,y}{}^{2}-0.002 \cdot NST_{x,y} \cdot HHI\ air_{x,y} \cdot 10^{-4}+0.345 \cdot HHI\ air_{x,y} \cdot 10^{-4}-0.034 \cdot Dlcc+0.105 \cdot Ddirect}, m = leisure \\ 0.78 \cdot e^{4.064+0.296 \cdot NST_{x,y}-0.008 \cdot NST_{x,y}{}^{2}-0.039 \cdot NST_{x,y} \cdot HHI\ air_{x,y} \cdot 10^{-4}+0.564 \cdot HHI\ air_{x,y} \cdot 10^{-4}-0.364 \cdot Dlcc+0.323 \cdot Ddirect}, m = business \end{cases} \quad (2$$

Where:

$fares_{x,h,y,m,a}$	Out of pocket fare costs (€) related to the airside trip between departure airport x, possibly with a transfer at hub h to final destination airport y with airline/alliance a, for passengers with travel motive m.
$NST_{x,y}$	Nonstop travel time in hours between departure airport x and final destination airport y.
$HHI\ air_{x,y}$	Concentration level in the airside market between departure airport x and final destination airport y.
$Dlcc$	Dummy variable for low cost carriers.
$Ddirect$	Dummy variable for direct flights.

The nonstop travel time is the actual direct travel time, according to airline schedules. For indirect connections, not offered directly, the nonstop travel time is estimated by calculating the great circle travel distance and assuming an average flight speed, adjusting for landing and take-off.

As reasoned above, we chose the Herfindahl-Hirschman Index (HHI) as a measure of competition. As noted earlier, to be effective in our analysis the difference in quality between direct and indirect should be taken into account. Therefore, connectivity shares of competing direct and indirect flights in specific airline markets are used to compute the concentration index instead of frequency shares. The connectivity shares are based on the connectivity levels (CNU) of each competitor in a specific airline market:

$$CNU_{x,y,a} = \sum_{h} (freq_{x,h,y,a} \cdot q_{x,h,y,a}) \quad (3)$$

Where:

[6] An exchange rate of 0.78 was used to convert dollars into euro's.

$CNU_{x,y,a}$	Connectivity offered by airline/alliance a between departure airport a and final destination airport y.
$freq_{r,x,h,y,a}$	Flight frequency between municipality r, via departure airport x, possibly via hub airport h to final destination airport y offered by airline/alliance a.
$q_{x,h,y,a}$	The quality of the indirect flight frequency.

Connectivity levels are obtained by weighing frequency levels for quality, using a quality index. This way, the quality aspect is accounted for when calculating the HHI. For details on how to weigh frequencies for quality, see Veldhuis (1997), Burghouwt and Veldhuis (2006), Wit et al. (2009) and Burghouwt et al. (2009). Aggregating the squares of the connectivity shares of each of the competing airlines (alliances) in a specific market between x and y results in the HHI of the airside market.

$$HHI\ air_{x,y} = \sum_a \left(\frac{CNU_{x,y,a}}{\sum_a CNU_{x,y,a}} \cdot 100 \right)^2 \tag{4}$$

Access time costs

The cost associated with travel time is obtained by multiplying the time spent during the trip with a value of travel time. Access time costs are therefore represented as follows:

$$access\ time\ costs_{r,x,m} = access\ time_{r,x} \cdot VoTT_m \tag{5}$$

Where:

$access\ time\ costs_{r,x,m}$	Landside time costs (€) related to the trip between municipality r and departure airport x, for passengers with travel motive m.
$access\ time_{r,x}$	Access time in hours between municipality r and departure airport x.
$VoTT_m$	Value of travel time (€) for passengers with travel motive m.[7]

The access times between municipality r and departure airports x were also obtained from the Google online route planner. The travel times between the core of a municipality and the departure airport were taken. Egress time costs have not been included in the analysis, as this would significantly increase model runtime. It would also require access times and distances from all arrival airports to their surrounding regions. Competition between airports at the destination have been taken into account however. In case multiple arrival airports serve the

[7] The values of travel time for both motives were calibrated using MIDT data. The best fit was obtained with a value of 30 dollars per hour for leisure travelers and 65 dollars per hour for business travelers. An exchange rate of 0.78 was used to convert dollars into euro's.

same metropolitan area, we have assumed that all travel alternatives into these airports compete with one another.

Airside time costs

Indirect travel alternatives involve extra travel time compared to direct alternatives, because of the circuitous flight and the transfer at the intermediate hub. Circuitous flight time is defined as the time difference between the total indirect flight time and the nonstop travel time. The transfer time is defined as the time spent at an intermediate airport. The transfer time follows from the airline schedules. The nonstop and indirect travel times are calculated by the NetCost model based on the flight distance of the flight leg(s).

The valuation of in-flight travel time is assumed to be identical to access travel time. Circuitous time and transfer time are perceived with a higher degree of inconvenience than in-flight time. Therefore, circuity time and connecting time are penalized with specific factors in the model:

$$airside\ time\ costs_{x,h,y,a} = \left(NST_{x,y} + \mu_{x,y} \cdot \rho_m^{CT} \cdot CT_{x,h,y,a} + \mu_{x,y} \cdot \rho_m^{TT} \cdot TT_{x,h,y,a}\right) \cdot VoTT_m \tag{6}$$

Where:

$airside\ time\ costs_{x,h,y,m,a}$	Airside time costs (€) related to the trip between departure airport x, possibly with a transfer at hub h to final destination airport y with airline/alliance a, for passengers with travel motive m.
$\mu_{x,y}$	Adjusting penalty factor decreasing with travel time.
ρ_m^{CT}	Penalty factor on the VoTT for circuitous time for passengers with travel motive m.[8]
ρ_m^{TT}	Penalty factor on the VoTT for transfer time for passengers with travel motive m.[9]
$CT_{x,h,y,a}$	Circuitous travel time in hours between departure airport x, via hub airport h to destination airport y with airline/alliance a, compared to a direct flight between airports x and y.
$TT_{x,h,y,a}$	Transfer time in hours at intermediate hub airport h offered by airline/alliance a on connections between departure airport x and destination airport y.

The penalty factors for circuitous and transfer time are assumed to decrease when flight distance increases. This means that one hour of circuitous or transfer time is penalized more for short-haul routes than for long-haul routes. This is because one hour of circuitous or transfer time leads to relatively smaller increase and less inconvenience in the long-haul than in the short-haul. Furthermore, the penalty factor for transfer time is overall slightly higher, as this is perceived as

[8] This parameter was calibrated with using MIDT-data, the best fit was obtained for a value of 1.7 for both travel motives.

[9] This parameter was calibrated with using MIDT-data, the best fit was obtained for a value of 1.3 for leisure travelers and 1.5 for business travelers.

even more inconvenient than a circuitous flight. The adjusting penalty factor on circuitous and transfer time is as follows (see Wit et al., 2009):

$$\mu_{x,y} = 3 - 0.075 \cdot NST_{x,y} \tag{7}$$

This implies that the penalty factors for circuitous and transfer time are adjusted with a factor of almost 3 for short-haul routes with a nonstop flight time of - say - three hours. The penalty factors for long-haul routes with a direct flight time of - say - twelve hours are adjusted with a factor little over 2.

Utility functions

Using a Multinomial logit (MNL) with utility functions we estimate the attractiveness of a each travel alternative in a market to the consumer. The MNL model assumes that the traveller chooses the travel alternative that maximizes total utility (or minimizes total disutility / costs) (Ben-Akiva and Lerman, 1985). The attractiveness (or utility) of an alternative depends on the generalised travel cost associated to the alternative and the flight frequency:

$$U_{r,x,h,y,m,a} = e^{\ln(freq_{r,x,h,y,a}) + \alpha \cdot (access\ costs_{r,x,m} + fares_{x,h,y,m,a} + access\ time\ costs_{r,x,m} + airside\ time\ costs_{x,h,y,m,a})} \tag{8}$$

Where:

α_m Parameter indicating the sensitivity to changes in travel and time costs for passengers with travel motive m.[10]

Airline and airport market shares in each market

Based on the utility values for each alternative we estimate the market shares of each travel alternative. In case of airline competition, the airline market shares are estimated. To assess airport competition, the airport market shares are required. The airport market shares are determined by summing the market shares of the airlines operating out of each airport in a given market.

The market share of airline (alliance member airlines taken together) a in the market between municipality r and destination y for passengers with travel motive m is given by:

$$P_{r,y,m,a} = \frac{\sum_{x,h} e^{U_{r,x,h,y,m,a}}}{\sum_{x,h,a} e^{U_{r,x,h,y,m,a}}} \tag{9a}$$

10 This parameter was calibrated with available MIDT-data, the best fit was obtained for α = -0,01 for the business segment and α = -0,02 for the leisure segment.

For airport competition the market share of airport x in the market between municipality r and destination y for passengers with travel motive m is given by:

$$P_{r,x,y,m} = \frac{\sum_{h,a} e^{U_{r,x,h,y,m,a}}}{\sum_{x,h,a} e^{U_{r,x,h,y,m,a}}} \tag{9b}$$

Where:

$P_{r,y,m,a}$	Market share of airline/alliance a in the market between municipality r to destination y for passengers with travel motive m.
$P_{r,x,y,m}$	Market share of airport x in the market between municipality r to destination y for passengers with travel motive m.
$U_{r,x,h,y,m,a}$	Utility of the travel alternative between municipality r, via departure airport x, possibly with a transfer at hub h to destination airport y with airline/alliance a for passengers with travel motive m.

Airline and airport competition levels in each market

The market shares are used to determine the level of market concentration in each market. Market concentration is used as a proxy for competition. Airline competition levels are calculated based on airline/alliance market shares:

$$HHI\ municipality\ (airline)_{r,y,m} = \sum_{a} P_{r,y,m,a}{}^{2} \tag{10a}$$

Where:

$HHI\ municipality\ (airline)_{r,y,m}$	Airline concentration level in the market between municipality r and destination y for passengers with travel motive m.

The airport competition levels are based on the airport market shares:

$$HHI\ municipality\ (airport)_{r,y,m} = \sum_{x} P_{r,x,y,m}{}^{2} \tag{10b}$$

Where:

$HHI\ municipality\ (airport)_{r,y,m}$	Airport concentration level in the market between municipality r and destination y for passengers with travel motive m.

Weighted average airline and airport competition levels

By weighing the competition levels in each market by the size of each destination region in terms of departing passengers, one obtains a weighted average competition level for each municipality r. The weighted average airline competition level for municipality r and motive m is given by :

$$Weighted\ average\ HHI\ municipality\ (airline)_{r,m} = \sum_y HHI\ municipality\ (airline)_{r,y,m} \cdot \frac{pax_{r,x,y}}{\sum_y pax_{r,x,y}} \quad (11a)$$

The weighted average airport competition level is given by :

$$Weighted\ average\ HHI\ municipality\ (airport)_{r,m} = \sum_y HHI\ municipality\ (airport)_{r,y,m} \cdot \frac{pax_{r,x,y}}{\sum_y pax_{r,x,y}} \quad (11b)$$

Where:

$Weighted\ average\ HHI\ municipality\ (airline)_{r,m}$	Weighted average airline competition level in municipality r, for passengers with travel motive m.
$Weighted\ average\ HHI\ municipality\ (airport)_{r,m}$	Weighted average airport competition level in municipality r, for passengers with travel motive m.
$pax_{r,x,y}$	Passengers with travelling between municipality r via departure airport x to destination y.

Passenger numbers are generally not available at the detailed level of municipalities and final destinations. A solution would be to use a gravity model to estimate the number of passengers between each municipality and final destination. Here a simple gravity model is applied to estimate the number of departing passengers between the airport and each destination:

$$pax_{x,y} = 2.539\ x\ 10^{-4} \cdot \frac{seat\ capacity_x{}^{0.791} \cdot seat\ capacity_y{}^{0.791}}{distance_{x,y}{}^{1.037}} \quad (12)$$

Where:

$pax_{x,y}$	Passengers travelling from departure airport x to destination y.
$seat\ capacity_x$	Total yearly seat capacity offered from departure airport x.
$seat\ capacity_y$	Total yearly seat capacity offered from destination airport y.
$distance_{x,y}$	Great circle distance in kilometres between departure airport x and destination y.

The great circle distances between the departure airport x and destination airport y were calculated using the longitude and latitude of both airports. The yearly seat capacities for all departure and destination airports were determined using OAG airline schedules data. The coefficients were obtained by econometric regression analysis on MIDT passenger data. The gravity model passenger estimates for each city-pair now only need to be assigned to the various municipalities. Municipalities close to Schiphol will obtain a higher share of the gravity estimates. The utility values are used to calculate this share. In addition, regions with a larger population will have a larger share in the gravity estimates. Therefore the share also depends on the population share of a municipality.

3.4 An illustration of the methodology

The methodology presented in section 3 shall be illustrated for leisure passengers from the municipality of Milan, Italy. First we estimate the market shares of all airports serving the municipality of Milan to all destinations offered. Table 4.1 shows the most attractive travel alternatives for the destination New York. The municipality of Milan is served with direct flights to New York from Milan Malpensa airport by all three alliances. The SkyTeam alliance for which Malpensa is a hub, offers a twice-daily connection to New York JFK. STAR and OneWorld offer a daily connection to Newark and New York JFK respectively. In addition many indirect alternatives exist.

Table 4.1 Attractiveness of travel alternatives in the market between the municipality of Milan and New York, leisure passengers, 2012

Munici-pality	Route			Alliance	Frequency per day	Airport access		Flight time (mins)		Costs ($, one-way)				Utility	Market share
	Origin	Hub	Dest.			kms	mins	In flight	Connect	Access		Flight			
										Trip	Time	Fare	Time		
Milan	MXP	-	JFK	SkyTeam	2	46	43	550	-	17	3	290	214	5.67E-05	34.9%
Milan	MXP	-	JFK	OneWorld	1	46	43	555	-	17	3	293	216	2.57E-05	15.8%
Milan	MXP	-	EWR	Star	1	46	43	555	-	17	3	344	216	9.37E-06	5.8%
Milan	LIN	CDG	JFK	SkyTeam	9	17	30	584	99	12	1	251	439	1.14E-05	7.0%
Milan	MXP	ZRH	JFK	Star	3	46	43	585	92	17	3	262	372	7.61E-06	4.7%
Milan	LIN	LHR	JFK	OneWorld	11	17	30	590	118	12	1	251	470	7.84E-06	4.8%
Milan	MXP	LHR	JFK	OneWorld	2	46	43	578	110	17	3	262	382	4.89E-06	3.0%
Milan	BLQ	CDG	JFK	SkyTeam	5	210	130	601	99	50	14	243	447	1.70E-06	1.0%
Milan	VRN	CDG	JFK	SkyTeam	3	162	107	595	78	42	11	246	420	1.97E-06	1.2%
Milan	LIN	LHR	EWR	OneWorld	3	17	30	597	73	12	1	239	425	4.12E-06	2.5%
Milan	TRN	CDG	JFK	SkyTeam	5	148	102	583	111	40	10	249	460	1.55E-06	1.0%
Milan	MXP	BRU	JFK	Star	4	46	43	595	130	17	3	262	432	2.52E-06	1.6%
Milan	MXP	FRA	JFK	Star	2	46	43	603	98	17	3	262	405	2.49E-06	1.5%
Milan	VRN	ZRH	JFK	Star	1	162	107	590	55	42	11	246	385	1.16E-06	0.7%
Milan	BLQ	LHR	JFK	OneWorld	3	210	130	603	137	50	14	243	496	7.73E-07	0.5%
Milan	65 other indirect one-stop alternatives													2.26E-05	13.9%

We calculate the attractiveness/utility of all direct and indirect travel alternatives by applying formula 8. The attractiveness of an alternative depends not only on the frequency level offered, but also on the costs associated with the alternative. We distinguish access costs and airside costs. Linate airport is located relatively close to the municipality of Milan (at a distance of 17 kilometres or 30 minutes), limiting airport access costs. The access costs for Malpensa are around 60 percent higher as it is located less conveniently for passengers travelling to/from the municipality of Milan (46 kilometres or 43 minutes). The airside costs consist of the air fares and the time costs associated with the flight. The air fares for indirect travel alternatives are generally lower than those for direct alternatives to compensate for the longer travel times.

For direct alternatives, flight time costs are related directly to direct flight time. Direct flight time between Milan Malpensa and New York is just over 9 hours. Total flight time for indirect alternatives is longer due to circuitous flight paths. Indirect alternatives via London Heathrow, Paris Charles de Gaulle and Zurich lead to only modest increases in flight time compared to a direct connection. Rome Fiumicino, Atlanta and Istanbul are not included in the top rankings since they are less conveniently located as transfer points, leading to large increases in in-flight time. Indirect flight alternatives also include transfer time at the intermediate hub. Table 4.1 shows that transfer times differ considerably between the various alternatives. The costs associated to transfer time and circuitous flight time are higher than for direct flight time as they are perceived as less convenient.

The market shares of the various flight alternatives are also indicated in table 4.1 The direct flight alternatives have the highest market shares. Although air fares are higher for the direct flights, travel time costs are smaller due to a lack of circuity and transfer time. By aggregating the market shares of airlines and alliances in this market, we obtain the airline/alliance market shares in Table 4.2.

Table 4.2 Market shares by airline/alliance in the market between the municipality of Milan and New York, leisure passengers, 2012

Alliance	**Market share**		
	Direct	**Indirect**	**Total**
SkyTeam	34.9%	14.1%	49.0%
OneWorld	15.8%	12.2%	28.0%
Star	5.8%	17.2%	23.0%
Total	56.5%	43.5%	100.0%

In the same way the market shares for the departure airports are obtained. Table 4.3 shows the total market share of all the airports serving the municipality of Milan on the route to New York.

Table 4.3 Market shares by departure airport in the market between the municipality of Milan and New York, leisure passengers, 2012

Departure airport		**Market share**		
		Direct	**Indirect**	**Total**
Milan (Malpensa), Italy	MXP	56.5%	14.7%	71.2%
Milan (Linate), Italy	LIN		18.6%	18.6%
Verona, Italy	VRN		3.4%	3.4%
Bologna, Italy	BLQ		3.4%	3.4%
Genoa, Italy	GOA		0.7%	0.7%
Lugano, Switzerland	LUG		0.5%	0.5%
Turin, Italy	TRN		2.0%	2.0%
Milan (Orio Al Serio), Italy	BGY		0.2%	0.2%

Total	56.5%	43.5%	100.0%

Due to the four daily direct connections offered from Milan Malpensa to New York, the airport is most attractive as departure airport especially to business travellers with a high value of time. Leisure travellers with a lower value of time might prefer the cheaper air fares on the indirect alternatives that involve a longer travel time. Linate has the largest combined market share in the market for indirect travel. This is due to the many indirect alternatives offered from Linate to New York and the relatively low access costs.

Besides the route to New York we calculated the airport and airline/alliance market shares for all European destinations and for 39 other intercontinental destination regions. By weighing the market shares with the sizes of the respective markets, we obtain weighted average market shares of the departure airports serving the municipality of Milan

These weighted average market shares result in a HHI of 3,400 at the airline level and 3,000 at the airport level. This means that the airline product offered by airports serving the municipality of Milan is relatively competitive. In the next section we show the results for all European municipalities.

4. Results

In this section we show the state of competition in the air transport product for consumers in each of the 75,000+ European municipalities mentioned in table 3.1. First we illustrate the methodology for a single municipality.

4.1 Airline and airport competition across Europe

Figure 4.1 shows how airline competition differs among the municipalities analysed. A HHI of 10,000 means that passengers on average only have one viable airline to choose from. Airline competition is most intense in areas that have access to one or more airports from which multiple carriers offer identical route networks. Figure 4.1 shows that competition is generally quite fierce in areas surrounding the larger hub airports, such as London Heathrow, Madrid Barajas, Rome Fuimicino and Amsterdam Schiphol. At those airports multiple carriers compete on many different routings. However, competition is also intense in areas not served by the large European hubs, such as in Scotland, Northern Ireland, the Mediterranean Coast of Spain, the Basque area and the North-eastern and South-eastern parts of Italy. These areas are served by smaller airports, but most routings offered from those airports are served either by multiple carriers or by carriers operating from another small airport nearby.

In Germany the competition levels in areas surrounding the large airports of Frankfurt and Munich are relatively small. This has to do with the strong dominance of the Star alliance (mainly Lufthansa) in Germany. Weighing the airline market shares of the various German municipalities by their population size, results in an average market share for the Star alliance of 53 percent (see table 4.4). The Star alliance is also relatively dominant in Austria (Austrian Airlines) and Portugal (TAP) which also explains the relatively low competition levels there.

In parts of France and Spain airline competition is also very low. These areas are often served only by a handful of smaller airports with limited flights available. This results in limited airline choice and therefore less competition.

In large parts of Scandinavia, there is limited or no competition between airlines. Passengers in these areas often have very few airports to choose from and these are often very small airports with limited services. The results is that many of the 409 destination regions included in the analysis are served by only one carrier or not at all (also see figure 4.3). In the more densely populated areas in southern Scandinavia, passengers have more airlines to choose from and competition is more intense.

Figure 4.1 Airline competition across Europe, leisure passengers, 2012

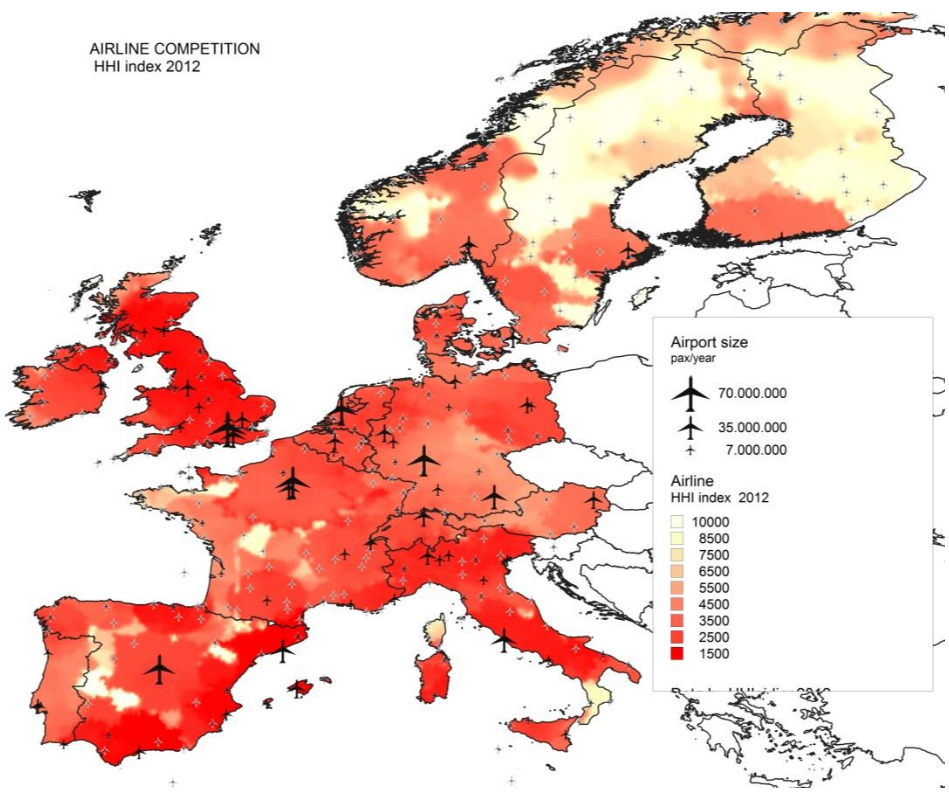
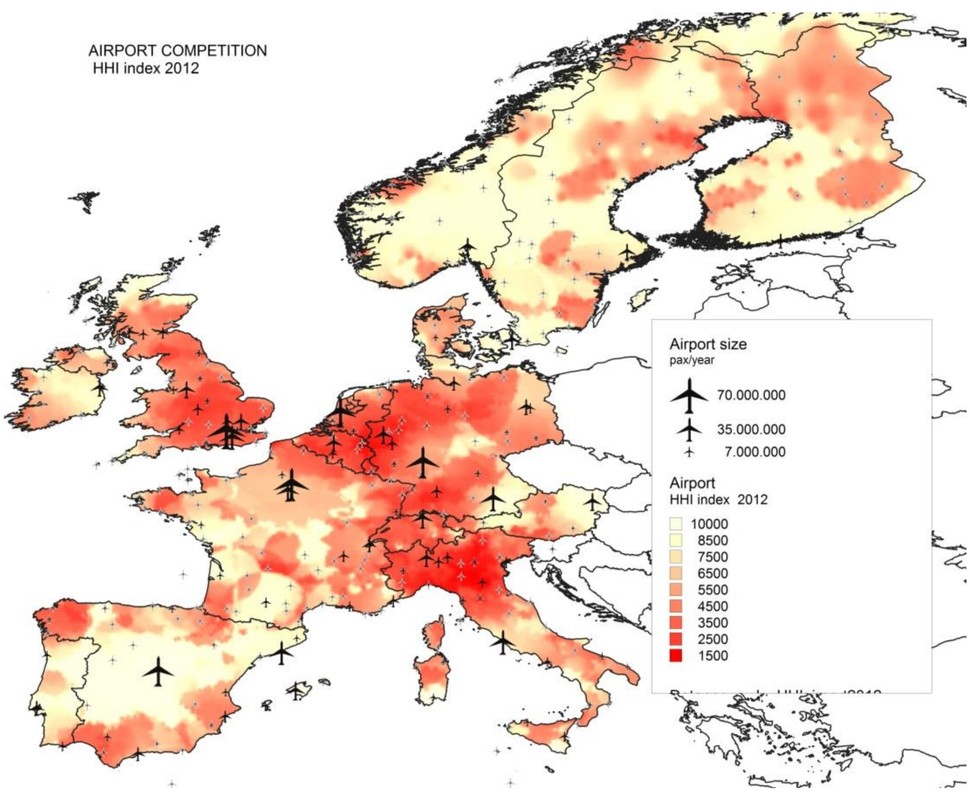


Figure 4.2 shows the results for airport competition. In large parts of France, Spain, Italy, Portugal, Ireland, Austria and Scandinavia, passengers have in general limited choice with respect to their departure airport. For many destinations they have only one airport to choose from. At these airports multiple airlines might however be competing with one another. Passengers around Madrid for instance can only choose Madrid Barajas airport as their departure airport for most destinations, but on many routes multiple airlines compete (as shown by figure 4.1).

In the United Kingdom, the Benelux (Belgium, the Netherlands and Luxemburg), Western Germany, Switzerland and Northern Italy airport competition is the greatest. This is mainly due to the presence of multiple large and medium sized airports offering a similar flight product to many destinations.

Airport competition around Paris is limited even though the area is served by a large hub airport (Paris Charles de Gaulle) and a medium sized airport (Paris Orly). Airport competition is limited due to the fact that the most important airline at both airports, Air France, operates most domestic flights out of Orly whereas the international and intercontinental flights are mostly operated out of Charles de Gaulle. The dominance of Air France at both airports and the lack of other airports in the region limits airport competition around Paris.

Figure 4.2 Airport competition across Europe, leisure passengers, 2012



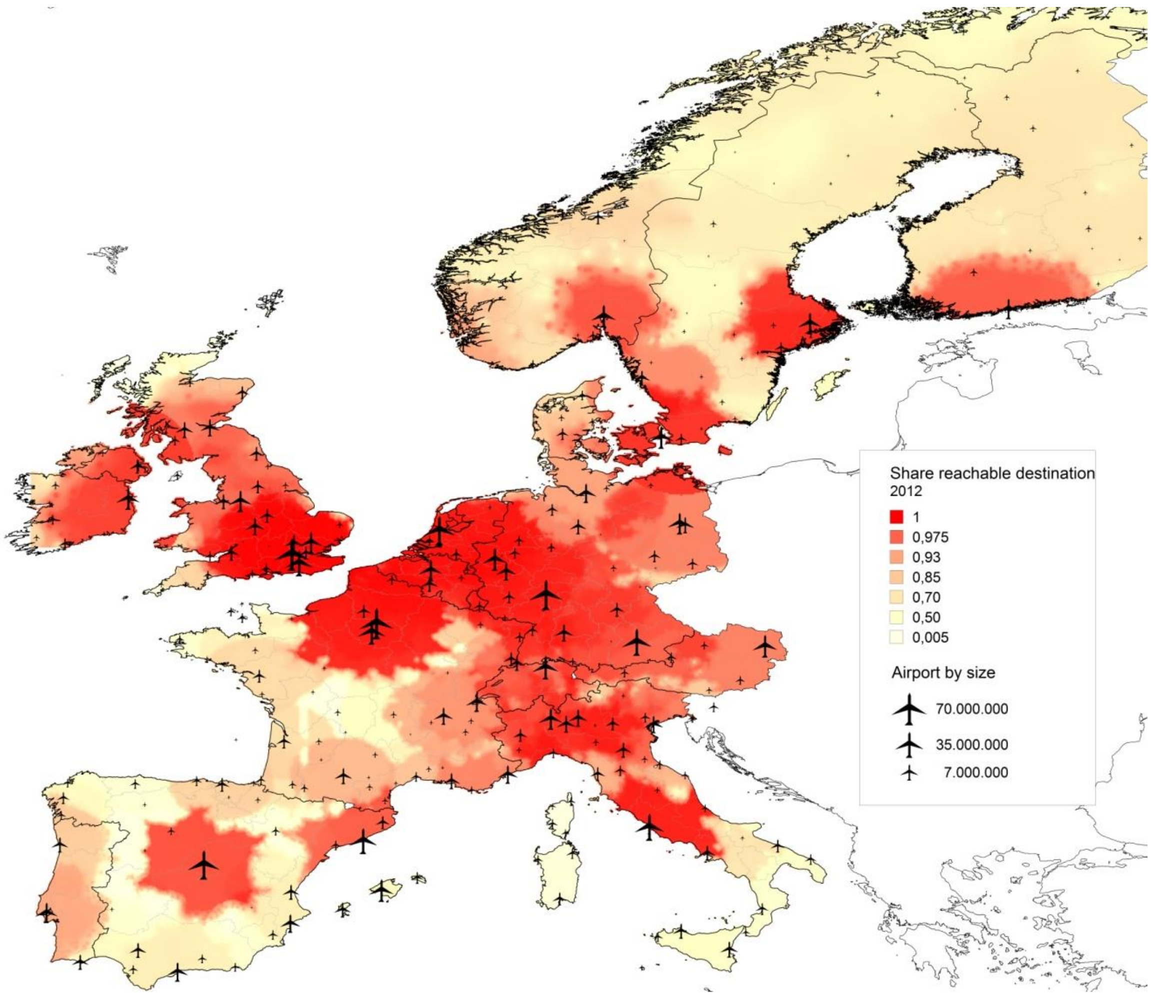
To obtain the average airline and airport competition levels for each country, we weigh the HHI's of each municipality in each country by their population size. Table 4.4 shows these weighted averages for each country, as well as the alliance market shares in each country. The table confirms the findings discussed above.

Table 4.4 Weighted average competition levels and alliance market shares by country, 2012

Country	HHI		Market shares		
	Airline level	Airport level	Star	SkyTeam	OneWorld
Austria	4,042	7,470	60.0%	10.8%	13.7%
Belgium	2,768	2,650	44.4%	23.3%	11.4%
Denmark	3,250	7,399	48.4%	18.1%	14.3%
Deutschland	3,556	4,286	53.0%	14.7%	17.4%
Finland	5,260	8,337	12.8%	4.2%	65.0%
France	3,255	5,935	23.7%	42.1%	8.9%
Ireland	2,528	8,152	13.2%	11.1%	10.3%
Italy	2,332	4,249	25.9%	30.3%	9.8%
Luxemburg	3,406	2,446	55.0%	8.1%	14.2%
Netherlands	2,654	3,690	33.8%	34.4%	12.6%
Norway	4,521	8,860	53.7%	15.6%	6.7%
Portugal	3,694	8,208	56.2%	5.1%	11.7%
Spain	2,127	7,194	15.3%	9.4%	28.6%
Sweden	4,475	8,072	54.2%	11.2%	12.0%
Switzerland	3,020	3,739	49.2%	16.1%	13.4%
United Kingdom	1,924	3,836	23.1%	14.8%	24.4%
Total	2,903	5,180	33.5%	21.6%	16.8%

The analysis is based on 409 destination regions, 369 in Europe and 40 outside of Europe. The destination regions cannot be accessed from each municipality however. Figure 4.3 shows the percentage of destination regions that is accessible by air (direct or indirect) from each municipality still considering a maximum access time of 3-hours to a departure airport. A value of 1 indicates that all of the 409 are accessible; a value of 0.5 means that only 50 percent of the destinations is accessible. The figure shows that the regions around large airports have access to almost all of the 409 destinations.

Figure 4.3 Accessibility of air services in Europe, 2012



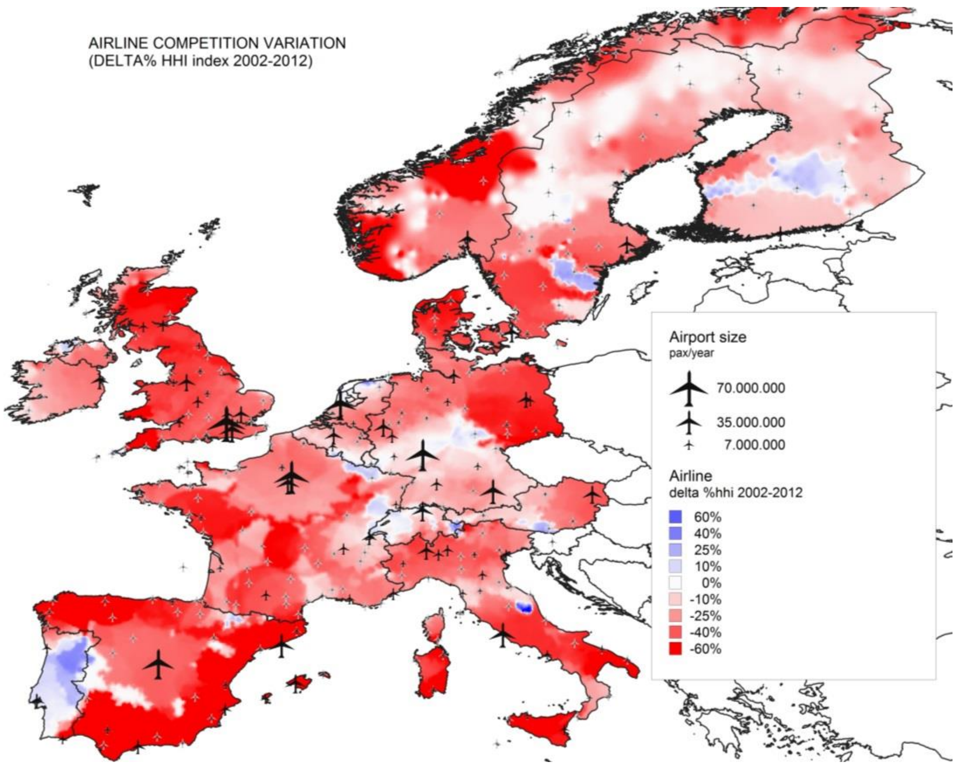
Although EU transport policy aims to reduce regional inequality and improve cohesion within the Union, large parts of Europe are still relatively poorly connected by air. This is especially the case for the more remote regions in France, Spain, Italy, Portugal and Scandinavia, which are most reliant on air transport links.

4.3 Changes in airline and airport competition between 2002 and 2012

In this section we show how airline and airport competition have changed between 2002 and 2012. First, figure 4.4 confirms that airline competition increased (decreasing HHI) in most parts of Europe since the liberalisation of the intra-European market. Most of this can be ascribed to the strong growth of the low cost airlines. The changes are most pronounced in areas that we previously not well served, such as the more remote regions in the United Kingdom, Spain and Italy.

Some regions also experienced a decline in airline competition. Most notable is the decline in Portugal. Portuguese passengers on average had fewer competing airlines to choose from in 2012 than in 2002. There can be various reasons for a decline in airline competition. The downsizing of an airline at an airport or the bankruptcy of an airline can limit competition. Furthermore, the strong growth of a single airline in a region means it becomes more dominant, which adversely affects competition. Airline mergers and consolidation of airlines in alliances also reduce airline competition. The large decline in airline competition in Portugal can be explained by the fact that TAP joined the STAR alliance in 2005.

Figure 4.4 Change in airline competition across Europe, 2002-2012



Note: As we did not have access to airport access times and distances for 2002, we used the 2012 values. This means that the widening effect of infrastructure improvements on airport catchment areas could not be taken into account. The 2002 catchment area sizes are therefore most likely overestimated for some airports. This leads to an overestimation of competition levels in 2002 and an underestimation of the competition changes in the figure above. We expect this to be limited as infrastructure improvements usually lead to only small decreases in travel times and therefore also relatively very small changes in travel costs.

When we look at the changes in airport competition, the changes are less pronounced. In many parts of Europe airport competition has increased. There are also some areas where competition decreased however. In many cases these are in the less populated regions. A decrease in airport competition does not necessarily mean that the airports serving these regions have become more dominant on existing routes. It could be that due to market growth new destinations could be operated from these airports, which were not offered in 2002 by any other airport serving the region. In these circumstances, the airport offering the new destination, has a monopoly for that destination, which has a negative impact on the weighted average competition level.

Figure 4.5 Change in airport competition across Europe, 2002-2012

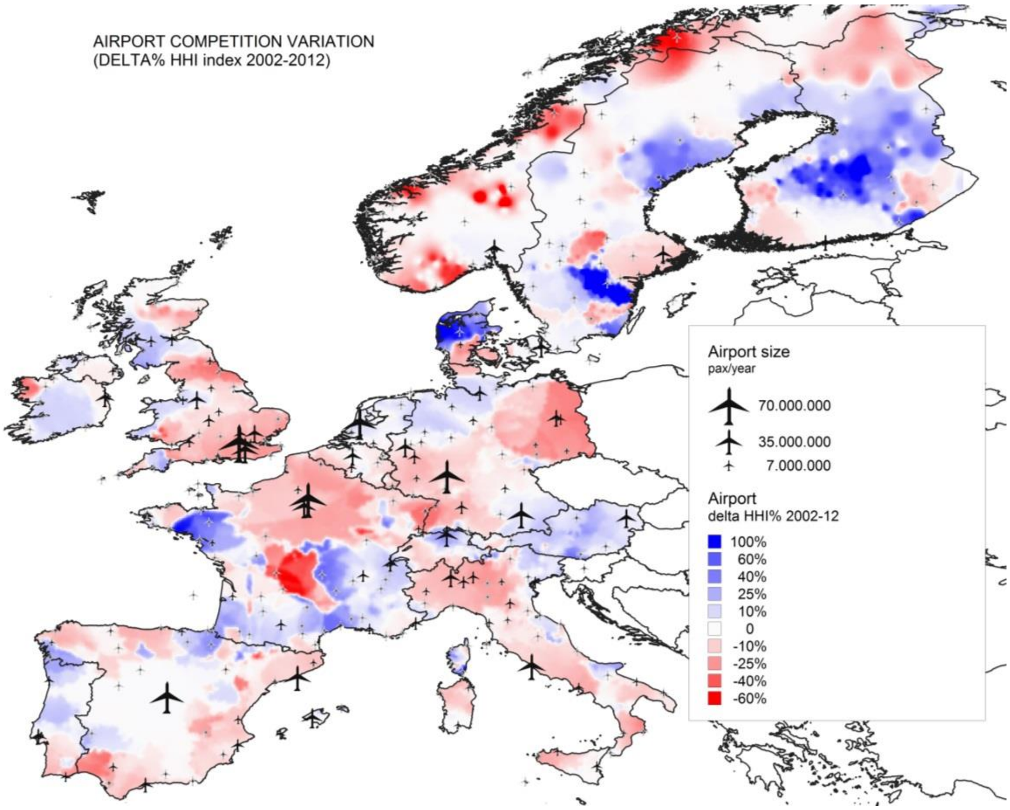


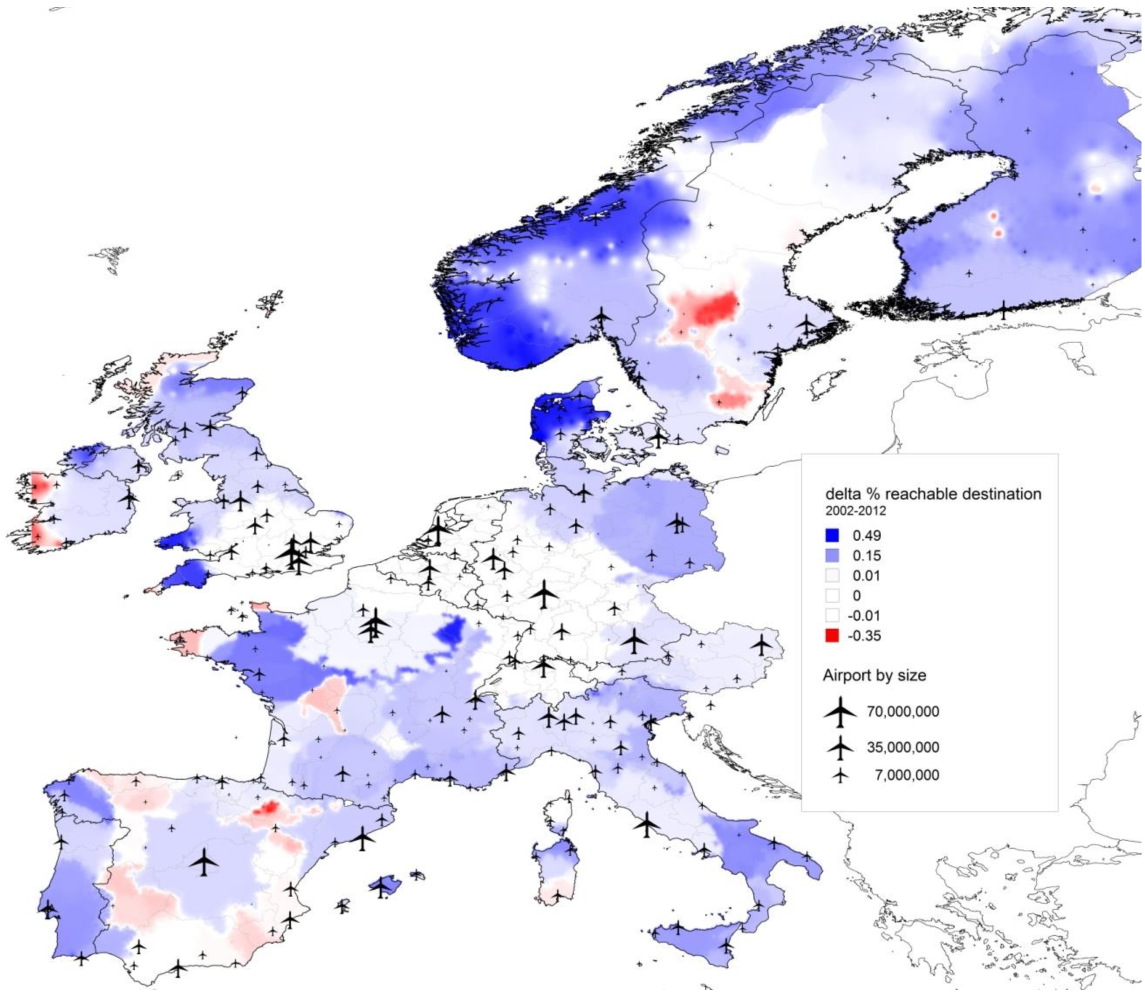
Table 4.5 shows that airline competition increased most in the United Kingdom, Spain, Italy and Denmark between 2002 and 2012. Much of this increase can be ascribed to the growth of the low cost carriers in these countries. This came at the expense of the three large alliances, which despite their expansion with new partners, lost market share. The OneWorld alliance lost most market share overall while the STAR alliance obtained significant market share, especially in Portugal, mainly due to the inclusion of TAP into the STAR alliance. The SkyTeam alliance gained a stronger position in The Netherlands and in Scandinavia.

Table 4.5 Change in weighted average competition levels and alliance market shares by country, 2002-2012

Country	**HHI (relative change)**		**Market shares (absolute change)**		
	Airline	Airport	STAR	SkyTeam	OneWorld
Austria	-27.3%	7.5%	-12.4%	0.9%	3.0%
Belgium	-18.0%	-3.6%	-4.8%	3.1%	-6.5%
Denmark	-44.8%	4.8%	-26.5%	13.0%	4.3%
Deutschland	-26.0%	-7.7%	-12.5%	1.4%	1.6%
Finland	-12.8%	4.7%	-14.0%	4.0%	0.3%
France	-30.7%	-3.3%	3.3%	-15.6%	-6.3%
Ireland	-28.0%	0.6%	-3.1%	-1.6%	-41.9%
Italy	-45.0%	-9.8%	-0.3%	-21.4%	-1.7%
Luxemburg	0.8%	-12.5%	2.2%	-0.5%	-4.5%
Netherlands	-20.1%	3.8%	-16.9%	17.7%	-6.7%
Norway	-34.7%	-1.5%	-14.1%	10.8%	1.1%
Portugal	-0.8%	4.7%	33.7%	-19.4%	-38.0%
Spain	-58.3%	-3.8%	6.5%	-6.5%	-37.0%
Sweden	-30.8%	-0.5%	-22.7%	4.4%	2.3%
Switzerland	-3.6%	9.0%	7.7%	-12.9%	-6.1%
United Kingdom	-43.3%	-9.6%	-0.7%	4.8%	-25.8%
Total	-35.1%	-4.4%	-2.8%	-5.3%	-10.6%

Most parts of Europe have become much more accessible by air since 2002. Especially the accessibility by air to and from Norway, Finland, Denmark, Eastern Germany, Southern Italy, Wales, Scotland, Portugal and large parts of France has increased. The accessibility to other parts of Europe did not change much. This is because some destination regions were already well-served in 2002, such as in the south-eastern part of England, The Benelux, the northern part of France and the western part of Germany. In other parts of Europe, the accessibility did not change, because no new destinations were offered either direct or indirect by the airlines. This was for instance the case in the central part of Sweden.

Figure 4.6 Changes (%) in the accessibility of air services in Europe, 2012



In only few regions the number of accessible destinations decreased. This can be attributed to the downsizing or bankruptcy of airlines at specific airports.

5. Conclusions

This paper showed in which parts of Europe airline and airport competition is most intense and how the competitive landscape has changed over the last decade. The Herfindahl-Hirschman concentration index was used as a proxy for competition. The index uses market shares as input, which were estimated with a MNL model. We defined the relevant markets as all competing travel alternatives perceived as viable by the passenger. This means that all direct and indirect alternatives were included as well as alternatives offered from nearby (secondary) airports. The quality of the various alternatives was taken into account by the MNL model through the inclusion of all generalised travel cost associated to each alternative, including access travel costs. This allowed us to estimate the airline and airport market shares and competition levels at the level of individual municipalities. This makes it the most extensive analysis of competition in the aviation industry performed to date.

The results show that competition between airlines is quite fierce in most parts of western Europe. In Germany airline competition in the areas surrounding the large hubs is lagging behind, due to the strong dominance of the STAR alliance. In large parts of Scandinavia, but also in parts of France and Spain, airline competition is very low. These areas are often served only by a handful of smaller airports with limited flights available. This results in limited airline choice and therefore competition.

Since the liberalisation of the intra-European market airline competition has increased in most parts of Europe, especially due to the penetration of low cost carriers into a wider array of airports. As a consequence the three large alliances lost market share, although they expanded by adding new partner airlines. The changes in airline competition are most pronounced in areas that we previously not well served, such as the more remote regions in the United Kingdom, Spain and Italy. Few regions experienced a decline in airline competition most notably the Portuguese regions.

Competition among airports is strongest in the United Kingdom, the Benelux (Belgium, the Netherlands and Luxemburg), Western Germany, Switzerland and Northern Italy. This is mainly due to the presence of multiple large and medium sized airports offering a similar flight product on many destinations. In large parts of France, Spain, Italy, Portugal, Ireland, Austria and Scandinavia, passengers have in general a limited choice with respect to their departure airport, resulting in a low competition. Airport competition is limited around a few large hubs, such as Paris Charles de Gaulle, Madrid, Munich and Rome, due to their strong dominance on the routes offered. This lack of competition around the large hub airports provides evidence for the fortress hub phenomenon. Airport competition however increased in most European regions between 2002 and 2012.

We grouped airlines belonging to an alliance together, assuming that these airlines do not compete with one another. A possible future development of this research would be to relax this assumption and to analyse the differences in the level of competition switching from an alliance perspective to a standalone airline perspective.

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Appendix A – Largest airports outside Europe

No.	Airport		Departing seats (mln)
1	Atlanta (Intl) GA USA	ATL	76.3
2	Beijing (Capital) China	PEK	55.6
3	Los Angeles (Intl) CA USA	LAX	49.0
4	Chicago (O'Hare) IL USA	ORD	46.1
5	Tokyo (Haneda) Japan	HND	44.9
6	Denver (Intl) CO USA	DEN	43.9
7	Dubai U.A. Emirates	DXB	40.5
8	Hong Kong (Intl) China	HKG	38.9
9	Dallas/Ft. Worth (Intl) TX USA	DFW	37.9
10	Jakarta (Intl) Indonesia	CGK	37.6
11	Singapore (Changi)	SIN	37.1
12	Las Vegas (Intl) NV USA	LAS	35.4
13	Bangkok (Intl) Thailand	BKK	35.1
14	Phoenix (Intl) AZ USA	PHX	33.9
15	San Francisco (Intl) CA USA	SFO	33.7
16	New York (Kennedy) NY USA	JFK	33.4
17	Guangzhou China	CAN	32.8
18	Shanghai (Pu Dong Intl) China	PVG	31.5
19	Delhi India	DEL	30.7
20	Houston (G.Bush Intl) TX USA	IAH	30.4
21	Istanbul (Ataturk) Turkey	IST	29.8
22	Orlando (Intl) FL USA	MCO	29.8
23	Newark/New York (Liberty) NJ USA	EWR	28.6
24	Kuala Lumpur (Intl) Malaysia	KUL	28.2
25	Charlotte NC USA	CLT	27.6
26	Minneapolis/St. Paul (Intl) MN USA	MSP	27.5
27	Detroit (Metro Wayne) MI USA	DTW	27.3
28	Sydney (Intl) NS Australia	SYD	26.7
29	Seoul (Incheon Intl) Rep. of Korea	ICN	26.6
30	Sao Paulo (Intl) SP Brazil	GRU	25.6
31	Mumbai India	BOM	25.4
32	Miami (Intl) FL USA	MIA	24.9
33	Philadelphia (Intl) PA USA	PHL	24.7
34	Seattle/Tacoma (Intl) WA USA	SEA	24.6
35	Toronto (Pearson Intl) ON Canada	YYZ	23.6
36	Shanghai (Hongqiao Intl) China	SHA	23.6
37	Tokyo (Narita) Japan	NRT	22.9
38	Boston (Intl) MA USA	BOS	22.8
39	Manila Philippines	MNL	22.3
40	Melbourne (Intl) VI Australia	MEL	19.8